Big Creek Research and Extension Team

University of Arkansas System Division of Agriculture

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

APPENDICES

BIG CREEK FINAL APPENDICES: OUTLINE

Title
A. ADEQ Memorandum of Agreement for Big Creek Project
B. NRCS soil mapping unit description
C. Ground-penetrating radar
D. Grid-soil sampled Mehlich-3 extractable elements
E. Spatial distribution of Mehlich-3 extractable elements
F. Soil P sorption saturation data
G. Piezometer installation and results
H. Water chemistry by site over project
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J. Manure treatment
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L. Related peer-reviewed publications and Fact Sheets using the data

APPENDIX A: MOA's

MEMORANDUM OF AGREEMENT
BETWEEN THE
BOARD OF TRUSTEES OF THE UNIVERSITY OF ARKANSAS SYSTEM
FOR AND ON BEHALF OF THE
UNIVERSITY OF ARKANSAS SYSTEM-DIVISION OF AGRICULTURE
AND THE
ARKANSAS DEPARTMENT OF ENVIRONMENTAL QUALITY

THIS MEMORANDUM OF AGREEMENT (hereinafter referred to as "MOA") is made and entered into between the Board of Trustees of the University of Arkansas System for and on behalf of the University of Arkansas System-Division of Agriculture (hereinafter referred to as "University") and the Arkansas Department of Environmental Quality (hereinafter referred to as "ADEQ" or the "Department").

WITNESSETH:

WHEREAS, ADEQ is an agency of the State of Arkansas vested with authority to administer environmental regulatory programs, and ADEQ's mission is to protect, enhance, and restore the natural environment for the well-being of all Arkansans; and

WHEREAS, one of the many duties of ADEQ is to issue permits for certain livestock operations, including confined animal feeding operations (hereinafter referred to as "CAFOs"); and

WHEREAS, pursuant to its statutory duties and in compliance with applicable state and federal environmental laws and regulations, ADEQ issued a general permit for CAFOs operating in the state; and

WHEREAS, the first facility permitted under the new general permit for CAFOs is C&H Hog Farm located in the Buffalo River watershed in Newton County; and

WHEREAS, the Buffalo River, designated as the nation's first national river, is unquestionably a scenic and environmental treasure and the maintenance of its natural beauty and pristine water is recognized as important to all citizens of the state; and

WHEREAS, out of concern for protecting the Buffalo River and its tributaries, the Governor has taken the extraordinary step of seeking authorization from the Legislature for $340,510.00 to conduct additional testing in areas on or near the permitted CAFO, C&H Hog Farm, in the Buffalo River watershed; and

WHEREAS, the University of Arkansas System-Division of Agriculture has professionals with expertise in soil and water monitoring and the design and implementation of best practices relevant to the compliance of farm operations to state and federal laws;

NOW, THEREFORE, in furtherance of ADEQ's mission to protect the environment and administer regulatory programs, University and ADEQ agree as follows:

I. Scope of Agreement

A. University agrees to:

1. Undertake and complete a study of the potential for water quality impacts within the Buffalo River watershed from animal wastes produced by the permitted CAFO, C&H Hog Farm, and its operations within the watershed. University shall designate individuals with professional qualifications and expertise sufficient to design and implement such study, including but not limited to best placement for monitoring wells, sampling and testing as necessary for a thorough and informed analysis. This study shall be for the review and consideration of ADEQ and other state officials. Although carried out for the use and benefit of ADEQ and to inform its ultimate performance of its regulatory functions, the study shall be funded and conducted independently of ADEQ and shall meet the requirements of an independent study conducted by professionals in the field of water quality.

2. Provide ADEQ with a Project Plan and time line for the implementation and completion of the water quality study as described herein.

3. Provide ADEQ with quarterly written reports due each quarter of each year this Agreement remains in effect, beginning with the first report due on or before January 31, 2014, the second report due on or before March 31, 2014 and continuing quarterly ending with the final report which will contain conclusions and recommendations, due on or before June 30, 2019. The quarterly reports shall be in a format approved mutually by ADEQ and University, and, at a minimum, shall include a summary of all Project Plan activities performed by University during the preceding quarter.

4. Seek additional funding from appropriate sources as needed for completion of the study in accordance with the Project Plan.

B. ADEQ agrees to:

1. Assist University with obtaining access to conduct the study if access is denied by any property owner.

2. Assist and support University's independent study as appropriate through the sharing of relevant data and information available to ADEQ.

II. Term

This Agreement shall become effective as soon as signed by both parties and shall remain in force until June 30, 2019, unless terminated earlier in accordance with other provisions herein.

III. Termination

A. This Agreement may be terminated by mutual consent of the parties, or by one party upon thirty (30) days written notice.

B. In the event the State of Arkansas fails to appropriate funds or make monies available for any fiscal year covered by the term of this Agreement, then this Agreement shall be automatically terminated on the last day of the fiscal year for which funds were appropriated or monies made available for such purposes.

IV. Amendment

Amendments to this Agreement may be proposed by either party upon written notice to the other party, and such amendments shall become effective as soon as signed by both parties hereto.

V. Notices

Any notices required hereunder shall be addressed as follows:

To ADEQ:

Teresa Marks, Director
Arkansas Dept. of Environmental Quality
5301 Northshore Dr.
North Little Rock, AR 72118-5317
Tel. (501) 682-0959
Fax (501) 682-0798

With a copy to:

Tammera Harrelson, Chief Counsel
Arkansas Dept. of Environmental Quality
5301 Northshore Dr.
North Little Rock, AR 72118-5317
Tel. (501) 682-0886
Fax (501) 682-0891

To UNIVERSITY:

Dr. Mark Cochran
Vice President for Agriculture
University of Arkansas System
Division of Agriculture
2404 N. University Ave.
Little Rock, AR 72207-3608
Tel. (501) 686-2540
Fax (501) 686-2543

With a copy to:

University of Arkansas System
Attn: Office of General Counsel
2404 North University Avenue
Little Rock, AR 72207-3608
Tel. (501) 686-2520
Fax (501) 686-2517

VI. Miscellaneous:

A. The officials executing this Agreement hereby represent and warrant that they have full and complete authority to act on behalf of University and ADEQ, respectively, and that the terms and provisions hereof constitute valid and enforceable obligations of each.

B. This Agreement shall be interpreted and construed in accordance with the laws of the State of Arkansas.

C. No transfer or assignment of this Agreement, or any part thereof or interest therein, shall be made unless all of the parties first approve such transfer or assignment in writing.

D. This Agreement constitutes the entire agreement between the parties. There are no understandings, agreements, or representations, oral or written, not specified within this Agreement.

BOARD OF TRUSTEES OF THE UNIVERSITY OF ARKANSAS SYSTEM FOR AND ON BEHALF OF THE UNIVERSITY OF ARKANSAS DIVISION OF AGRICULTURE

By: Ann Kemp
Ann KempVice-President
for Administration

Dated this 5 day of Sept., 2013.

ARKANSAS DEPARTMENT OF ENVIRONMENTAL QUALITY

By: Teresa Marks
Teresa Marks, Director

Dated this 6th day of Sept., 2013.

UofA DIVISION OF AGRICULTURE
RESEARCH & EXTENSION
University of Arkansas System

Department of Crop, Soil and Environmental Sciences

115 Plant Sciences Building • Fayetteville, Arkansas 72701 • (479) 575 5721 • (479) 575 7465 (FAX)

February 17, 2014

Robbie Flood
HC 72
P.O. Box
Mt. Judea, AR 72655

Re: Big Creek Research and Extension Project

Dear Robbie Flood;

On behalf of the Big Creek Research and Extension Team (Team) of the University of Arkansas System Division of Agriculture (Division), thank you (Landowner) for your prior permission to access your land for the purposes of baseline research work using ground penetrating radar and grid soil sampling. In continuation of this project to the next phase, the Team is hereby requesting Landowner written approval to enter Landowner property for the purposes of placing soil/water sampling equipment, sub-surface water collection equipment, and access to the same.

As previously agreed, all such equipment will be specifically sited with Landowner approval. In particular, equipment will be placed on edge-of-field outside the immediate production areas and in such a way so as not to interfere with Landowner's normal production practices and equipment.

Research equipment noted herein will be placed no later than April 18, 2014, and will remain on the property no later than five years from the date of placement, unless the parties agree in writing to the contrary.

Vehicles used to bring research equipment and Team members to and from shall be chosen so as to have minimal impact to the land.

The only persons allowed access under this agreement are faculty and technicians on the Team. The Team will make every effort to minimize disturbance or disruption to Landowner property. The Team will be responsible for any damage to the property attributable to its negligence, provided that responsibility for such payment must be determined by the Arkansas Claims Commission in accordance with state law.

Access by Team members for the purposes of data collection, equipment maintenance, and water and soil sampling will normally occur between 10 am and 3 pm. All efforts will be made to alert Landowner of such planned access 24 hours or more prior to entering the property. Expected access will be approximately once a month, with greater frequency following rainfall events and land application of fertilizer or manure.

Any questions or issues may be directed to:

Andrew Sharpley, Project Leader
Big Creek Research and Extension Project
PTSC 115
University of Arkansas
Fayetteville, Arkansas 72701

Office: (479) 575-5721
Cell: (479) 871-6703
Email: sharpley@uark.edu

A signature below by Landowner indicates this is the entire agreement and that consent to property access under the terms noted herein for the next phase of the Big Creek Research and Extension Project is expressly given. Thank you again for your cooperation.

Sincerely,

Andrew Sharpley
Project Leader

Approval: ______________________ Date: 2-20-2014
Landowner: Robbie Flood

DIVISION OF AGRICULTURE
RESEARCH & EXTENSION
University of Arkansas System

Department of Crop, Soil and Environmental Sciences

115 Plant Sciences Building • Fayetteville, Arkansas 72701 • (479) 575 5721• (479) 575 7465 (FAX)

February 17, 2014

Jewel Fowler
HC 72
P.O. Box
Mt. Judea, AR 72655

Re: Big Creek Research and Extension Project

Dear Jewel Fowler;

On behalf of the Big Creek Research and Extension Team (Team) of the University of Arkansas System Division of Agriculture (Division), we are requesting your (Landowner) written approval to enter Landowner property for the purposes of placing water collection equipment, and access to the same.

All such equipment will be specifically sited with Landowner approval. In particular, equipment will be placed outside of any immediate production areas or rights of way and in such a way so as not to interfere with Landowner's normal practices and land access.

Research equipment noted herein will be placed no later than April 18, 2014, and will remain on the property no later than five years from the date of placement, unless the parties agree in writing to the contrary.

Vehicles used to bring research equipment and Team members to and from shall be chosen so as to have minimal impact to the land.

The only persons allowed access under this agreement are faculty and technicians on the Team. The Team will make every effort to minimize disturbance or disruption to Landowner property. The Team will be responsible for any damage to the property attributable to its negligence, provided that responsibility for such payment must be determined by the Arkansas Claims Commission in accordance with state law.

Access by Team members for the purposes of data collection, equipment maintenance, and water sampling will normally occur between 10 am and 3 pm. All efforts will be made to alert Landowner of such planned access 24 hours or more prior to entering the property. Expected access will be approximately once a week, with greater frequency following rainfall events.

Any questions or issues may be directed to:

Andrew Sharpley, Project Leader
Big Creek Research and Extension Project
PTSC 115
University of Arkansas
Fayetteville, Arkansas 72701

Office: (479) 575-5721
Cell: (479) 871-6703
Email: sharpley@uark.edu

A signature below by Landowner indicates this is the entire agreement and that consent to property access under the terms noted herein for the next phase of the Big Creek Research and Extension Project is expressly given. Thank you again for your cooperation.

Sincerely,

Andrew Sharpley

Andrew Sharpley
Project Leader

Approval: Jewell Fowler Date: 2/26/14
Landowner: Jewel Fowler

DIVISION OF AGRICULTURE
RESEARCH & EXTENSION
University of Arkansas System

Department of Crop, Soil and Environmental Sciences

115 Plant Sciences Building • Fayetteville, Arkansas 72701
• (479) 575 5721 • (479) 575 7465 (FAX)

February 17, 2014

Donald Haddock

Re: Big Creek Research and Extension Project

Dear Landowner;

On behalf of the Big Creek Research and Extension Team (Team) of the University of Arkansas System Division of Agriculture (Division), we are requesting your (Landowner) written approval to enter Landowner property for the purposes of placing water collection equipment, and access to the same.

All such equipment will be specifically sited with Landowner approval. In particular, equipment will be placed outside of any immediate production areas or rights of way and in such a way so as not to interfere with Landowner's normal practices and land access.

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Any questions or issues may be directed to:

Andrew Sharpley, Project Leader
Big Creek Research and Extension Project
PTSC 115
University of Arkansas
Fayetteville, Arkansas 72701

Office: (479) 575-5721
Cell: (479) 871-6703
Email: sharpley@uark.edu

A signature below by Landowner indicates this is the entire agreement and that consent to property access under the terms noted herein for the next phase of the Big Creek Research and Extension Project is expressly given. Thank you again for your cooperation.

Sincerely,

Andrew Sharpley
Project Leader

Approval: Donald Haddock Date: 4-8-14
Landowner: Donald Haddock

DIVISION OF AGRICULTURE
RESEARCH & EXTENSION
University of Arkansas System

Department of Crop, Soil and Environmental Sciences

115 Plant Sciences Building • Fayetteville, Arkansas 72701 • (479) 575 5721 • (479) 575 7465 (FAX)

February 17, 2014

Jason Henson
HC 72
P.O. Box 10
Mt. Judea, AR 72655

Re: Big Creek Research and Extension Project

Dear Jason Henson;

On behalf of the Big Creek Research and Extension Team (Team) of the University of Arkansas System Division of Agriculture (Division), thank you (Landowner) for your prior permission to access your land for the purposes of baseline research work using ground penetrating radar and grid soil sampling. In continuation of this project to the next phase, the Team is hereby requesting Landowner written approval to enter Landowner property for the purposes of placing soil/water sampling equipment, sub-surface water collection equipment, and access to the same.

As previously agreed, all such equipment will be specifically sited with Landowner approval. In particular, equipment will be placed on edge-of-field outside the immediate production areas and in such a way so as not to interfere with Landowner's normal production practices and equipment.

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Any questions or issues may be directed to:

Andrew Sharpley, Project Leader
Big Creek Research and Extension Project
PTSC 115
University of Arkansas
Fayetteville, Arkansas 72701

Office: (479) 575-5721
Cell: (479) 871-6703
Email: sharpley@uark.edu

A signature below by Landowner indicates this is the entire agreement and that consent to property access under the terms noted herein for the next phase of the Big Creek Research and Extension Project is expressly given. Thank you again for your cooperation.

Sincerely,

Andrew Sharpley
Project Leader

Approval: Jason Henson Date: 2-21-14
Landowner: Jason Henson

DIVISION OF AGRICULTURE
RESEARCH & EXTENSION
University of Arkansas System

Department of Crop, Soil and Environmental Sciences

115 Plant Sciences Building • Fayetteville, Arkansas 72701 • (479) 575 5721• (479) 575 7465 (FAX)

February 17, 2014

County Judge
Newton County
Arkansas

Re: Big Creek Research and Extension Project

Dear County Judge;

On behalf of the Big Creek Research and Extension Team (Team) of the University of Arkansas System Division of Agriculture (Division), we are requesting your (Landowner) written approval to enter Landowner property for the purposes of placing water collection equipment, and access to the same.

All such equipment will be specifically sited with Landowner approval. In particular, equipment will be placed outside of any immediate production areas or rights of way and in such a way so as not to interfere with Landowner's normal practices and land access.

Research equipment noted herein will be placed no later than April 18, 2014, and will remain on the property no later than five years from the date of placement, unless the parties agree in writing to the contrary.

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Access by Team members for the purposes of data collection, equipment maintenance, and water sampling will normally occur between 10 am and 3 pm. All efforts will be made to alert Landowner of such planned access 24 hours or more prior to entering the property. Expected access will be approximately once a week, with greater frequency following rainfall events.

Any questions or issues may be directed to:

Andrew Sharpley, Project Leader
Big Creek Research and Extension Project
PTSC 115
University of Arkansas
Fayetteville, Arkansas 72701

Office: (479) 575-5721
Cell: (479) 871-6703
Email: sharpley@uark.edu

A signature below by Landowner indicates this is the entire agreement and that consent to property access under the terms noted herein for the next phase of the Big Creek Research and Extension Project is expressly given. Thank you again for your cooperation.

Sincerely,

Andrew Sharpley
Project Leader

Approval: Warren Campbell Date: 2-24-14
Landowner: Country Judge

APPENDIX B: SOIL MAPPING UNIT DESCRIPTION FROM NRCS, NEWTON CO., AR

Figure 1. Soil type distribution in the vicinity of the C&H Farm operation Mt. Judea, Newton Co., AR. Minor map unit components are excluded from this report.

Map unit 1: Arkana very cherty silt loam, 3 to 8 percent slopes

Component: Arkana (100%)

The Arkana component makes up 100 percent of the map unit. Slopes are 3 to 8 percent. This component is on hills, hills. The parent material consists of clayey residuum weathered from cherty limestone. Depth to a root restrictive layer, bedrock, lithic, is 20 to 40 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is very low. Available water to a depth of 60 inches is very low. Shrink-swell potential is high. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 3 percent. Nonirrigated land capability classification is 6e. This soil does not meet hydric criteria.

Map unit 2: Arkana-Moko complex, 8 to 20 percent slopes

Component: Arkana (50%)

The Arkana component makes up 50 percent of the map unit. Slopes are 8 to 20 percent. This component is on hills, hills. The parent material consists of clayey residuum weathered from cherty limestone. Depth to a root restrictive layer, bedrock, lithic, is 20 to 40 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is very low. Available water to a depth of 60 inches is very low. Shrink-swell potential is high. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 3 percent. Nonirrigated land capability classification is 6e. This soil does not meet hydric criteria.

Component: Moko (35%)

The Moko component makes up 35 percent of the map unit. Slopes are 8 to 20 percent. This component is on hills, hills. The parent material consists of loamy residuum weathered from cherty limestone. Depth to a root restrictive layer, bedrock, lithic, is 6 to 20 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately low. Available water to a depth of 60 inches is very low. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 3 percent. This component is in the R116AY001AR Limestone Ledge ecological site. Nonirrigated land capability classification is 7s. This soil does not meet hydric criteria.

Map unit 3: Arkana-Moko complex, 20 to 40 percent slopes

Component: Arkana (45%)

The Arkana component makes up 45 percent of the map unit. Slopes are 20 to 40 percent. This component is on hillsides, hills. The parent material consists of clayey residuum weathered from cherty limestone. Depth to a root restrictive layer, bedrock, lithic, is 20 to 40 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is very low. Available water to a depth of 60 inches is very low. Shrink-swell potential is high. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 3 percent. Nonirrigated land capability classification is 7s. This soil does not meet hydric criteria.

Map unit 3: Arkana-Moko complex, 20 to 40 percent slopes

Component: Moko (45%)

The Moko component makes up 45 percent of the map unit. Slopes are 20 to 40 percent. This component is on hillsides, hills. The parent material consists of loamy residuum weathered from cherty limestone. Depth to a root restrictive layer, bedrock, lithic, is 6 to 20 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately low. Available water to a depth of 60 inches is very low. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 3 percent. This component is in the R116AY001AR Limestone Ledge ecological site. Nonirrigated land capability classification is 7s. This soil does not meet hydric criteria.

Map unit 6: Ceda-Kenn complex, frequently flooded

Component: Ceda (55%)

The Ceda component makes up 55 percent of the map unit. Slopes are 0 to 3 percent. This component is on flood plains, hills. The parent material consists of gravelly alluvium. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is high. Available water to a depth of 60 inches is moderate. Shrink-swell potential is low. This soil is frequently flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 1 percent. Nonirrigated land capability classification is 7w. This soil does not meet hydric criteria.

Component: Kenn (30%)

The Kenn component makes up 30 percent of the map unit. Slopes are 0 to 3 percent. This component is on flood plains, hills. The parent material consists of loamy alluvium derived from sandstone and shale. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is low. Shrink-swell potential is moderate. This soil is frequently flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 1 percent. Nonirrigated land capability classification is 5w. This soil does not meet hydric criteria.

Map unit 7: Clarksville very cherty silt loam, 20 to 50 percent slopes

Component: Clarksville (100%)

The Clarksville component makes up 100 percent of the map unit. Slopes are 20 to 50 percent. This component is on hillsides, hills. The parent material consists of clayey residuum weathered from cherty limestone. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is somewhat excessively drained. Water movement in the most restrictive layer is high. Available water to a depth of 60 inches is low. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 1 percent. Nonirrigated land capability classification is 7s. This soil does not meet hydric criteria.

Map unit 8: Eden-Newnata complex, 8 to 20 percent slopes

Component: Eden (55%)

The Eden component makes up 55 percent of the map unit. Slopes are 8 to 20 percent. This component is on hillslopes, hills. The parent material consists of clayey residuum weathered from limestone and shale. Depth to a root restrictive layer, bedrock, paralithic, is 20 to 40 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately low. Available water to a depth of 60 inches is very low. Shrink-swell potential is moderate. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. Nonirrigated land capability classification is 6e. This soil does not meet hydric criteria.

Component: Newnata (30%)

The Newnata component makes up 30 percent of the map unit. Slopes are 8 to 20 percent. This component is on hillslopes, hills. The parent material consists of residuum weathered from limestone and shale. Depth to a root restrictive layer, bedrock, lithic, is 40 to 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately low. Available water to a depth of 60 inches is moderate. Shrink-swell potential is high. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 3 percent. Nonirrigated land capability classification is 6s. This soil does not meet hydric criteria.

Map unit 9: Eden-Newnata complex, 20 to 40 percent slopes

Component: Eden (50%)

The Eden component makes up 50 percent of the map unit. Slopes are 20 to 40 percent. This component is on mountain slopes, hills. The parent material consists of clayey residuum weathered from limestone and shale. Depth to a root restrictive layer, bedrock, paralithic, is 20 to 40 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately low. Available water to a depth of 60 inches is very low. Shrink-swell potential is moderate. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. Nonirrigated land capability classification is 7e. This soil does not meet hydric criteria.

Component: Newnata (40%)

The Newnata component makes up 40 percent of the map unit. Slopes are 20 to 40 percent. This component is on mountain slopes, hills. The parent material consists of residuum weathered from limestone and shale. Depth to a root restrictive layer, bedrock, lithic, is 40 to 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately low. Available water to a depth of 60 inches is moderate. Shrink-swell potential is high. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 3 percent. Nonirrigated land capability classification is 7s. This soil does not meet hydric criteria.

Map unit 11: Enders gravelly loam, 3 to 8 percent slopes

Component: Enders (80%)

The Enders component makes up 80 percent of the map unit. Slopes are 3 to 8 percent. This component is on hillslopes on hills. The parent material consists of clayey residuum weathered from acid shale. Depth to a root restrictive layer, bedrock, paralithic, is 40 to 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is very low. Available water to a depth of 60 inches is moderate. Shrink-swell potential is high. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 3 percent. Nonirrigated land capability classification is 4e. This soil does not meet hydric criteria.

Map unit 12: Enders gravelly loam, 8 to 15 percent slopes

Component: Enders (80%)

The Enders component makes up 80 percent of the map unit. Slopes are 8 to 15 percent. This component is on hillslopes on hills. The parent material consists of clayey residuum weathered from acid shale. Depth to a root restrictive layer, bedrock, paralithic, is 40 to 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is very low. Available water to a depth of 60 inches is moderate. Shrink-swell potential is high. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 3 percent. Nonirrigated land capability classification is 6e. This soil does not meet hydric criteria.

Map unit 13: Enders stony loam, 3 to 15 percent slopes

Component: Enders (85%)

The Enders component makes up 85 percent of the map unit. Slopes are 3 to 15 percent. This component is on hillslopes on hills. The parent material consists of clayey residuum weathered from acid shale. Depth to a root restrictive layer, bedrock, paralithic, is 40 to 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is very low. Available water to a depth of 60 inches is moderate. Shrink-swell potential is high. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 3 percent. Nonirrigated land capability classification is 6s. This soil does not meet hydric criteria.

Map unit 14: Enders stony loam, 15 to 40 percent slopes

Component: Enders (80%)

The Enders component makes up 80 percent of the map unit. Slopes are 15 to 40 percent. This component is on hillslopes on hills. The parent material consists of clayey residuum weathered from acid shale. Depth to a root restrictive layer, bedrock, paralithic, is 40 to 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is very low. Available water to a depth of 60 inches is moderate. Shrink-swell potential is high. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 3 percent. Nonirrigated land capability classification is 7s. This soil does not meet hydric criteria.

Map unit 15: Enders-Leesburg complex, 8 to 20 percent slopes

Component: Enders (60%)

The Enders component makes up 60 percent of the map unit. Slopes are 8 to 20 percent. This component is on hillslopes on hills. The parent material consists of clayey residuum weathered from acid shale. Depth to a root restrictive layer, bedrock, paralithic, is 40 to 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is low. Available water to a depth of 60 inches is moderate. Shrink-swell potential is high. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 3 percent. Nonirrigated land capability classification is 6s. This soil does not meet hydric criteria.

Component: Leesburg (30%)

The Leesburg component makes up 30 percent of the map unit. Slopes are 8 to 20 percent. This component is on mountains on mountains. The parent material consists of loamy colluvium derived from sandstone and shale. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is moderate. Shrink-swell potential is moderate. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. Nonirrigated land capability classification is 6s. This soil does not meet hydric criteria.

Map unit 16: Enders-Leesburg complex, 20 to 40 percent slopes

Component: Enders (50%)

The Enders component makes up 50 percent of the map unit. Slopes are 20 to 40 percent. This component is on hillslopes on hills. The parent material consists of clayey residuum weathered from acid shale. Depth to a root restrictive layer, bedrock, paralithic, is 40 to 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is low. Available water to a depth of 60 inches is moderate. Shrink-swell potential is high. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 3 percent. Nonirrigated land capability classification is 7s. This soil does not meet hydric criteria.

Component: Leesburg (40%)

The Leesburg component makes up 40 percent of the map unit. Slopes are 20 to 40 percent. This component is on -- Error in Exists On --. The parent material consists of loamy colluvium derived from sandstone and shale. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is moderate. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. Nonirrigated land capability classification is 7s. This soil does not meet hydric criteria.

Map unit 25: Linker-Mountainburg complex, 8 to 20 percent slopes

Component: Linker (50%)

The Linker component makes up 50 percent of the map unit. Slopes are 8 to 20 percent. This component is on mountains, hills. The parent material consists of loamy residuum weathered from sandstone. Depth to a root restrictive layer, bedrock, lithic, is 20 to 40 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately low. Available water to a depth of 60 inches is low. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. Nonirrigated land capability classification is 6e. This soil does not meet hydric criteria.

Component: Mountainburg (45%)

The Mountainburg component makes up 45 percent of the map unit. Slopes are 8 to 20 percent. This component is on mountains, hills. The parent material consists of gravelly and stony, loamy residuum weathered from sandstone and siltstone. Depth to a root restrictive layer, bedrock, lithic, is 12 to 20 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately low. Available water to a depth of 60 inches is very low. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. This component is in the R117XY004AR Sandstone Ridge ecological site. Nonirrigated land capability classification is 7s. This soil does not meet hydric criteria.

Map unit 26: Moko-Rock outcrop complex, 15 to 50 percent slopes

Component: Moko (50%)

The Moko component makes up 50 percent of the map unit. Slopes are 15 to 50 percent. This component is on hillslopes, hills. The parent material consists of loamy residuum weathered from cherty limestone. Depth to a root restrictive layer, bedrock, lithic, is 6 to 20 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately low. Available water to a depth of 60 inches is very low. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 3 percent. This component is in the R116AY001AR Limestone Ledge ecological site. Nonirrigated land capability classification is 7s. This soil does not meet hydric criteria.

Component: Rock outcrop (40%)

Generated brief soil descriptions are created for major soil components. The Rock outcrop is a miscellaneous area.

Map unit 35: Nella-Enders stony loams, 8 to 20 percent slopes

Component: Nella (45%)

The Nella component makes up 45 percent of the map unit. Slopes are 8 to 20 percent. This component is on mountains, hills. The parent material consists of loamy colluvium derived from sandstone and shale and/or loamy residuum weathered from sandstone and shale. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is moderate. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. Nonirrigated land capability classification is 6s. This soil does not meet hydric criteria.

Component: Enders (40%)

The Enders component makes up 40 percent of the map unit. Slopes are 8 to 20 percent. This component is on mountains, hills. The parent material consists of clayey residuum weathered from acid shale. Depth to a root restrictive layer, bedrock, paralithic, is 40 to 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is very low. Available water to a depth of 60 inches is moderate. Shrink-swell potential is high. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 3 percent. Nonirrigated land capability classification is 6s. This soil does not meet hydric criteria.

Map unit 36: Nella-Enders stony loams, 20 to 40 percent slopes

Component: Nella (50%)

The Nella component makes up 50 percent of the map unit. Slopes are 20 to 40 percent. This component is on mountain slopes, hills. The parent material consists of loamy colluvium derived from sandstone and shale and/or loamy residuum weathered from sandstone and shale. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is moderate. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. Nonirrigated land capability classification is 7s. This soil does not meet hydric criteria.

Component: Enders (35%)

The Enders component makes up 35 percent of the map unit. Slopes are 20 to 40 percent. This component is on mountain slopes, hills. The parent material consists of clayey residuum weathered from acid shale. Depth to a root restrictive layer, bedrock, paralithic, is 40 to 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is very low. Available water to a depth of 60 inches is moderate. Shrink-swell potential is high. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 3 percent. Nonirrigated land capability classification is 7s. This soil does not meet hydric criteria.

Map unit 37: Nella-Steprock complex, 8 to 20 percent slopes

Component: Nella (50%)

The Nella component makes up 50 percent of the map unit. Slopes are 8 to 20 percent. This component is on hills, hills. The parent material consists of loamy colluvium derived from sandstone and shale and/or loamy residuum weathered from sandstone and shale. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is moderate. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. Nonirrigated land capability classification is 6s. This soil does not meet hydric criteria.

Component: Steprock (35%)

The Steprock component makes up 35 percent of the map unit. Slopes are 8 to 20 percent. This component is on hills, hills. The parent material consists of skeletal loamy residuum weathered from sandstone. Depth to a root restrictive layer, bedrock, paralithic, is 20 to 40 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is very low. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 1 percent. Nonirrigated land capability classification is 6s. This soil does not meet hydric criteria.

Map unit 38: Nella-Steprock-Mountainburg very stony loams, 20 to 40 percent slopes

Component: Nella (45%)

The Nella component makes up 45 percent of the map unit. Slopes are 20 to 40 percent. This component is on hillslopes, hills. The parent material consists of loamy colluvium derived from sandstone and shale and/or loamy residuum weathered from sandstone and shale. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is moderate. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. Nonirrigated land capability classification is 7s. This soil does not meet hydric criteria.

Component: Steprock (25%)

The Steprock component makes up 25 percent of the map unit. Slopes are 20 to 40 percent. This component is on hillslopes, hills. The parent material consists of skeletal loamy residuum weathered from sandstone. Depth to a root restrictive layer, bedrock, paralithic, is 20 to 40 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is very low. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 1 percent. Nonirrigated land capability classification is 7s. This soil does not meet hydric criteria.

Map unit 38: Nella-Steprock-Mountainburg very stony loams, 20 to 40 percent slopes

Component: Mountainburg (15%)

The Mountainburg component makes up 15 percent of the map unit. Slopes are 20 to 40 percent. This component is on hillslopes, hills. The parent material consists of gravelly and stony, loamy residuum weathered from sandstone and siltstone. Depth to a root restrictive layer, bedrock, lithic, is 12 to 20 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately low. Available water to a depth of 60 inches is very low. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. This component is in the R117XY004AR Sandstone Ridge ecological site. Nonirrigated land capability classification is 7s. This soil does not meet hydric criteria.

Map unit 39: Nella-Steprock-Mountainburg very stony loams, 40 to 60 percent slopes

Component: Nella (45%)

The Nella component makes up 45 percent of the map unit. Slopes are 40 to 60 percent. This component is on hillslopes, hills. The parent material consists of loamy colluvium derived from sandstone and shale and/or loamy residuum weathered from sandstone and shale. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is moderate. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. Nonirrigated land capability classification is 7s. This soil does not meet hydric criteria.

Component: Steprock (20%)

The Steprock component makes up 20 percent of the map unit. Slopes are 40 to 60 percent. This component is on hillslopes, hills. The parent material consists of skeletal loamy residuum weathered from sandstone. Depth to a root restrictive layer, bedrock, paralithic, is 20 to 40 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is very low. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 1 percent. Nonirrigated land capability classification is 7s. This soil does not meet hydric criteria.

Component: Mountainburg (10%)

The Mountainburg component makes up 10 percent of the map unit. Slopes are 40 to 60 percent. This component is on hills, hills. The parent material consists of loamy residuum weathered from sandstone. Depth to a root restrictive layer, bedrock, lithic, is 12 to 20 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately low. Available water to a depth of 60 inches is very low. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. This component is in the R117XY004AR Sandstone Ridge ecological site. Nonirrigated land capability classification is 7s. This soil does not meet hydric criteria.

Map unit 42: Noark very cherty silt loam, 3 to 8 percent slopes

Component: Noark (100%)

The Noark component makes up 100 percent of the map unit. Slopes are 3 to 8 percent. This component is on hills, hills. The parent material consists of clayey residuum weathered from cherty limestone. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is moderate. Shrink-swell potential is moderate. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. Nonirrigated land capability classification is 4e. This soil does not meet hydric criteria.

Map unit 43: Noark very cherty silt loam, 8 to 20 percent slopes

Component: Noark (100%)

The Noark component makes up 100 percent of the map unit. Slopes are 8 to 20 percent. This component is on hills, hills. The parent material consists of clayey residuum weathered from cherty limestone. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is moderate. Shrink-swell potential is moderate. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. Nonirrigated land capability classification is 6e. This soil does not meet hydric criteria.

Map unit 44: Noark very cherty silt loam, 20 to 40 percent slopes

Component: Noark (100%)

The Noark component makes up 100 percent of the map unit. Slopes are 20 to 40 percent. This component is on hillslopes, hills. The parent material consists of clayey residuum weathered from cherty limestone. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is moderate. Shrink-swell potential is moderate. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. Nonirrigated land capability classification is 7e. This soil does not meet hydric criteria.

Map unit 48: Razort loam, occasionally flooded

Component: Razort (95%)

The Razort component makes up 95 percent of the map unit. Slopes are 0 to 3 percent. This component is on flood plains, hills. The parent material consists of loamy alluvium. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is high. Shrink-swell potential is low. This soil is occasionally flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. Nonirrigated land capability classification is 2w. This soil does not meet hydric criteria.

Map unit 49: Riverwash, frequently flooded

Component: Riverwash (95%)

Generated brief soil descriptions are created for major soil components. The Riverwash is a miscellaneous area.

Map unit 50: Spadra loam, occasionally flooded

Component: Spadra (95%)

The Spadra component makes up 95 percent of the map unit. Slopes are 0 to 3 percent. This component is on flood plains, hills. The parent material consists of loamy alluvium derived from sandstone and shale. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is moderate. Shrink-swell potential is low. This soil is occasionally flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. Nonirrigated land capability classification is 2w. This soil does not meet hydric criteria.

Map unit 51: Spadra loam, 2 to 5 percent slopes

Component: Spadra (95%)

The Spadra component makes up 95 percent of the map unit. Slopes are 2 to 5 percent. This component is on stream terraces, hills. The parent material consists of loamy alluvium derived from sandstone and shale. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is moderate. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. Nonirrigated land capability classification is 3e. This soil does not meet hydric criteria.

Map unit 54: Water

Component: Water (100%)

Generated brief soil descriptions are created for major soil components. The Water is a miscellaneous area.

APPENDIX C: GROUND PENETRATING RADAR SURVEY REPORT

Contents

Summary

1. Field 1: Radar suggests that there could be an irregularly shaped boundary between soil and bedrock across the survey. This apparent contact is wavy in nature, and resembles the dissolution features that are manifested in cutter and pinnacle karst. Depth to bedrock and karst features appear to be more shallow near the top of the hill surveyed, which would conform to standard soil landscape models for the area.
2. Field 5a: Radar shows a contrasting layer at a depth near 50 to 60-cm across much of the field. Field observations found that clay content increased near this depth consistently, changing from silt loam or fine sandy loam to clay, clay loam, or silty clay loam at greater depths for field soils adjacent to Big Creek.
3. Field 12: Radar suggests that an argillic layer around 25-cm and a wavy gravel layer (about 35 to 45%) around a depth of 80 to 120 cm, which is typical of the other fields surveyed adjacent to Big Creek. However, the gravel layer appears to be overlain with fine sandy loam (0 to 25 cm depth) and sandy clay loam material (25 to 80 cm depth) that is of valley and alluvial origin.

4. Overall, soils varied in depth across and among fields. Field 1 had an overlying layer of soil that varied from zero (rock outcrops) to 50 cm (20 inches). Fields 5a and 12 adjacent to Big Creek had soils varying in depth from 80 to 150 cm deep (30 to 60 inches). The deeper soil profiles for Fields 5a and 12 were adjacent to Big Creek, with the thinner soils on the side of the field further from the Creek. This is typical of periodic flooding of Big Creek depositing alluvial material adjacent to the stream bank over the last century following land settlement.

List of Figures

Purpose and Overview

A series of ground penetrating radar surveys were conducted on two fields permitted to receive slurry applications (Fields 1 and 12) and one planned for possible future applications (Field 5a), to investigate subsurface soil properties. Participating were Wes Tuttle, Geophysical Soil Scientist, NRCS; Richard Vaught, Soils Scientist and GPR operator, NRCS; Dr. Kris Brye and Lawrence Berry, University of AR Crop, Soil and Environmental Science Department; Dr. Mike Daniels, Professor, Extension Water Quality, University of AR Division of Agriculture; and Cory Hallmark and Josh Hesselbein, University of AR Extension, University of AR Extension.

Field 1

1. A SIR-3000 Ground-Penetrating Radar (GPR) system (Geophysical Survey Systems Inc) with 200-Mhz antenna was used at this site (Figures 1 and 2).
2. A metal plate was buried at the site at a depth of 50-cm to calibrate the instrument and to ground-truth soil conditions. A second hole was hand dug to 50-cm to further ground-truth soil conditions.
3. Conditions were too rocky at the site to successfully use a Giddings soil probe to a depth of deeper than 20-cm.
4. Two 90-m transects were laid out. The transects were flagged at 10-m intervals.
5. Transect/GPR survey #18 proceeded in a generally northeasterly direction, up hill, where slopes ranged from 3 to 15 % or greater (Figure 2).


Figure 1. Preparing a transect for the Ground Penetrating Radar assessment at C&H Farm.

6. Transect/GPR survey #20 ran at a right angle to transect #18, and traveled in a northwesterly direction, where slopes ranged from 3-5% (Figure 2).

Figure 2. Conducting the Ground Penetrating Radar assessment at C&H Farm.

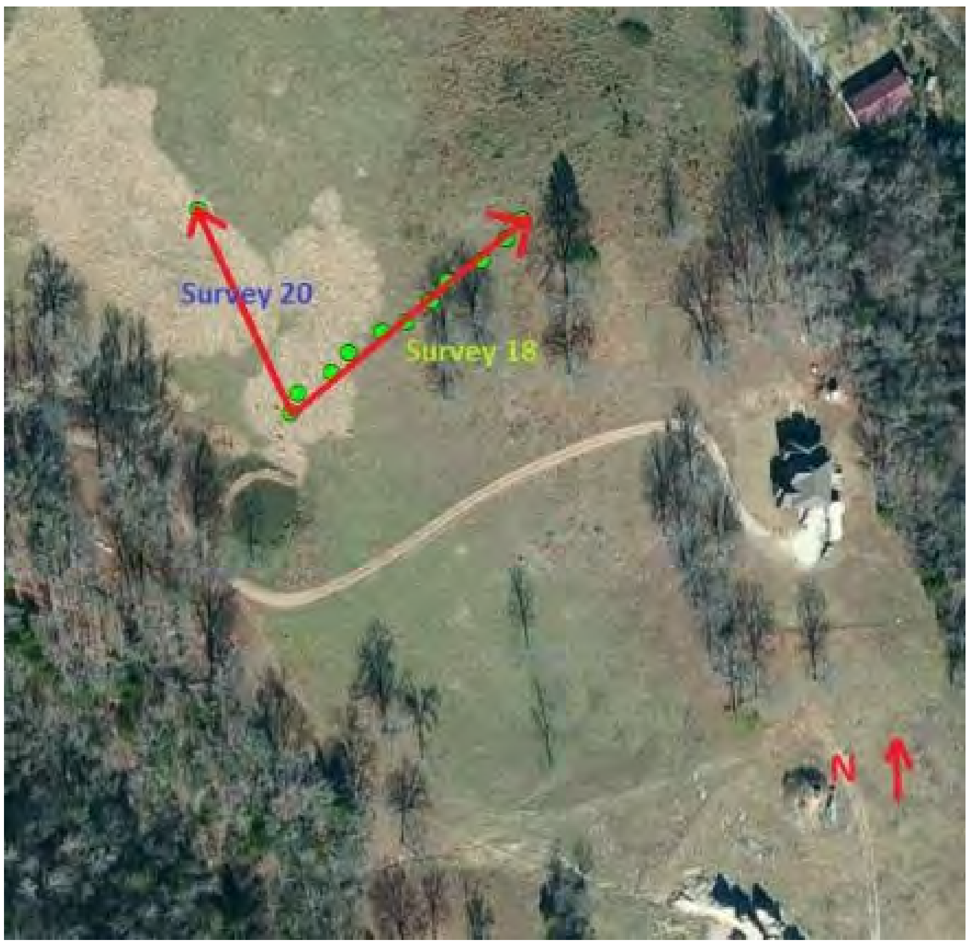

Figure 3. Location of ground penetrating radar surveys at field 1 near Mount Judea, AR. Surveys were 90-m in length.

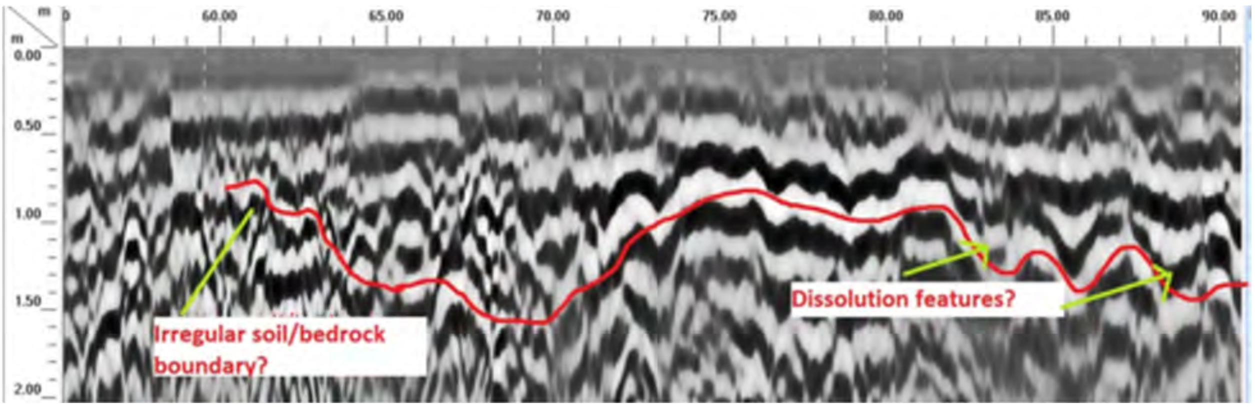

Figure 4. Possible solution features on the end sections of survey 18.

Summary: Transect 18

1. Soils observed at the site seemed to agree with the Newton county soil survey, and resembled the Noark series, which is formed in residuum and colluvium of clayey limestone.
2. The radar records from this site are of good interpretative quality. Several features that were not readily evident in the field became more noticeable after processing the data.
3. Excavation to identify many of the subsurface features was not feasible due to rocky conditions. Thus, it should be noted that most features "observed" in the radar record have not been verified in the field.
4. The radar record indicates that soil features across survey 18 are not homogenous, which is not surprising, since the landform changed across the survey.
5. The data suggests that there could be an irregularly shaped boundary between soil and bedrock across the survey (Figures 4 and 5). This apparent contact is wavy in nature, and resembles the dissolution features that are manifested in cutter and pinnacle karst.
6. Depth to bedrock and karst features appear to be more shallow near the top of the hill surveyed, which would conform to standard soil landscape models for the area.

Summary: Transect 20

1. The radar record suggests (as was verified at both test holes) that there is a horizon boundary that is mostly located in the vicinity of 50-cm. This horizon was observed to be a BC horizon, heavy silt loam or silty clay loam, with approximately 60% coarse fragments.
2. The radar record suggests an irregularly shaped boundary between soil and bedrock across the survey (Figure 6). This apparent contact is wavy in nature, and resembles the dissolution features that are manifested in cutter and pinnacle karst.

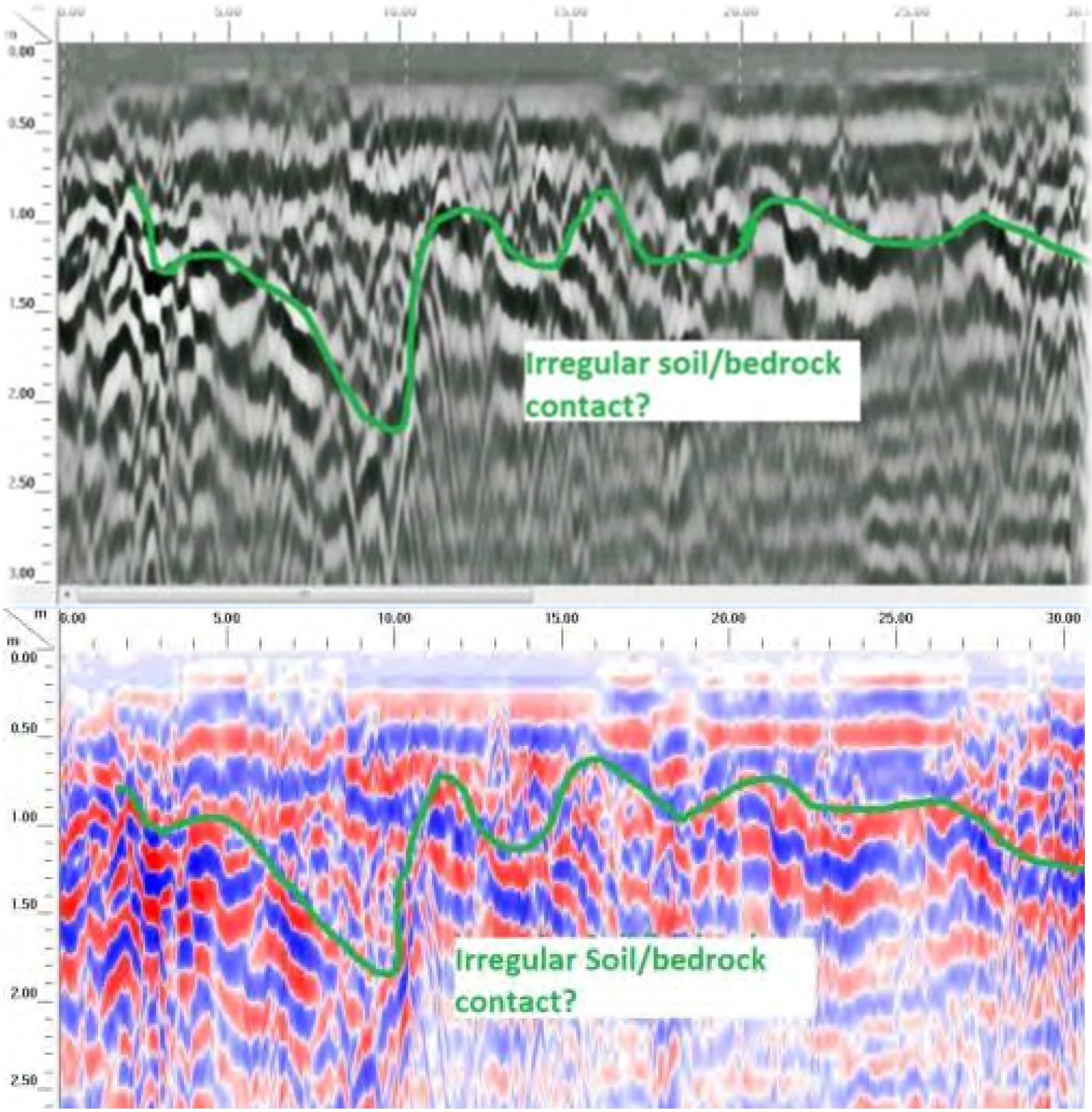

Figure 5. Two different representations of possible soil/bedrock interface at the beginning of survey 18.

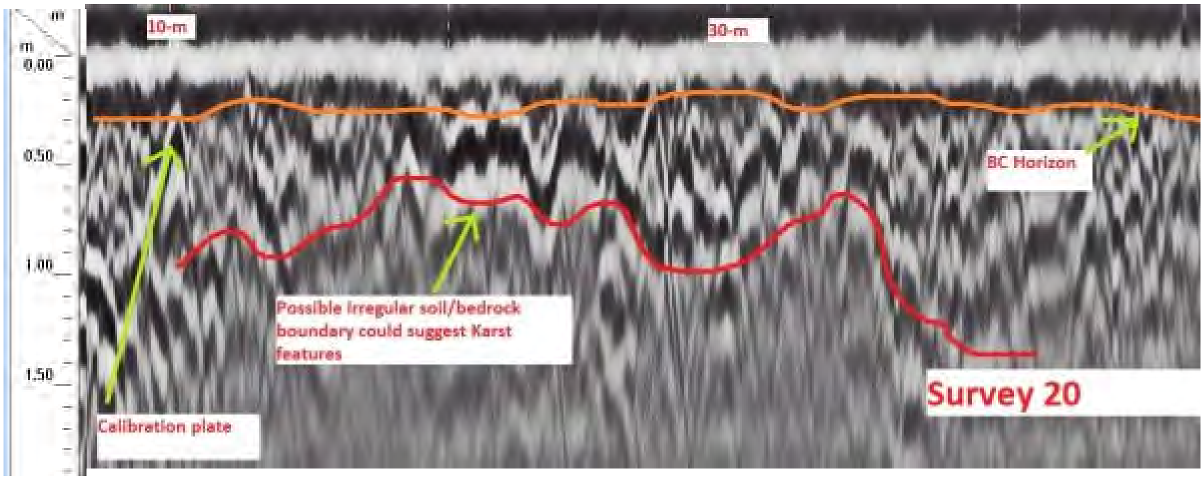

Figure 6. The apparent soil/bedrock contact was wavy in nature across survey 20.

Field 5a

Activities: Surveys 27, 28 and 29

1. A SIR-3000 Ground-Penetrating Radar (GPR) system (Geophysical Survey Systems Inc.) with 400-mhz antenna was used at this site.
2. A metal plate was buried at the site at a depth of 50-cm to calibrate the instrument and to ground-truth soil conditions.
3. A series of three transects were laid out and flagged at 10-m increments perpendicular to Big Creek, progressing from a portion of a toe slope , over a terrace to the flood plain. The bulk of the transects were located on the terrace (Figure 7).
4. Three holes were hand dug on survey 27 to observe soil conditions.
5. Three to four holes were bored with a Giddings soil probe to a depth of around 80-cm along each of the transects to collect samples and to ground-truth the radar survey.

Figure 7. Field 5.

Summary: Transect 27

1. The radar record and field observations indicated an argillic layer beginning in the vicinity of 25-cm over much of the transect. Field textures for this layer were mostly silt loam.
2. The radar record shows a contrasting layer at a depth near 50 to 60-cm over much of the transect. Field observations found that clay content increased near this depth consistently, changing from silt loam or fine sandy loam to clay, clay loam, or silty clay loam at greater depths.
3. Coarse fragment content observed in most of the borings was less than 10%. The Giddings probe worked well due to lack of fragments.
4. An anomaly was noted on the radar record near the end of survey 27, near the 160-m mark. Boring with the Giddings probe was not possible at this location, due to coarse fragment content. Further digging with a spade showed that coarse fragment content was 40-60% at a depth of 30-cm. Heavy coarse fragment content made further digging unfeasible due to time constraints.
5. Based on the radar records, field observation, and proximity to the creek, the area with an increase in coarse fragment content could be a gravel lens.

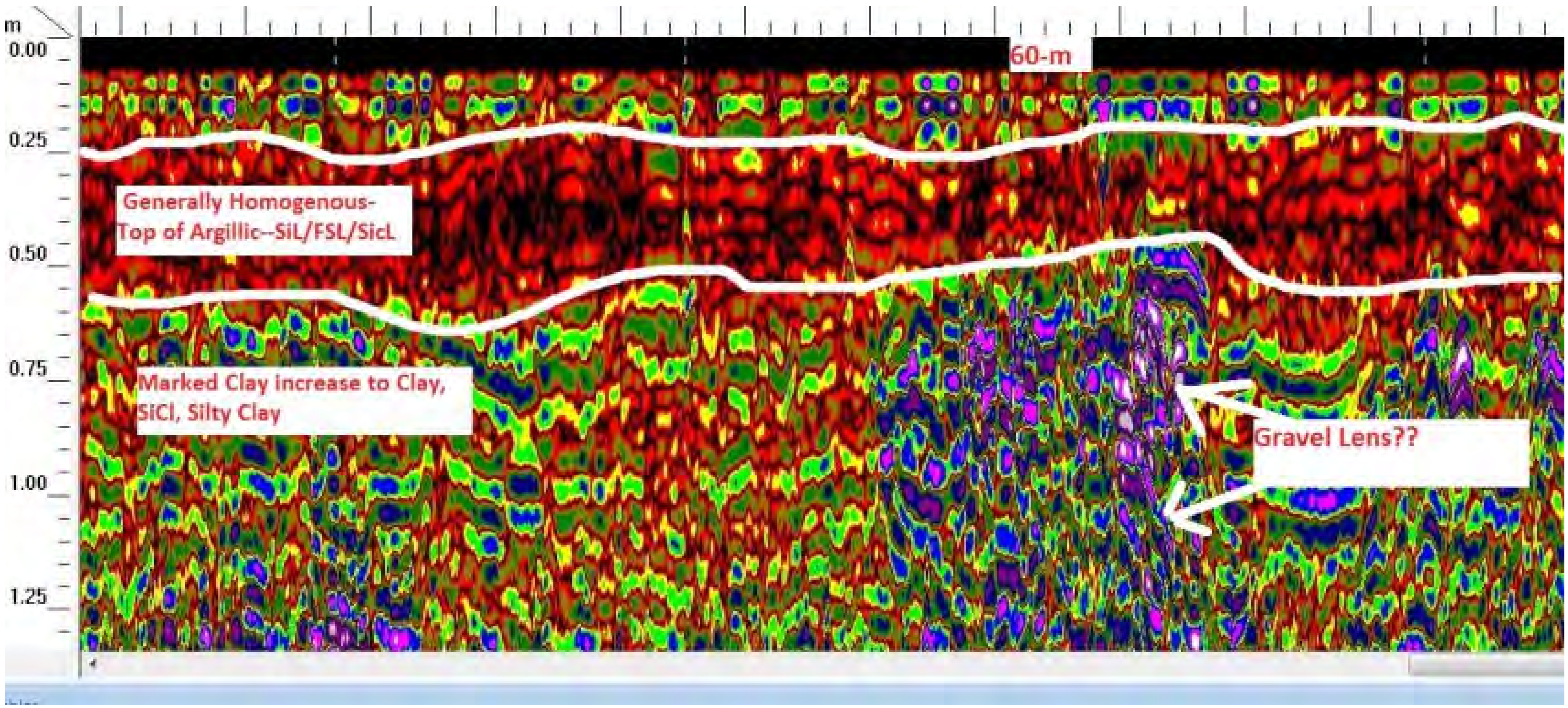

Figure 8. A marked increase in coarse fragments was observed in the field at the 60-m mark of survey 27.

Summary: Transect 28

1. Much like survey 27, the radar record and field observations indicated an argillic layer beginning at around 25-cm over much of the transect. Field textures for this layer were mostly silt loam.
2. The beginning portion of the transect occurred on a toe-slope. The radar record suggests that the soil-bedrock interface could be wavy in nature, which may suggest cutter and pinnacle karst (Figure 8).
3. The radar record shows a contrasting layer at a depth of around 50 to 60-cm over much of the transect. Field observations found that clay content increased near this depth consistently, changing from silt loam or fine sandy loam to clay, clay loam, or silty clay loam at greater depths (Figure 9).
4. Signatures from portions of this radar record resembled the area from transect 27 where coarse fragment content greatly increased. These areas could contain gravel lenses in the subsurface (Figure 10).
5. Based on field observations, soils near the end of the survey (closer to the creek) were younger and less developed.

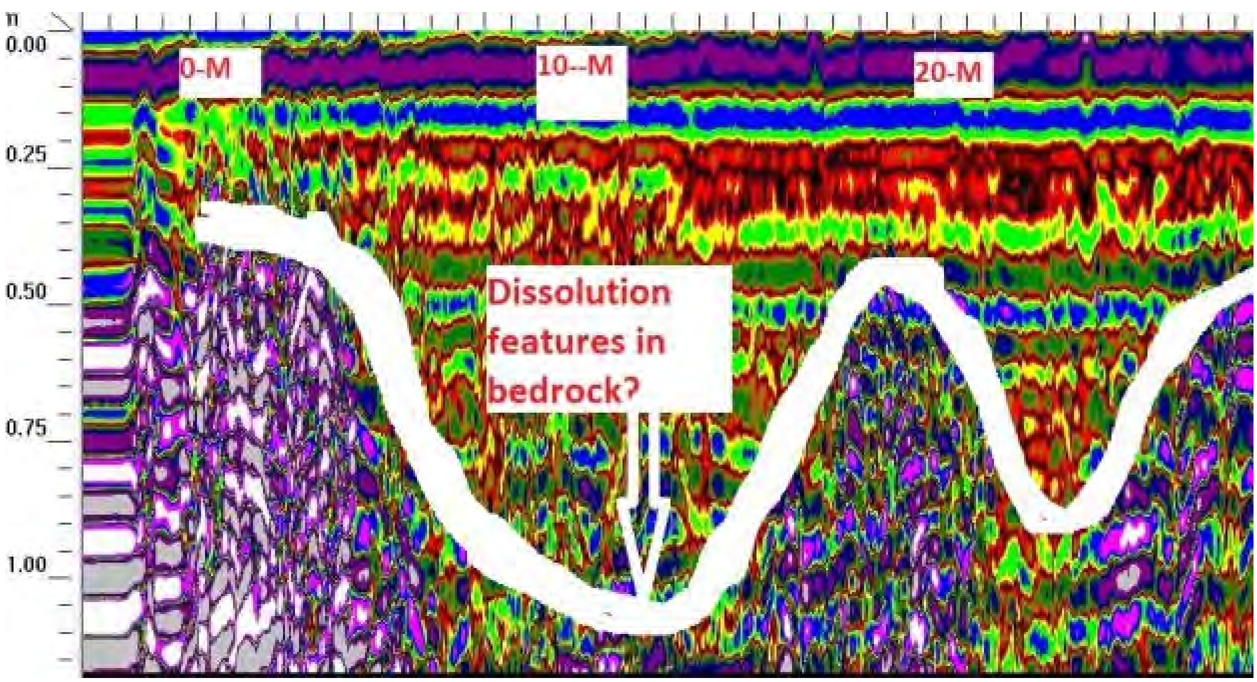

Figure 9. The first portion of transects 27-28 began on a toe-slope. The transect then dropped down onto a terrace. The toe-slope portion (above) may be underlain by dissolution features.

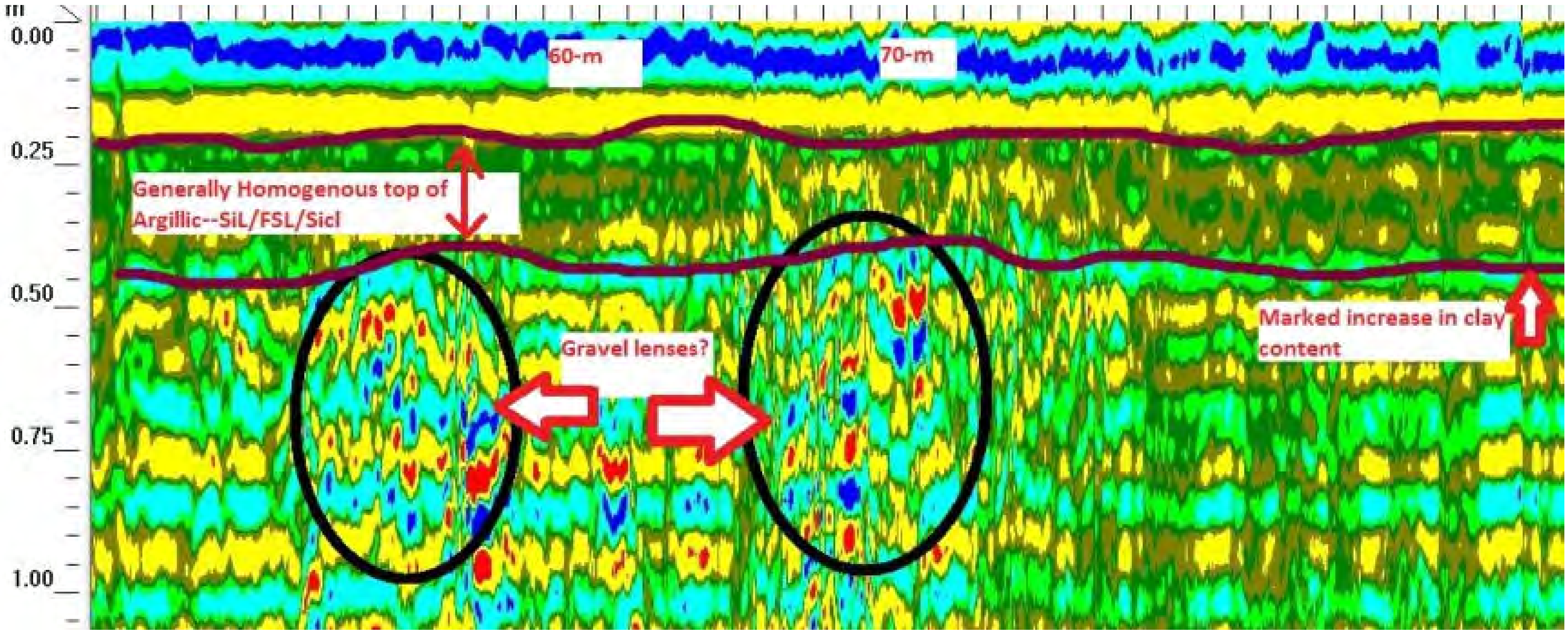

Figure 10. From survey 28. The right hand portion of the radar record seems to exemplify the overall nature of the field: a layer of silt loam or fine sandy loam, which transitions to clay or silty clay at around 50-cm. Possible gravel lenses were detected between 50-m and 70-m on the transect.

Summary: Transect 29

1. Much like surveys 27 and 28, the radar record and field observations indicated an argillic layer beginning at around 25-cm over much of the transect. Field textures for this layer were mostly silt loam.
2. The beginning portion of the transect occurred on a toe-slope. The radar record suggests that the soil-bedrock interface could be wavy in nature, which would be indicative of cutter and pinnacle karst.
3. The radar record shows a contrasting layer at a depth of around 50 to 60-cm over much of the transect. Field observations found that clay content increased near this depth consistently, changing from silt loam or fine sandy loam to clay, clay loam, or silty clay loam at greater depths (Figure 11).
4. There were no potential grave lenses observed on this radar record.
5. Based on field observations, soils near the end of the survey (closer to the creek) were younger and less developed.

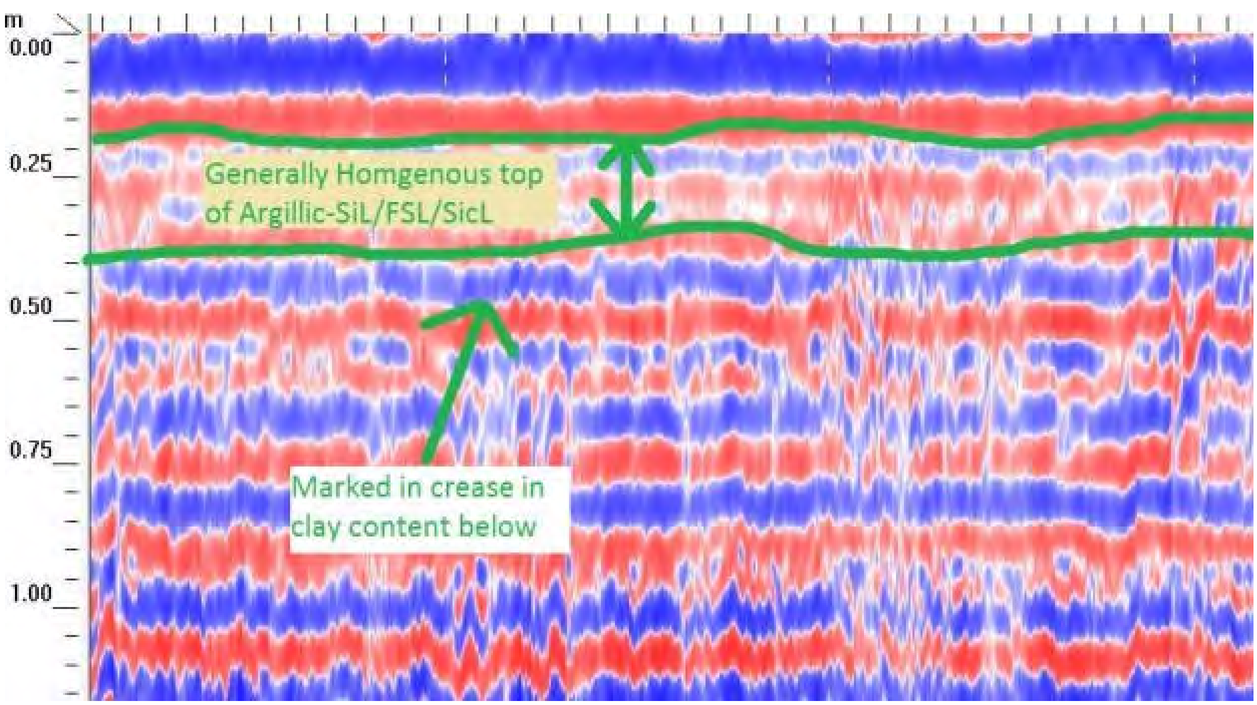

Figure 11. Typical portion of the radar record from survey 29, along the terrace/flood plain NRCS report and brief interpretation.

Field 12

Activities

1. Five transects were flagged on the field in an east-west direction, roughly perpendicular to Big Creek (Figure 12). The transects were spaced at 50 meters. Each transect was flagged at 10-m intervals, and the approximate location of each flag was recorded with a Garmin 76s GPS. All radar surveys proceeded from east to west.
2. A SIR-3000 Ground-Penetrating Radar (GPR) system (Geophysical Survey Systems Inc.) with 200-Mhz antenna was used.
3. A metal plate was buried at the site at a depth of 50-cm to calibrate the instrument and to ground-truth soil conditions. The plate was buried along transect #4.
4. Three holes were augured on both transect #3 and #4 to ground-truth soil conditions. Ground-truthing along transects #5, #6 and #7 was not possible.

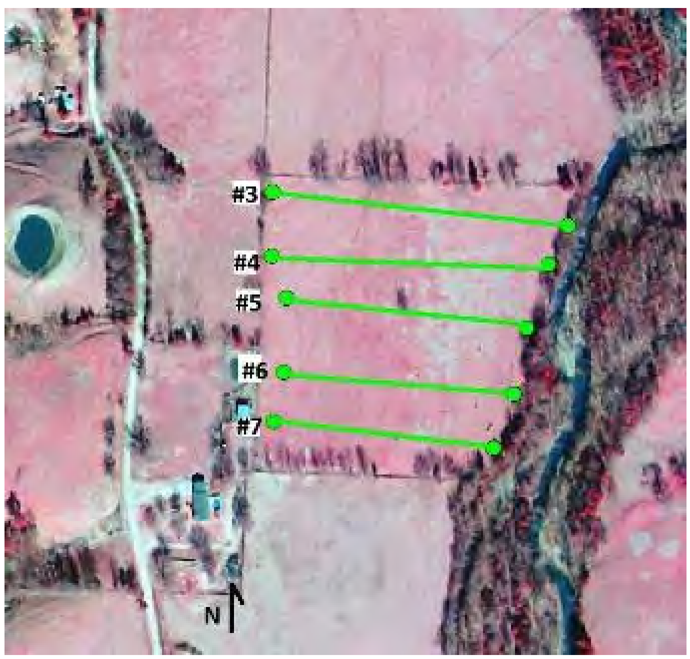

Figure 12. Location of ground penetrating radar surveys at field 12, south of Mount Judea, AR.

Summary: Transect 3

1. Soils observed at the site via test hole mostly agreed with the Newton County soil survey, and resembled the Spadra series, which is an Ultisol. From the county soil survey: "Spadra is a very deep, well-drained soil on stream terraces. This soil formed in loamy alluvial material derived from sandstone, siltstone, and shale. Permeability is moderate and available water capacity is high. This soil is occasionally flooded for brief periods during the winter and spring."

2. Soils observed were well drained; however, conditions were wet due to recent rains. Rafted debris, indicative of overland flow, was observed on the fence row along the north edge of the field.
3. The radar records from this site were of good interpretative quality.
4. Based on the holes augured along the transect, the radar record from this site, and from sites viewed in November 2013 along Big Creek in the same vicinity, the horizonation of the soils seems to be fairly consistent for the first 170-m of the transect.
5. An "A" horizon with a depth of around 0-20 cm seems to be consistent across most of the transect. Field textures observed were silt loam, with fine sandy loam surface texture becoming more common in closer proximity to the creek (after the 150-m mark).
6. The argillic layer along the transect commonly begins at 20-30 cm (Figure 13). Field textures observed between 20-80-cm of the argillic horizon were silty clay loam.
7. The radar suggests that the solum along the transect is deeper than 1.5-m. Two test holes were augered to greater than 1-m.
8. Several hyperbola shaped anomalies were evident in the radar record, they were likely tree roots.
9. At around the 170-m mark (Figure 14), the soil horizons become more wavy in nature. This change could be related to more recent scouring and deposition from Big Creek.
10. An anomaly at the 170-m mark, at around 1-m deep, could be a pocket of coarse fragments deposited by Big Creek (Figure 14).
11. An anomaly was noted on the radar record at the end of survey 3 upon data collection (Figure 15). It resembled possible coarse fragment deposits from the previous field visit. A test whole was augered at around the 225-m mark. The upper soil horizons (0-55-cm) were more sandy in nature than observations further from the creek along this transect. Subsurface textures were sandy loam. At 55-cm, augering was not possible due to coarse fragment content. Coarse fragment content was estimated at 35-45%.

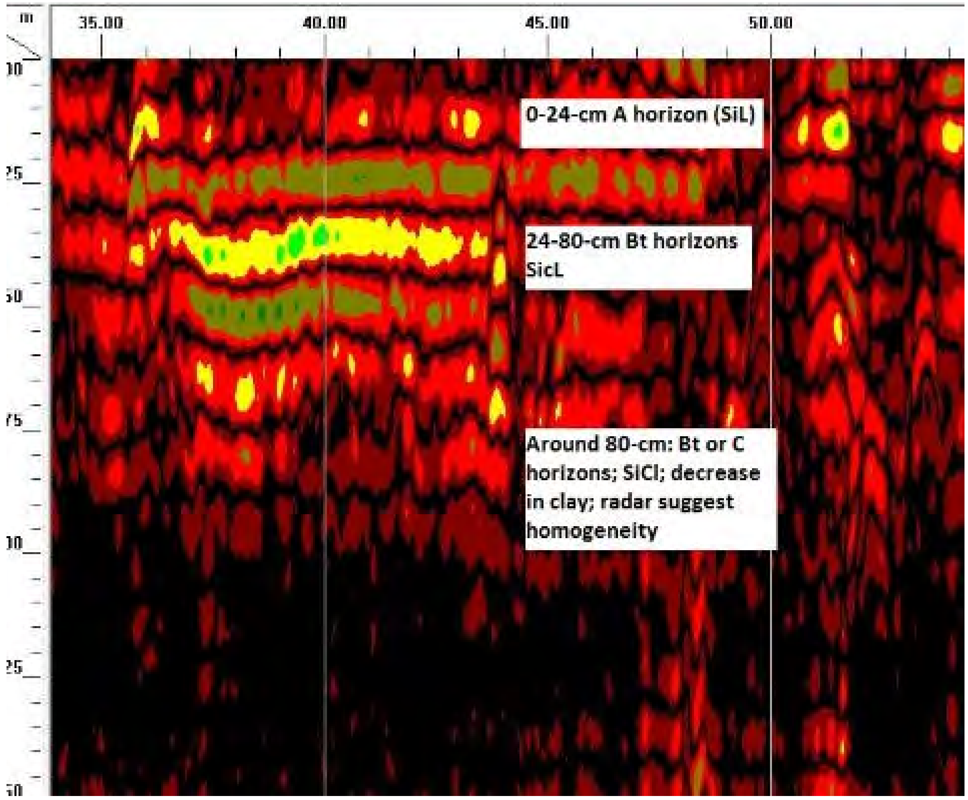

Figure 13. Typical profile from transect #3. A test hole was observed near the 50-m mark.

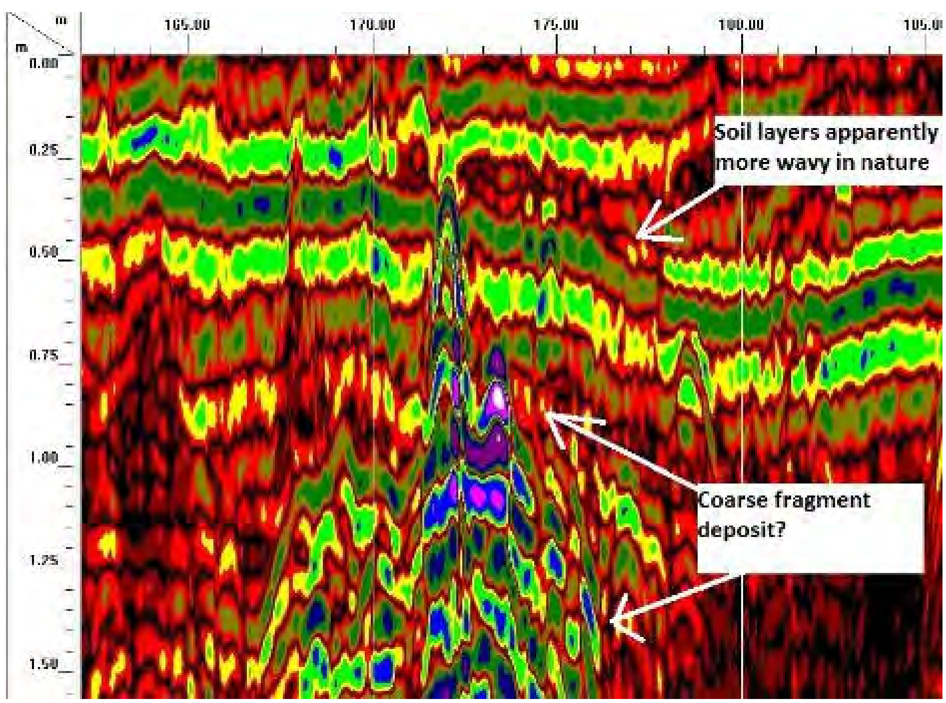

Figure 14. Along Transect 3, possible gravel layers were noted as the survey approaches Big Creek.

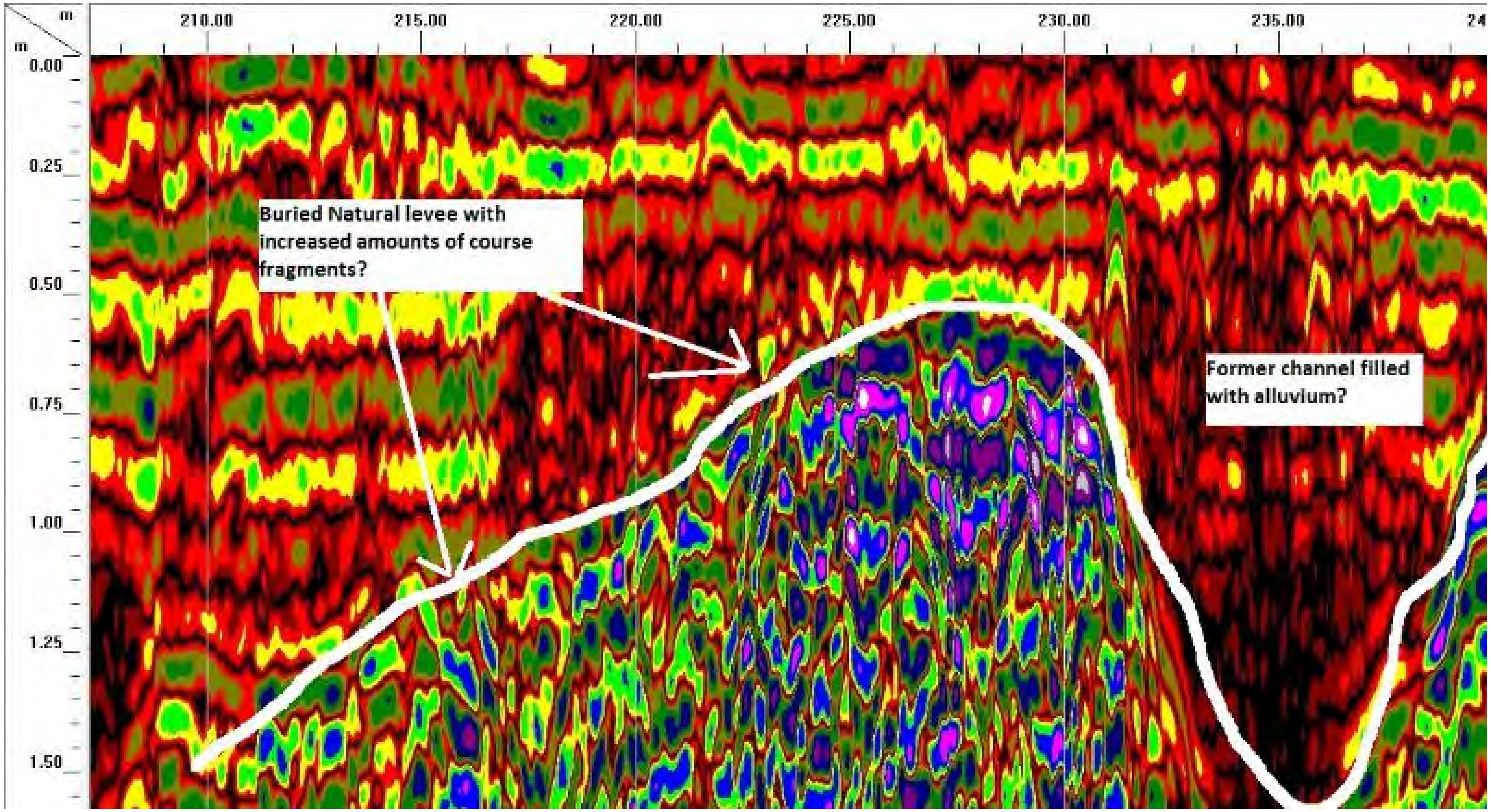

Figure 15. This anomaly at the end of Survey 3 may be a gravel bar deposited by Big Creek.

Summary: Transect 4

1. The soils along this transect appear to be uniformly stratified for about the first 120-m of the survey (Figure 16).
2. Test holes observed generally followed the Spadra series concept, except for one where gravels were observed in the subsoil
3. Based on the radar record, soil horizons apparently become more wavy in nature between 120 and 130-m along the transect (Figure 17). This area is also underlain by radar signature that was found to be indicative of gravel deposits in previous test holes.
4. A test hole was augured at the 200-m mark on transect 4, as summarized below. A suspected area of gravel deposition was confirmed to be present (Figure 18). The upper 80-cm was covered with loamy alluvium.

   A: 0-25-cm; Fine sandy loam
   Bt1: 25-50-cm; Sandy clay loam
   Bt2: 50-80-cm Sandy clay loam (marked clay increase)
   BC: 80-120-cm Very gravelly Sandy loam 35% fragments
   C: 120-cm plus; Very gravelly (or cobbly) Sandy loam >40% fragments

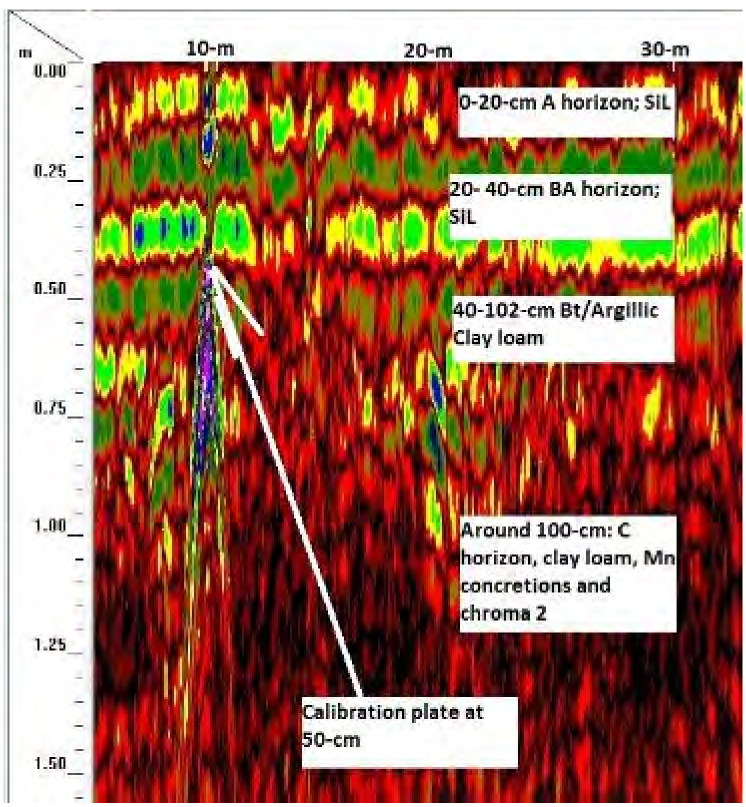

Figure 16. The first 30-m of survey number 4.

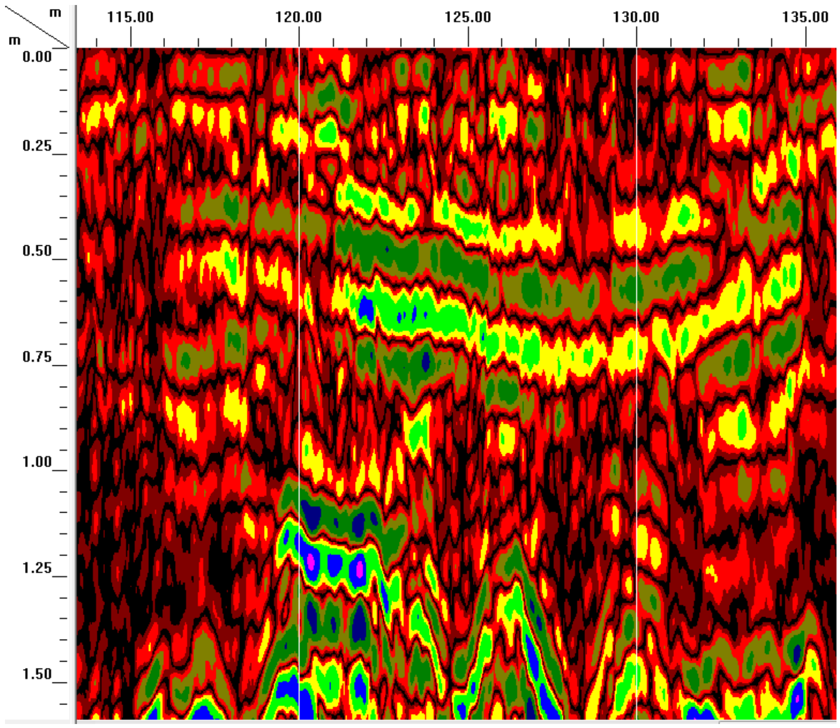

Figure 17. Features at bottom may be gravel deposits along survey number 4.

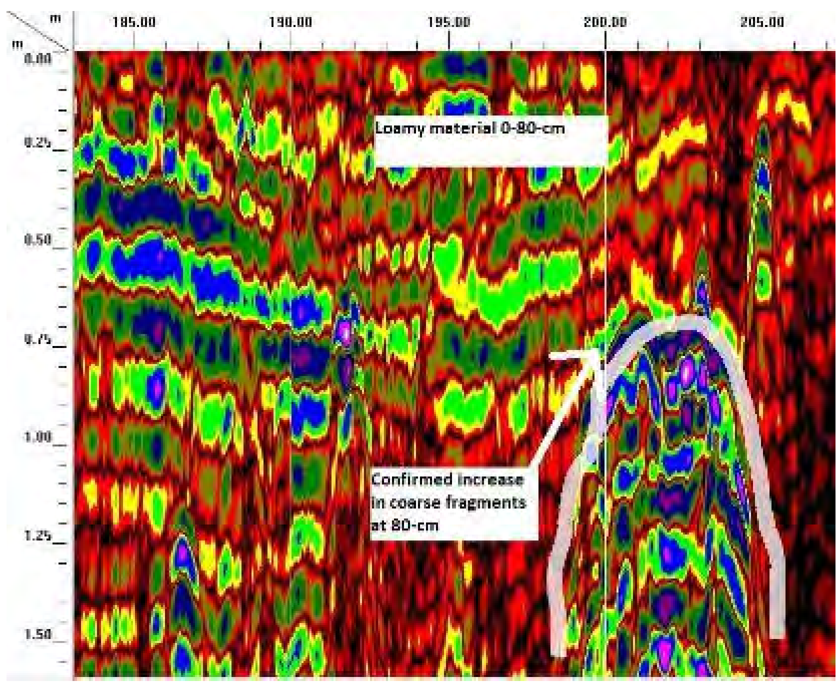

Figure 18. A subsurface horizon with increased fragment content was suspected and confirmed in the field along survey # 4.

Summary: Transect 5

1. No points were ground-truthed along this radar survey
2. The data indicates that most of this soil is uniformly layered, with a radar record resembling surveys # 3 and # 4. The survey indicates that the argillic layer usually starts around 25-cm.
3. There were no anomalies associated with gravel at the end of this radar survey.
4. There were highly contrasting materials noted at a depth of >1-m over the first 30-m of this transect (Figure 19). This could be layers that greatly increase in clay content, or layers that increase in coarse fragments that are alluvial in nature . Less likely at this position would be “valley fill” material from nearby uplands that is overlain by alluvium.

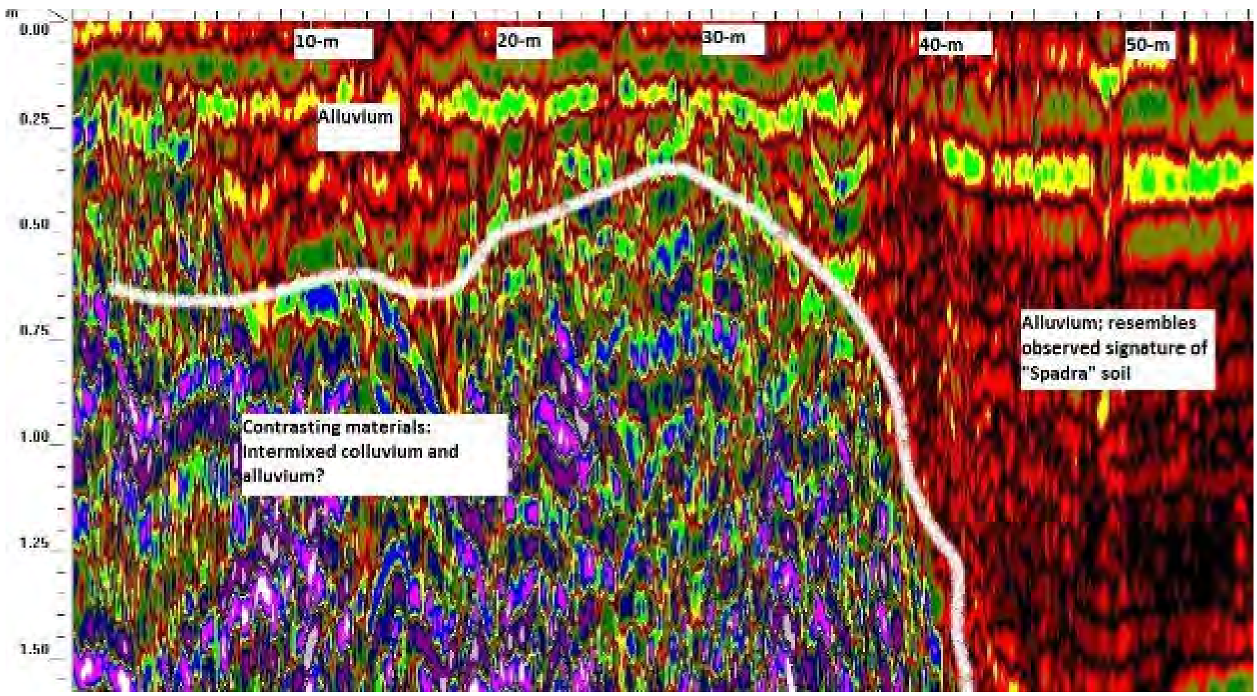

Figure 19. Contrasting, high amplitude features noted at the beginning of transect #5.

Summary: Transect 6

1. No points were ground-truthed along this radar survey
2. The data indicates that most of this soil is uniformly layered, with a radar record resembling surveys # 3 and # 4. The survey indicates that the argillic layer usually starts around 25-cm.

3. There were highly contrasting materials noted at a depth of 60-cm from around the 40-m mark of this transect until around the 90-m mark (Figure 20). This could be layers that greatly increase in clay content, or an increase in coarse fragments that are alluvial in nature.

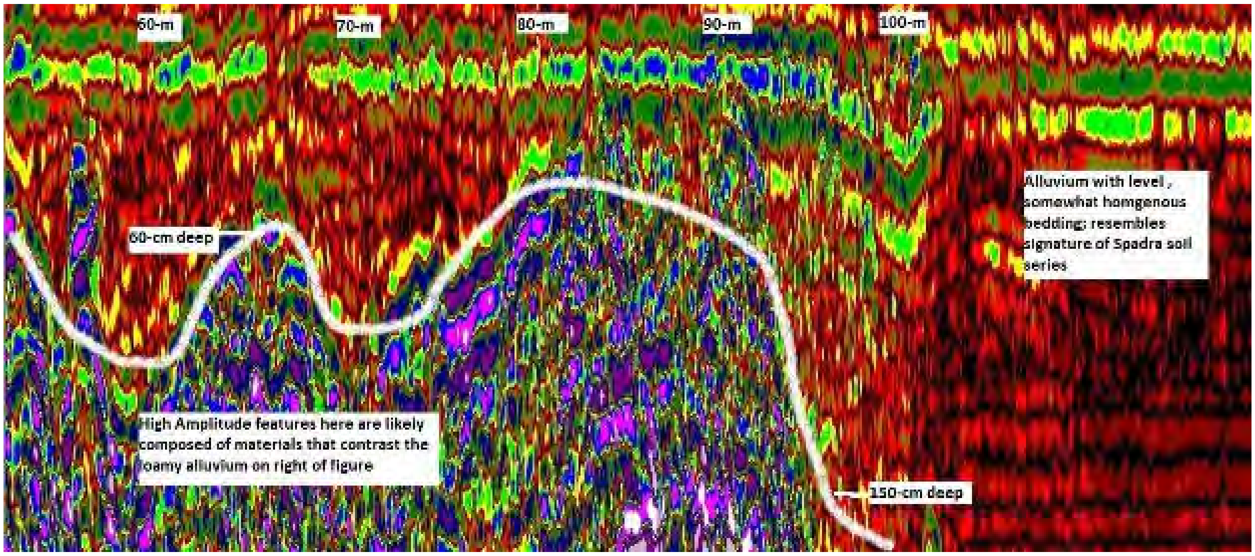

Figure 20. Contrasting materials below loamy alluvium disappear at the 100-m mark on transect #6.

Summary: Transect 7

1. From the 0-m to 80-m mark on this survey, the radar record suggests that most of the soil is level bedded and relatively homogenous. There are areas on this first portion of the transect that exhibit high amplitude and likely contrasting features (Figure 21) that could contain higher amounts of coarse fragments or clay.

2. From the about the 80-m mark through the 130-m mark on the survey, there are subsurface deposits at depths deeper than 100-cm that contrast with what is likely loamy alluvium in the upper portion of the soil profile (Figure 22). Again, speculatively, these contrasting materials could be an increase in coarse fragments, or an increase in clay content.

3. There were no anomalies noted on the radar record from the 130-m mark to the end of the survey at 170-m (Figure 22). The radar record suggests that most of the soil is level bedded and relatively homogenous in this portion of the survey. The radar record mimics the loamy alluvium that resembled the Spadra series in surveys #3 and #4.

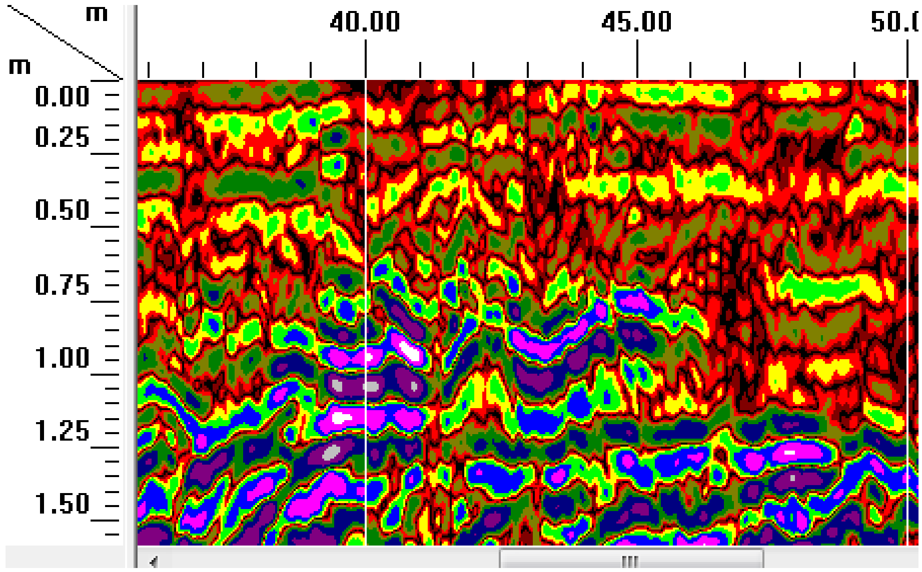

Figure 21. Purple features above could possibly be pockets of increased fragment deposition.

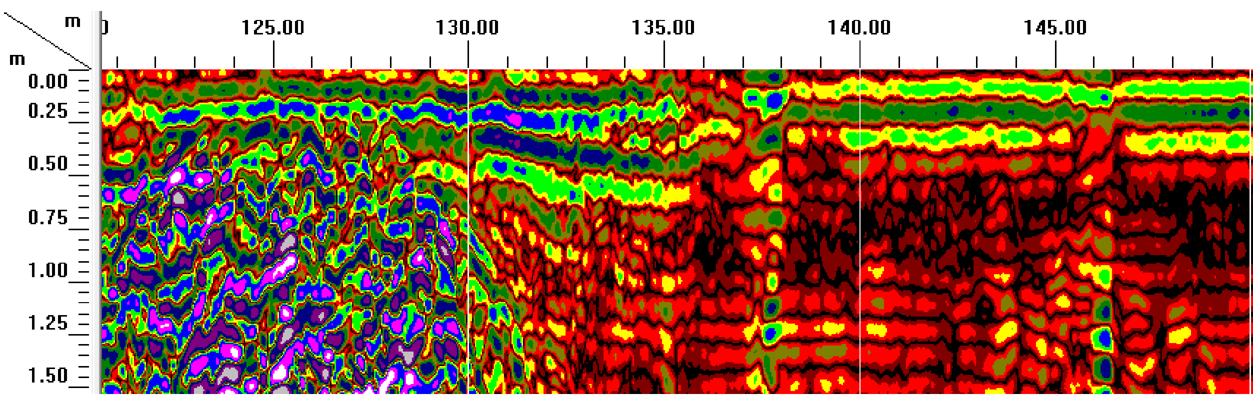

Figure 22. Highly contrasting features (left) were suggested by the radar record from the 80-m to 130-m marks along survey 7. The eastern most portion of the survey appears to be more evenly stratified and mimics similar radar signatures where fine-loamy Ultisols where observed in test holes on previous transects.

APPENDIX D: GRID-SOIL SAMPLED MEHLICH-3 EXTRACTABLE ELEMENTS

List of Tables

Table 1. Soil analyses of 0 to 4 inch samples collected from Field 1, 2014.

Lab Number	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
		-----------	-----------	-----------	-----------	-----------	mg/kg	-----------	-----------	-----------	-----------	-----------
166760	7.3	30	183	8465	142	14	23	35	230	1	4.7	1.1
166776	7.8	32	104	5672	78	12	11	61	108	0.5	3.9	0.5
166702	6.7	99	571	1821	116	28	15	232	117	0.4	4	0.7
166703	7.8	18	123	7643	92	43	13	44	156	0.9	2.3	0.6
166752	6.5	28	80	2741	110	16	20	76	86	0.5	3	0.4
167144	6.1	83	706	1415	158	22	22	159	266	0.9	5.6	0.6
166704	6.3	98	597	2478	227	10	25	172	251	0.7	8	0.7
166694	6.5	22	144	1298	89	14	13	118	374	0.6	2.6	0.3
166715	7	100	329	2229	144	13	18	134	232	0.9	6.1	0.6
166716	6.6	59	469	2007	150	14	21	101	267	1	9.7	0.7
166698	6.6	82	405	2022	152	12	18	149	360	1.1	7.1	0.7
166699	6.9	50	84	1667	85	12	17	121	346	0.6	4.2	0.3
166714	6.1	57	151	1613	139	14	23	101	532	0.4	3	0.4
166713	6	44	107	1700	158	19	22	94	316	0.8	7.5	0.5
167143	4.4	49	53	456	53	16	17	188	31	0.2	2.2	0.2
166721	6	52	108	1398	96	10	17	70	50	0.2	1.8	0.2
166722	5.3	102	163	1072	122	9	21	107	97	0.3	3.5	0.2

Lab Number	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
166712	5.5	93	187	922	95	12	19	200	148	0.3	3.1	0.4
166710	6.6	50	84	1598	77	17	15	127	106	0.5	2.4	0.4
166711	6.2	67	191	1290	143	20	19	148	214	0.5	4.3	0.4
166708	7	77	245	1310	127	13	16	128	326	0.4	4	0.5
166707	6.3	169	771	2073	216	17	29	128	258	0.6	10.6	0.9
166706	5.5	100	90	1357	131	44	19	141	257	0.7	9.4	0.3
166728	6.6	80	189	1454	110	14	15	117	84	0.4	3.6	0.4
166723	7	48	277	1898	107	12	16	78	129	0.4	2.7	0.4
166724	6.8	56	223	1503	110	20	16	110	174	0.5	3.3	0.5
166727	6.4	41	61	1200	71	12	16	116	289	0.4	2.1	0.3
166725	6.3	109	707	1502	144	16	28	170	318	1	9.1	0.6
166726	6.5	56	420	1442	145	12	20	105	219	0.7	4.8	0.4
166718	6.8	82	366	2051	150	18	24	124	173	0.8	6.9	0.5
166720	6.4	55	93	1730	105	13	17	95	280	0.6	5	0.4
166736	5.4	60	88	889	69	10	17	119	171	0.2	3.3	0.2
166737	6.3	71	314	1638	94	9	17	97	193	0.3	5.3	0.4
166738	6.3	66	143	1247	84	8	17	114	122	0.3	3.3	0.4
166739	7.5	39	148	2056	62	7	13	84	238	0.4	2.1	0.4
166740	5.8	35	269	675	61	10	20	115	388	0.3	2.5	0.3

Lab Number	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
166732	6.5	63	208	1149	128	12	17	118	381	0.8	4.1	0.4
166733	6.7	90	251	1649	139	11	17	111	362	0.9	6.1	0.5
166734	5.9	54	238	1275	131	11	20	153	253	1.1	5.1	0.4
166735	7.3	77	675	4064	161	10	26	52	380	0.8	5.6	0.9
166730	6.6	52	231	1591	120	14	19	109	188	0.6	3.7	0.4
166745	5.5	54	174	955	107	17	18	124	190	0.7	6	0.2
166746	6	30	49	1299	44	12	13	89	244	0.3	2.1	0.2
166764	5.7	81	52	941	69	12	15	110	168	0.4	3.9	0.2
166763	6.7	37	121	3098	176	10	20	64	341	0.8	7.5	0.6
166759	5.2	58	44	641	47	12	16	166	130	0.5	2.5	0.2
166749	5.5	44	67	801	76	10	16	96	316	0.5	2.3	0.3
166750	5.7	53	67	1046	62	11	18	89	360	0.5	2.2	0.2
166747	6.4	33	127	1230	83	8	15	86	444	0.5	2.3	0.4
166748	7	62	172	1767	156	10	19	90	448	0.9	4.2	0.5
166768	7.4	52	473	2717	123	8	22	70	321	0.8	4.3	0.5
166742	6.4	56	373	4822	230	16	19	40	308	0.9	3.8	0.7
166743	6.3	28	66	1665	89	15	15	94	231	0.6	2.7	0.3
166751	6.2	46	51	1510	74	13	18	95	222	0.4	3.6	0.2
166772	6.6	32	88	2359	86	11	19	79	486	0.5	3.3	0.3

Lab Number	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
166691	5.9	65	63	1231	72	25	17	144	137	0.4	2.5	0.3
166692	6.2	55	78	1620	101	11	18	129	235	0.5	2.9	0.5
166775	5.6	36	62	1337	79	10	15	96	164	0.2	2	0.2
166754	6.1	40	161	1284	149	12	20	130	361	0.6	4.1	0.4
166761	7	42	109	2258	95	10	17	80	462	1	6.4	0.4
166762	7	45	224	3777	166	9	17	45	339	0.9	5.5	0.5
166755	6.7	40	136	2241	117	10	19	86	330	0.6	6.2	0.4
166757	6.9	36	248	2385	134	12	23	92	363	0.6	4.7	0.5
166758	5.3	49	48	736	63	11	18	169	309	0.4	3.1	0.2
166771	6.8	30	83	2047	59	10	14	79	269	0.3	3.3	0.3
166766	5.4	66	71	848	107	16	16	115	131	0.4	3.9	0.3
166767	5.4	72	73	605	92	10	20	128	326	0.4	4.1	0.2
166773	5.8	88	101	1181	96	11	21	124	346	0.5	3.2	0.3
166769	6.2	37	86	1835	126	11	19	83	511	0.8	4.3	0.3
166770	7.5	70	83	4550	127	19	18	50	311	0.9	6.1	0.5
166774	6.4	51	72	1430	99	11	17	79	311	0.6	3.3	0.3
Mean	6.35	59	204	1936	113	14	18	109	262	0.59	4.34	0.42
Median	6.40	54	143	1591	107	12	18	109	258	0.50	3.90	0.40
Minimum	4.4	18	44	456	44	7	11	35	31	0.2	1.8	0.2

Lab Number	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
Maximum	7.8	169	771	8465	230	44	29	232	532	1.1	10.6	1.1
Standard deviation	0.66	25	178	1423	40	6	3	38	113	0.24	2.01	0.18
Coefficient of variation, %	10.39	43	88	73	36	46	19	35	43	41	46	44
Count	71											

Table 2. Soil analyses of 4 to 8 inch samples collected from Field 1, 2014.

Lab Number	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
		------------------------------------ mg/kg ------------------------------										
166695	6.4	11	71	1002	75	17	10	108	354	0.6	2	0.3
166700	6.6	25	41	1024	62	14	9	104	310	0.4	1.6	0.2
166709	6.6	24	117	861	71	13	9	141	303	0.3	1.6	0.3
166731	6.6	22	112	1226	97	13	9	94	269	0.4	2.9	0.2
166744	6.6	14	51	1440	54	11	10	86	193	0.5	1.5	0.2
166756	6.9	22	68	1853	89	14	15	77	297	0.6	3.3	0.2
Mean	6.62	20	77	1234	75	14	10	102	288	0.5	2.2	0.2
Median	6.60	22	70	1125	73	14	10	99	300	0.45	1.80	0.20
Minimum	6.4	11	41	861	54	11	9	77	193	0.3	1.5	0.2
Maximum	6.9	25	117	1853	97	17	15	141	354	0.6	3.3	0.3
Standard deviation	0.16	6	31	364	16	2	2	22	54	0.12	0.77	0.05
Coefficient of variation, %	2	29	41	29	22	14	23	22	19	26	36	22
Count	6											

Table 3. Soil analyses of 8 to 12 inch samples collected from Field 1, 2014.

Lab Number	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	Bo
		- mg/kg -										
166696	6.2	7	69	836	67	13	9	129	415	0.4	0.9	0.2
166701	6.5	12	45	936	70	11	6	114	322	0.3	1	0.2
166719	7	12	228	3587	139	25	8	59	102	0.4	0.6	0.3
Mean	6.57	10	114	1786	92	16	8	101	280	0.37	0.83	0.23
Median	6.53	11	92	1361	81	15	8	107	301	0.38	0.87	0.22
Minimum	6.2	7	45	836	67	11	6	59	102	0.3	0.6	0.2
Maximum	7	12	228	3587	139	25	9	129	415	0.4	1	0.3
Standard deviation	0.40	3	99	1560	41	8	2	37	161	0.06	0.21	0.06
Coefficient of variation, %	6.15	28	87	87	44	46	20	37	57	16	25	25
Count	3											

Table 4. Soil analyses of 0 – 4 inch samples collected from Field 5a, 2015.

Lab Number	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
		- mg/kg -										
58314	6.6	34	98	3168	108	16	16	116	138	2	7.3	0.9
58318	7	36	115	3404	96	15	15	154	214	2.5	6.9	1
58323	6.4	17	71	2413	92	28	10	111	197	2.2	3.5	0.6
58329	5.6	35	56	1692	86	13	11	143	230	2.7	4.2	0.4
58332	5.4	55	49	1028	81	9	12	197	212	0.9	2.9	0.4
58338	5.9	40	40	1299	71	9	10	177	169	1.1	3.8	0.4
58343	6	28	45	1578	83	9	10	178	204	1.3	3.3	0.5
58348	6.3	27	49	2031	85	11	11	147	211	1.4	4	0.6
58354	6	26	44	1762	72	13	11	161	188	1.2	3.6	0.3
58359	5.5	74	55	1040	69	14	11	230	210	1.1	2.9	0.1
58364	5.6	61	61	987	57	10	11	180	198	1.4	1.8	0.1
58369	6.4	29	65	1984	57	16	11	143	268	1.9	3.3	0.3
58375	6.1	23	65	2257	66	11	12	123	186	1.9	3.7	0.3
58380	6.6	32	103	2914	95	17	15	123	227	2.1	5.4	0.6
58383	5.4	50	63	840	93	14	14	192	275	1.4	2.6	0.1
58389	5.5	86	70	877	76	10	14	207	341	2	4.4	0.2
58394	5.3	59	50	922	65	11	13	188	215	0.9	2	0.1

Lab Number	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
58400	6.2	19	42	2055	82	11	12	135	223	1.6	4.7	0.5
58404	6.1	22	46	1776	81	13	12	130	224	1.4	5.1	0.4
58410	5.2	33	44	565	63	13	15	151	247	1.1	1.5	0.1
58415	5	51	57	584	69	13	17	170	232	0.9	1.2	0.1
58420	5.1	55	176	795	70	11	13	176	285	2	3.3	0.2
58426	5.3	69	78	846	83	11	15	161	163	0.8	1.6	0.2
58431	5.1	43	46	574	54	12	15	142	249	1.2	1.2	0.1
58436	4.8	47	48	484	50	13	20	153	254	1.1	0.9	0.1
58441	5.3	51	39	513	61	13	14	148	246	1.1	1.9	0.1
58444	5.3	85	51	829	61	14	15	167	167	0.8	1.8	0.2
58450	4.9	61	60	628	81	12	16	122	143	1	1.7	0
58455	5	54	38	350	62	11	14	118	200	1	1.5	0
58461	4.5	91	25	167	32	6	11	163	110	0.7	1	0
58466	6.4	18	60	2016	57	11	9	96	150	1.6	2.8	0.3
58471	4.6	51	25	359	42	8	14	155	168	0.8	1.2	0
58476	4.8	64	29	315	49	5	12	138	129	0.6	1.1	0
58482	6.4	20	81	2022	53	7	11	104	157	1.5	3.4	0.4
58487	4.8	38	70	682	52	9	7	115	39	0.4	0.3	0
58492	5	23	46	644	53	7	13	118	128	0.4	0.7	0
Mean	5.63	45	59	1315	70	12	13	154	205	1.4	3.0	0.3

Lab Number	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
Median	5.50	47	51	987	69	11	12	153	211	1.2	2.9	0.2
Minimum	4.50	17	21	167	32	5	9	96	110	0.4	0.7	0.0
Maximum	7.00	91	176	3404	108	28	20	230	341	2.7	7.3	1.0
Standard deviation	0.65	21	30	881	17	4	2	32	50	0.6	1.7	0.3
Coefficient of variation, %	12	46	51	67	24	35	19	21	24	42	57	90
Count	33											

Table 5. Soil analyses of 4 – 8 inch samples collected from Field 5a, 2015.

Lab Number	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
		- mg/kg -										
527386	6.4	42	192	2927	118	54	7	127	77	2.9	6.9	0.3
527400	6.6	45	41	1577	42	50	7	104	100	1.3	2.0	0.1
527407	6.4	33	92	2964	86	12	6	93	64	2.4	4.6	0.1
527414	6.1	36	114	3270	105	16	8	106	38	2.5	4.0	0.2
527421	5.8	49	129	2870	124	13	10	150	34	2.3	4.3	0.2
527442	6.3	22	71	1005	67	7	6	104	148	0.8	16.2	0.2
527456	6.7	41	131	4381	101	17	8	95	91	2.2	6.3	0.2
527463	6.1	30	98	2877	117	16	7	124	39	2.0	4.7	0.2
527470	5.9	33	119	2873	89	12	8	100	58	2.0	3.8	0.2
527477	6.3	49	144	921	48	6	10	113	243	1.0	4.1	0.2
527491	6.0	37	115	2754	126	11	8	143	36	2.3	4.9	0.1
527498	6.2	36	102	3093	109	11	7	111	35	2.6	5.0	0.1
527533	6.3	73	175	861	70	6	11	109	246	1.2	7.0	0.1
527540	6.2	67	176	2139	96	8	13	125	84	2.1	5.6	0.1
527547	6.4	28	143	3379	135	15	7	96	41	2.6	4.5	0.1
527554	5.6	42	111	2661	133	16	10	184	32	2.4	7.9	0.1
527575	6.4	57	80	981	44	27	8	122	233	0.8	2.2	0.1

Lab Number	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
527582	5.9	96	315	589	52	7	12	113	200	0.9	3.2	0.1
527589	6.4	41	169	2823	132	20	7	95	38	2.0	3.9	0.1
527596	6.1	36	127	2754	109	11	12	101	43	2.1	3.9	0.1
527603	6.7	50	151	2927	144	12	9	100	49	1.7	3.8	0.1
527624	6.8	17	59	2361	61	10	7	62	96	1.8	1.8	0.1
527631	6.4	46	55	1819	88	16	8	78	130	1.9	3.3	0.1
527638	6.3	98	67	1267	68	23	7	125	136	1.4	2.4	0.1
527645	6.6	43	82	1800	74	15	7	97	132	1.7	3.3	0.1
527652	6.8	23	63	2477	78	9	7	93	99	2.0	4.2	0.2
527673	6.3	15	104	3322	116	11	9	69	115	2.6	4.6	0.2
527680	6.3	14	116	3031	65	13	8	68	128	2.4	2.5	0.1
527694	6.4	70	94	1972	107	35	9	101	97	1.3	4.3	0.2
527701	6.8	46	82	1922	81	11	9	118	88	1.2	4.4	0.3
527708	6.8	20	38	2056	54	9	10	116	114	1.3	3.6	0.5
527715	7.2	28	46	1640	56	8	6	115	101	0.9	3.0	0.2
527750	6.6	17	73	2889	56	29	9	70	115	2.4	16.7	0.5
527757	6.8	25	80	2168	71	18	8	77	119	1.9	2.9	0.2
527764	6.8	50	79	2347	81	15	10	97	154	2.4	5.3	0.3
527771	7.0	30	50	1981	69	10	9	125	157	1.4	4.1	0.4

Lab Number	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
527778	7.0	21	74	1746	43	42	8	102	136	1.1	2.9	0.5
527785	7.1	21	35	1548	37	8	6	108	116	0.9	2.5	0.2
527820	6.6	17	68	2730	58	18	11	84	154	2.3	12.3	0.4
527827	6.7	11	81	2769	50	29	8	68	149	2.3	1.9	0.3
527834	6.7	14	67	2419	62	11	8	97	178	2.2	3.5	0.3
527841	7.1	33	62	1363	43	24	7	109	110	0.9	4.8	0.3
527848	7.0	34	38	1685	46	10	8	117	164	1.3	4.3	0.4
527855	6.8	21	28	1338	27	8	4	108	112	0.9	7.6	0.2
Mean	6.5	38	99	2256	80	17	8	105	110	1.8	4.9	0.2
Median	6.4	35	82	2354	73	13	8	104	111	2.0	4.2	0.2
Minimum	5.6	11	28	589	27	6	4	62	32	0.8	1.8	0.1
Maximum	7.2	98	315	4381	144	54	13	184	246	2.9	16.7	0.5
Standard deviation	0.4	20	53	817	31	11	2	23	57	0.6	3.2	0.1
Coefficient of variation, %	6	53	54	36	39	67	22	22	52	34	65	58
Count	44											

Table 6. Soil analyses of 8 – 12 inch samples collected from Field 5a, 2015.

Lab Number	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
		- mg/kg -										
527388	6.1	33	159	3411	124	26	5	99	55	2.6	4.5	0.1
527402	6.7	36	50	1445	34	11	5	93	64	1.0	1.2	0.1
527409	6.5	21	130	4104	95	15	6	95	52	2.9	3.6	0.1
527416	6.1	23	143	3790	104	17	8	98	42	2.4	3.4	0.1
527423	5.4	42	158	3067	125	18	12	129	27	2.3	3.0	0.1
527444	6.6	24	65	1162	100	24	3	113	93	0.8	0.9	0.1
527451	6.6	23	133	4357	110	40	7	116	67	2.1	3.9	0.2
527458	7.1	11	121	4154	57	16	5	74	105	2.3	4.0	0.3
527465	6.2	22	119	3375	95	16	6	96	32	2.3	2.8	0.3
527472	5.7	30	127	3330	93	21	9	94	30	2.1	3.0	0.3
527479	6.6	30	91	824	31	31	6	118	209	0.9	3.6	0.3
527493	5.8	21	119	3024	113	17	6	95	32	2.2	7.7	0.3
527500	6.3	26	122	3266	113	14	7	100	41	2.5	3.4	0.1
527535	6.5	59	144	765	43	5	8	123	236	1.0	0.9	0.1
527542	6.3	36	137	2919	121	16	9	102	83	2.4	4.9	0.2
527549	6.2	28	140	3769	148	14	7	93	36	2.9	3.1	0.2
527556	5.3	42	140	2727	123	20	12	193	25	2.2	4.4	0.2

Lab Number	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
527577	6.5	46	61	910	25	11	4	139	165	0.5	0.7	0.2
527591	6.3	30	123	3392	119	18	4	89	33	1.7	3.9	0.2
527598	5.9	22	93	2971	99	15	10	93	35	1.9	2.8	0.2
527605	6.4	37	152	3089	155	11	7	77	39	2.1	4.0	0.2
527626	6.7	10	69	2474	49	10	7	70	113	2.0	2.9	0.2
527633	6.5	23	61	1979	64	28	7	78	131	2.0	2.8	0.2
527647	6.5	25	68	2073	77	29	5	80	100	1.9	2.8	0.2
527654	6.7	24	92	2946	96	12	6	97	77	2.4	3.8	0.2
527682	6.4	5	86	3016	33	16	5	55	86	1.8	1.2	0.1
527696	6.4	57	123	2771	138	16	7	91	48	1.2	0.9	0.1
527703	6.7	34	102	2023	88	16	8	114	131	1.7	4.2	0.2
527710	6.9	14	55	2327	62	10	8	92	99	1.6	3.0	0.4
527717	7.0	20	42	1539	61	10	6	117	95	0.9	3.1	0.2
527759	6.9	15	114	2659	64	19	6	84	82	1.9	0.8	0.2
527766	6.8	19	93	2896	85	35	9	82	163	2.7	4.7	0.5
527773	7.0	27	56	1615	56	86	6	120	141	1.5	2.9	0.5
527787	7.3	21	36	1418	41	19	5	102	117	0.9	4.1	0.1
527822	6.6	7	104	2964	31	19	7	74	86	2.6	1.0	0.3
527829	6.7	5	103	3189	40	16	6	62	85	1.9	1.4	0.1

Lab Number	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
527836	6.7	10	87	2756	60	14	7	84	174	2.4	6.2	0.3
527843	7.0	30	40	1108	34	11	5	114	107	1.1	2.8	0.1
527850	7.0	48	51	1563	41	11	6	119	156	1.4	2.9	0.2
527857	6.4	22	45	1554	33	10	4	114	112	1.4	2.0	0.2
Mean	6.5	26	99	2568	80	19	7	99	90	1.9	3.1	0.2
Median	6.5	24	103	2834	81	16	6	96	86	2.0	3.0	0.2
Minimum	5.3	5	36	765	25	5	3	55	25	0.5	0.7	0.1
Maximum	7.3	59	159	4357	155	86	12	193	236	2.9	7.7	0.5
Standard deviation	0.4	13	37	973	37	13	2	24	52	0.6	1.5	0.1
Coefficient of variation, %	7	49	37	38	47	69	30	24	58	34	49	51
Count	40											

Table 7. Soil analyses of 12 - 18 inch samples collected from Field 5a, 2015.

Lab Number	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
	------------------------------------ mg/kg ------------------------------------											
527389	6.3	35	159	3619	127	73	5	98	38	2.3	5	0.1
527393	6.4	59	87	1896	83	17	3	92	24	0.7	0.5	0
527398	6.7	16	139	4601	95	18	7	94	74	2.8	4.3	0.4
527402	6.2	19	133	3892	79	30	6	83	43	2.3	3.4	0.1
527407	5.2	48	156	3048	115	19	11	132	40	2.2	2.6	0
527411	6.2	49	100	2014	133	15	2	108	46	0.7	1.2	0
527418	7	9	114	3998	52	42	4	68	106	2.3	7.3	0.3
527423	6.2	21	108	3248	79	20	6	93	33	2.2	2.3	0
527427	5.8	31	128	3272	81	30	8	105	36	2.3	3.3	0
527432	6.3	41	74	1027	50	44	4	143	149	0.6	1.3	0
527437	5.9	26	124	3258	104	23	8	108	32	2.5	2.6	0.1
527442	6	34	128	3110	113	20	8	141	19	2.1	2.9	0.1
527447	6.3	41	117	697	38	6	7	136	208	0.7	2	0
527451	6.4	19	122	3279	112	17	6	86	57	2	3.4	0
527455	6.1	39	137	3336	130	26	7	94	30	2.2	2.6	0
527459	5.2	45	148	2873	121	38	12	243	22	2.3	2.9	0.2
527464	6.6	53	53	707	19	12	2	139	98	0.3	1.1	0

Lab Number	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
527474	6	17	125	3590	114	22	8	95	44	2.5	4.1	0.2
527482	6.8	8	72	2268	32	15	4	79	110	1.9	1.2	0
527493	6.5	26	85	2595	84	15	4	85	98	2.4	3.6	0
527497	6.3	15	117	3586	114	17	6	92	58	2.4	3	0.3
527505	6.5	5	116	3373	26	22	7	79	105	1.8	5.8	0.2
527509	6.6	61	129	3098	121	20	6	110	48	0.9	3.2	0.1
527513	6.7	27	114	2957	112	24	8	92	93	2.4	4	0.4
527519	6.9	13	86	3115	90	15	7	84	100	2.1	2.5	0.4
527525	7	30	64	1769	62	9	6	106	101	1.3	2.8	0.1
527531	6.9	17	121	2889	61	30	5	75	74	1.7	0.7	0.2
527539	6.8	22	102	2950	99	16	6	89	114	1.9	2.3	0.4
527546	7.1	23	46	1505	47	9	5	106	124	1.1	1.8	0.1
527551	6.7	6	121	3263	35	30	6	75	66	2.4	1.1	0.3
527555	6.7	5	107	3158	27	18	5	66	69	1.8	1.5	0.1
527560	6.6	8	109	3303	65	18	8	86	160	2.5	3.1	0.4
527565	6.9	26	68	1853	65	21	6	101	199	1.7	3.3	0.3
527570	6.9	50	74	2094	61	17	5	133	136	1.6	2.1	0.2
527574	6.5	33	72	2250	46	10	5	145	127	2	2.7	0.1
Mean	6.4	28	107	2785	80	22	6	105	82	1.9	2.8	0.1

Lab Number	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
Median	6.5	26	114	3098	81	19	6	94	74	2.1	2.7	0.1
Minimum	5.2	5	46	697	19	6	2	66	19	0.3	0.5	0.0
Maximum	7.1	61	159	4601	133	73	12	243	208	2.8	7.3	0.4
Standard deviation	0.5	16	29	914	34	12	2	33	49	0.7	1.4	0.1
Coefficient of variation, %	7	57	27	33	43	56	35	31	60	36	51	99
Count	35											

Table 8. Soil analyses of 18 - 24 inch samples collected from Field 5a, 2015.

Lab Number	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
		mg/kg										
527389	6.5	42	156	3756	136	78	3	118	37	2.3	3.8	0.2
527394	5.7	59	97	1401	111	21	4	106	15	0.6	0.8	0.2
527403	6.5	20	138	4317	74	25	6	88	51	2.2	10.1	0.2
527412	6.1	45	119	2011	180	20	3	95	27	0.6	1.0	0.2
527419	7.0	8	120	4131	42	40	4	70	99	2.1	4.0	0.5
527428	5.7	35	150	3653	79	23	7	107	47	2.0	5.9	0.1
527433	6.2	51	75	1011	63	24	3	125	93	0.3	2.8	0.1
527438	6.1	19	128	3450	97	25	8	108	43	2.6	5.1	0.1
527443	5.8	34	132	3376	108	24	11	118	26	2.5	3.2	0.2
527460	5.4	33	132	3240	113	36	9	169	32	2.2	3.0	0.2
527470	6.4	16	114	3252	76	22	4	86	62	1.9	3.4	0.2
527475	5.9	25	118	3288	102	23	6	110	47	2.2	3.4	0.1
527483	6.7	14	76	2148	25	20	2	61	62	1.5	0.6	0.1
527498	6.3	20	117	3861	127	21	6	83	43	2.1	3.0	0.2
527514	6.4	32	119	3326	123	22	8	95	60	2.3	3.5	0.3
527520	6.8	14	101	3450	102	13	8	88	90	2.2	6.0	0.4
527532	6.8	20	120	2928	61	28	5	76	58	1.4	0.7	0.1
527540	6.9	19	90	2525	85	32	5	85	82	1.4	1.4	0.3

Lab Number	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
527547	6.5	38	77	2050	55	14	6	115	133	1.8	2.0	0.2
527556	6.8	6	105	2975	20	19	4	72	68	1.6	0.8	0.1
527561	6.6	8	116	3433	64	18	8	79	153	2.7	3.2	0.4
527566	6.8	19	88	2870	88	16	7	97	176	2.3	4.7	0.6
527389	6.5	42	156	3756	136	78	3	118	37	2.3	3.8	0.2
Mean	6.4	26	113	3021	88	26	6	98	68	1.9	3.3	0.2
Median	6.5	20	118	3270	87	23	6	95	59	2.1	3.2	0.2
Minimum	5.4	6	75	1011	20	13	2	61	15	0.3	0.6	0.1
Maximum	7.0	59	156	4317	180	78	11	169	176	2.7	10.1	0.6
Standard deviation	0.4	14	23	850	38	13	2	24	42	0.7	2.2	0.1
Coefficient of variation, %	7	55	20	28	43	52	40	24	61	35	68	61
Count	22											

Table 9. Soil analyses of 24 – 30 inch samples collected from Field 5a, 2015.

Lab Number	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
						- - - - - - - - - - mg/kg - - - - - - - - - -						
527484	6.5	42	156	3756	136	78	3	118	37	2.3	3.8	0.2
527499	5.7	59	97	1401	111	21	4	106	15	0.6	0.8	0.2
527515	6.5	20	138	4317	74	25	6	88	51	2.2	10.1	0.2
527521	6.1	45	119	2011	180	20	3	95	27	0.6	1.0	0.2
Mean	6.5	24	111	3237	97	22	6	90	62	2.0	3.3	0.2
Median	6.6	22	107	3243	105	22	7	97	52	2.1	3.8	0.2
Minimum	6.2	16	88	2708	32	18	2	61	41	1.7	0.9	0.1
Maximum	6.6	35	140	3755	144	24	9	104	103	2.3	4.7	0.3
Standard deviation	0.2	8	22	529	51	3	3	19	28	0.3	1.8	0.1
Coefficient of variation, %	3	34	20	16	53	12	49	22	45	16	55	58
Count							4					

Table 10. Soil analyses of 0 to 4 inch samples collected from Field 12, 2014.

Lab Number	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
		--- mg/kg ---										
24422	5.9	138	115	776	81	10	18	149	186	1.2	3.2	0.2
24427	6.0	143	196	763	79	7	14	138	226	0.9	3.2	0.2
24432	5.6	147	88	681	68	13	17	155	245	1.2	2.4	0.1
24438	6.0	65	70	1621	98	9	13	128	181	1.4	3.7	0.3
24443	5.7	117	117	721	72	10	15	146	187	0.8	2.1	0.1
24449	5.9	147	223	726	93	12	17	145	231	0.8	2.7	0.2
24452	5.7	126	174	608	94	7	14	154	197	0.8	2.6	0.1
24456	5.7	101	96	1169	101	9	17	151	177	1.3	2.7	0.2
24461	5.8	61	61	1367	82	10	14	153	168	1.2	2.4	0.2
24466	5.3	71	56	734	67	9	13	261	157	0.7	2.5	0.1
24472	5.5	60	57	788	62	8	17	107	218	0.8	1.3	0.1
24476	5.6	128	202	690	80	7	17	151	172	1.0	2.6	0.1
24480	5.8	109	69	956	75	10	16	143	159	0.9	2.1	0.3
24486	5.8	45	54	1441	87	12	14	117	170	1.2	1.8	0.2
24491	5.6	39	60	993	73	9	12	151	193	1.0	2.1	0.1
24497	5.6	53	212	873	69	14	12	155	165	0.7	2.6	0.1
24502	5.3	53	29	743	43	9	10	167	131	0.7	2.2	0.0

Lab Number	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
24508	6.1	43	76	1530	83	9	12	134	184	1.4	3.3	0.2
24513	6.0	37	81	1207	90	10	13	102	143	1.0	1.9	0.1
24519	5.8	63	62	1039	65	13	18	118	190	1.6	2.1	0.1
24524	5.8	52	45	828	49	9	15	92	119	0.9	3.0	0.1
24530	5.9	43	50	1318	49	14	15	101	185	1.5	1.4	0.2
24535	6.0	30	70	1781	105	14	15	102	98	1.6	5.7	0.2
24540	6.2	29	67	1767	83	17	14	108	173	1.5	1.5	0.3
24546	5.6	73	88	1048	86	8	15	136	154	1.1	2.2	0.1
24551	5.8	30	47	1143	81	19	11	113	149	1.1	2.8	0.2
24557	5.8	47	212	820	52	10	13	133	121	0.7	2.0	0.2
24562	5.9	42	76	1838	117	11	15	96	96	1.4	2.4	0.3
24563	6.1	24	59	1953	84	12	13	83	64	1.5	1.5	0.3
24569	5.9	19	54	1758	77	19	12	87	84	1.6	1.1	0.2
24574	6.3	17	56	1908	85	17	10	87	96	1.6	1.8	0.2
24580	6.3	30	43	1537	55	12	10	100	109	1.5	1.4	0.1
24585	6.1	33	54	1416	56	13	10	102	110	1.5	1.8	0.1
24591	6.1	32	43	970	57	15	8	115	106	1.2	1.5	0.1
24596	6.0	26	53	1120	38	10	8	108	102	1.7	1.5	0.1
24602	6.0	36	58	1338	63	9	10	101	78	1.3	1.3	0.1

Lab Number	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
24607	5.9	39	40	853	56	9	9	116	103	1.1	1.5	0.1
24612	6.0	52	98	1357	106	12	12	107	88	1.7	1.6	0.2
24617	6.0	34	72	1453	85	11	13	118	122	1.3	1.7	0.2
24622	6.0	97	282	1723	148	12	16	139	69	1.5	2.6	0.3
Mean	5.86	63	92	1184	77	11	13	127	148	1.2	2.2	0.2
Median	5.90	50	68	1132	80	10	14	118	156	1.2	2.1	0.2
Minimum	5.30	17	29	608	38	7	8	83	64	0.7	1.1	0.0
Maximum	6.30	147	282	1953	148	19	18	261	245	1.7	5.7	0.3
Standard deviation	0.23	40	62	405	21	3	3	32	48	0.3	0.8	0.1
Coefficient of variation, %	4	63	67	34	28	27	20	25	32	26	38	47
Count												

Table 11. Soil analyses of 4 to 8 inch samples collected from Field 12, 2014.

Lab Number	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
			- -				mg/kg		- -			
24423	6.4	47	47	650	26	6	11	94	103	0.7	0.8	0
24428	5.8	73	112	663	39	6	11	110	145	0.8	2.2	0.1
24434	5.9	81	47	678	38	9	12	123	177	1.1	2.4	0.1
24439	6	32	56	1447	58	9	11	117	98	1.4	1.7	0.2
24444	5.8	69	64	670	43	8	11	100	119	0.7	0.9	0
24450	5.6	102	106	682	51	16	14	128	154	0.8	1.6	0.1
24453	5.7	62	127	601	49	9	11	108	105	0.7	1.2	0
24458	5.7	36	70	1307	57	10	14	106	72	1.4	1	0.2
24462	5.9	27	62	1489	52	15	11	105	82	1.5	1	0.1
24467	5.3	62	37	488	28	8	8	160	101	0.5	0.9	0
24473	5.8	32	41	713	24	7	12	80	114	0.7	0.4	0
24477	5.7	88	115	723	57	7	14	121	111	0.8	1.2	0.1
24482	5.9	77	45	879	41	8	12	116	118	0.9	1.1	0.1
24487	6.1	13	73	1778	52	12	11	90	64	1.1	0.5	0.2
24492	5.8	17	55	1315	40	13	11	119	147	1.3	1.1	0.2
24498	5.8	26	45	767	33	10	8	105	78	0.5	0.8	0
24503	6	38	27	675	24	6	6	121	81	0.6	1	0

Lab Number	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
24509	6.1	21	54	1670	65	8	9	111	144	1.5	1.7	0.2
24514	6.1	17	65	1297	63	11	10	97	117	1.1	2.8	0
24520	5.9	47	49	1171	48	13	15	98	112	1.7	9.6	0.1
24525	6	23	42	785	29	8	11	73	67	0.6	0.4	0
24531	6.3	32	43	1257	32	13	12	90	132	1.7	3.4	0.1
24536	5.9	18	77	2257	111	16	15	107	75	2	2.2	0.3
24542	6.4	15	59	1681	50	19	11	92	115	1.5	0.8	0.2
24547	5.3	39	82	926	66	9	15	110	106	1.2	1	0
24552	5.9	17	54	1404	70	13	11	103	127	1.4	1	0.2
24558	6	35	116	630	28	9	9	99	77	0.6	0.7	0
24564	6.1	15	67	2386	81	19	14	87	30	1.6	0.8	0.3
24570	5.9	12	51	1844	68	17	11	72	44	1.3	0.7	0.2
24575	6.3	9	79	2453	105	15	10	92	78	1.8	1.4	0.4
24581	6.2	22	49	1419	54	13	9	99	89	1.5	1.1	0.1
24586	6.2	16	66	1631	59	11	10	97	81	1.5	0.9	0.1
24592	6.2	19	60	1552	47	12	8	113	85	1.6	1.3	0.2
24597	6.1	33	63	1375	46	15	9	104	79	1.8	1.8	0.1
24603	6.1	28	64	1360	67	10	9	94	53	1.3	0.8	0.1
24608	6	24	42	848	36	8	7	108	96	1.2	0.9	0

Lab Number	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
24614	6.1	23	92	1432	102	12	12	101	55	1.6	0.6	0.1
24618	6.1	17	60	1440	67	13	11	95	100	1.5	1	0.1
24623	5.9	48	202	1841	116	12	14	100	44	1.6	1.1	0.2
Mean	5.96	36	68	1236	54	11	11	104	97	1.2	1.4	0.1
Median	6.00	28	60	1307	51	11	11	103	98	1.3	1.0	0.1
Minimum	5.30	9	27	488	24	6	6	72	30	0.5	0.4	0.0
Maximum	6.40	102	202	2453	116	19	15	160	177	2.0	9.6	0.4
Standard deviation	0.25	24	32	523	23	4	2	16	33	0.4	1.5	0.1
Coefficient of variation, %	4	65	47	42	43	32	20	15	34	35	104	89
Count												

Table 12. Soil analyses of 8 to 12 inch samples collected from Field 12, 2014.

Lab Number	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
		- - - - - - - -	- - - - - - - -	- - - - - - - -	- - - - - - - -	- - - - - - - -	- - - - - -	mg/kg	- - - - - -	- - - - - -	- - - - - -	- - - - - -
24424	6	82	63	713	45	7	14	101	139	1	1.3	0.1
24429	6	42	96	607	29	7	9	95	104	0.6	0.9	0
24435	6.2	44	49	716	24	8	8	107	117	0.8	0.6	0
24440	6.1	22	78	1755	72	20	11	103	73	1.5	1.5	0.2
24446	5.8	50	77	681	40	9	9	107	88	0.4	0.9	0
24451	5.8	53	65	673	34	6	10	101	91	0.6	0.5	0
24454	5.8	45	106	712	39	8	9	99	78	0.6	0.3	0
24459	5.9	21	80	1779	56	11	15	104	53	1.4	0.7	0.2
24463	5.8	32	72	1493	49	12	13	102	48	1.4	0.4	0.1
24468	5.2	39	46	481	23	8	8	126	95	0.6	1.6	0
24474	5.9	22	52	781	23	9	9	90	93	0.5	0.2	0
24478	5.7	46	128	681	42	9	12	94	70	0.7	0.4	0
24483	6.1	34	52	1121	31	8	11	93	72	1.1	0.6	0
24488	6.1	13	86	1787	76	13	11	103	90	0.9	0.5	0.2
24494	6	10	74	1760	48	15	9	104	96	1.4	3	0.2
24499	5.9	11	57	1297	40	13	13	89	49	0.9	0.4	0.1
24504	6.1	30	34	720	25	8	5	124	96	0.7	1.6	0

Lab Number	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
24510	6.1	14	70	2050	78	11	9	105	119	1.8	1.5	0.2
24515	6.3	10	82	1722	75	16	11	93	71	1.3	0.3	0.1
24521	5.9	28	48	1104	44	10	12	88	60	1.4	1.3	0.1
24526	6	19	40	643	22	9	7	69	43	0.2	0.5	0
24532	6.1	26	52	1505	34	13	12	91	93	2	2.8	0.2
24537	5.9	14	79	2443	118	18	15	103	44	1.9	0.9	0.3
24543	6.5	12	75	1849	53	18	10	90	63	1.6	0.5	0.1
24548	5.2	18	104	1219	75	12	19	106	73	1.3	1.5	0.1
24554	6.1	11	74	1752	79	15	11	108	112	1.5	1.3	0.2
24559	6	24	71	936	41	10	10	98	86	1	0.7	0.1
24566	6.1	16	63	2099	66	21	15	90	13	1.6	0.6	0.1
24571	5.9	10	69	2043	78	22	15	86	21	1.3	0.5	0.1
24576	6.3	7	88	2536	104	19	10	98	58	1.7	0.8	0.3
24582	6	20	60	1768	77	17	13	100	60	1.6	1.1	0.2
24587	6.1	18	71	1493	74	17	9	100	53	1.3	0.7	0.1
24593	6.2	13	61	1805	54	11	9	105	55	1.5	1.1	0.2
24598	5.9	39	65	1301	51	14	9	99	54	1.5	0.9	0.1
24604	6.1	31	76	1468	69	12	9	96	41	1.2	0.5	0.1
24609	6.1	25	53	942	42	10	7	120	107	1.3	1.2	0

Lab Number	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
24615	6.2	25	85	1559	108	13	11	105	41	1.3	0.8	0.1
24619	6.1	10	71	1899	90	14	13	87	61	1.3	0.9	0.2
24624	5.9	19	164	1848	109	12	15	88	25	1.4	0.5	0.1
Mean	5.98	26	73	1378	57	12	11	99	72	1.18	0.93	0.11
Median	6.00	22	71	1493	51	12	11	100	71	1.3	0.8	0.1
Minimum	5.20	7	34	481	22	6	5	69	13	0.20	0.20	0.00
Maximum	6.50	82	164	2536	118	22	19	126	139	2.00	3.00	0.30
Standard deviation	0.24	16	24	562	26	4	3	11	29	0.44	0.61	0.09
Coefficient of variation, %	4	61	33	41	46	34	26	11	40	37	66	84
Count												

Table 13. Soil analyses of 12 to 18 inch samples collected from Field 12, 2014.

Lab Number	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
		----------	----------	----------	----------	----------	---------- mg/kg ----------	----------	----------	----------	----------	----------
24425	6.1	50	54	674	29	11	7	107	77	0.5	0.8	0
24430	6.1	40	101	656	33	8	7	103	85	0.4	1	0
24436	6.3	59	60	817	28	12	6	121	86	0.6	0.3	0
24441	6.1	19	88	1909	75	15	12	99	61	1.2	0.8	0.3
24447	5.9	57	79	746	39	12	8	113	64	0.2	0.3	0
24455	6	61	80	942	43	13	7	103	45	0.3	0.3	0
24460	6.1	14	75	1699	57	14	14	93	28	1.2	0.6	0.1
24464	5.3	38	80	1308	55	14	16	110	40	1.2	0.4	0
24470	5.2	20	87	1151	45	9	16	118	73	1.3	0.6	0.1
24475	5.9	28	48	616	26	11	6	89	61	0.1	0.5	0
24479	5.8	33	185	646	35	8	11	90	53	0.5	0.3	0
24484	6.2	24	62	1349	39	13	10	94	58	1.3	0.7	0.1
24489	6.1	23	57	1630	51	11	12	100	89	1.3	1	0.2
24495	6.3	12	82	1821	66	16	9	104	76	1.2	0.9	0.1
24500	5.7	11	78	1674	55	13	15	93	36	0.8	0.6	0
24506	6.1	29	59	1385	42	9	8	144	108	1.3	1.1	0.1
24511	6.4	11	78	1934	85	13	10	107	86	1.6	2.6	0.2

Lab Number	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
24516	6.1	11	80	1765	86	24	12	87	41	1.1	0.2	0.1
24522	5.8	27	57	1622	61	12	16	87	47	1.5	0.4	0.2
24527	5.6	40	56	644	27	13	10	94	33	0.2	2.5	0
24533	6	20	50	1832	46	16	12	92	50	1.9	3.9	0.2
24538	5.9	11	80	2372	116	19	17	100	25	1.6	0.6	0.2
24544	6.6	18	77	1703	57	14	9	89	41	1.3	3.7	0.1
24549	5.4	11	85	1457	81	14	17	97	41	1	0.5	0.1
24555	6	9	79	1640	79	16	10	99	67	1.3	1	0.1
24560	5.7	16	80	1440	64	13	11	103	81	1.3	0.7	0.1
24567	5.8	11	63	1630	46	20	16	91	14	1.1	0.4	0
24572	5.9	8	70	1711	70	24	13	87	28	1	0.4	0.1
24578	6.2	9	89	2387	100	22	10	98	59	1.7	0.9	0.3
24583	5.4	19	63	1671	78	20	17	111	49	1.7	0.9	0.1
24588	5.6	18	80	1380	86	25	11	100	45	1.1	0.6	0
24594	6.1	12	67	2121	74	15	10	105	35	1.4	0.7	0.2
24599	5.9	44	68	1202	61	16	8	101	43	1.2	0.5	0
24605	6.3	29	66	1186	54	12	7	85	24	0.6	0.5	0
24610	5.9	14	60	1730	72	16	9	119	54	1.5	1.1	0.2
24616	5.7	33	84	1334	94	16	12	106	33	1	0.5	0

Lab Number	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
24620	6.1	8	76	1908	97	17	12	87	51	1.1	0.4	0.1
24625	6	13	128	1740	104	22	14	84	25	1.3	0.8	0.1
Mean	5.94	24	77	1459	62	15	11	100	53	1.08	0.89	0.09
Median	6.00	19	78	1626	59	14	11	100	50	1.2	0.6	0.1
Minimum	5.20	8	48	616	26	8	6	84	14	0.10	0.20	0.00
Maximum	6.60	61	185	2387	116	25	17	144	108	1.90	3.90	0.30
Standard deviation	0.30	15	24	478	24	4	3	12	22	0.46	0.85	0.09
Coefficient of variation, %	5	63	31	33	38	29	30	12	41	42	95	100
Count												

Table 14. Soil analyses of 18 to 24 inch samples collected from Field 12, 2014.

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

Lab Number	Point	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
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
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		5.91	35	75	1413	73	15	12	106	70	0.99	1.43	0.11
Median		6.00	28	74	1558	75	14	12	101	45	1.10	0.60	0.10
Minimum		4.90	8	43	443	30	9	6	84	21	0.10	0.30	0.00

Lab Number	Point	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
Maximum		6.50	101	125	2005	134	27	19	154	158	1.70	7.00	0.30
Standard deviation		0.34	26	18	397	24	5	3	17	48	0.43	1.50	0.09
Coefficient of variation, %		6	74	25	28	32	31	29	16	69	43	105	87
Count													

Table 15. Soil analyses of 0 to 4 inch samples collected from Field 1, collected February 2016.

Lab Number	pH	CEC	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
			mg/kg										
77294	7.2	49	17	189	9104	111	15	12	38	180	1.8	3.6	1
77296	7.5	49	29	117	9064	107	17	6	26	31	1.7	5.4	0.3
77298	6.8	18	123	176	2895	105	12	12	199	105	1.7	4.8	0.6
77300	7.4	39	32	163	7008	118	15	13	69	178	2	5.1	0.7
77302	6.7	31	65	241	5045	205	16	17	77	224	2.4	9.9	1
77304	6.9	18	77	202	2813	141	14	15	121	182	1.8	6.1	0.5
77307	6.4	16	121	274	2031	183	12	15	147	137	1.6	9.8	0.6
77309	6.7	12	44	241	1552	99	15	12	109	254	1.6	3.9	0.4
77311	6.8	14	89	350	1988	129	14	14	117	172	1.5	6.7	0.5
77313	6.1	15	74	238	2028	129	16	19	145	184	1.6	7.7	0.6
77315	6.1	13	63	245	1602	115	11	17	127	259	1.4	5.3	0.6
77318	6.0	12	45	192	1360	101	14	17	124	277	1.4	4.4	0.4
77320	5.8	13	54	185	1334	142	17	17	106	356	1.4	6.7	0.4
77322	5.3	15	72	590	1311	151	16	21	140	285	1.5	9	0.5
77324	5.2	9	43	77	494	53	7	11	195	66	1	2	0.2
77326	5.7	9	21	60	896	60	10	8	117	25	0.8	1.4	0.2
77328	5.2	10	45	106	776	72	13	12	166	58	1	2.5	0.3

Lab Number	pH	CEC	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
77331	5.2	11	59	151	828	81	13	14	205	90	0.9	3.3	0.4
77333	6.0	12	55	207	1395	93	12	14	147	80	1	4.2	0.6
77335	5.6	10	70	212	870	105	14	13	149	138	1.1	5.2	0.5
77337	6.1	14	85	279	1646	157	12	15	152	169	1.3	7.4	0.6
77339	5.8	18	96	351	2035	178	14	22	160	146	1.3	9.3	0.7
77342	5.5	9	31	176	724	77	11	10	108	148	1.2	2.5	0.4
77343	6.0	12	93	224	1255	148	11	16	137	269	1.7	7	0.5
77345	5.8	12	83	223	1148	96	12	10	143	190	1.5	4.5	0.5
77346	5.7	16	274	165	1927	146	16	20	250	101	12.3	28.6	0.7
77348	6.0	8	31	173	715	76	11	10	109	147	1.2	2.6	0.4
77350	6.4	9	77	206	1037	88	11	8	135	186	1.4	3.9	0.4
77355	6.3	16	130	413	2061	176	10	16	115	273	1.9	9.7	0.6
77357	5.8	16	87	418	1736	202	12	18	131	170	1.6	8.2	0.6
77359	6.3	14	56	154	1769	108	12	13	98	198	1.4	6.2	0.5
77361	5.5	11	109	177	986	177	12	14	149	155	1.5	10.2	0.5
77363	6.2	9	33	104	1075	91	9	8	90	226	1.1	5	0.5
77366	5.1	10	38	123	695	91	8	12	103	65	0.9	3.1	0.3
77368	6.9	13	49	161	1924	81	12	14	104	234	1.4	4.1	0.7
77370	5.1	10	28	98	748	77	16	14	102	390	1.1	2.8	0.4

Lab Number	pH	CEC	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
77372	5.6	12	115	348	1064	181	11	23	132	297	1.5	7	0.6
77374	6.0	15	126	334	1904	155	17	22	115	340	1.6	9.6	0.7
77376	5.6	14	90	283	1461	159	18	23	153	304	1.6	8.3	0.6
77379	5.4	21	66	378	2463	228	21	24	104	136	1.5	8.1	0.6
77381	5.7	17	103	382	1799	183	19	19	167	113	1.7	8.2	0.7
77383	5.4	14	67	124	1293	178	14	17	110	228	1.5	7.8	0.6
77385	6.0	14	16	85	1960	68	12	13	84	247	1.2	2.5	0.6
77387	5.4	12	51	110	1140	67	11	14	101	168	0.9	3.1	0.4
77390	6.3	22	19	65	3467	59	12	12	75	164	0.9	2.7	0.4
77392	5.0	9	44	69	568	40	14	16	143	75	0.8	2	0.3
77394	5.3	10	29	69	975	82	17	17	115	372	1.2	2.8	0.5
77396	5.4	9	33	60	739	56	13	17	121	374	1.2	3.2	0.4
77398	5.3	12	49	173	1124	78	16	19	105	383	1.2	2.7	0.5
77400	5.8	13	58	318	1361	133	23	19	120	442	1.5	5.8	0.7
77403	6.3	16	74	224	2235	126	16	18	103	295	1.5	6.5	0.7
77405	6.0	24	84	409	3299	226	19	18	80	215	1.4	6	0.7
77407	6.2	13	40	239	1643	108	15	16	128	201	1.1	4.1	0.6
77409	5.5	12	31	119	1102	86	18	14	155	193	0.9	3.2	0.4
77411	5.8	16	19	101	1956	83	17	15	87	364	1	3.3	0.5

Lab Number	pH	CEC	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
77414	4.9	10	36	43	656	34	12	11	115	70	0.5	1.4	0.3
77416	5.6	9	27	40	1005	37	14	14	118	215	0.8	2.1	0.4
77418	4.9	10	20	54	649	65	14	14	108	131	0.6	1.5	0.3
77420	5.8	10	17	148	900	90	16	12	104	283	0.8	1.8	0.4
77422	5.7	13	40	120	1555	93	14	18	106	290	1.2	3.6	0.4
77424	6.1	18	25	146	2516	123	17	16	69	280	1.8	4.5	0.6
77427	5.8	15	26	113	1832	97	13	18	77	222	0.9	2.2	0.3
77429	5.9	12	26	69	1478	65	15	17	103	232	1	3.3	0.3
77431	5.3	10	24	38	950	47	18	17	132	277	0.8	2.5	0.2
77433	6.0	16	22	93	2273	54	14	17	74	234	0.9	2.6	0.4
77435	4.9	9	25	43	528	47	12	13	115	94	0.6	1.5	0.2
77438	4.9	10	25	42	590	56	11	15	115	225	0.8	2	0.3
77440	5.6	12	55	142	1206	123	11	20	109	191	1	3.3	0.4
77442	5.5	14	27	71	1490	85	12	19	86	349	1.5	3.1	0.3
77444	6.5	26	22	181	4371	115	11	18	49	224	1.3	2.6	0.5
77446	5.4	14	28	81	1547	98	10	19	90	291	1.2	4.2	0.3
Mean	5.86	15	57	183	1845	110	14	15	118	209	1.4	5.1	0.5
Median	5.80	13	47	164	1428	99	14	16	115	208	1.3	4.1	0.5
Minimum	4.80	8	16	38	494	34	7	6	26	25	0.5	1.4	0.2

Lab Number	pH	CEC	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
Maximum	7.50	49	274	590	9104	228	23	24	250	442	12.3	28.6	1.0
Standard deviation	0.59	8	40	113	1635	47	3	4	37	95	1.4	3.8	0.2
Coefficient of variation, %	10	53	71	62	89	43	22	25	31	45	95	74	34
Count							71						

Table 16. Soil analyses of 4 to 8 inch samples collected from Field 1, collected February 2016.

Lab Number	pH	CEC	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
			---------------------------------- mg/kg ----------------------------										
77295	7.1	47	11	151	8836	94	27	12	40	130	1.8	4.9	0.7
77297	7.9	48	29	77	9031	84	13	5	22	26	1.4	4.5	0.2
77299	6.8	13	118	136	1911	88	13	11	165	108	1.6	3.8	0.4
77301	7.7	38	18	126	7061	84	20	10	58	216	1.9	4.2	0.6
77303	7.0	34	53	174	5890	192	18	15	69	273	2.4	8.7	1.0
77306	7.1	18	36	133	2893	97	14	11	86	153	1.3	2.9	0.4
77308	6.1	14	83	220	1738	124	24	15	115	120	1.9	5.5	0.4
77310	6.4	9	25	243	1056	84	14	10	114	312	1.3	2.4	0.3
77312	6.6	11	52	278	1431	108	17	13	122	225	1.3	3.7	0.4
77314	6.1	13	54	143	1623	93	12	12	126	166	1.3	5.2	0.5
77316	6.3	10	42	187	1146	78	15	11	112	247	1.2	3.4	0.4
77319	6.3	10	26	115	1236	82	14	11	111	272	1.2	2.7	0.3
77321	6.0	12	17	83	1454	67	18	10	86	364	1.1	3.4	0.3
77323	5.8	11	36	324	1043	88	15	12	111	226	1.2	5.2	0.4
77325	6.5	5	12	51	319	31	10	8	182	37	1.0	1.2	0.2
77327	5.1	9	5	43	596	36	10	8	60	6	0.7	0.6	0.1
77330	5.3	8	24	75	510	45	9	11	132	41	0.9	1.5	0.3

Lab Number	pH	CEC	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
77332	5.0	9	43	112	547	54	11	12	193	80	0.9	2.5	0.4
77334	6.1	9	37	163	1008	70	11	10	123	60	0.9	2.5	0.4
77336	5.7	8	29	128	640	57	12	9	114	118	0.9	2.1	0.3
77338	6.0	10	44	158	1130	103	14	11	114	171	1.1	4.1	0.4
77340	6.0	9	49	193	907	89	9	9	144	107	0.9	3.4	0.5
77344	6.3	7	28	162	750	72	12	8	100	250	1.3	2.5	0.4
77347	5.7	19	27	113	2538	116	10	13	118	298	1.6	3.7	0.7
77349	6.0	8	28	178	806	75	10	8	102	261	1.3	2.6	0.4
77354	6.1	14	119	251	1767	136	12	16	172	207	1.7	8.3	0.6
77356	6.4	13	69	291	1564	128	11	11	95	323	1.6	4.5	0.5
77358	6.0	14	38	279	1763	151	14	15	95	196	1.4	4.5	0.5
77360	6.2	9	24	66	1053	67	15	9	80	163	1.5	3.3	0.3
77362	5.6	7	55	129	497	72	10	8	107	86	1.0	2.9	0.3
77364	6.4	8	22	79	1048	60	11	7	99	221	1.0	3.6	0.5
77367	5.3	7	18	92	412	39	9	7	83	25	0.8	1.0	0.3
77369	6.5	9	21	96	1183	49	12	9	99	228	1.1	2.0	0.4
77371	5.6	7	8	35	554	46	14	8	93	360	1.0	1.4	0.3
77373	6.1	9	51	245	819	123	12	10	101	300	1.2	2.6	0.5
77375	6.3	9	40	147	1056	70	10	8	94	344	1.2	2.7	0.5

Lab Number	pH	CEC	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
77378	5.7	13	26	148	1469	132	21	13	117	362	1.6	6.5	0.5
77380	5.9	29	4	248	4646	115	36	13	43	35	0.8	1.4	0.4
77382	5.8	16	50	214	1746	142	23	13	100	128	1.3	3.2	0.5
77384	5.9	10	41	90	1083	113	17	12	134	249	1.3	4.6	0.5
77386	6.5	16	4	70	2430	29	14	6	68	263	1.0	1.3	0.5
77388	6.1	6	18	32	589	26	11	7	88	84	0.7	1.3	0.4
77391	6.1	17	4	65	2689	20	16	6	69	118	0.8	1.3	0.4
77393	5.0	8	24	32	493	23	12	10	102	46	0.7	1.1	0.3
77395	5.8	8	6	33	721	31	12	7	94	303	1.0	1.2	0.4
77397	4.9	10	12	44	648	36	13	11	99	309	1.0	1.9	0.4
77399	5.4	8	10	149	561	33	12	14	109	330	1.0	1.0	0.3
77402	6.0	9	14	153	993	82	14	8	105	391	1.0	2.3	0.4
77404	6.4	11	16	84	1340	70	20	9	90	310	0.9	2.1	0.4
77406	6.6	32	22	236	5404	141	25	11	49	142	0.9	2.2	0.5
77408	6.0	9	13	124	1047	74	12	9	80	138	0.7	1.5	0.4
77410	5.5	10	10	50	961	55	13	8	85	145	0.7	1.2	0.3
77412	6.3	20	9	110	3113	45	19	12	84	333	1.0	1.9	0.5
77415	5.4	7	7	26	527	21	12	6	75	38	0.4	0.9	0.2
77417	5.6	8	9	26	851	16	9	7	92	186	0.6	1.1	0.3

Lab Number	pH	CEC	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
77419	5.0	11	6	42	857	68	12	8	66	65	0.5	0.8	0.3
77421	5.4	9	4	73	765	62	14	7	107	256	0.6	1.2	0.3
77423	5.7	11	12	65	1138	52	16	9	102	266	0.9	1.6	0.3
77426	5.8	18	13	94	2471	74	17	15	70	293	1.5	2.1	0.4
77428	5.0	20	6	109	2601	54	17	16	53	106	0.6	1.2	0.2
77430	5.8	10	7	37	1045	29	13	10	85	216	0.6	1.1	0.2
77432	5.6	9	14	34	999	31	18	13	108	230	0.8	1.7	0.2
77434	5.9	17	8	76	2627	25	16	12	64	193	0.7	1.6	0.3
77436	4.8	9	6	35	531	36	15	8	60	36	0.4	1.0	0.2
77439	5.1	9	9	35	599	40	12	11	104	211	0.7	1.3	0.2
77441	5.8	9	28	73	846	80	12	14	98	151	0.8	1.7	0.3
77443	5.5	13	13	56	1391	59	14	15	87	351	1.4	1.7	0.2
77445	6.8	24	7	135	4178	53	15	11	40	189	1.0	1.3	0.5
77447	5.8	15	17	69	2181	57	12	17	77	336	1.4	3.0	0.4
Mean	5.98	13	27	121	1759	72	14	10	96	196	1.1	2.7	0.4
Median	6.00	10	21	110	1056	70	13	10	98	207	1.0	2.2	0.4
Minimum	4.80	5	4	26	319	16	9	5	22	6	0.4	0.6	0.1
Maximum	7.90	48	119	324	9031	192	36	17	193	391	2.4	8.7	1.0
Standard deviation	0.62	8.8	24	75	1808	37	5	3	32	105	0.4	1.7	0.1

Lab Number	pH	CEC	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
Coefficient of variation, %	10.34	66	89	62	103	52	32	27	33	53	36	64	37
Count	69												

Table 17. Soil analyses of 0 to 4 inch samples collected from Field 5a, collected February 2016.

Lab Number	pH	CEC	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
			- mg/kg -										
77198	4.6	8	49	38	260	28	7	26	114	237	0.5	1.3	0.2
77200	4.4	14	12	77	905	150	12	12	55	37	0.3	0.4	0.1
77202	5.9	19	10	95	2810	42	11	9	104	114	2.1	3.6	0.6
77204	6.7	19	20	94	3068	66	15	12	135	174	2.5	4.9	0.8
77206	5.9	15	16	73	2090	82	10	9	115	179	2.1	3.4	0.4
77208	5.4	14	24	67	1570	87	9	11	132	151	2.2	3.0	0.3
77211	5.5	12	37	58	1147	72	9	10	184	184	1.5	2.9	0.3
77213	5.2	11	33	40	987	55	7	8	164	120	1.0	2.7	0.3
77215	5.7	11	26	39	1212	74	10	8	159	154	1.1	2.8	0.3
77217	5.0	11	50	95	830	99	8	14	86	181	0.6	2.9	0.3
77219	4.6	9	84	36	441	30	11	23	107	264	0.6	1.6	0.2
77222	4.7	9	75	58	525	58	10	20	112	220	0.7	2.1	0.2
77224	5.9	17	29	88	2492	78	14	14	105	123	1.9	4.4	0.6
77226	5.2	11	30	67	980	87	9	13	147	149	1.3	1.7	0.3
77228	5.3	12	65	79	1161	83	11	12	187	189	1.9	2.8	0.3
77230	5.2	13	51	75	1130	85	19	11	196	140	1.3	2.4	0.3
77232	5.7	12	28	39	1287	73	11	9	143	145	1.2	3.4	0.4

Lab Number	pH	CEC	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
77235	6.3	15	25	52	2198	81	10	11	142	172	1.5	4.1	0.7
77237	4.5	9	61	50	377	37	11	23	112	259	0.7	1.7	0.2
77239	6.3	21	34	150	3177	95	23	14	117	141	2.2	5.7	0.8
77241	5.1	10	47	76	778	85	8	12	174	202	1.5	2.6	0.3
77243	5.4	10	43	57	874	62	8	9	183	173	1.0	2.5	0.3
77246	5.1	11	79	96	945	80	7	11	186	236	2.4	4.2	0.3
77248	5.8	15	21	55	1834	79	7	10	143	158	1.5	4.1	0.5
77250	5.7	16	23	51	1953	91	8	9	138	182	1.5	4.0	0.6
77252	5.5	10	46	62	854	74	8	11	172	240	2.0	3.6	0.3
77254	5.0	11	58	80	841	89	10	12	165	113	0.7	1.7	0.2
77256	5.1	9	33	45	506	71	9	14	165	210	1.1	2.3	0.2
77259	5.7	22	21	103	3059	70	19	18	146	158	2.5	5.2	0.8
77261	5.2	10	49	78	756	93	12	18	178	270	1.7	2.2	0.3
77263	6.0	13	24	73	1785	50	16	11	142	142	1.5	2.4	0.5
77265	5.1	9	45	47	468	67	15	14	171	212	1.4	2.8	0.2
77267	5.0	10	47	84	622	88	8	16	171	209	1.7	2.6	0.3
77270	4.9	10	41	64	626	67	8	15	170	240	2.3	2.5	0.3
77272	5.2	11	39	73	905	83	10	13	136	82	1.5	1.8	0.4
77274	6.7	19	19	87	3128	56	11	12	121	145	2.0	3.5	0.7

Lab Number	pH	CEC	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
77276	4.7	8	77	40	341	48	7	16	207	134	1.3	2.1	0.3
77278	5.9	11	46	61	1288	110	10	15	140	181	1.9	3.0	0.4
77280	5.2	10	44	84	609	86	7	14	138	110	1.2	2.4	0.3
77283	4.7	8	40	38	358	34	10	15	173	152	1.6	1.6	0.3
77285	4.9	9	39	48	457	57	11	14	165	189	1.8	1.9	0.3
77287	5.1	12	35	100	987	93	10	12	202	134	1.6	2.0	0.3
77289	6.1	13	12	67	1719	27	14	7	131	177	2.4	2.3	0.4
77291	4.9	13	30	73	1027	87	10	16	187	128	1.6	2.1	0.3
Mean	5.36	12	39	68	1258	73	11	13	148	171	1.5	2.8	0.4
Median	5.20	11	38	67	984	76	10	12	145	173	1.5	2.6	0.3
Minimum	4.40	8	10	36	260	27	7	7	55	37	0.3	0.4	0.1
Maximum	6.70	22	84	150	3177	150	23	26	207	270	2.5	5.7	0.8
Standard deviation	0.57	3.5	18	23	837	24	4	4	33	49	0.6	1.1	0.2
Coefficient of variation, %	11	29	47	34	66	32	33	31	22	29	38	39	47
Count	44												

Table 18. Soil analyses of 4 to 8 inch samples collected from Field 5a, collected February 2016.

Lab Number	pH	CEC	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
			---------------------------------- mg/kg ----------------------------										
77199	4.7	7	22	24	212	16	9	19	108	281	0.5	0.9	0.1
77201	4.2	12	36	60	656	105	10	20	93	151	0.3	0.8	0.2
77203	5.9	19	19	96	2859	72	13	12	115	114	2.1	5.0	0.6
77205	6.3	18	10	83	2760	50	14	8	106	211	2.5	3.4	0.6
77207	6.1	15	8	71	2088	47	10	6	110	185	2.3	2.4	0.4
77210	5.5	17	15	81	2096	65	11	10	139	155	3	2.4	0.4
77212	5.6	11	32	56	1198	42	9	6	152	143	1.8	2.0	0.2
77214	5.5	9	34	37	918	30	7	6	184	111	1.0	2.1	0.2
77216	5.9	10	19	40	1176	42	9	5	137	123	1.2	1.9	0.3
77218	4.9	9	32	50	477	47	8	12	97	246	0.6	1.6	0.2
77220	4.9	8	35	23	358	22	18	13	98	236	0.8	1.2	0.2
77223	4.9	9	26	29	466	24	15	13	100	230	0.8	1.2	0.2
77225	5.8	16	13	68	2016	40	14	9	98	161	1.7	2.9	0.5
77227	5.2	12	18	66	1075	64	8	11	138	114	1.4	1.1	0.3
77229	5.3	13	50	75	1376	50	9	7	154	148	2.0	1.7	0.3
77231	5.5	12	43	72	1218	45	9	7	173	116	1.1	1.3	0.3
77234	5.8	9	21	30	1005	29	8	5	149	119	1.1	2.2	0.3

Lab Number	pH	CEC	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
77236	6.5	12	18	41	1675	38	10	7	127	128	1.4	3	0.5
77238	4.5	9	37	33	381	21	11	21	104	253	0.8	1.3	0.2
77240	6.6	19	12	116	3024	76	19	8	103	163	2.3	4.1	0.6
77242	5.1	10	30	58	802	56	10	8	156	159	1.6	1.7	0.2
77244	5.7	9	44	53	895	38	8	7	171	134	1.1	1.6	0.2
77247	5.4	10	65	81	1059	45	8	8	178	204	2.9	3.2	0.3
77249	6.0	14	12	58	2010	51	10	7	129	131	1.5	2.4	0.5
77251	6.0	10	17	35	1220	39	7	5	123	134	1.1	2.5	0.4
77253	5.5	10	33	50	936	43	9	7	148	171	2.3	2.4	0.3
77255	5.0	10	65	74	858	57	9	8	144	58	0.8	0.9	0.2
77258	4.9	9	22	42	498	51	9	13	155	174	1.5	1.6	0.2
77260	6.2	17	11	85	2596	40	15	10	123	177	2.5	3.5	0.6
77262	5.1	9	19	50	579	44	17	12	133	138	1.2	1.0	0.2
77264	6.0	13	18	73	1694	34	15	7	138	125	1.3	1.3	0.3
77266	5.2	8	26	38	480	43	9	9	150	222	1.6	2.0	0.2
77268	5.3	8	22	61	664	49	12	12	153	179	2.0	1.3	0.3
77271	5.3	9	24	55	814	44	9	10	165	226	2.6	1.8	0.3
77273	4.8	11	37	73	827	63	12	12	127	64	1.4	1.0	0.5
77275	6.4	16	12	71	2310	29	9	8	120	165	1.9	2.9	0.5

Lab Number	pH	CEC	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
77277	4.7	8	66	32	307	34	6	11	176	143	1.3	1.9	0.2
77279	6.0	10	26	51	1167	88	9	11	130	161	1.6	2.1	0.4
77282	5.0	10	36	72	645	64	16	11	143	90	1.7	1.3	0.3
77284	4.9	9	26	33	471	23	10	10	159	163	1.6	1.3	0.3
77286	4.9	9	21	45	564	31	10	8	137	133	1.6	1.1	0.2
77288	5.1	11	32	99	907	90	13	10	158	102	1.4	1.2	0.3
77290	6.0	14	22	62	1902	50	27	14	141	190	2.3	3.6	0.6
77292	4.8	11	14	72	805	57	12	14	150	96	1.2	1.1	0.3
Mean	5.43	11	27	59	1183	47	11	10	136	157	1.6	2.0	0.3
Median	5.35	10	23	58	927	45	10	10	138	153	1.5	1.8	0.3
Minimum	4.20	7	8	23	212	16	6	5	93	58	0.3	0.8	0.1
Maximum	6.60	19	66	116	3024	105	27	21	184	281	3.0	5.0	0.6
Standard deviation	0.58	3	14	21	749	19	4	4	25	50	0.6	1.0	0.1
Coefficient of variation, %	11	28	53	37	63	40	35	38	18	32	41	48	43
Count	44												

Table 19. Soil analyses of 0 to 4 inch samples collected from Field 12, collected February 2016.

Lab Number	pH	CEC	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
			---------------------------------- mg/kg										----------------------------
77102	5.4	11	148	353	961	129	14	15	214	254	1.5	7.4	0.7
77104	5.5	11	190	183	981	112	16	18	211	244	1.6	5.3	0.5
77106	5.3	10	160	183	912	96	18	16	175	238	1.6	4.8	0.4
77108	5.4	10	178	146	795	92	12	15	196	256	1.7	4.1	0.4
77110	5.2	10	172	119	766	78	11	13	206	216	1.4	3.5	0.4
77112	5.8	16	97	129	1830	134	14	15	215	140	2.4	5.3	0.6
77115	5.2	11	193	189	864	113	22	17	215	251	1.6	6.3	0.4
77117	5.1	11	167	185	751	108	16	16	192	247	1.4	4.8	0.3
77119	5.2	11	168	159	883	117	27	16	206	222	1.6	5.9	0.4
77121	5.5	12	73	82	1176	86	15	13	162	156	1.7	3.2	0.4
77123	5.6	12	49	70	1307	104	16	11	157	156	1.5	3.0	0.4
77126	5.4	10	40	63	991	65	9	8	143	123	1.1	2.2	0.2
77128	5.3	9	115	115	661	88	18	15	149	193	1.3	4.1	0.3
77130	4.9	12	186	276	739	103	24	19	185	215	1.5	5.2	0.4
77132	5.7	12	112	101	1297	115	25	16	172	200	1.9	4.7	0.4
77134	5.3	14	123	75	1316	154	26	16	227	216	2.0	7.2	0.5
77136	5.6	14	101	95	1568	162	27	17	204	175	1.8	5.8	0.5

Lab Number	pH	CEC	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
77139	5.3	10	64	48	976	80	9	15	241	174	1.3	3.6	0.3
77141	5.1	11	138	147	772	99	24	22	147	174	1.2	5.3	0.3
77143	5.2	15	103	98	1408	128	27	23	175	169	2.1	4.5	0.5
77145	6.0	13	76	121	1575	135	23	19	163	159	1.4	4.2	0.5
77147	5.5	14	97	107	1333	126	21	18	197	232	1.7	6.5	0.5
77150	5.5	10	81	60	962	80	12	16	255	219	1.4	4.0	0.4
77152	5.5	14	57	109	1479	115	30	19	161	195	1.6	3.9	0.5
77154	5.1	17	123	117	1752	165	24	23	195	138	2.1	6.7	0.5
77156	5.5	13	91	102	1225	109	24	22	153	227	1.8	5.2	0.4
77158	5.3	17	59	91	1848	139	29	20	170	109	2.0	4.3	0.5
77160	5.7	13	79	122	1393	122	23	22	187	201	1.8	5.1	0.5
77163	5.6	12	65	164	1135	111	19	15	183	187	1.4	4.0	0.4
77165	5.9	9	77	94	930	108	21	14	181	161	1.2	4.3	0.4
77167	6.1	11	27	59	1378	107	6	9	163	164	1.3	3.8	0.5
77169	5.8	12	55	59	1386	98	9	12	177	174	1.7	3.9	0.4
77171	5.8	17	65	95	2178	139	31	15	133	90	2.1	5.3	0.7
77174	5.4	16	72	85	1697	141	31	15	143	110	2.3	5.1	0.6
77176	5.9	16	65	109	2099	151	40	14	157	137	2.5	5.2	0.6
77178	5.4	14	76	94	1389	101	27	15	187	162	2.2	4.3	0.5

Lab Number	pH	CEC	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
77180	5.3	14	77	110	1493	121	19	16	192	178	2.4	5.0	0.6
77182	5.5	11	117	79	941	124	23	13	234	202	1.8	7.5	0.6
77184	6.0	17	63	107	2593	75	28	18	136	141	2.3	6.0	1.0
77187	5.3	17	146	245	1791	178	27	19	178	88	2.3	7.0	0.4
77189	5.4	17	117	207	1737	162	20	15	166	94	1.8	5.1	0.5
77191	5.6	15	65	123	1632	142	27	14	161	113	1.8	3.8	0.4
77193	5.3	15	151	315	1326	185	24	18	165	144	1.6	6.9	0.5
77195	5.6	13	82	110	1464	128	22	13	159	143	1.6	5.0	0.4
77470	5.4	10	104	84	845	106	12	16	220	162	1.6	4.2	0.3
Mean	5.48	13	104	129	1301	118	21	16	182	177	1.7	4.9	0.5
Median	5.40	12	97	109	1316	115	22	16	178	174	1.7	5.0	0.4
Minimum	4.90	9	27	48	661	65	6	8	133	88	1.1	2.2	0.2
Maximum	6.10	17	193	353	2593	185	40	23	255	256	2.5	7.5	1.0
Standard deviation	0.27	2	45	66	433	28	7	3	29	47	0.4	1.2	0.1
Coefficient of variation, %	5	19	43	52	33	23	35	21	16	26	21	25	29
Count	45												

Table 20. Soil analyses of 4 to 8 inch samples collected from Field 12, collected February 2016.

Lab Number	pH	CEC	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
			---------------------------------- mg/kg ----------------------------------										
77103	5.7	9	107	315	701	96	17	13	158	249	1.3	4.5	0.4
77105	5.6	9	142	97	814	67	16	12	154	170	1.3	2.4	0.3
77107	5.5	10	88	93	847	59	20	12	141	202	1.5	2.1	0.3
77109	5.6	9	118	68	883	65	20	12	163	210	1.7	2.1	0.3
77111	5.7	9	116	77	827	45	14	11	164	149	1.4	1.7	0.4
77114	5.7	15	49	92	1766	104	17	11	153	115	2.4	2.9	0.7
77116	5.6	9	106	107	799	71	17	13	165	203	1.3	2.4	0.4
77118	5.2	10	104	103	723	71	16	13	160	195	1.4	2.3	0.3
77120	5.8	8	73	77	763	47	16	8	131	137	1.2	1.5	0.2
77122	5.7	12	41	66	1356	59	17	10	133	111	1.9	2.0	0.3
77124	6.1	12	25	63	1491	69	15	9	119	115	1.6	1.6	0.4
77127	5.7	10	24	56	1009	48	11	7	106	81	1.1	1.2	0.2
77129	5.4	9	45	66	691	41	18	10	106	127	1.5	1.4	0.2
77131	5.2	10	120	106	756	57	19	14	149	149	1.4	2.4	0.3
77133	5.8	13	60	62	1483	66	25	12	140	143	2.0	2.1	0.4
77135	5.7	13	38	57	1575	73	19	10	146	160	2.0	2.2	0.4

Lab Number	pH	CEC	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
77138	5.7	14	28	64	1639	81	21	14	133	142	1.6	1.8	0.4
77140	5.8	8	35	32	675	28	9	9	134	94	0.9	1.4	0.2
77142	5.1	9	33	56	653	28	14	16	95	99	0.8	0.9	0.2
77144	5.7	11	47	44	1108	54	20	15	106	92	1.8	1.4	0.3
77146	5.8	13	27	67	1547	83	17	14	115	116	1.4	1.4	0.4
77148	6.0	12	23	54	1472	72	18	12	134	162	1.9	2.1	0.4
77151	5.7	9	45	42	859	43	15	12	157	145	1.2	2.0	0.3
77153	6.2	12	19	57	1567	60	28	14	115	123	1.7	1.2	0.4
77155	5.6	16	50	68	1904	96	23	16	145	121	2.2	2.9	0.5
77157	5.9	10	34	57	1154	44	17	15	103	144	1.5	1.5	0.4
77159	5.6	17	23	65	2111	104	24	18	124	97	2.1	1.9	0.4
77162	5.6	12	26	73	1350	82	20	15	117	114	1.8	1.9	0.3
77164	5.8	12	32	96	1314	81	20	12	132	142	1.8	1.8	0.4
77166	5.5	11	21	67	1072	65	13	11	106	78	1.0	1.2	0.2
77168	6.1	11	27	61	1288	77	7	7	151	125	1.8	3.0	0.4
77170	5.8	12	35	56	1291	46	7	8	133	131	1.8	2.1	0.3
77172	5.9	15	22	65	2202	83	26	11	108	75	1.9	1.9	0.7
77175	5.8	17	19	68	2190	95	28	11	118	86	2.5	1.9	0.5
77177	6.1	17	20	85	2477	97	24	11	132	101	2.6	2.3	0.6

Lab Number	pH	CEC	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
77179	5.7	13	37	72	1516	72	27	11	148	132	2.3	2.6	0.5
77181	5.8	15	28	86	1714	81	16	12	147	141	2.7	2.5	0.6
77183	5.6	10	36	50	962	64	16	9	142	143	1.7	2.6	0.6
77186	6.2	17	17	81	2600	35	29	11	108	113	1.7	2.0	0.6
77188	5.7	16	55	140	1864	117	21	12	145	62	2.1	2.5	0.4
77190	5.7	15	50	122	1810	126	17	11	135	66	1.9	2.2	0.4
77192	5.7	14	30	75	1592	104	16	11	124	88	1.7	1.9	0.4
77194	5.4	13	61	181	1272	131	15	13	137	86	1.5	2.3	0.4
77196	6.0	11	37	68	1381	86	17	8	131	123	1.6	2.3	0.3
77471	5.4	10	64	76	885	60	14	13	156	105	1.7	1.9	0.3
Mean	5.71	12	50	81	1332	72	18	12	134	128	1.7	2.0	0.4
Median	5.70	12	37	68	1314	71	17	12	134	123	1.7	2.0	0.4
Minimum	5.10	8	17	32	653	28	7	7	95	62	0.8	0.9	0.2
Maximum	6.20	17	142	315	2600	131	29	18	165	249	2.7	4.5	0.7
Standard deviation	0.24	3	33	44	509	25	5	2	19	40	0.4	0.6	0.1
Coefficient of variation, %	4	22	66	55	38	34	28	21	14	31	25	30	33
Count	45												

Table 21. Soil analyses of 0 to 4 inch samples collected from Field 1, collected March 2018.

Lab number	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
	cmolc/kg	---------- mg/kg ----------										
54582	7.7	49.7	31	220	9224	112	14	30	165	1.3	4.1	1.0
54581	7.8	60.7	43	104	11512	97	10	33	48	1.1	7.9	0.4
54580	6.8	17.0	145	291	2552	111	21	189	117	1.3	6.4	0.6
54579	7.6	36.5	63	144	6629	113	17	48	170	1.6	6.5	0.7
54578	6.6	21.3	173	295	3091	240	23	118	175	2.1	17.4	1.1
54576	6.6	13.5	127	252	1631	188	22	143	222	1.3	10.4	0.5
54575	6.8	13.0	164	325	1600	200	27	159	191	1.2	13.1	0.5
54574	7.3	18.6	56	233	3021	104	19	82	270	0.9	3.5	0.4
54573	7.6	22.2	130	260	3646	154	19	91	196	1.2	8.2	0.5
54572	6.4	15.6	131	277	1972	178	25	135	228	1.3	12.2	0.7
54571	7.8	22.3	128	486	3584	128	25	106	296	1.1	6.2	0.8
54570	6.6	14.8	96	396	1902	140	26	130	314	0.9	6.0	0.5
54569	6.6	14.9	104	247	1929	191	17	103	343	1.2	10.5	0.5
54568	6.2	13.7	64	243	1698	117	18	117	209	1.1	6.7	0.5
54567	5.3	10.3	71	141	948	70	16	154	91	0.5	2.3	0.3
54566	6.1	10.9	60	199	1204	88	14	91	54	0.5	2.1	0.2

Lab number	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
54564	6.2	9.0	79	196	1000	108	15	126	112	0.6	3.7	0.3
54563	6.0	8.6	84	232	822	100	18	193	140	0.5	3.2	0.4
54562	6.3	13.2	128	418	1499	189	27	219	125	0.9	7.0	0.6
54561	6.2	9.8	104	396	970	162	23	154	225	0.9	7.2	0.5
54560	6.3	14.4	147	528	1593	236	24	135	205	1.3	11.8	0.6
54559	6.6	14.5	189	557	1622	232	30	150	199	1.1	11.7	0.7
54558	6.0	14.1	247	325	1521	258	23	166	137	1.5	27.7	0.6
54557	6.7	13.0	135	330	1599	187	21	133	83	0.9	7.7	0.6
54556	6.1	11.3	92	313	1147	147	19	127	160	0.8	5.7	0.5
54555	6.2	8.8	76	258	933	107	16	109	153	0.7	3.9	0.4
54554	6.5	11.0	114	398	1212	157	19	128	194	0.9	6.5	0.6
54552	6.5	11.8	136	338	1388	170	17	135	228	1.8	10.0	0.5
54551	6.5	16.0	196	660	1788	272	31	108	355	1.9	15.7	0.6
54550	6.3	15.0	178	451	1660	242	27	129	179	1.9	15.0	0.5
54549	6.2	15.0	233	289	1670	275	21	122	171	2.4	23.2	0.4
54548	5.8	14.3	186	402	1308	256	29	137	192	1.7	14.9	0.5
54547	6.4	12.9	94	235	1568	161	20	100	201	1.2	5.7	0.5
54546	5.9	9.7	86	123	1042	131	18	107	117	1.1	4.6	0.2
54545	6.3	10.3	81	214	1144	113	17	98	216	1.5	6.1	0.4

Lab number	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
54544	6.4	8.5	91	179	877	128	20	89	340	1.6	6.2	0.3
54543	6.2	9.5	120	447	851	176	24	108	310	1.6	8.1	0.4
54542	6.4	11.5	152	392	1169	194	21	119	318	1.8	10.4	0.5
54540	6.5	11.9	128	556	1237	208	25	134	261	1.6	10.3	0.5
54539	6.1	18.3	141	442	2259	270	26	101	163	1.7	15.0	0.5
54538	6.3	13.1	120	457	1462	184	24	146	134	1.4	10.7	0.4
54537	5.9	11.7	121	315	1141	198	23	115	266	1.5	15.4	0.3
54536	6.1	11.3	52	154	1310	87	15	91	196	0.9	3.5	0.3
54535	6.3	12.0	87	218	1429	149	17	107	200	0.9	6.2	0.3
54534	7.1	20.9	40	135	3487	128	20	49	309	1.3	6.6	0.7
54533	5.7	8.4	57	89	696	79	16	120	170	1.1	3.2	0.2
54532	6.1	7.8	39	123	741	83	17	83	304	0.9	3.1	0.2
54531	5.9	6.5	41	105	522	62	15	96	225	0.7	1.7	0.2
54530	6.8	9.0	27	102	1135	59	10	68	232	1.0	2.0	0.2
54528	6.8	12.1	105	297	1435	192	18	97	322	1.4	8.7	0.5
54527	6.9	14.3	98	211	1976	156	17	80	280	1.5	8.3	0.5
54526	6.9	27.3	105	557	4198	271	27	62	206	1.3	8.7	0.6
54525	6.3	12.2	52	330	1420	134	19	98	221	0.9	5.0	0.4
54524	6.0	8.7	43	133	904	87	15	93	228	0.9	3.1	0.2

Lab number	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
54523	6.4	16.0	42	187	2182	126	20	64	355	1.1	4.9	0.4
54522	5.9	6.9	55	52	668	41	13	97	94	0.5	1.3	0.1
54521	6.2	8.7	47	53	1066	80	13	105	133	0.9	3.5	0.2
54520	6.4	11.3	18	66	1494	68	11	63	150	0.7	1.5	0.2
54519	6.4	8.2	30	160	910	85	15	92	332	1.0	2.2	0.2
54518	6.5	11.4	42	242	1496	93	16	78	284	1.1	3.8	0.3
54516	6.2	16.5	33	249	2236	136	19	63	281	2.0	4.4	0.4
54515	6.5	13.4	38	169	1796	109	14	76	211	1.7	4.1	0.3
54514	6.7	11.3	27	86	1599	61	14	77	218	1.5	2.3	0.2
54513	5.7	7.9	36	72	640	53	15	122	253	1.6	2.5	0.1
54512	6.3	14.1	29	112	1941	62	17	68	274	1.7	3.4	0.4
54511	5.9	7.0	58	82	632	71	14	113	133	1.4	2.8	0.2
54510	6.0	7.0	32	64	636	74	12	97	204	1.3	2.2	0.2
54509	6.7	10.3	64	287	1124	169	17	101	174	1.5	4.1	0.4
54508	6.4	11.7	31	179	1463	101	15	60	373	1.8	3.4	0.2
54507	7.2	25.8	33	135	4477	116	12	35	209	1.8	3.4	0.4
54506	6.0	11.2	38	112	1318	95	17	77	298	1.6	3.6	0.3
Mean	6.44	14.4	91	258	1909	143	19	106	213	1.3	7.1	0.4
Median	6.40	12.1	84	242	1463	128	18	105	206	1.3	6.1	0.4

Lab number	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
Minimum	5.3	6.5	18	52	522	41	10	30	48	0.5	1.3	0.1
Maximum	7.8	60.7	247	660	11512	275	31	219	373	2.4	27.7	1.1
Standard deviation	0.5	8.7	54	143	1781	62	5	37	76	0.4	5.1	0.2
Coefficient of variation, %	8	61	59	55	93	44	26	34	36	33	72	46
Count	71											

Table 22. Soil analyses of 0 to 4 inch samples collected from Field 5a, collected March 2018.

Lab number	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
		cmolc/kg	----------------------------------					mg/kg	----------------------------------			
54504	4.9	8.6	66	48	408	52	21	87	187	1.1	1.7	0.1
54503	5.0	9.6	65	62	640	88	22	95	197	0.9	1.6	0.1
54502	6.8	18.9	29	79	3096	74	14	81	107	2.4	5.9	0.7
54501	6.9	19.9	28	89	3307	68	14	113	153	3.0	5.9	0.8
54500	6.9	16.5	25	92	2630	70	13	105	206	2.8	4.0	0.5
54499	5.9	12.6	44	58	1628	91	12	121	230	3.1	4.8	0.2
54498	5.6	10.1	35	47	1071	69	10	148	157	1.9	4.2	0.2
54497	6.0	9.8	31	37	1119	67	7	139	143	1.7	3.5	0.2
54496	6.0	10.6	31	41	1250	84	8	141	163	1.8	3.8	0.3
54495	5.2	9.1	150	64	587	54	28	127	286	2.0	3.0	0.1
54494	6.3	11.3	46	92	1376	138	16	78	231	1.4	3.0	0.4
54492	6.6	15.8	26	70	2395	68	11	95	143	3.0	4.8	0.5
54491	5.5	8.9	78	53	737	61	18	94	182	2.2	2.8	0.1
54490	6.6	12.0	31	62	1664	60	10	111	197	2.7	3.6	0.3
54489	5.6	9.5	59	69	919	77	10	153	192	2.6	2.8	0.2
54488	5.6	9.2	55	46	898	62	9	162	156	2.1	3.4	0.2
54487	6.0	11.2	24	35	1409	65	8	125	153	2.2	3.7	0.3

Lab number	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
54486	6.3	13.2	27	43	1789	71	10	124	167	2.3	4.4	0.4
54485	5.2	9.1	101	75	572	64	24	111	276	2.2	3.2	0.1
54484	6.9	18.8	44	125	3041	81	13	107	120	3.3	5.9	0.7
54483	5.6	8.6	50	84	724	82	12	156	186	2.6	3.2	0.2
54482	5.7	9.4	64	66	907	74	11	157	206	3.2	4.6	0.2
54480	5.8	11.4	77	68	1216	70	10	176	132	2.4	3.7	0.2
54479	6.1	14.3	20	51	1980	87	10	124	193	2.1	4.0	0.4
54478	6.2	11.3	25	41	1505	72	8	121	169	1.9	4.1	0.3
54477	6.5	18.1	35	77	2854	69	17	96	130	2.7	5.6	0.7
54476	5.3	8.4	34	52	619	77	13	144	178	1.7	2.5	0.1
54475	5.3	8.5	38	62	628	81	13	137	170	1.6	2.0	0.1
54474	5.8	9.5	51	60	919	80	11	147	193	2.6	3.9	0.2
54473	5.4	9.8	56	79	859	87	14	142	128	1.5	2.6	0.1
54472	7.0	17.3	31	85	2903	63	13	104	120	2.1	3.1	0.5
54471	5.4	7.9	55	42	524	70	13	148	192	1.7	2.9	0.1
54470	5.5	9.0	65	70	697	87	17	131	219	1.9	3.0	0.1
54468	5.5	8.5	43	55	621	74	13	128	210	2.4	2.9	0.2
54467	5.3	10.0	49	92	904	85	12	128	72	1.5	1.9	0.1
54466	7.2	23.3	20	63	4139	49	11	96	103	2.5	3.9	0.5

Lab number	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
54465	5.2	8.2	62	33	421	52	12	165	96	1.8	2.4	0.1
54464	5.5	7.9	58	46	531	67	14	128	179	2.1	2.7	0.1
54463	5.3	8.3	40	60	595	77	13	129	131	1.7	1.9	0.1
54462	5.2	8.3	33	31	468	37	13	146	137	1.6	1.5	0.1
54461	5.3	7.2	78	32	432	55	13	148	118	2.1	2.9	0.1
54460	5.6	10.2	39	96	1030	87	13	168	122	1.8	2.4	0.1
54459	6.6	13.2	26	62	1906	48	11	113	145	2.6	3.1	0.4
54458	5.3	10.9	28	79	1099	83	16	166	141	1.7	2.3	0.2
Mean	5.85	11.5	47	63	1341	72	13	128	166	2.1	3.4	0.3
Median	5.60	9.9	42	62	975	71	13	128	165	2.1	3.2	0.2
Minimum	4.90	7.2	20	31	408	37	7	78	72	0.9	1.5	0.1
Maximum	7.20	23.3	150	125	4139	138	28	176	286	3.3	5.9	0.8
Standard deviation	0.62	3.8	24	20	932	16	4	25	45	0.6	1.1	0.2
Coefficient of variation, %	11	34	**52**	**32**	**69**	**22**	**32**	**20**	**27**	**26**	**34**	**75**
Count	44											

Table 23. Soil analyses of 4 to 8 inch samples collected from Field 5a, collected March 2018.

Lab number	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
		cmolc/kg	- mg/kg -									
76427	4.9	7	42	31	211	21	30	105	256	0.6	0.8	0.6
76426	5.1	12	22	74	1015	98	17	90	107	0.4	0.4	0.7
76425	5.8	18	28	76	2405	52	17	122	102	2.3	3.0	0.8
76424	7.0	21	22	104	3648	61	16	138	189	3.1	5.6	1.2
76423	6.5	19	20	96	3004	74	13	115	179	2.7	4.1	1.1
76420	5.6	13	34	78	1490	55	12	142	179	2.9	3.2	0.6
76422	5.8	11	34	49	1122	43	9	149	157	1.4	2.2	0.2
76421	5.9	8	31	34	1002	32	7	170	133	1.1	2.1	0.2
76419	5.9	9	28	33	1037	45	8	167	141	1.1	2.1	0.3
76418	5.8	7	64	31	588	30	19	111	300	1.1	1.8	0.2
76416	5.1	8	76	32	500	22	26	125	273	1.1	1.9	0.6
76415	5.3	8	55	40	589	25	27	117	279	1.2	1.7	0.6
76414	6.6	19	17	84	3075	53	11	125	204	3.0	4.4	1.0
76413	6.6	12	19	57	1785	39	8	119	223	2.4	2.5	0.7
76412	5.6	11	53	67	1199	45	8	158	151	2.0	1.2	0.6
76411	5.8	9	60	52	938	38	7	178	153	1.5	2.0	0.7
76410	6.1	10	21	32	1213	34	8	145	129	1.2	2.1	0.3

Lab number	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
76409	6.3	14	21	43	1972	42	10	144	165	1.9	3.1	0.5
76408	5.0	8	40	31	463	21	25	106	264	1.2	1.1	0.2
76407	6.4	21	14	105	3281	63	10	103	194	2.7	3.9	0.9
76406	5.7	10	35	80	924	59	10	167	203	2.2	2.1	0.7
76404	5.6	10	80	58	1018	43	9	175	225	2.8	3.2	0.6
76403	5.7	10	40	54	1070	36	6	155	143	0.9	1.1	0.6
76402	6.2	14	13	46	2044	42	8	117	168	1.6	2.4	0.8
76401	6.3	18	13	73	2868	31	11	107	181	2.3	3.2	1.0
76400	5.3	7	24	36	373	42	11	133	165	1.0	1.1	0.5
76399	5.5	8	20	42	625	39	12	127	187	1.3	0.8	0.6
76398	5.7	9	40	53	895	36	9	146	193	2.1	2.1	0.6
76397	5.3	9	65	77	870	48	8	144	87	0.8	0.5	0.5
76396	5.1	9	38	44	551	52	13	131	120	1.0	1.0	0.3
76395	5.3	7	31	35	476	39	13	137	199	1.4	1.7	0.3
76394	5.5	8	26	59	665	49	14	132	190	1.4	1.1	0.2
76392	5.5	8	27	53	668	39	10	147	188	2.0	1.1	0.7
76391	5.0	10	49	83	716	52	12	135	71	0.9	0.5	0.7
76390	6.5	14	11	50	2168	21	6	117	154	1.4	1.5	0.8
76389	5.2	8	38	29	354	35	12	152	140	0.9	1.4	0.6

Lab number	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
76388	5.4	7	29	31	380	29	11	126	167	1.1	1.0	0.5
76387	5.2	10	31	73	687	62	13	126	105	0.8	0.7	0.6
76386	5.0	8	28	31	415	23	13	144	150	0.8	0.8	0.6
76385	5.2	9	21	49	576	33	9	121	116	1.0	0.7	0.6
76384	5.5	10	23	75	935	72	10	149	135	0.8	0.8	0.2
76383	6.1	11	16	46	1425	29	10	115	178	1.4	1.4	0.4
76382	5.1	10	28	68	803	66	16	129	107	0.9	0.9	0.2
Mean	5.67	11	33	56	1210	43	12	134	171	1.5	1.9	0.6
Median	5.60	10	28	52	935	42	11	132	167	1.3	1.7	0.6
Minimum	4.90	7	11	29	211	21	6	90	71	0.4	0.4	0.2
Maximum	7.00	21	80	105	3648	98	30	178	300	3.1	5.6	1.2
Standard deviation	0.53	4	17	21	886	16	6	21	52	0.7	1.2	0.3
Coefficient of variation, %	9	36	51	38	73	37	45	15	31	48	63	45
Count	43											

Table 24. Soil analyses of 0 to 4 inch samples collected from Field 12, collected March 2016.

Lab number	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
		cmolc/kg	---------------------------------- mg/kg ----------------------------------									
54583	7.1	12.0	161	770	1332	158	24	165	283	1.6	10.7	0.6
54456	6.2	8.7	192	194	950	107	14	164	190	1.5	6.1	0.4
54455	6.2	9.4	256	238	986	151	15	172	204	1.8	9.2	0.4
54454	6.1	8.9	230	124	893	118	13	180	193	1.8	6.6	0.4
54453	6.2	8.5	198	304	850	105	13	175	140	1.7	5.3	0.4
54452	6.3	14.7	125	126	1900	151	14	171	150	2.1	6.3	0.5
54451	6.2	8.2	180	204	836	105	13	160	187	1.5	6.0	0.4
54450	6.0	8.3	198	249	713	116	15	164	187	1.5	6.5	0.4
54449	5.9	8.2	149	243	716	95	14	167	177	1.5	5.0	0.4
54448	6.0	11.2	144	135	1212	146	13	165	131	2.1	6.4	0.4
54447	6.2	10.9	91	96	1297	126	11	161	165	1.7	5.1	0.4
54446	5.8	8.3	59	99	674	73	11	204	114	1.1	2.4	0.3
54444	5.8	8.7	119	182	678	83	14	141	199	1.3	4.3	0.3
54443	6.1	8.7	201	370	731	114	15	164	149	1.5	6.9	0.4
54442	5.9	8.4	176	156	766	126	13	176	144	1.6	7.0	0.4
54441	6.0	11.3	101	110	1226	148	13	163	165	1.5	5.4	0.4
54440	6.1	10.9	108	122	1162	134	12	154	194	1.8	6.8	0.4

Lab number	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
54439	6.2	8.4	97	53	986	89	12	194	140	1.5	5.3	0.3
54438	5.9	8.1	143	125	767	99	14	122	133	1.4	5.1	0.3
54437	5.7	11.8	137	166	1130	132	17	144	166	2.0	6.5	0.4
54436	5.8	13.8	150	165	1454	167	19	153	201	2.2	9.0	0.5
54435	6.2	11.3	99	111	1344	141	14	162	195	1.7	5.6	0.5
54434	6.1	11.6	100	111	1294	143	13	171	211	1.9	7.3	0.4
54432	5.9	8.7	91	74	912	98	11	173	166	1.4	4.9	0.3
54431	6.0	9.5	118	137	1027	114	14	126	194	2.0	7.1	0.4
54430	5.6	14.3	77	164	1593	151	16	135	128	2.0	5.0	0.4
54429	5.8	12.3	78	116	1268	126	14	133	170	1.8	4.4	0.4
54428	6.1	11.6	76	117	1303	133	13	146	183	1.8	5.4	0.4
54427	6.1	9.9	77	133	1073	122	13	149	179	1.5	5.3	0.4
54426	6.1	8.7	96	77	894	105	10	179	140	1.5	5.9	0.4
54425	5.9	11.0	31	42	1351	72	10	134	198	1.9	3.5	0.4
54424	5.9	15.1	90	94	1968	162	15	113	116	2.2	6.3	0.5
54423	6.0	13.7	74	95	1723	147	14	121	143	2.1	5.2	0.4
54422	5.8	15.2	78	113	1710	151	14	131	178	2.2	6.1	0.5
54420	6.2	10.2	81	95	1195	104	12	136	159	2.6	5.0	0.4
54419	5.9	11.3	120	100	1227	149	12	151	163	2.6	7.3	0.4

Lab number	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
54418	5.9	8.9	93	72	944	103	11	161	130	2.2	5.0	0.3
54417	5.9	11.5	52	50	1417	85	11	140	181	2.5	3.7	0.4
54416	6.4	17.9	91	86	2674	82	15	97	140	2.8	7.8	0.7
54415	5.9	13.9	124	231	1660	169	15	154	123	2.9	8.7	0.4
54414	6.0	13.6	159	257	1585	172	15	142	110	2.4	6.1	0.4
54413	6.1	13.0	119	162	1501	170	15	155	162	2.5	7.5	0.5
54412	5.9	12.5	170	199	1369	186	15	141	126	2.4	8.2	0.4
54411	6.1	11.0	119	73	1231	128	11	149	154	2.4	6.9	0.4
54410	5.8	8.4	72	50	700	91	9	153	132	1.8	3.1	0.2
Mean	6.03	10.9	122	155	1205	125	14	154	164	1.9	6.1	0.4
Median	6.00	11.0	118	124	1212	126	14	154	165	1.8	6.1	0.4
Minimum	5.60	8.1	31	42	674	72	9	97	110	1.1	2.4	0.2
Maximum	7.10	17.9	256	770	2674	186	24	204	283	2.9	10.7	0.7
Standard deviation	0.24	2.4	50	117	407	29	2	21	33	0.4	1.6	0.1
Coefficient of variation, %	4	22	41	76	34	23	18	14	20	23	27	20
Count	45											

Table 25. Soil analyses of 4 to 8 inch samples collected from Field 12, collected March 2018.

Lab number	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
		cmolc/kg	- mg/kg -									
86530	7.1	7.3	95	59	804	60	8	155	178	1.1	1.7	0.7
76470	6.2	9.3	24	51	1153	43	12	111	87	0.9	0.8	0.2
76380	6.2	7.9	52	64	840	50	11	109	126	1.0	1.2	0.3
76379	6.1	8.2	137	132	668	58	13	154	111	1.0	2.2	0.3
76378	6.2	9.3	79	73	914	58	11	138	122	1.2	2.4	0.3
76377	6.3	12.3	24	65	1560	82	10	118	107	1.3	1.6	0.3
76376	6.2	11.2	31	55	1363	78	8	125	133	1.5	2.0	0.3
76375	6.0	7.3	46	52	740	44	6	142	102	0.9	1.6	0.2
76374	5.9	8.6	50	50	809	39	14	101	82	1.0	1.2	0.7
76373	6.0	12.4	80	82	1187	76	18	141	112	2.0	2.6	0.8
76372	6.2	15.2	53	72	1830	89	13	133	108	2.1	3.0	0.8
86484	5.8	10.0	67	81	1113	79	13	186	236	1.8	3.5	0.6
76370	5.8	12.2	30	68	1540	83	8	130	155	1.8	2.4	0.9
76368	6.1	7.0	36	35	719	31	5	134	99	0.9	1.3	0.2
76367	5.9	9.8	45	56	1229	53	12	107	163	1.5	2.2	0.3
86529	6.0	14.1	30	52	1903	104	10	141	152	1.8	3.6	1.0
86528	6.1	9.6	43	62	1123	86	8	151	146	1.5	2.8	0.8

Lab number	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
76364	6.2	11.3	26	55	1381	73	9	114	111	1.4	1.7	0.3
76363	5.9	10.3	31	79	1173	70	8	124	141	1.4	1.5	0.3
76362	5.7	7.7	32	54	802	50	7	126	97	0.8	1.4	0.5
76361	5.8	9.9	25	47	1171	48	7	129	110	1.6	2.0	0.6
86527	6.2	11.3	84	152	1267	116	13	175	143	1.9	5.9	0.7
76359	6.1	14.8	27	65	2038	95	12	106	82	1.9	2.2	0.8
76358	5.9	15.8	25	70	2238	89	11	117	114	2.2	3.0	0.8
76356	6.0	11.3	32	57	1497	62	10	130	102	2.1	1.8	0.7
76355	5.6	13.1	54	95	1687	96	12	141	128	2.3	3.1	0.7
76354	5.8	8.3	57	52	901	71	9	150	115	1.6	3.4	0.6
76353	6.1	10.3	28	49	1249	43	8	129	116	2.0	1.6	0.6
76352	6.1	16.3	44	87	2508	51	12	108	134	1.9	4.3	1.0
76351	6.1	14.6	76	165	1895	130	15	163	78	2.3	4.3	0.8
86526	5.9	10.9	51	45	1371	103	11	133	143	1.6	3.1	0.8
76349	5.9	12.5	39	88	1563	105	12	123	107	1.9	2.1	0.6
76348	6.0	11.0	139	147	1192	136	13	171	134	1.9	6.3	0.7
76347	5.8	9.0	52	49	1126	72	8	133	124	1.7	2.9	0.6
76346	6.2	7.6	60	48	801	54	9	146	120	1.4	1.5	0.5
Mean	6.05	10.9	52	72	1296	74	10	134	123	1.6	2.5	0.6

Lab number	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
Median	6.00	11.0	45	62	1192	72	11	133	116	1.6	2.2	0.6
Minimum	5.50	8.1	24	35	668	31	5	101	78	0.8	0.8	0.2
Maximum	6.50	17.9	139	165	2508	136	18	186	236	2.3	6.3	1.0
Standard deviation	0.23	2.4	29	32	454	26	3	20	30	0.4	1.2	0.2
Coefficient of variation, %	4	22	56	44	35	35	26	15	25	28	50	41
Count	35											

Table 26. Soil analyses of 0 to 4 inch samples collected from the slurry application zone of Field 1, collected 2014.

Field point	pH	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
		------------------------------------ mg/kg ------------------------------------									
126	7.3	30	183	8465	142	23	35	230	1	4.7	1.1
142	7.8	32	104	5672	78	11	61	108	0.5	3.9	0.5
143	6.7	99	571	1821	116	15	232	117	0.4	4	0.7
144	7.8	18	123	7643	92	13	44	156	0.9	2.3	0.6
145	6.5	28	80	2741	110	20	76	86	0.5	3	0.4
162	6.1	83	706	1415	158	22	159	266	0.9	5.6	0.6
163	6.3	98	597	2478	227	25	172	251	0.7	8	0.7
180	6.5	22	144	1298	89	13	118	374	0.6	2.6	0.3
181	7.0	100	329	2229	144	18	134	232	0.9	6.1	0.6
182	6.6	59	469	2007	150	21	101	267	1	9.7	0.7
198	6.6	82	405	2022	152	18	149	360	1.1	7.1	0.7
199	6.9	50	84	1667	85	17	121	346	0.6	4.2	0.3
200	6.1	57	151	1613	139	23	101	532	0.4	3	0.4
201	6.0	44	107	1700	158	22	94	316	0.8	7.5	0.5
215	5.5	93	187	922	95	19	200	148	0.3	3.1	0.4
216	6.6	50	84	1598	77	15	127	106	0.5	2.4	0.4
217	6.2	67	191	1290	143	19	148	214	0.5	4.3	0.4

Field point	pH	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
218	7.0	77	245	1310	127	16	128	326	0.4	4	0.5
219	6.3	169	771	2073	216	29	128	258	0.6	10.6	0.9
221	5.5	100	90	1357	131	19	141	257	0.7	9.4	0.3
231	6.6	80	189	1454	110	15	117	84	0.4	3.6	0.4
232	7.0	48	277	1898	107	16	78	129	0.4	2.7	0.4
233	6.8	56	223	1503	110	16	110	174	0.5	3.3	0.5
234	6.4	41	61	1200	71	16	116	289	0.4	2.1	0.3
235	6.3	109	707	1502	144	28	170	318	1	9.1	0.6
236	6.5	56	420	1442	145	20	105	219	0.7	4.8	0.4
237	6.8	82	366	2051	150	24	124	173	0.8	6.9	0.5
240	5.4	60	88	889	69	17	119	171	0.2	3.3	0.2
241	6.3	71	314	1638	94	17	97	193	0.3	5.3	0.4
250	7.5	39	148	2056	62	13	84	238	0.4	2.1	0.4
251	5.8	35	269	675	61	20	115	388	0.3	2.5	0.3
252	6.5	63	208	1149	128	17	118	381	0.8	4.1	0.4
253	6.7	90	251	1649	139	17	111	362	0.9	6.1	0.5
254	5.9	54	238	1275	131	20	153	253	1.1	5.1	0.4
255	7.3	77	675	4064	161	26	52	380	0.8	5.6	0.9
259	5.7	81	52	941	69	15	110	168	0.4	3.9	0.2

Field point	pH	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
269	5.5	44	67	801	76	16	96	316	0.5	2.3	0.3
270	5.7	53	67	1046	62	18	89	360	0.5	2.2	0.2
271	6.4	33	127	1230	83	15	86	444	0.5	2.3	0.4
Mean	6.47	65	266	2046	118	19	116	256	0.6	4.7	0.5
Median	6.50	59	191	1598	116	18	116	253	0.5	4.0	0.4
Minimum	5.4	18	52	675	61	11	35	84	0.2	2.1	0.2
Maximum	7.8	169	771	8465	227	29	232	532	1.1	10.6	1.1
Standard deviation	0.61	30	206	1673	40	4	40	106	0.2	2.3	0.2
Coefficient of variation, %	9	46	77	82	34	22	34	41	40	50	41
Count	39										

Table 27. Soil analyses of 0 to 4 inch samples collected from the slurry application zone of Field 1, collected February 2016.

Field point	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
		cmolc/kg	---------------------------------- mg/kg ----------------------------------									
126	7.2	49	17	189	9104	111	12	38	180	1.8	3.6	1
142	7.5	49	29	117	9064	107	6	26	31	1.7	5.4	0.3
143	6.8	18	123	176	2895	105	12	199	105	1.7	4.8	0.6
144	7.4	39	32	163	7008	118	13	69	178	2	5.1	0.7
145	6.7	31	65	241	5045	205	17	77	224	2.4	9.9	1
162	6.9	18	77	202	2813	141	15	121	182	1.8	6.1	0.5
163	6.4	16	121	274	2031	183	15	147	137	1.6	9.8	0.6
180	6.7	12	44	241	1552	99	12	109	254	1.6	3.9	0.4
181	6.8	14	89	350	1988	129	14	117	172	1.5	6.7	0.5
182	6.1	15	74	238	2028	129	19	145	184	1.6	7.7	0.6
198	6.1	13	63	245	1602	115	17	127	259	1.4	5.3	0.6
199	6.0	12	45	192	1360	101	17	124	277	1.4	4.4	0.4
200	5.8	13	54	185	1334	142	17	106	356	1.4	6.7	0.4
201	5.3	15	72	590	1311	151	21	140	285	1.5	9	0.5
215	5.2	11	59	151	828	81	14	205	90	0.9	3.3	0.4
216	6.0	12	55	207	1395	93	14	147	80	1	4.2	0.6
217	5.6	10	70	212	870	105	13	149	138	1.1	5.2	0.5

Field point	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
218	6.1	14	85	279	1646	157	15	152	169	1.3	7.4	0.6
219	5.8	18	96	351	2035	178	22	160	146	1.3	9.3	0.7
221	5.5	9	31	176	724	77	10	108	148	1.2	2.5	0.4
231	6.0	12	93	224	1255	148	16	137	269	1.7	7	0.5
232	5.8	12	83	223	1148	96	10	143	190	1.5	4.5	0.5
233	5.7	16	274	165	1927	146	20	250	101	12.3	28.6	0.7
234	6.0	8	31	173	715	76	10	109	147	1.2	2.6	0.4
235	6.4	9	77	206	1037	88	8	135	186	1.4	3.9	0.4
236	6.3	16	130	413	2061	176	16	115	273	1.9	9.7	0.6
237	5.8	16	87	418	1736	202	18	131	170	1.6	8.2	0.6
240	5.5	11	109	177	986	177	14	149	155	1.5	10.2	0.5
241	6.2	9	33	104	1075	91	8	90	226	1.1	5	0.5
250	6.9	13	49	161	1924	81	14	104	234	1.4	4.1	0.7
251	5.1	10	28	98	748	77	14	102	390	1.1	2.8	0.4
252	5.6	12	115	348	1064	181	23	132	297	1.5	7	0.6
253	6.0	15	126	334	1904	155	22	115	340	1.6	9.6	0.7
254	5.6	14	90	283	1461	159	23	153	304	1.6	8.3	0.6
255	5.4	21	66	378	2463	228	24	104	136	1.5	8.1	0.6
259	5.4	12	51	110	1140	67	14	101	168	0.9	3.1	0.4

Field point	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
269	5.3	10	29	69	975	82	17	115	372	1.2	2.8	0.5
270	5.4	9	33	60	739	56	17	121	374	1.2	3.2	0.4
271	5.3	12	49	173	1124	78	19	105	383	1.2	2.7	0.5
Mean	6.04	16	228	2106	125	73	21	118	213	1	8.8	0.5
Median	6.00	13	206	1461	115	66	21	118	201	1	7.2	0.5
Minimum	5.10	8	60	715	56	17	10	30	48	1	1.7	0.2
Maximum	7.50	49	590	9104	228	274	31	219	355	2	27.7	1.1
Standard deviation	0.63	10	108	2021	44	45	5	39	72	0	5.1	0.2
Coefficient of variation, %	8	60	47	96	35	62	24	33	34	31	58	35
Count	39											

Table 28. Soil analyses of 0 to 4 inch samples collected from the slurry application zone of Field 1, collected March 2018.

Field point	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
		cmolc/kg	------------------------------------ mg/kg ------------------------------------									
126	7.7	50	31	220	9224	112	14	30	165	1.3	4.1	1.0
142	7.8	61	43	104	11512	97	10	33	48	1.1	7.9	0.4
143	6.8	17	145	291	2552	111	21	189	117	1.3	6.4	0.6
144	7.6	37	63	144	6629	113	17	48	170	1.6	6.5	0.7
145	6.6	21	173	295	3091	240	23	118	175	2.1	17.4	1.1
162	6.6	13	127	252	1631	188	22	143	222	1.3	10.4	0.5
163	6.8	13	164	325	1600	200	27	159	191	1.2	13.1	0.5
180	7.3	19	56	233	3021	104	19	82	270	0.9	3.5	0.4
181	7.6	22	130	260	3646	154	19	91	196	1.2	8.2	0.5
182	6.4	16	131	277	1972	178	25	135	228	1.3	12.2	0.7
198	7.8	22	128	486	3584	128	25	106	296	1.1	6.2	0.8
199	6.6	15	96	396	1902	140	26	130	314	0.9	6.0	0.5
200	6.6	15	104	247	1929	191	17	103	343	1.2	10.5	0.5
201	6.2	14	64	243	1698	117	18	117	209	1.1	6.7	0.5
215	6.0	9	84	232	822	100	18	193	140	0.5	3.2	0.4
216	6.3	13	128	418	1499	189	27	219	125	0.9	7.0	0.6
217	6.2	10	104	396	970	162	23	154	225	0.9	7.2	0.5

Field point	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
218	6.3	14	147	528	1593	236	24	135	205	1.3	11.8	0.6
219	6.6	15	189	557	1622	232	30	150	199	1.1	11.7	0.7
221	6.0	14	247	325	1521	258	23	166	137	1.5	27.7	0.6
231	6.7	13	135	330	1599	187	21	133	83	0.9	7.7	0.6
232	6.1	11	92	313	1147	147	19	127	160	0.8	5.7	0.5
233	6.2	9	76	258	933	107	16	109	153	0.7	3.9	0.4
234	6.5	11	114	398	1212	157	19	128	194	0.9	6.5	0.6
235	6.5	12	136	338	1388	170	17	135	228	1.8	10.0	0.5
236	6.5	16	196	660	1788	272	31	108	355	1.9	15.7	0.6
237	6.3	15	178	451	1660	242	27	129	179	1.9	15.0	0.5
240	5.8	14	186	402	1308	256	29	137	192	1.7	14.9	0.5
241	6.4	13	94	235	1568	161	20	100	201	1.2	5.7	0.5
250	6.3	10	81	214	1144	113	17	98	216	1.5	6.1	0.4
251	6.4	8	91	179	877	128	20	89	340	1.6	6.2	0.3
252	6.2	9	120	447	851	176	24	108	310	1.6	8.1	0.4
253	6.4	12	152	392	1169	194	21	119	318	1.8	10.4	0.5
254	6.5	12	128	556	1237	208	25	134	261	1.6	10.3	0.5
255	6.1	18	141	442	2259	270	26	101	163	1.7	15.0	0.5
259	6.3	12	87	218	1429	149	17	107	200	0.9	6.2	0.3

Field point	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
269	6.1	8	39	123	741	83	17	83	304	0.9	3.1	0.2
270	5.9	6	41	105	522	62	15	96	225	0.7	1.7	0.2
271	6.8	9	27	102	1135	59	10	68	232	1.0	2.0	0.2
Mean	6.56	16.1	115	318	2205	164	21	118	213	1	8.8	0.5
Median	6.40	13.5	120	295	1593	161	21	118	201	1	7.2	0.5
Minimum	5.80	6.5	27	102	522	59	10	30	48	1	1.7	0.2
Maximum	7.80	60.7	247	660	11512	272	31	219	355	2	27.7	1.1
Standard deviation	0.53	10.7	50	135	2220	58	5	39	72	0	5.1	0.2
Coefficient of variation, %	8	66	44	43	101	36	24	33	34	31	58	35
Count	39											

Table 29. Soil analyses of 0 to 4 inch samples collected from the buffer zone of Field 1, collected 2014.

Field point	pH	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
		mg/kg									
274	6.4	56	373	4822	230	19	40	308	0.9	3.8	0.7
275	6.3	28	66	1665	89	15	94	231	0.6	2.7	0.3
276	6.2	46	51	1510	74	18	95	222	0.4	3.6	0.2
278	6.6	32	88	2359	86	19	79	486	0.5	3.3	0.3
287	5.9	65	63	1231	72	17	144	137	0.4	2.5	0.3
288	6.2	55	78	1620	101	18	129	235	0.5	2.9	0.5
289	5.6	36	62	1337	79	15	96	164	0.2	2	0.2
291	6.1	40	161	1284	149	20	130	361	0.6	4.1	0.4
292	7.0	42	109	2258	95	17	80	462	1	6.4	0.4
293	7.0	45	224	3777	166	17	45	339	0.9	5.5	0.5
294	6.7	40	136	2241	117	19	86	330	0.6	6.2	0.4
295	6.9	36	248	2385	134	23	92	363	0.6	4.7	0.5
296	5.3	49	48	736	63	18	169	309	0.4	3.1	0.2
297	6.8	30	83	2047	59	14	79	269	0.3	3.3	0.3
309	5.4	66	71	848	107	16	115	131	0.4	3.9	0.3
310	5.4	72	73	605	92	20	128	326	0.4	4.1	0.2
311	5.8	88	101	1181	96	21	124	346	0.5	3.2	0.3

Field point	pH	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
312	6.2	37	86	1835	126	19	83	511	0.8	4.3	0.3
313	7.5	70	83	4550	127	18	50	311	0.9	6.1	0.5
314	6.4	51	72	1430	99	17	79	311	0.6	3.3	0.3
Mean	6.20	52	128	1803	106	18	101	269	0.6	3.9	0.3
Median	6.25	52	91	1551	100	18	95	294	0.6	3.7	0.3
Minimum	4.4	28	44	456	44	13	40	31	0.2	1.8	0.2
Maximum	7.5	102	473	4822	230	23	188	511	1.0	7.5	0.7
Standard deviation	0.70	17	96	1052	40	2	35	123	0.2	1.4	0.1
Coefficient of variation, %	11	32	75	58	38	12	35	46	42	36	39
Count	32										

Table 30. Soil analyses of 0 to 4 inch samples collected from the buffer zone of Field 1, collected February 2016.

Lab number	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
		cmolc/kg	- mg/kg	- -								
212	5.2	9	43	77	494	53	11	195	66	1	2	0.2
213	5.7	9	21	60	896	60	8	117	25	0.8	1.4	0.2
214	5.2	10	45	106	776	72	12	166	58	1	2.5	0.3
238	6.3	14	56	154	1769	108	13	98	198	1.4	6.2	0.5
249	5.1	10	38	123	695	91	12	103	65	0.9	3.1	0.3
256	5.7	17	103	382	1799	183	19	167	113	1.7	8.2	0.7
257	5.4	14	67	124	1293	178	17	110	228	1.5	7.8	0.6
258	6.0	14	16	85	1960	68	13	84	247	1.2	2.5	0.6
260	6.3	22	19	65	3467	59	12	75	164	0.9	2.7	0.4
268	5.0	9	44	69	568	40	16	143	75	0.8	2	0.3
272	5.8	13	58	318	1361	133	19	120	442	1.5	5.8	0.7
273	6.3	16	74	224	2235	126	18	103	295	1.5	6.5	0.7
274	6.0	24	84	409	3299	226	18	80	215	1.4	6	0.7
275	6.2	13	40	239	1643	108	16	128	201	1.1	4.1	0.6
276	5.5	12	31	119	1102	86	14	155	193	0.9	3.2	0.4
278	5.8	16	19	101	1956	83	15	87	364	1	3.3	0.5
287	4.9	10	36	43	656	34	11	115	70	0.5	1.4	0.3

Lab number	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
288	5.6	9	27	40	1005	37	14	118	215	0.8	2.1	0.4
289	4.9	10	20	54	649	65	14	108	131	0.6	1.5	0.3
291	5.8	10	17	148	900	90	12	104	283	0.8	1.8	0.4
292	5.7	13	40	120	1555	93	18	106	290	1.2	3.6	0.4
293	6.1	18	25	146	2516	123	16	69	280	1.8	4.5	0.6
294	5.8	15	26	113	1832	97	18	77	222	0.9	2.2	0.3
295	5.9	12	26	69	1478	65	17	103	232	1	3.3	0.3
296	5.3	10	24	38	950	47	17	132	277	0.8	2.5	0.2
297	6.0	16	22	93	2273	54	17	74	234	0.9	2.6	0.4
309	4.9	9	25	43	528	47	13	115	94	0.6	1.5	0.2
310	4.9	10	25	42	590	56	15	115	225	0.8	2	0.3
311	5.6	12	55	142	1206	123	20	109	191	1	3.3	0.4
312	5.5	14	27	71	1490	85	19	86	349	1.5	3.1	0.3
313	6.5	26	22	181	4371	115	18	49	224	1.3	2.6	0.5
314	5.4	14	28	81	1547	98	19	90	291	1.2	4.2	0.3
Mean	5.63	13	38	127	1527	91	15	109	205	1.1	3.4	0.4
Median	5.70	13	28	104	1420	86	16	107	219	1.0	2.9	0.4
Minimum	4.90	9	16	38	494	34	8	49	25	0.5	1.4	0.2
Maximum	6.50	26	103	409	4371	226	20	195	442	1.8	8.2	0.7

Lab number	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
Standard deviation	0.46	4	21	95	917	45	3	31	99	0.3	1.8	0.2
Coefficient of variation, %	8	32	56	74	60	49	20	29	48	30.7	54.0	38.7
Count	32											

Table 31. Soil analyses of 0 to 4 inch samples collected from the buffer zone of Field 1, collected March 2018.

Field point	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
		cmolc/kg	- mg/kg -									
212	5.3	10	71	141	948	70	16	154	91	0.5	2.3	0.3
213	6.1	11	60	199	1204	88	14	91	54	0.5	2.1	0.2
214	6.2	9	79	196	1000	108	15	126	112	0.6	3.7	0.3
238	6.2	15	233	289	1670	275	21	122	171	2.4	23.2	0.4
249	5.9	10	86	123	1042	131	18	107	117	1.1	4.6	0.2
256	6.3	13	120	457	1462	184	24	146	134	1.4	10.7	0.4
257	5.9	12	121	315	1141	198	23	115	266	1.5	15.4	0.3
258	6.1	11	52	154	1310	87	15	91	196	0.9	3.5	0.3
260	7.1	21	40	135	3487	128	20	49	309	1.3	6.6	0.7
268	5.7	8	57	89	696	79	16	120	170	1.1	3.2	0.2
272	6.8	12	105	297	1435	192	18	97	322	1.4	8.7	0.5
273	6.9	14	98	211	1976	156	17	80	280	1.5	8.3	0.5
274	6.9	27	105	557	4198	271	27	62	206	1.3	8.7	0.6
275	6.3	12	52	330	1420	134	19	98	221	0.9	5.0	0.4
276	6.0	9	43	133	904	87	15	93	228	0.9	3.1	0.2
278	6.4	16	42	187	2182	126	20	64	355	1.1	4.9	0.4
287	5.9	7	55	52	668	41	13	97	94	0.5	1.3	0.1

Field point	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
288	6.2	9	47	53	1066	80	13	105	133	0.9	3.5	0.2
289	6.4	11	18	66	1494	68	11	63	150	0.7	1.5	0.2
291	6.4	8	30	160	910	85	15	92	332	1.0	2.2	0.2
292	6.5	11	42	242	1496	93	16	78	284	1.1	3.8	0.3
293	6.2	17	33	249	2236	136	19	63	281	2.0	4.4	0.4
294	6.5	13	38	169	1796	109	14	76	211	1.7	4.1	0.3
295	6.7	11	27	86	1599	61	14	77	218	1.5	2.3	0.2
296	5.7	8	36	72	640	53	15	122	253	1.6	2.5	0.1
297	6.3	14	29	112	1941	62	17	68	274	1.7	3.4	0.4
309	5.9	7	58	82	632	71	14	113	133	1.4	2.8	0.2
310	6.0	7	32	64	636	74	12	97	204	1.3	2.2	0.2
311	6.7	10	64	287	1124	169	17	101	174	1.5	4.1	0.4
312	6.4	12	31	179	1463	101	15	60	373	1.8	3.4	0.2
313	7.2	26	33	135	4477	116	12	35	209	1.8	3.4	0.4
314	6.0	11	38	112	1318	95	17	77	298	1.6	3.6	0.3
Mean	6.28	12	62	185	1549	117	17	92	214	1.3	5.1	0.3
Median	6.25	11	50	157	1369	98	16	93	210	1.3	3.6	0.3
Minimum	5.3	7	18	52	632	41	11	35	54	0.5	1.3	0.1
Maximum	7.2	27	233	557	4477	275	27	154	373	2.4	23.2	0.7

Field point	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
Standard deviation	0.43	5	42	117	937	58	4	27	83	0.5	4.5	0.1
Coefficient of variation, %	7	39	68	63	61	50	22	30	39	36.2	87.7	44.3
Count	32											

Table 32. Soil analyses of 0 to 4 inch samples collected from the slurry application zone of Field 5a, collected 2014.

Field point	pH	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
		mg/kg									
21	6.4	17	71	2413	92	10	111	197	2.2	3.5	0.6
22	5.6	35	56	1692	86	11	143	230	2.7	4.2	0.4
23	5.4	55	49	1028	81	12	197	212	0.9	2.9	0.4
24	5.9	40	40	1299	71	10	177	169	1.1	3.8	0.4
25	5.2	47	21.2	448	65.4	9	196	212	1.0	1.9	0.2
32	5.5	74	55	1040	69	11	230	210	1.1	2.9	0.1
33	5.6	61	61	987	57	11	180	198	1.4	1.8	0.1
34	6.4	29	65	1984	57	11	143	268	1.9	3.3	0.3
35	6.1	23	65	2257	66	12	123	186	1.9	3.7	0.3
46	5.4	50	63	840	93	14	192	275	1.4	2.6	0.1
47	5.5	86	70	877	76	14	207	341	2.0	4.4	0.2
48	5.3	59	50	922	65	13	188	215	0.9	2.0	0.1
49	6.2	19	42	2055	82	12	135	223	1.6	4.7	0.5
50	6.1	22	46	1776	81	12	130	224	1.4	5.1	0.4
59	5.2	33	44	565	63	15	151	247	1.1	1.5	0.1
60	5.0	51	57	584	69	17	170	232	0.9	1.2	0.1
61	5.1	55	176	795	70	13	176	285	2.0	3.3	0.2

Field point	pH	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
62	5.3	69	78	846	83	15	161	163	0.8	1.6	0.2
73	4.8	47	48	484	50	20	153	254	1.1	0.9	0.1
74	5.3	51	39	513	61	14	148	246	1.1	1.9	0.1
75	5.3	85	51	829	61	15	167	167	0.8	1.8	0.2
85	5.0	54	38	350	62	14	118	200	1.0	1.5	0.0
86	4.5	91	25	167	32	11	163	110	0.7	1.0	0.0
Mean	5.5	50	57	1076	69	13	163	220	1.3	2.7	0.2
Median	5.4	51	51	877	69	12	163	215	1.1	2.6	0.2
Minimum	4.5	17	21	167	32	9	111	110	0.7	0.9	0.0
Maximum	6.4	91	176	2413	93	20	230	341	2.7	5.1	0.6
Standard deviation	0.5	21	30	644	14	3	30	48	0.5	1.3	0.2
Coefficient of variation, %	9	43	52	60	20	20	19	22	40	47	74
Count	23										

Table 33. Soil analyses of 0 to 4 inch samples collected from the slurry application zone of Field 5a, collected February 2016.

Field point	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
		cmolc/kg	---------------------------------- mg/kg ----------------------------------									
21	5.9	15	16	73	2090	82	9	115	179	2.1	3.4	0.4
22	5.4	14	24	67	1570	87	11	132	151	2.2	3	0.3
23	5.5	12	37	58	1147	72	10	184	184	1.5	2.9	0.3
24	5.2	11	33	40	987	55	8	164	120	1	2.7	0.3
25	5.7	11	26	39	1212	74	8	159	154	1.1	2.8	0.3
32	4.7	9	75	58	525	58	20	112	220	0.7	2.1	0.2
33	5.9	17	29	88	2492	78	14	105	123	1.9	4.4	0.6
34	5.2	11	30	67	980	87	13	147	149	1.3	1.7	0.3
35	5.3	12	65	79	1161	83	12	187	189	1.9	2.8	0.3
36	5.2	13	51	75	1130	85	11	196	140	1.3	2.4	0.3
37	5.7	12	28	39	1287	73	9	143	145	1.2	3.4	0.4
38	6.3	15	25	52	2198	81	11	142	172	1.5	4.1	0.7
46	6.3	21	34	150	3177	95	14	117	141	2.2	5.7	0.8
47	5.1	10	47	76	778	85	12	174	202	1.5	2.6	0.3
48	5.4	10	43	57	874	62	9	183	173	1	2.5	0.3
49	5.1	11	79	96	945	80	11	186	236	2.4	4.2	0.3
50	5.8	15	21	55	1834	79	10	143	158	1.5	4.1	0.5

Field point	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
51	5.7	16	23	51	1953	91	9	138	182	1.5	4	0.6
59	5.5	10	46	62	854	74	11	172	240	2	3.6	0.3
60	5.0	11	58	80	841	89	12	165	113	0.7	1.7	0.2
61	5.1	9	33	45	506	71	14	165	210	1.1	2.3	0.2
62	5.2	10	49	78	756	93	18	178	270	1.7	2.2	0.3
72	5.1	9	45	47	468	67	14	171	212	1.4	2.8	0.2
73	5.0	10	47	84	622	88	16	171	209	1.7	2.6	0.3
74	4.9	10	41	64	626	67	15	170	240	2.3	2.5	0.3
75	5.2	11	39	73	905	83	13	136	82	1.5	1.8	0.4
85	4.7	8	77	40	341	48	16	207	134	1.3	2.1	0.3
86	5.9	11	46	61	1288	110	15	140	181	1.9	3	0.4
Mean	5.4	12	42	66	1198	78	12	157	175	1.6	3.0	0.4
Median	5.3	11	40	63	984	81	12	165	176	1.5	2.8	0.3
Minimum	4.7	8	16	39	341	48	8	105	82	0.7	1.7	0.2
Maximum	6.3	21	79	150	3177	110	20	207	270	2.4	5.7	0.8
Standard deviation	0.4	2.9	17	23	676	13	3	27	44	0.5	0.9	0.1
Coefficient of variation, %	8	24	41	34	56	17	25	17	25	30	31	42
Count	28											

Table 34. Soil analyses of 0 to 4 inch samples collected from the slurry application zone of Field 5a, collected March 2018.

Field point	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
		cmolc/kg	------------------------------------ mg/kg									------------------------------------
21	6.9	17	25	92	2630	70	13	105	206	2.8	4.0	0.5
22	5.9	13	44	58	1628	91	12	121	230	3.1	4.8	0.2
23	5.6	10	35	47	1071	69	10	148	157	1.9	4.2	0.2
24	6.0	10	31	37	1119	67	7	139	143	1.7	3.5	0.2
25	6.0	11	31	41	1250	84	8	141	163	1.8	3.8	0.3
32	6.6	16	26	70	2395	68	11	95	143	3.0	4.8	0.5
33	5.5	9	78	53	737	61	18	94	182	2.2	2.8	0.1
34	6.6	12	31	62	1664	60	10	111	197	2.7	3.6	0.3
35	5.6	9	59	69	919	77	10	153	192	2.6	2.8	0.2
36	5.6	9	55	46	898	62	9	162	156	2.1	3.4	0.2
37	6.0	11	24	35	1409	65	8	125	153	2.2	3.7	0.3
38	6.3	13	27	43	1789	71	10	124	167	2.3	4.4	0.4
46	6.9	19	44	125	3041	81	13	107	120	3.3	5.9	0.7
47	5.6	9	50	84	724	82	12	156	186	2.6	3.2	0.2
48	5.7	9	64	66	907	74	11	157	206	3.2	4.6	0.2
49	5.8	11	77	68	1216	70	10	176	132	2.4	3.7	0.2
50	6.1	14	20	51	1980	87	10	124	193	2.1	4.0	0.4

Field point	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
51	6.2	11	25	41	1505	72	8	121	169	1.9	4.1	0.3
59	5.3	8	34	52	619	77	13	144	178	1.7	2.5	0.1
60	5.3	9	38	62	628	81	13	137	170	1.6	2.0	0.1
61	5.8	9	51	60	919	80	11	147	193	2.6	3.9	0.2
62	5.4	10	56	79	859	87	14	142	128	1.5	2.6	0.1
72	5.4	8	55	42	524	70	13	148	192	1.7	2.9	0.1
73	5.5	9	65	70	697	87	17	131	219	1.9	3.0	0.1
74	5.5	8	43	55	621	74	13	128	210	2.4	2.9	0.2
75	5.3	10	49	92	904	85	12	128	72	1.5	1.9	0.1
85	5.2	8	62	33	421	52	12	165	96	1.8	2.4	0.1
86	5.5	8	58	46	531	67	14	128	179	2.1	2.7	0.1
Mean	5.83	11	45	60	1200	74	12	134	169	2.2	3.5	0.2
Median	5.65	10	44	57	919	73	12	134	174	2.2	3.6	0.2
Minimum	5.20	8	20	33	421	52	7	94	72	1.5	1.9	0.1
Maximum	6.90	19	78	125	3041	91	18	176	230	3.3	5.9	0.7
Standard deviation	0.48	2.8	16	21	670	10	3	21	37	0.5	0.9	0.1
Coefficient of variation, %	8	26	37	35	56	13	22	15	22	24	27	63
Count	28											

Table 35. Soil analyses of 0 to 4 inch samples collected from the buffer zone of Field 5a, collected 2014.

Field point	pH	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
		----- mg/kg -----									
19	6.6	34	98	3168	108	16	116	138	2.0	7.3	0.9
20	7.0	36	115	3404	96	15	154	214	2.5	6.9	1.0
30	6.3	27	49	2031	85	11	147	211	1.4	4.0	0.6
31	6.0	26	44	1762	72	11	161	188	1.2	3.6	0.3
45	6.6	32	103	2914	95	15	123	227	2.1	5.4	0.6
87	6.4	18	60	2016	57	9	96	150	1.6	2.8	0.3
98	4.6	51	25	359	42	14	155	168	0.8	1.2	0.0
99	4.8	64	29	315	49	12	138	129	0.6	1.1	0.0
100	6.4	20	81	2022	53	11	104	157	1.5	3.4	0.4
111	5.0	23	46	644	53	13	118	128	0.4	0.7	0.0
Mean	6.0	33	65	1864	71	13	131	171	1.4	3.6	0.4
Median	6.4	30	55	2019	65	13	131	163	1.4	3.5	0.4
Minimum	4.6	18	25	315	42	9	96	128	0.4	0.7	0.0
Maximum	7.0	64	115	3404	108	16	161	227	2.5	7.3	1.0
Standard deviation	0.9	14	32	1126	23	2	23	37	0.7	2.3	0.4
Coefficient of variation, %	14	44	49	60	33	18	17	22	48	64	89

Field point	pH	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
Count	10										

Table 36. Soil analyses of 0 to 4 inch samples collected from the buffer zone of Field 5a, collected February 2016.

Lab number	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
		cmolc/kg	----------------				mg/kg					----------------
16	4.6	8	49	38	260	28	26	114	237	0.5	1.3	0.2
17	4.4	14	12	77	905	150	12	55	37	0.3	0.4	0.1
19	5.9	19	10	95	2810	42	9	104	114	2.1	3.6	0.6
20	6.7	19	20	94	3068	66	12	135	174	2.5	4.9	0.8
30	5.0	11	50	95	830	99	14	86	181	0.6	2.9	0.3
31	4.6	9	84	36	441	30	23	107	264	0.6	1.6	0.2
45	4.5	9	61	50	377	37	23	112	259	0.7	1.7	0.2
58	5.7	22	21	103	3059	70	18	146	158	2.5	5.2	0.8
71	6.0	13	24	73	1785	50	11	142	142	1.5	2.4	0.5
84	6.7	19	19	87	3128	56	12	121	145	2	3.5	0.7
87	5.2	10	44	84	609	86	14	138	110	1.2	2.4	0.3
98	4.7	8	40	38	358	34	15	173	152	1.6	1.6	0.3
99	4.9	9	39	48	457	57	14	165	189	1.8	1.9	0.3
100	5.1	12	35	100	987	93	12	202	134	1.6	2	0.3
111	6.1	13	12	67	1719	27	7	131	177	2.4	2.3	0.4
112	4.9	13	30	73	1027	87	16	187	128	1.6	2.1	0.3
Mean	5.3	13	34	72	1364	63	15	132	163	1.5	2.5	0.4

Lab number	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
Median	5.1	13	33	75	946	57	14	133	155	1.6	2.2	0.3
Minimum	4.4	8	10	36	260	27	7	55	37	0.3	0.4	0.1
Maximum	6.7	22	84	103	3128	150	26	202	264	2.5	5.2	0.8
Standard deviation	0.8	4	20	24	1080	33	5	38	58	0.7	1.3	0.2
Coefficient of variation, %	14	35	59	33	79	53	35	28	36	51	51	56
Count	16											

Table 37. Soil analyses of 0 to 4 inch samples collected from the buffer zone of Field 5a, collected March 2018.

Field point	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
		cmolc/kg	------------------------------------ mg/kg ------------------------------------									
16	4.9	9	66	48	408	52	21	87	187	1.1	1.7	0.1
17	5.0	10	65	62	640	88	22	95	197	0.9	1.6	0.1
19	6.8	19	29	79	3096	74	14	81	107	2.4	5.9	0.7
20	6.9	20	28	89	3307	68	14	113	153	3.0	5.9	0.8
30	5.2	9	150	64	587	54	28	127	286	2.0	3.0	0.1
31	6.3	11	46	92	1376	138	16	78	231	1.4	3.0	0.4
45	5.2	9	101	75	572	64	24	111	276	2.2	3.2	0.1
58	6.5	18	35	77	2854	69	17	96	130	2.7	5.6	0.7
71	7.0	17	31	85	2903	63	13	104	120	2.1	3.1	0.5
84	7.2	23	20	63	4139	49	11	96	103	2.5	3.9	0.5
87	5.3	8	40	60	595	77	13	129	131	1.7	1.9	0.1
98	5.2	8	33	31	468	37	13	146	137	1.6	1.5	0.1
99	5.3	7	78	32	432	55	13	148	118	2.1	2.9	0.1
100	5.6	10	39	96	1030	87	13	168	122	1.8	2.4	0.1
111	6.6	13	26	62	1906	48	11	113	145	2.6	3.1	0.4
112	5.3	11	28	79	1099	83	16	166	141	1.7	2.3	0.2
Mean	5.9	13	51	68	1588	69	16	116	162	2.0	3.2	0.3

Field point	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
Median	5.5	11	37	70	1065	66	16	116	162	2.0	3.2	0.3
Minimum	4.9	7	20	31	408	37	14	112	139	2.1	3.0	0.2
Maximum	7.2	23	150	96	4139	138	11	78	103	0.9	1.5	0.1
Standard deviation	0.8	5	34	19	1256	24	28	168	286	3.0	5.9	0.8
Coefficient of variation, %	14	40	68	29	79	34	5	29	58	0.6	1.5	0.3
Count												

Table 38. Soil analyses of 0 to 4 inch samples collected from the slurry application zone of Field 12, collected 2014.

Field point	pH	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
		---------------------------------- mg/kg ----------------------------------									
17	5.7	117	117	721	72	15	146	187	0.8	2.1	0.1
18	5.9	147	223	726	93	17	145	231	0.8	2.7	0.2
19	5.7	126	174	608	94	14	154	197	0.8	2.6	0.1
20	5.7	101	96	1169	101	17	151	177	1.3	2.7	0.2
21	5.8	61	61	1367	82	14	153	168	1.2	2.4	0.2
25	5.5	60	57	788	62	17	107	218	0.8	1.3	0.1
26	5.6	128	202	690	80	17	151	172	1.0	2.6	0.1
27	5.8	109	69	956	75	16	143	159	0.9	2.1	0.3
28	5.8	45	54	1441	87	14	117	170	1.2	1.8	0.2
29	5.6	39	60	993	73	12	151	193	1.0	2.1	0.1
33	5.3	53	29	743	43	10	167	131	0.7	2.2	0.0
34	6.1	43	76	1530	83	12	134	184	1.4	3.3	0.2
35	6.0	37	81	1207	90	13	102	143	1.0	1.9	0.1
37	5.8	63	62	1039	65	18	118	190	1.6	2.1	0.1
41	5.9	43	50	1318	49	15	101	185	1.5	1.4	0.2
42	6.0	30	70	1781	105	15	102	98	1.6	5.7	0.2
43	6.2	29	67	1767	83	14	108	173	1.5	1.5	0.3

Field point	pH	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
44	5.6	73	88	1048	86	15	136	154	1.1	2.2	0.1
45	5.8	30	47	1143	81	11	113	149	1.1	2.8	0.2
46	5.8	47	212	820	52	13	133	121	0.7	2.0	0.2
49	6.1	24	59	1953	84	13	83	64	1.5	1.5	0.3
50	5.9	19	54	1758	77	12	87	84	1.6	1.1	0.2
51	6.3	17	56	1908	85	10	87	96	1.6	1.8	0.2
52	6.3	30	43	1537	55	10	100	109	1.5	1.4	0.1
53	6.1	33	54	1416	56	10	102	110	1.5	1.8	0.1
54	6.1	32	43	970	57	8	115	106	1.2	1.5	0.1
57	6.0	26	53	1120	38	8	108	102	1.7	1.5	0.1
58	6.0	36	58	1338	63	10	101	78	1.3	1.3	0.1
59	5.9	39	40	853	56	9	116	103	1.1	1.5	0.1
60	6.0	52	98	1357	106	12	107	88	1.7	1.6	0.2
61	6.0	34	72	1453	85	13	118	122	1.3	1.7	0.2
Mean	5.9	56	81	1210	75	13	121	144	1.2	2.1	0.2
Median	5.9	43	61	1169	80	13	116	149	1.2	1.9	0.2
Minimum	5.3	17	29	608	38	8	83	64	0.7	1.1	0.0
Maximum	6.3	147	223	1953	106	18	167	231	1.7	5.7	0.3
Standard deviation	0.2	36	51	384	18	3	23	45	0.3	0.9	0.1

Field point	pH	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
Coefficient of variation, %	4	64	63	32	24	22	19	31	26	41	46
Count	31										

Table 39. Soil analyses of 0 to 4 inch samples collected from the slurry application zone of Field 12, collected February 2016.

Field point	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
		cmolc/kg	- mg/kg -									
11	5.4	10	178	146	795	92	15	196	256	1.7	4.1	0.4
12	5.2	10	172	119	766	78	13	206	216	1.4	3.5	0.4
17	5.2	11	193	189	864	113	17	215	251	1.6	6.3	0.4
18	5.1	11	167	185	751	108	16	192	247	1.4	4.8	0.3
19	5.2	11	168	159	883	117	16	206	222	1.6	5.9	0.4
20	5.5	12	73	82	1176	86	13	162	156	1.7	3.2	0.4
21	5.6	12	49	70	1307	104	11	157	156	1.5	3.0	0.4
25	5.3	9	115	115	661	88	15	149	193	1.3	4.1	0.3
26	4.9	12	186	276	739	103	19	185	215	1.5	5.2	0.4
27	5.7	12	112	101	1297	115	16	172	200	1.9	4.7	0.4
28	5.3	14	123	75	1316	154	16	227	216	2.0	7.2	0.5
29	5.6	14	101	95	1568	162	17	204	175	1.8	5.8	0.5
33	5.1	11	138	147	772	99	22	147	174	1.2	5.3	0.3
34	5.2	15	103	98	1408	128	23	175	169	2.1	4.5	0.5
35	6.0	13	76	121	1575	135	19	163	159	1.4	4.2	0.5
36	5.5	14	97	107	1333	126	18	197	232	1.7	6.5	0.5
37	5.5	14	57	109	1479	115	19	161	195	1.6	3.9	0.5

Field point	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
41	5.1	17	123	117	1752	165	23	195	138	2.1	6.7	0.5
42	5.5	13	91	102	1225	109	22	153	227	1.8	5.2	0.4
43	5.3	17	59	91	1848	139	20	170	109	2.0	4.3	0.5
44	5.7	13	79	122	1393	122	22	187	201	1.8	5.1	0.5
45	5.6	12	65	164	1135	111	15	183	187	1.4	4.0	0.4
49	5.8	17	65	95	2178	139	15	133	90	2.1	5.3	0.7
50	5.4	16	72	85	1697	141	15	143	110	2.3	5.1	0.6
51	5.9	16	65	109	2099	151	14	157	137	2.5	5.2	0.6
52	5.4	14	76	94	1389	101	15	187	162	2.2	4.3	0.5
53	5.3	14	77	110	1493	121	16	192	178	2.4	5.0	0.6
54	5.5	11	117	79	941	124	13	234	202	1.8	7.5	0.6
57	6.0	17	63	107	2593	75	18	136	141	2.3	6.0	1.0
58	5.3	17	146	245	1791	178	19	178	88	2.3	7.0	0.4
59	5.4	17	117	207	1737	162	15	166	94	1.8	5.1	0.5
60	5.6	15	65	123	1632	142	14	161	113	1.8	3.8	0.4
61	5.3	15	151	315	1326	185	18	165	144	1.6	6.9	0.5
62	5.6	13	82	110	1464	128	13	159	143	1.6	5.0	0.4
Mean	5.4	14	107	131	1364	124	17	177	173	1.8	5.1	0.5
Median	5.4	14	99	110	1361	122	16	174	175	1.8	5.1	0.5

Field point	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
Minimum	4.9	9	49	70	661	75	11	133	88	1.2	3.0	0.3
Maximum	6.0	17	193	315	2593	185	23	234	256	2.5	7.5	1.0
Standard deviation	0.3	2	43	57	454	28	3	25	47	0.3	1.2	0.1
Coefficient of variation, %	5	17	40	44	33	22	19	14	27	19	23	27
Count	34											

Table 40. Soil analyses of 0 to 4 inch samples collected from the slurry application zone of Field 12, collected March 2018.

Field point	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
		cmolc/kg	------------	------------	------------	------------	mg/kg	------------	------------	------------	------------	------------
11	6.1	9	230	124	893	118	13	180	193	1.8	6.6	0.4
12	6.2	8	198	304	850	105	13	175	140	1.7	5.3	0.4
17	6.2	8	180	204	836	105	13	160	187	1.5	6.0	0.4
18	6.0	8	198	249	713	116	15	164	187	1.5	6.5	0.4
19	5.9	8	149	243	716	95	14	167	177	1.5	5.0	0.4
20	6.0	11	144	135	1212	146	13	165	131	2.1	6.4	0.4
21	6.2	11	91	96	1297	126	11	161	165	1.7	5.1	0.4
25	5.8	9	119	182	678	83	14	141	199	1.3	4.3	0.3
26	6.1	9	201	370	731	114	15	164	149	1.5	6.9	0.4
27	5.9	8	176	156	766	126	13	176	144	1.6	7.0	0.4
28	6.0	11	101	110	1226	148	13	163	165	1.5	5.4	0.4
29	6.1	11	108	122	1162	134	12	154	194	1.8	6.8	0.4
33	5.9	8	143	125	767	99	14	122	133	1.4	5.1	0.3
34	5.7	12	137	166	1130	132	17	144	166	2.0	6.5	0.4
35	5.8	14	150	165	1454	167	19	153	201	2.2	9.0	0.5
36	6.2	11	99	111	1344	141	14	162	195	1.7	5.6	0.5
37	6.1	12	100	111	1294	143	13	171	211	1.9	7.3	0.4

Field point	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
41	6.0	10	118	137	1027	114	14	126	194	2.0	7.1	0.4
42	5.6	14	77	164	1593	151	16	135	128	2.0	5.0	0.4
43	5.8	12	78	116	1268	126	14	133	170	1.8	4.4	0.4
44	6.1	12	76	117	1303	133	13	146	183	1.8	5.4	0.4
45	6.1	10	77	133	1073	122	13	149	179	1.5	5.3	0.4
49	5.9	15	90	94	1968	162	15	113	116	2.2	6.3	0.5
50	6.0	14	74	95	1723	147	14	121	143	2.1	5.2	0.4
51	5.8	15	78	113	1710	151	14	131	178	2.2	6.1	0.5
52	6.2	10	81	95	1195	104	12	136	159	2.6	5.0	0.4
53	5.9	11	120	100	1227	149	12	151	163	2.6	7.3	0.4
54	5.9	9	93	72	944	103	11	161	130	2.2	5.0	0.3
57	6.4	18	91	86	2674	82	15	97	140	2.8	7.8	0.7
58	5.9	14	124	231	1660	169	15	154	123	2.9	8.7	0.4
59	6.0	14	159	257	1585	172	15	142	110	2.4	6.1	0.4
60	6.1	13	119	162	1501	170	15	155	162	2.5	7.5	0.5
61	5.9	13	170	199	1369	186	15	141	126	2.4	8.2	0.4
62	6.1	11	119	73	1231	128	11	149	154	2.4	6.9	0.4
Mean	**6.0**	11	126	153	1239	131	14	149	162	2.0	6.2	0.4
Median	**6.0**	11	119	129	1227	130	14	152	164	2.0	6.2	0.4

Field point	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
Minimum	**5.6**	8	74	72	678	82	11	97	110	1.3	4.3	0.3
Maximum	**6.4**	18	230	370	2674	186	19	180	211	2.9	9.0	0.7
Standard deviation	**0.2**	2	43	69	419	26	2	19	28	0.4	1.2	0.1
Coefficient of variation, %	**3**	22	34	45	34	20	12	13	17	22	19	17
Count	34											

Table 41. Soil analyses of 0 to 4 inch samples collected from the buffer zone of Field 12, collected 2014.

Field point	pH	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
		------------------------------------ mg/kg ------------------------------------									
9	5.9	138	115	776	81	18	149	186	1.2	3.2	0.2
10	6.0	143	196	763	79	14	138	226	0.9	3.2	0.2
11	5.6	147	88	681	68	17	155	245	1.2	2.4	0.1
13	6.0	65	70	1621	98	13	128	181	1.4	3.7	0.3
22	5.3	71	56	734	67	13	261	157	0.7	2.5	0.1
30	5.6	53	212	873	69	12	155	165	0.7	2.6	0.1
38	5.8	52	45	828	49	15	92	119	0.9	3.0	0.1
47	5.9	42	76	1838	117	15	96	96	1.4	2.4	0.3
63	6.0	97	282	1723	148	16	139	69	1.5	2.6	0.3
Mean	5.8	90	127	1093	86	15	146	160	1.1	2.8	0.2
Median	5.9	71	88	828	79	15	139	165	1.2	2.6	0.2
Minimum	5.3	42	45	681	49	12	92	69	0.7	2.4	0.1
Maximum	6.0	147	282	1838	148	18	261	245	1.5	3.7	0.3
Standard deviation	0.2	43	83	482	30	2	49	58	0.3	0.5	0.1
Coefficient of variation, %	4	47	66	44	35	13	34	36	28	16	49
Count	9										

Table 42. Soil analyses of 0 to 4 inch samples collected from the buffer zone of Field 12, collected February 2016.

Lab number	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
		cmolc/kg	- mg/kg -									
8	5.4	11	148	353	961	129	15	214	254	1.5	7.4	0.7
9	5.5	11	190	183	981	112	18	211	244	1.6	5.3	0.5
10	5.3	10	160	183	912	96	16	175	238	1.6	4.8	0.4
13	5.8	16	97	129	1830	134	15	215	140	2.4	5.3	0.6
22	5.4	10	40	63	991	65	8	143	123	1.1	2.2	0.2
30	5.3	10	64	48	976	80	15	241	174	1.3	3.6	0.3
38	5.5	10	81	60	962	80	16	255	219	1.4	4.0	0.4
46	5.9	9	77	94	930	108	14	181	161	1.2	4.3	0.4
47	6.1	11	27	59	1378	107	9	163	164	1.3	3.8	0.5
55	5.8	12	55	59	1386	98	12	177	174	1.7	3.9	0.4
63	5.4	10	104	84	845	106	16	220	162	1.6	4.2	0.3
Mean	5.6	10.9	95	120	1105	101	14	200	187	1.5	4.4	0.4
Median	5.5	10.0	81	84	976	106	15	211	174	1.5	4.2	0.4
Minimum	5.3	9.0	27	48	845	65	8	143	123	1.1	2.2	0.2
Maximum	6.1	16.0	190	353	1830	134	18	255	254	2.4	7.4	0.7
Standard deviation	0.3	1.9	52	92	300	21	3	34	45	0.3	1.3	0.1

Lab number	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
Coefficient of variation, %	5	5	55	77	27	20	35	22	17	24	23	29
Count	11											

Table 43. Soil analyses of 0 to 4 inch samples collected from the buffer zone of Field 12, collected March 2018.

Field point	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
		cmolc/kg	- mg/kg -									
8	7.1	12.0	161	770	1332	158	24	165	283	1.6	10.7	0.6
9	6.2	8.7	192	194	950	107	14	164	190	1.5	6.1	0.4
10	6.2	9.4	256	238	986	151	15	172	204	1.8	9.2	0.4
13	6.3	14.7	125	126	1900	151	14	171	150	2.1	6.3	0.5
22	5.8	8.3	59	99	674	73	11	204	114	1.1	2.4	0.3
30	6.2	8.4	97	53	986	89	12	194	140	1.5	5.3	0.3
38	5.9	8.7	91	74	912	98	11	173	166	1.4	4.9	0.3
46	6.1	8.7	96	77	894	105	10	179	140	1.5	5.9	0.4
47	5.9	11.0	31	42	1351	72	10	134	198	1.9	3.5	0.4
55	5.9	11.5	52	50	1417	85	11	140	181	2.5	3.7	0.4
63	5.8	8.4	72	50	700	91	9	153	132	1.8	3.1	0.2
Mean	6.1	10.0	112	161	1100	107	13	168	173	1.7	5.6	0.4
Median	6.1	8.7	96	77	986	98	11	171	166	1.6	5.3	0.4
Minimum	5.8	8.3	31	42	674	72	9	134	114	1.1	2.4	0.2
Maximum	7.1	14.7	256	770	1900	158	24	204	283	2.5	10.7	0.6
Standard deviation	0.4	2.1	67	212	364	32	4	21	47	0.4	2.5	0.1

Field point	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
Coefficient of variation, %	6	6	60	131	33	29		33	12	27	22	46
Count	11											

APPENDIX E: SPATIAL DISTRIBUTION OF MEHLICH-3 EXTRACTABLE ELEMENTS

List of Figures

Field 1, 0 to 4 inch depth: 2014

pH

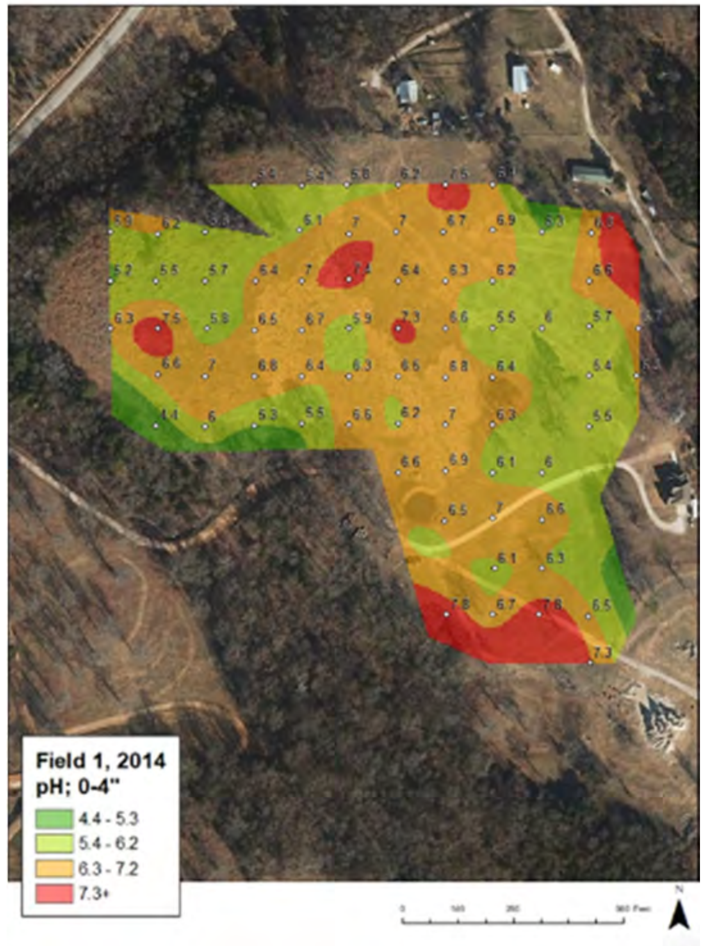

Figure 1. Distribution of soil pH for 0 to 4 inch depth of grid sampling of Field 1 in 2014.

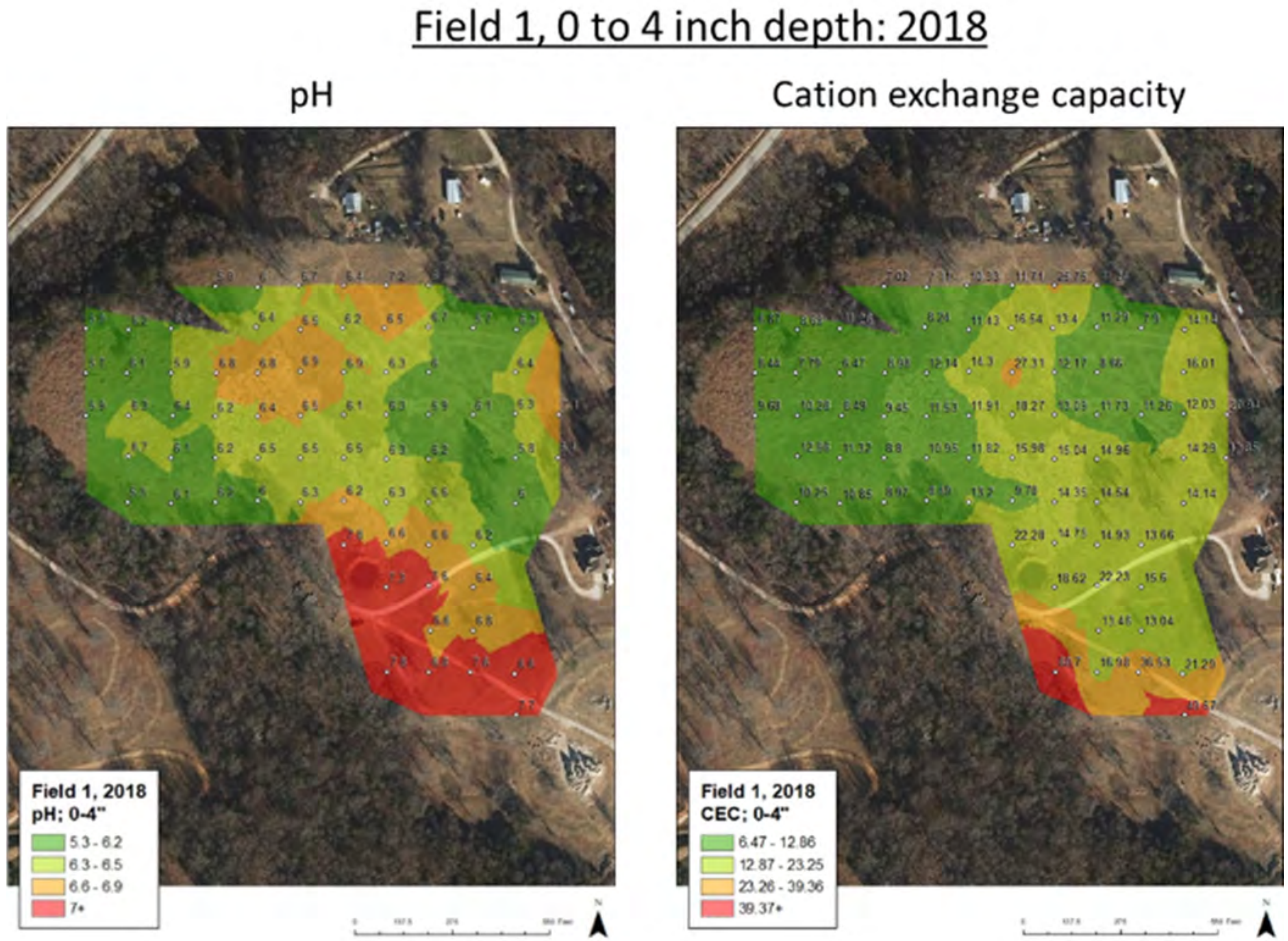

Figure 2. **Distribution of soil pH and cation exchange capacity for 0 to 4 inch depth of grid sampling of Field 1 in 2018.**

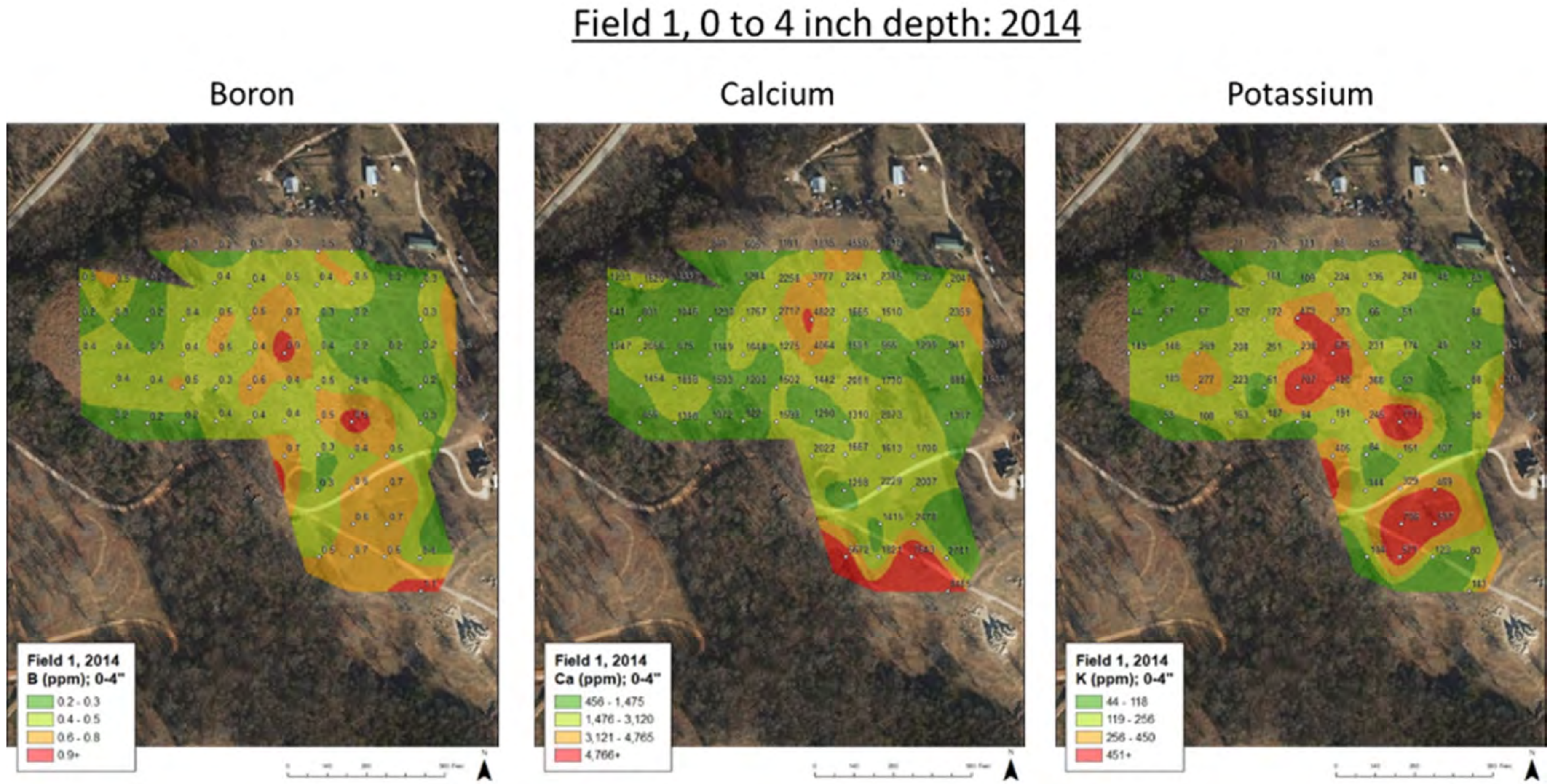

Figure 3. **Distribution of Mehlich-3 extractable Boron, Calcium, and Potassium for 0 to 4 inch depth of grid sampling of Field 1 in 2014.**

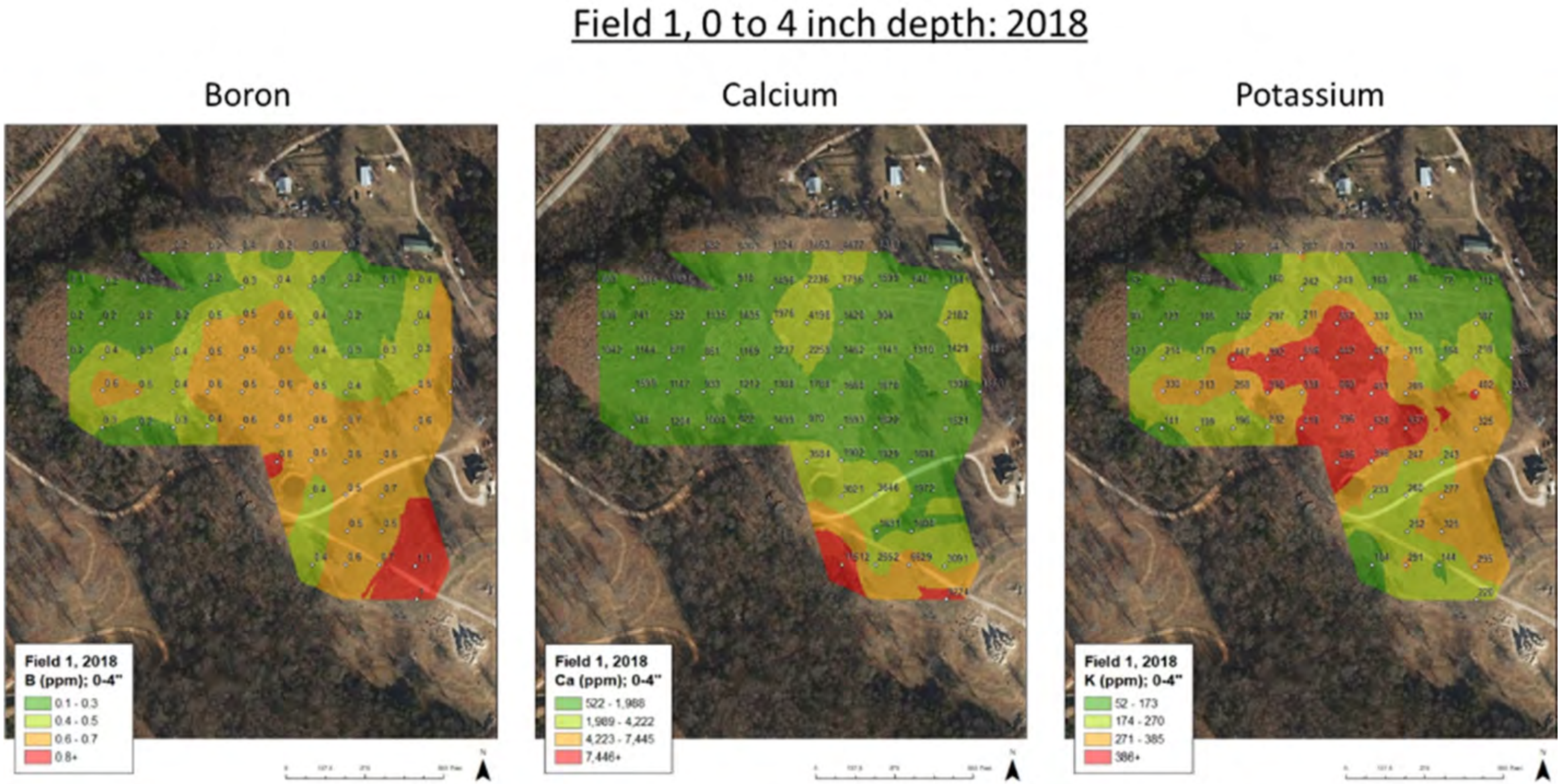

Figure 4. **Distribution of Mehlich-3 extractable Boron, Calcium, and Potassium for 0 to 4 inch depth of grid sampling of Field 1 in 2018.**

Field 1, 0 to 4 inch depth: 2014

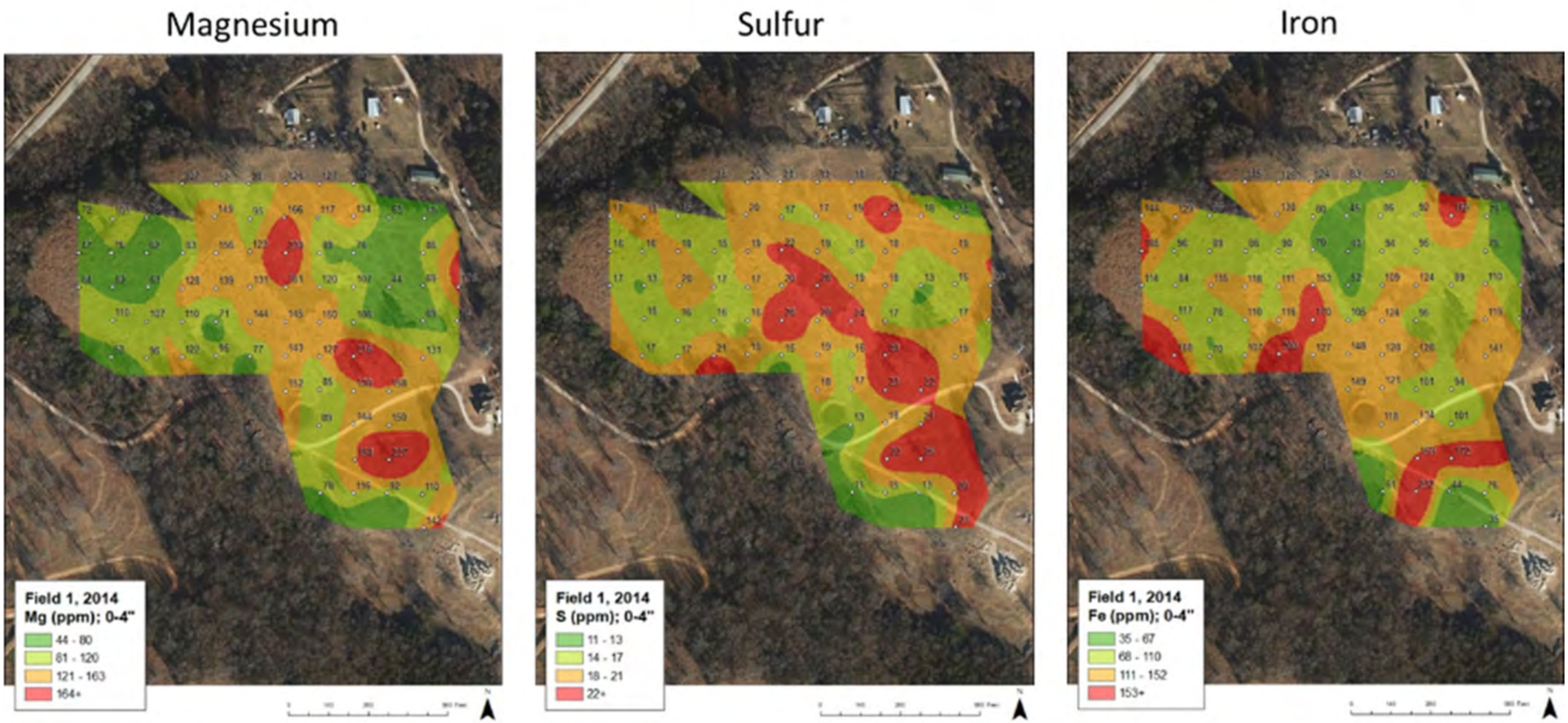

Figure 5. **Distribution of Mehlich-3 extractable Magnesium, Sulfur, and Iron for 0 to 4 inch depth of grid sampling of Field 1 in 2014.**

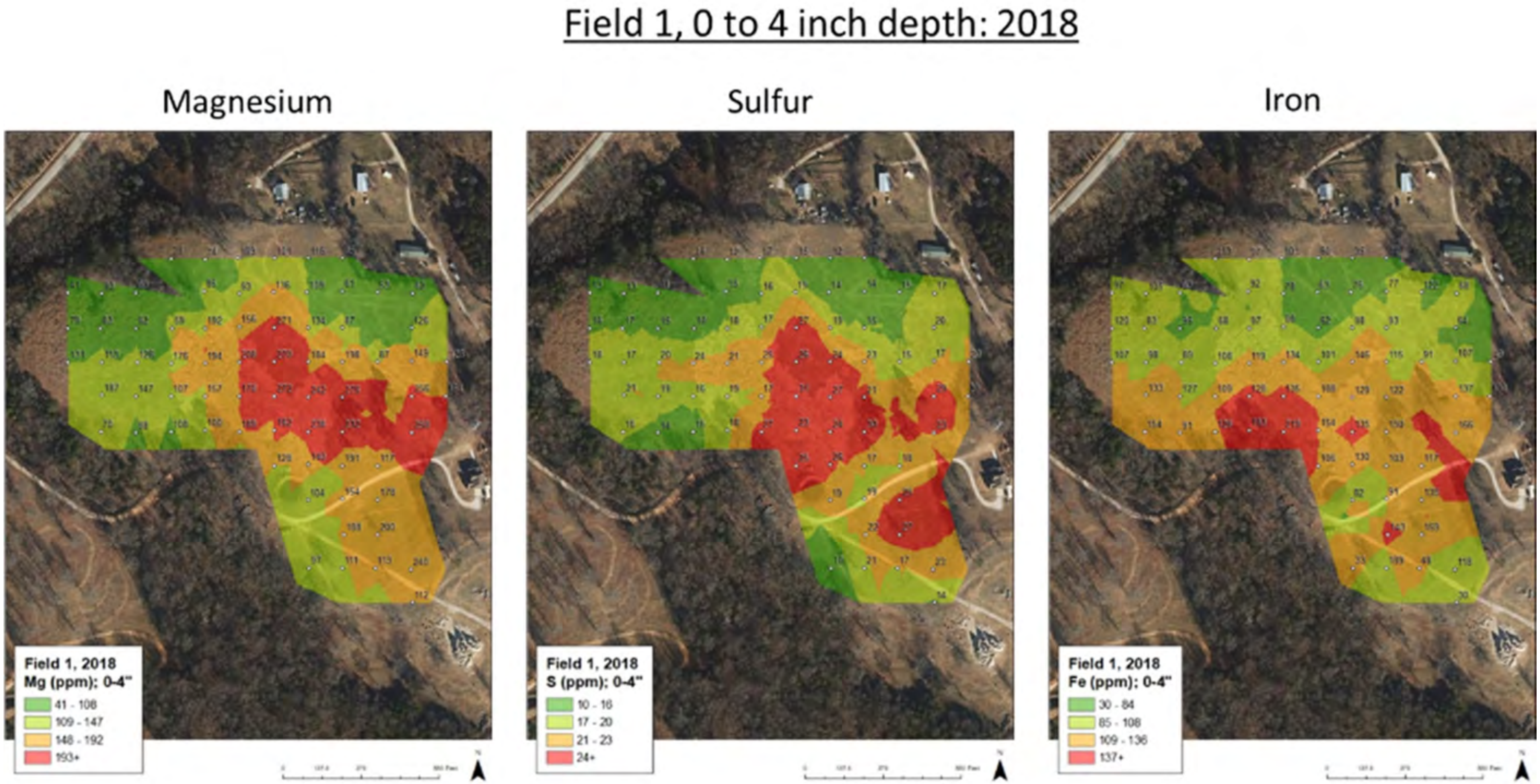

Figure 6. **Distribution of Mehlich-3 extractable Magnesium, Sulfur, and Iron for 0 to 4 inch depth of grid sampling of Field 1 in 2018.**

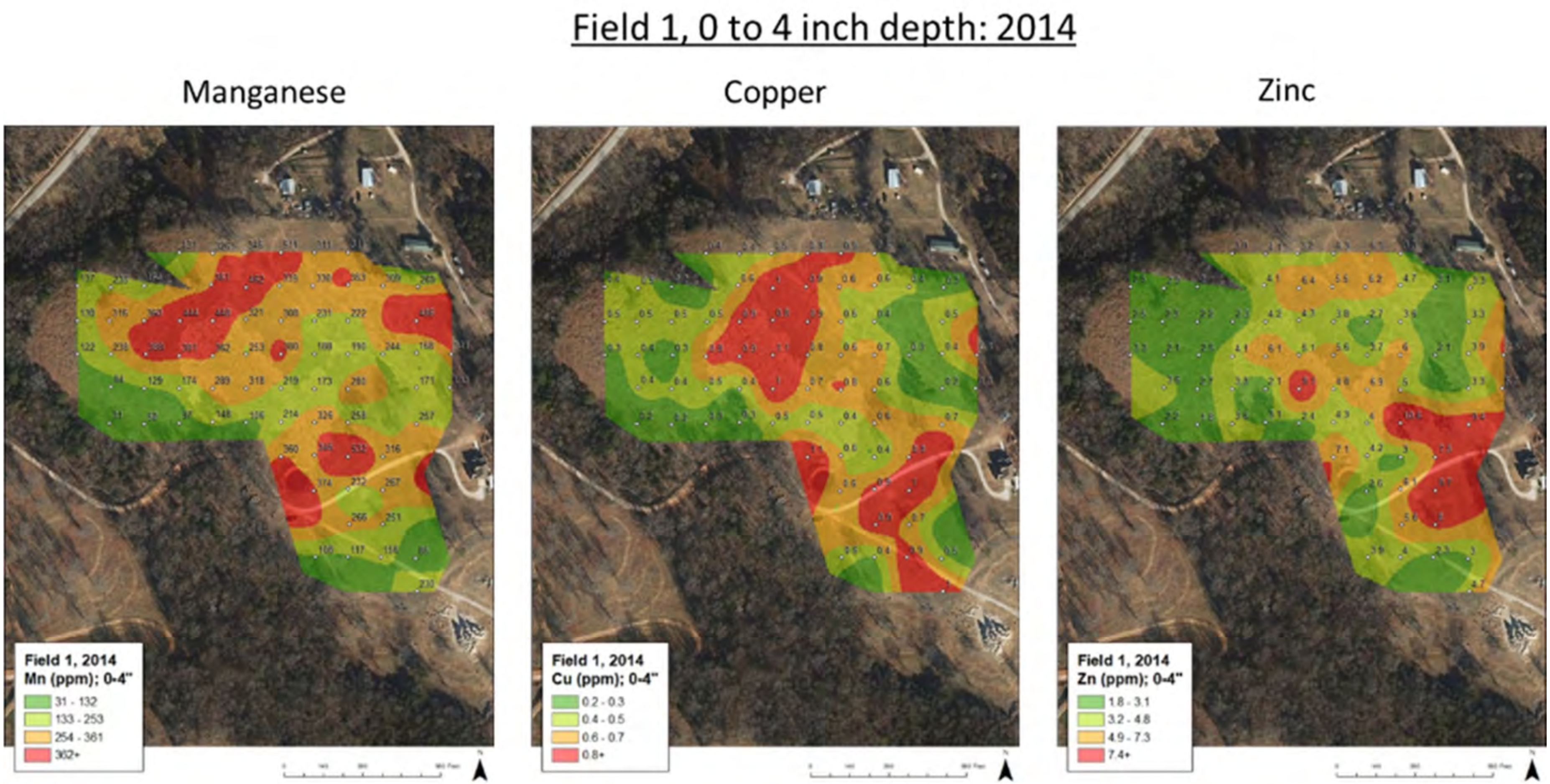

Figure 7. **Distribution of Mehlich-3 extractable Manganese, Copper and Zinc for 0 to 4 inch depth of grid sampling of Field 1 in 2014.**

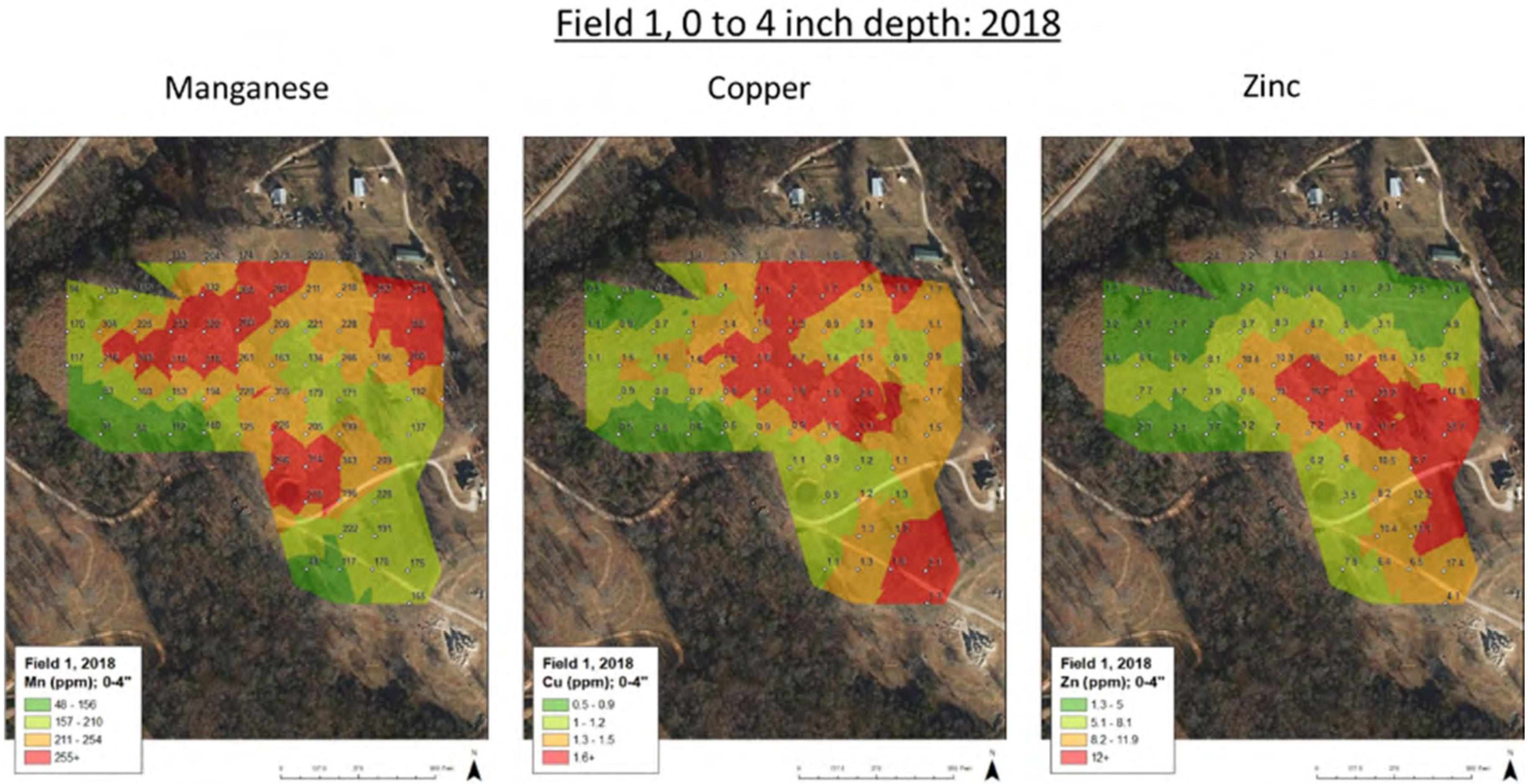

Figure 8. Distribution of Mehlich-3 extractable Manganese, Copper and Zinc for 0 to 4 inch depth of grid sampling of Field 1 in 2018.

Field 5a, 0 to 4 inch depth: 2014

pH

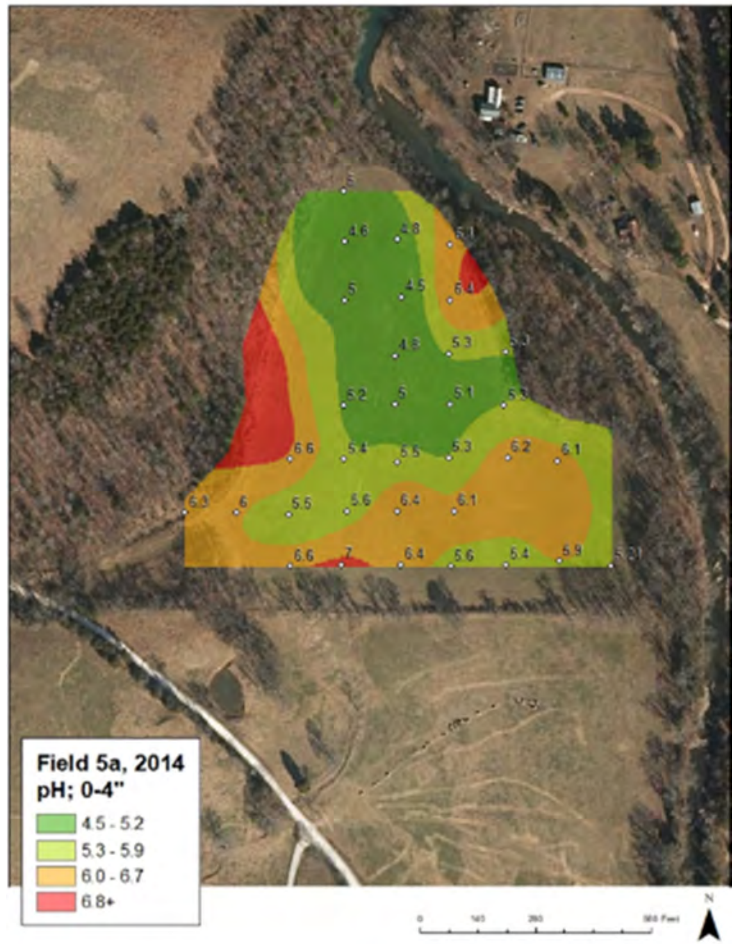

Figure 9. **Distribution of soil pH for 0 to 4 inch depth of grid sampling of Field 5a in 2014.**

Field 5a, 0 to 4 inch depth: 2018

pH | Cation exchange capacity

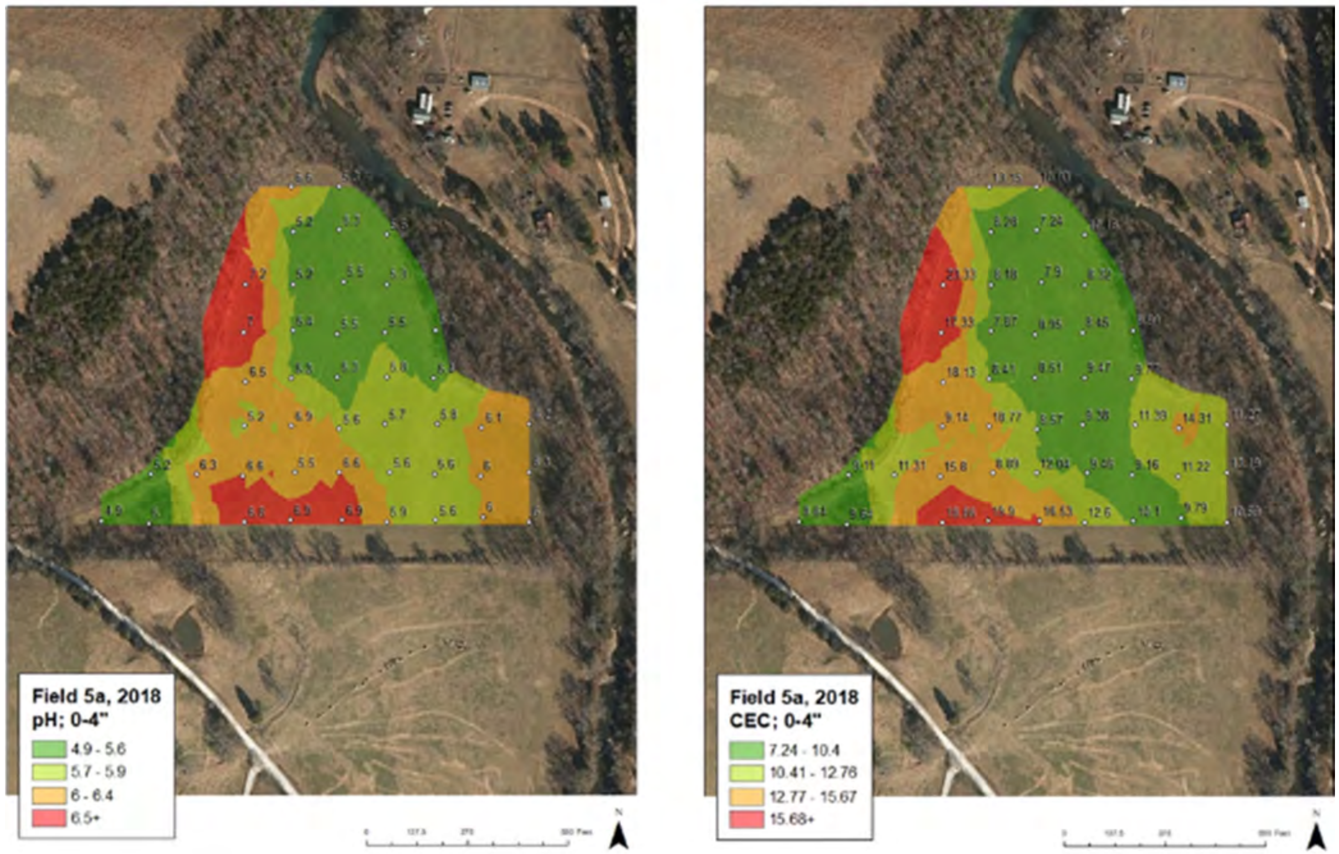

Figure 10. **Distribution of soil pH and cation exchange capacity for 0 to 4 inch depth of grid sampling of Field 5a in 2018.**

Field 5a, 0 to 4 inch depth: 2014

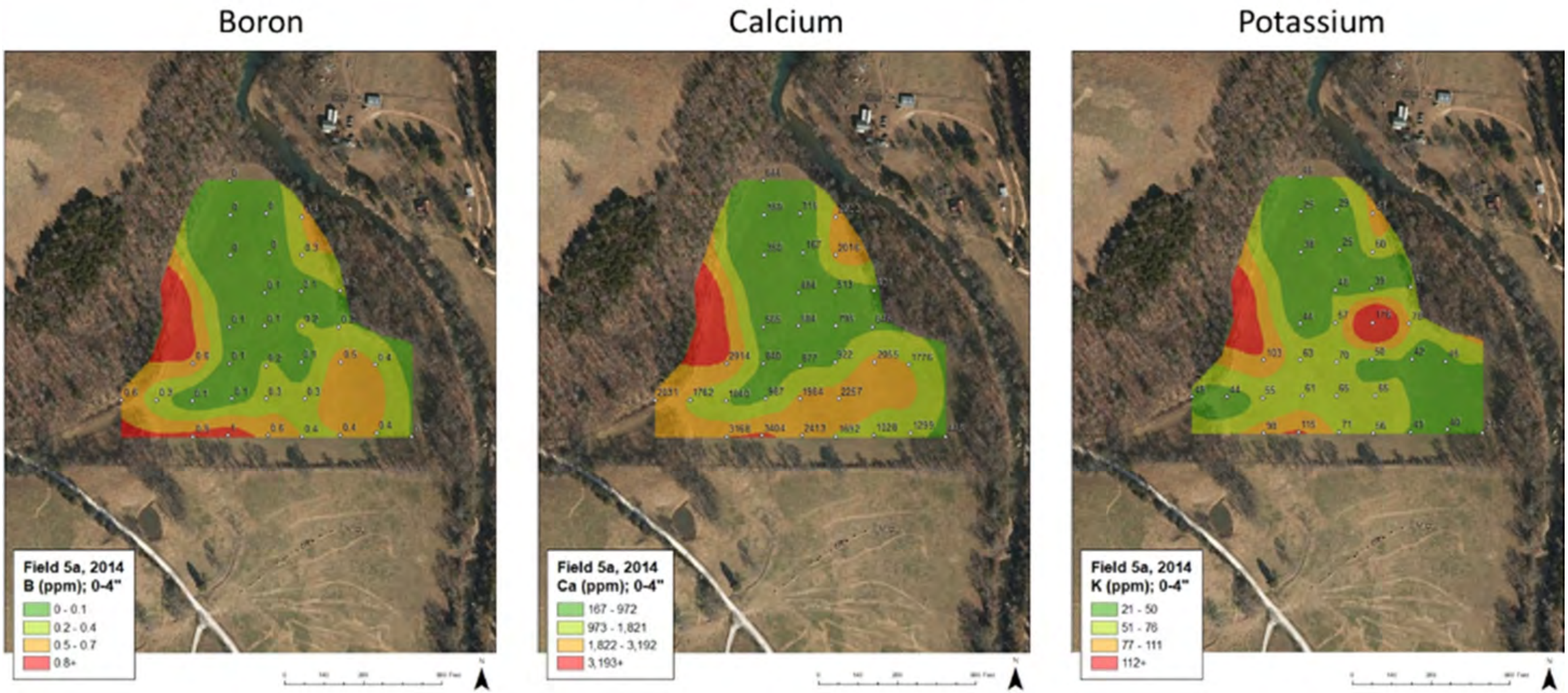

Figure 11. **Distribution of Mehlich-3 extractable Boron, Calcium, and Potassium for 0 to 4 inch depth of grid sampling of Field 5a in 2014.**

Field 5a, 0 to 4 inch depth: 2018

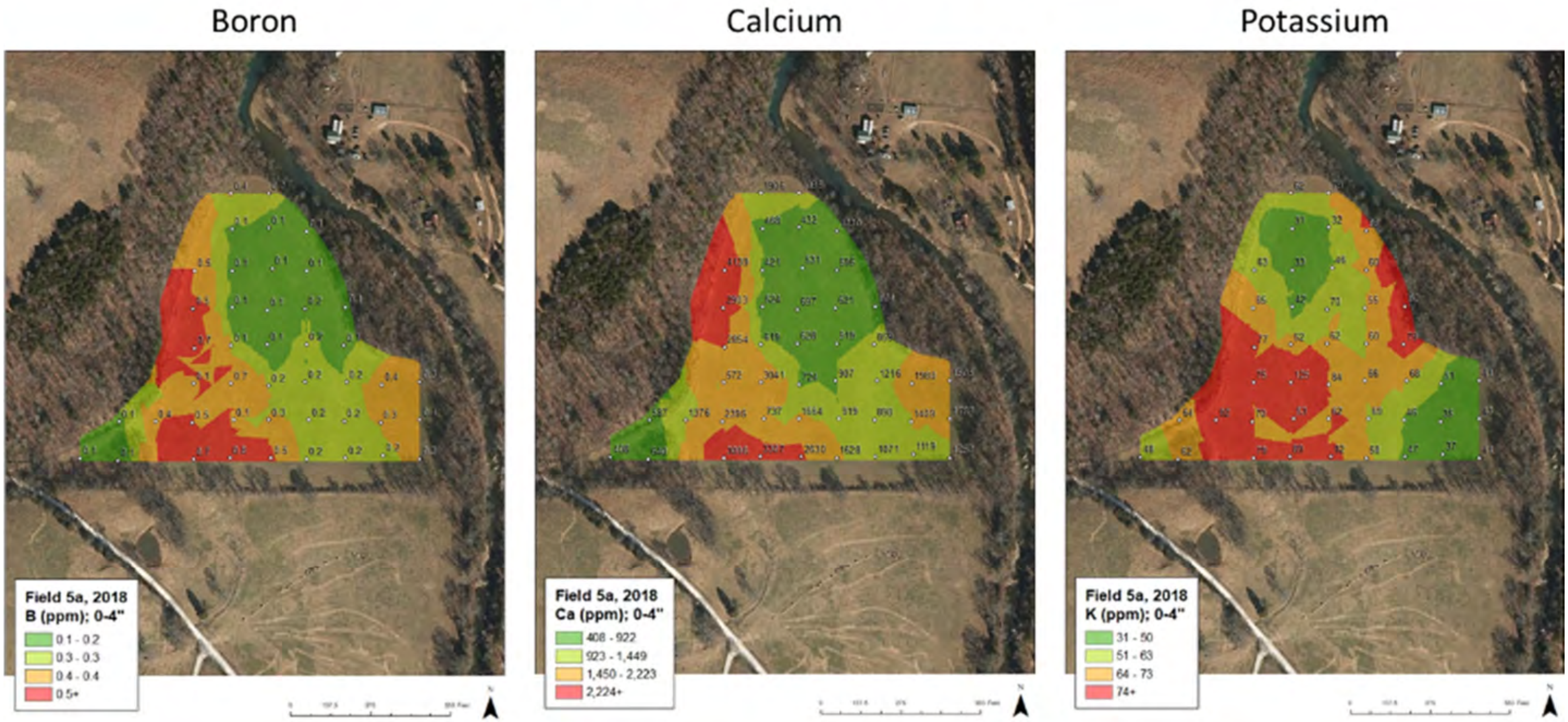

Figure 12. **Distribution of Mehlich-3 extractable Boron, Calcium, and Potassium for 0 to 4 inch depth of grid sampling of Field 5a in 2018.**

Field 5a, 0 to 4 inch depth: 2014

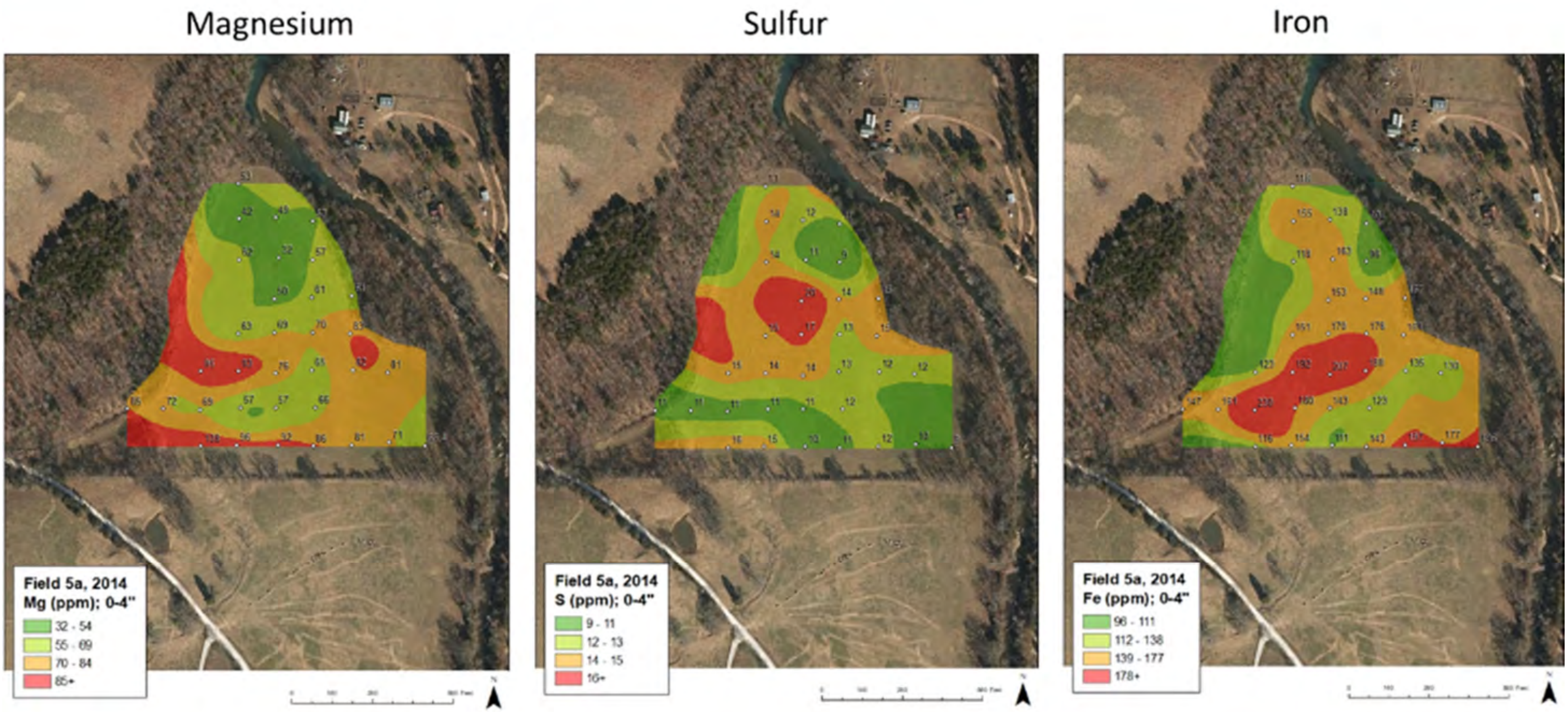

Figure 13. Distribution of Mehlich-3 extractable Magnesium, Sulfur, and Iron for 0 to 4 inch depth of grid sampling of Field 5a in 2014.

Field 5a, 0 to 4 inch depth: 2018

Magnesium | Sulfur | Iron

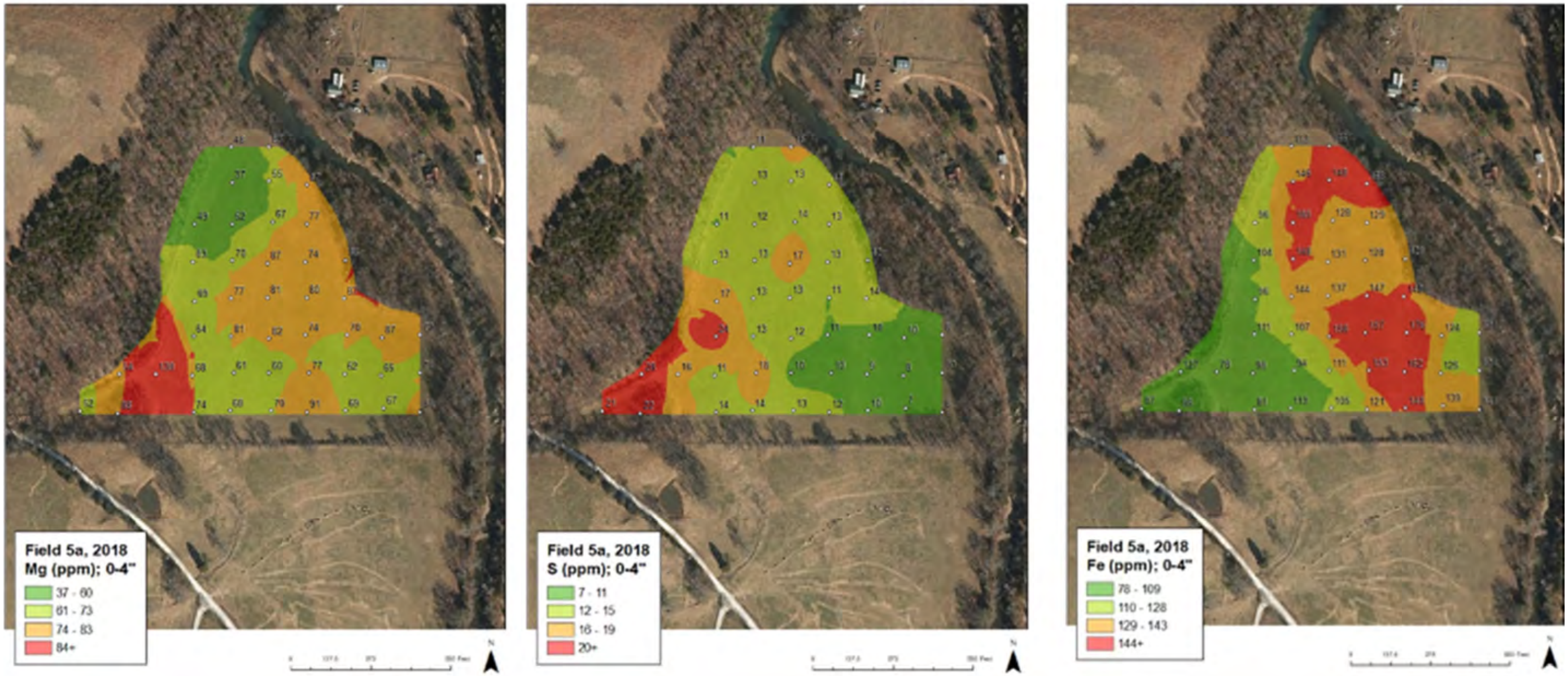

Figure 14. **Distribution of Mehlich-3 extractable Magnesium, Sulfur, and Iron for 0 to 4 inch depth of grid sampling of Field 5a in 2018.**

Field 5a, 0 to 4 inch depth: 2014

Manganese Copper Zinc

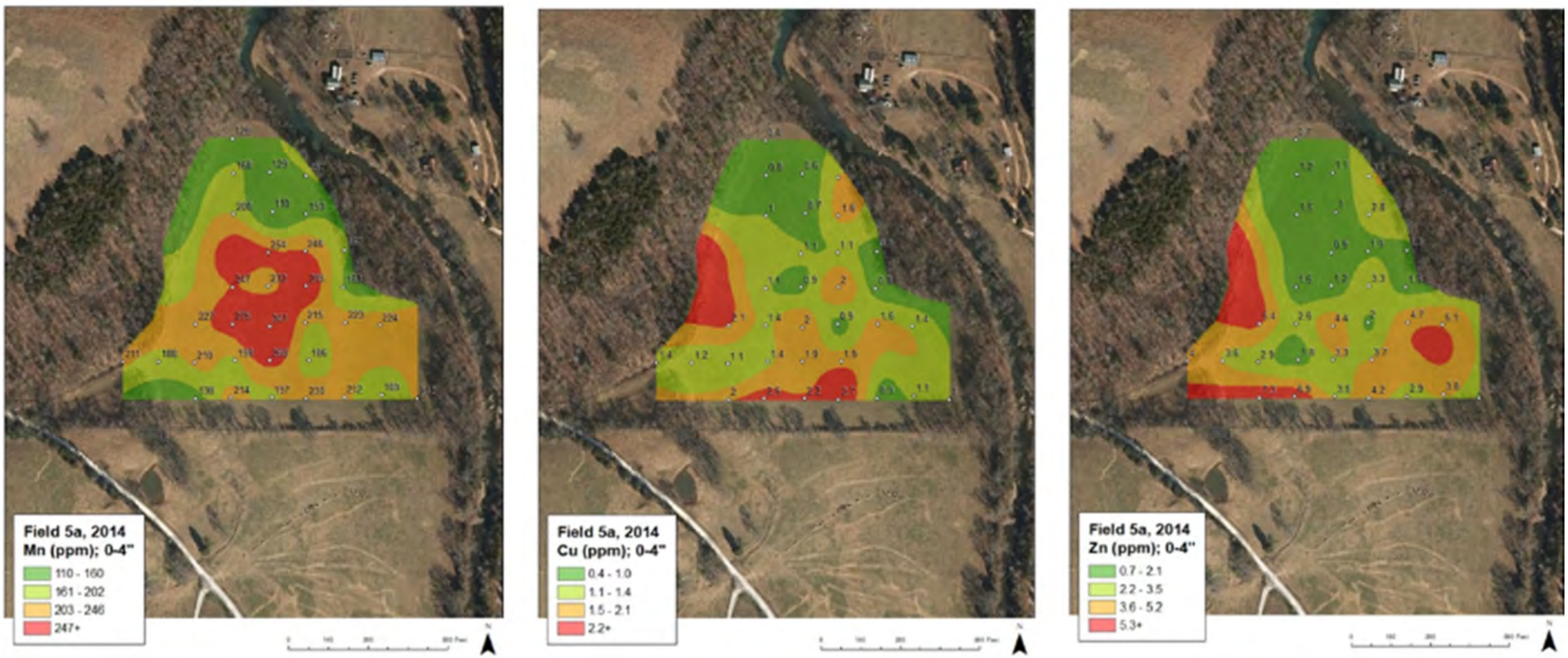

Figure 15. Distribution of Mehlich-3 extractable Manganese, Copper and Zinc for 0 to 4 inch depth of grid sampling of Field 5a in 2014.

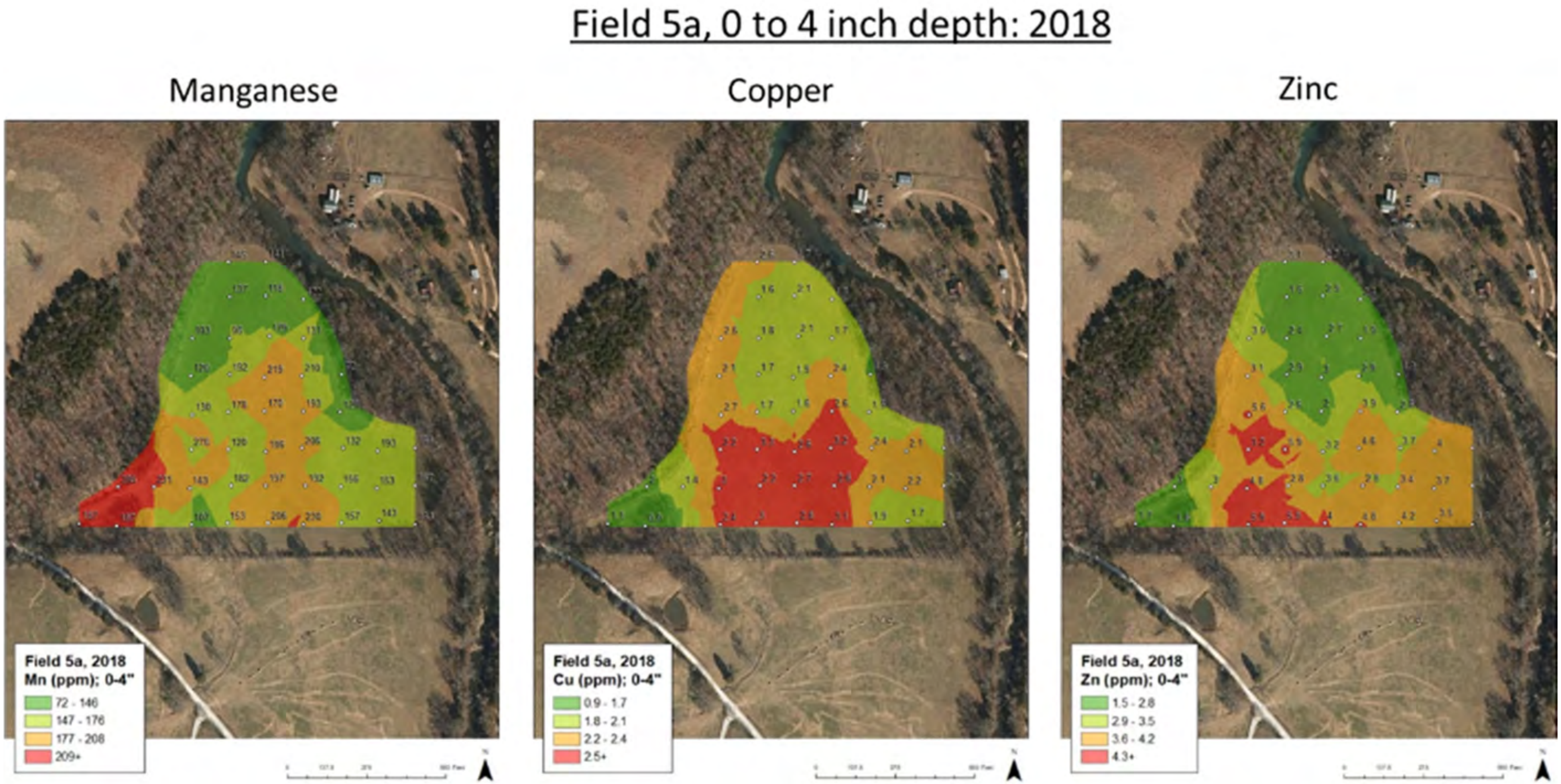

Figure 16. **Distribution of Mehlich-3 extractable Manganese, Copper and Zinc for 0 to 4 inch depth of grid sampling of Field 5a in 2018.**

Field 12, 0 to 4 inch depth: 2014

pH

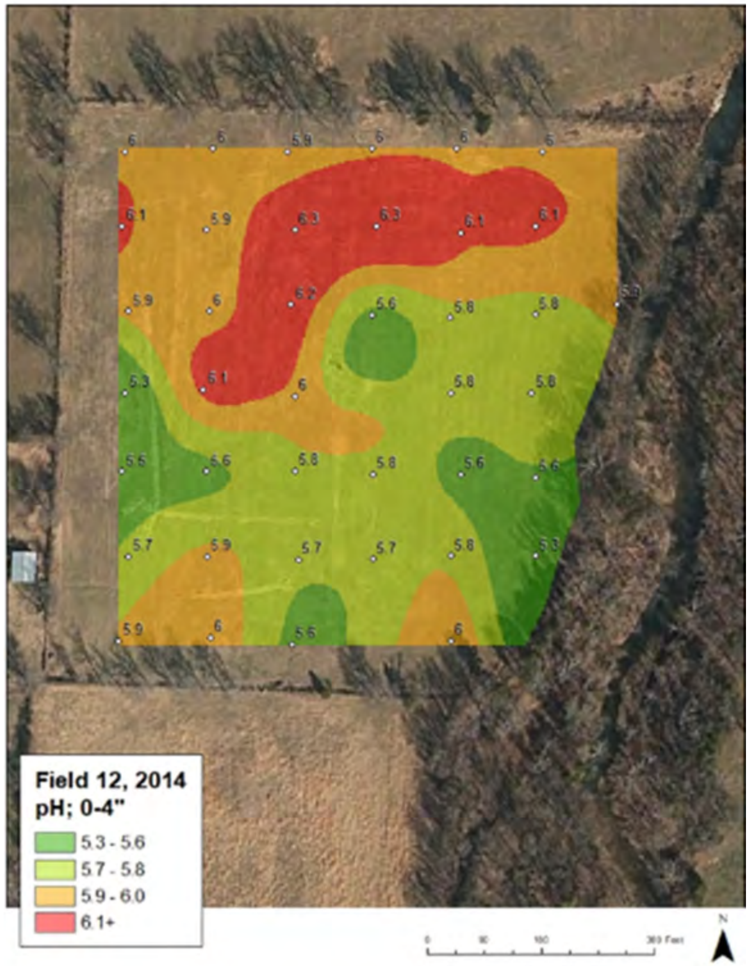

Figure 17. **Distribution of soil pH for 0 to 4 inch depth of grid sampling of Field 12 in 2014.**

Field 12, 0 to 4 inch depth: 2018

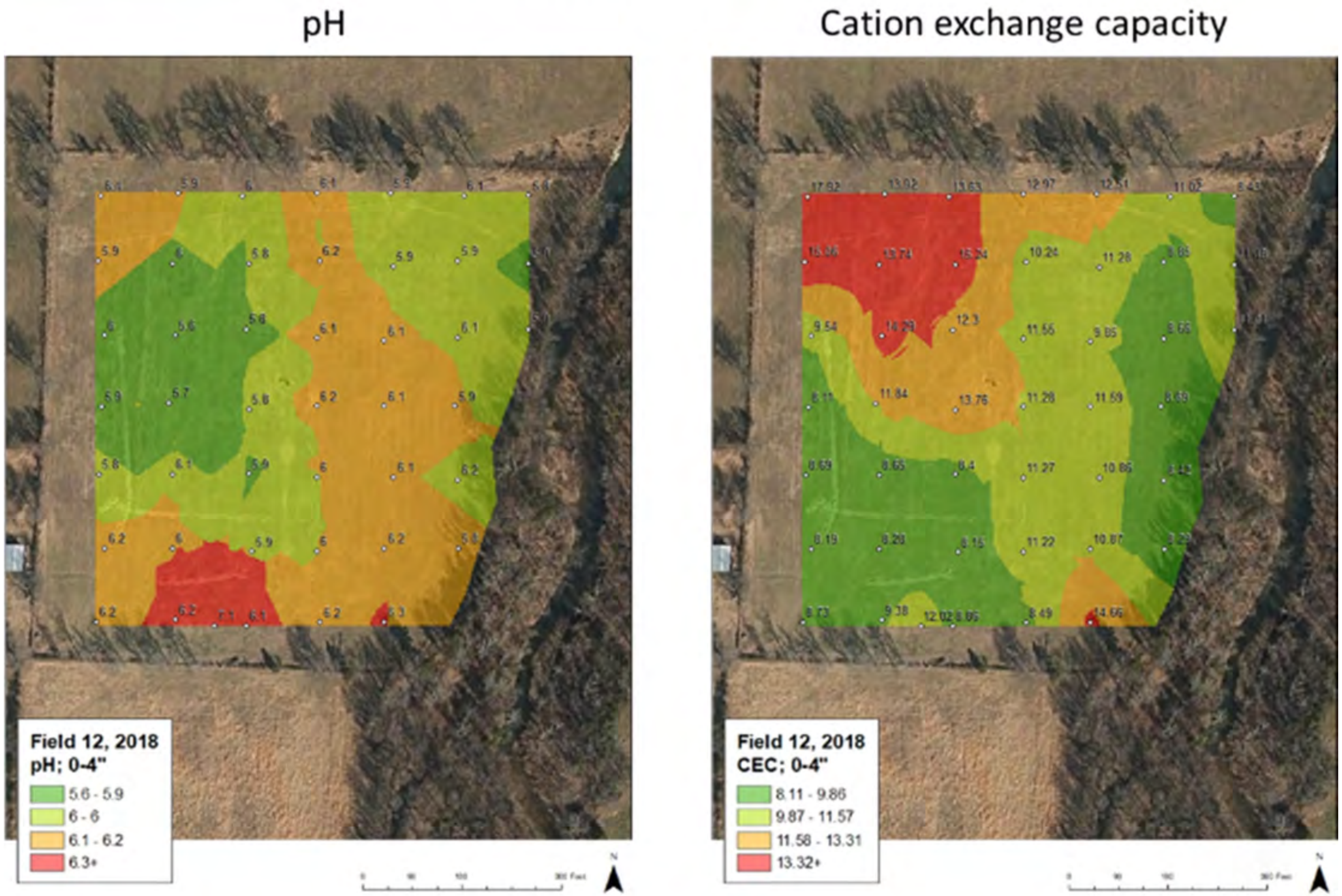

Figure 18. Distribution of soil pH and cation exchange capacity for 0 to 4 inch depth of grid sampling of Field 12 in 2018.

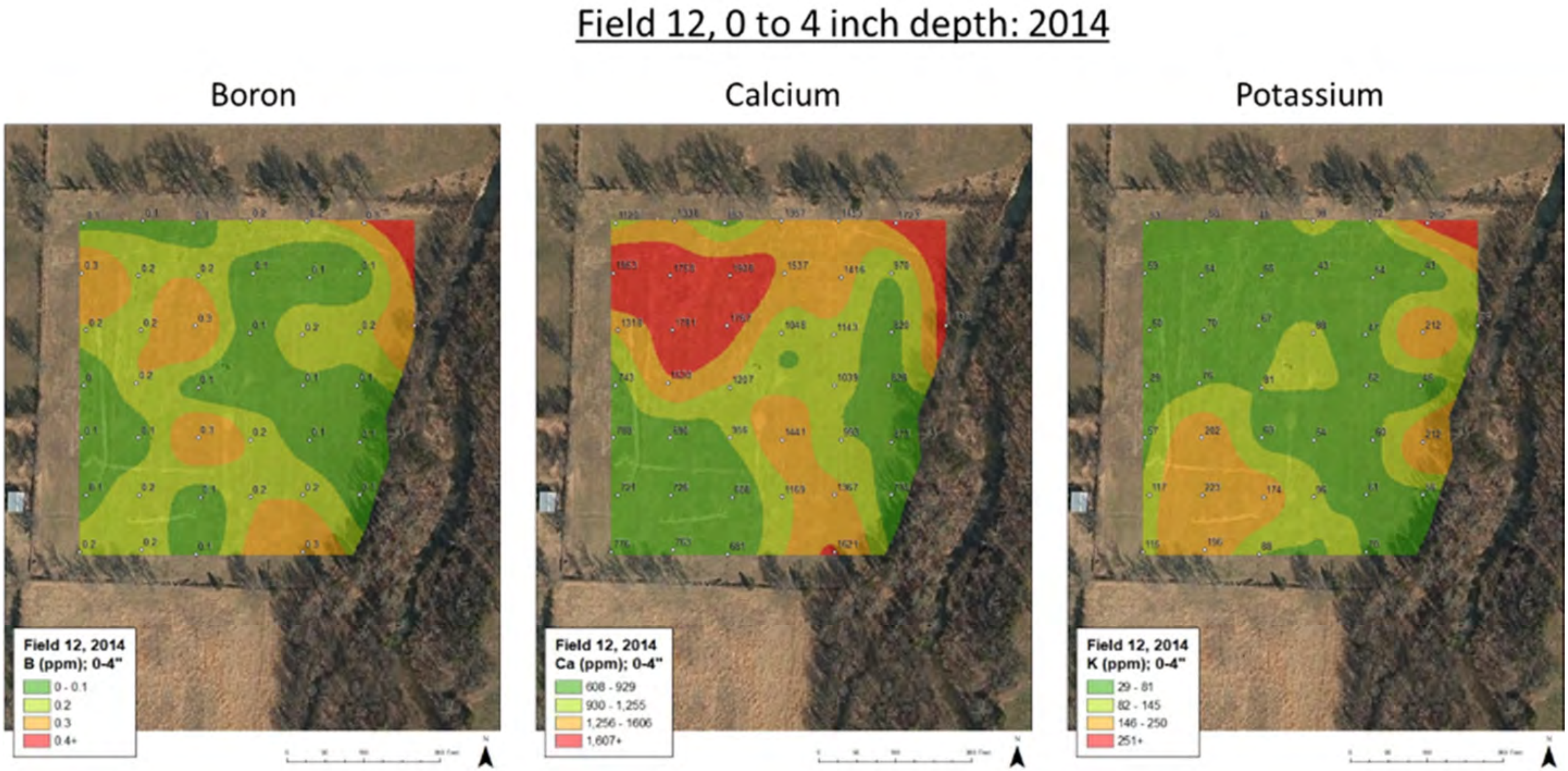

Figure 19. **Distribution of Mehlich-3 extractable Boron, Calcium, and Potassium for 0 to 4 inch depth of grid sampling of Field 12 in 2014.**

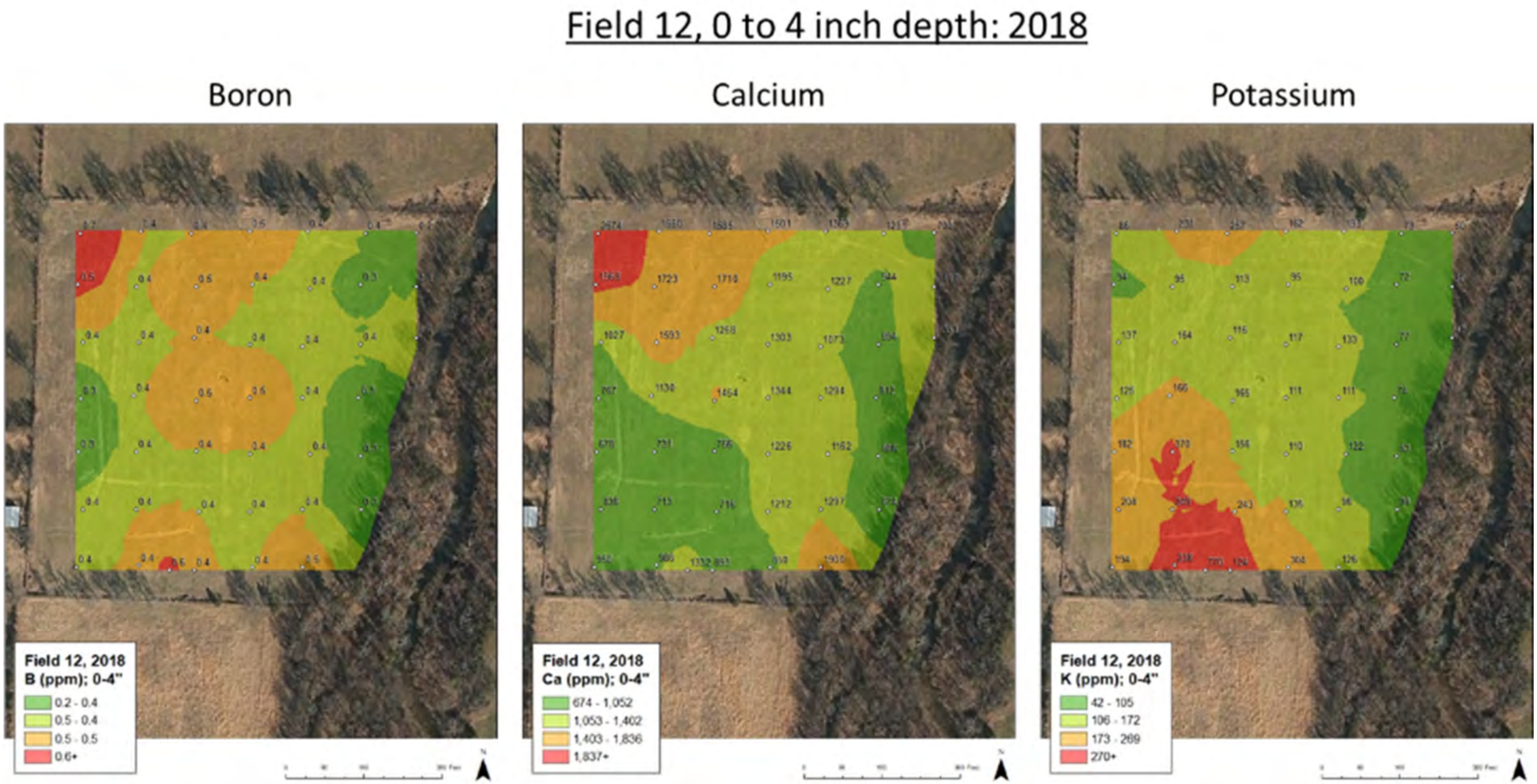

Figure 20. **Distribution of Mehlich-3 extractable Boron, Calcium, and Potassium for 0 to 4 inch depth of grid sampling of Field 12 in 2018.**

Field 12, 0 to 4 inch depth: 2014

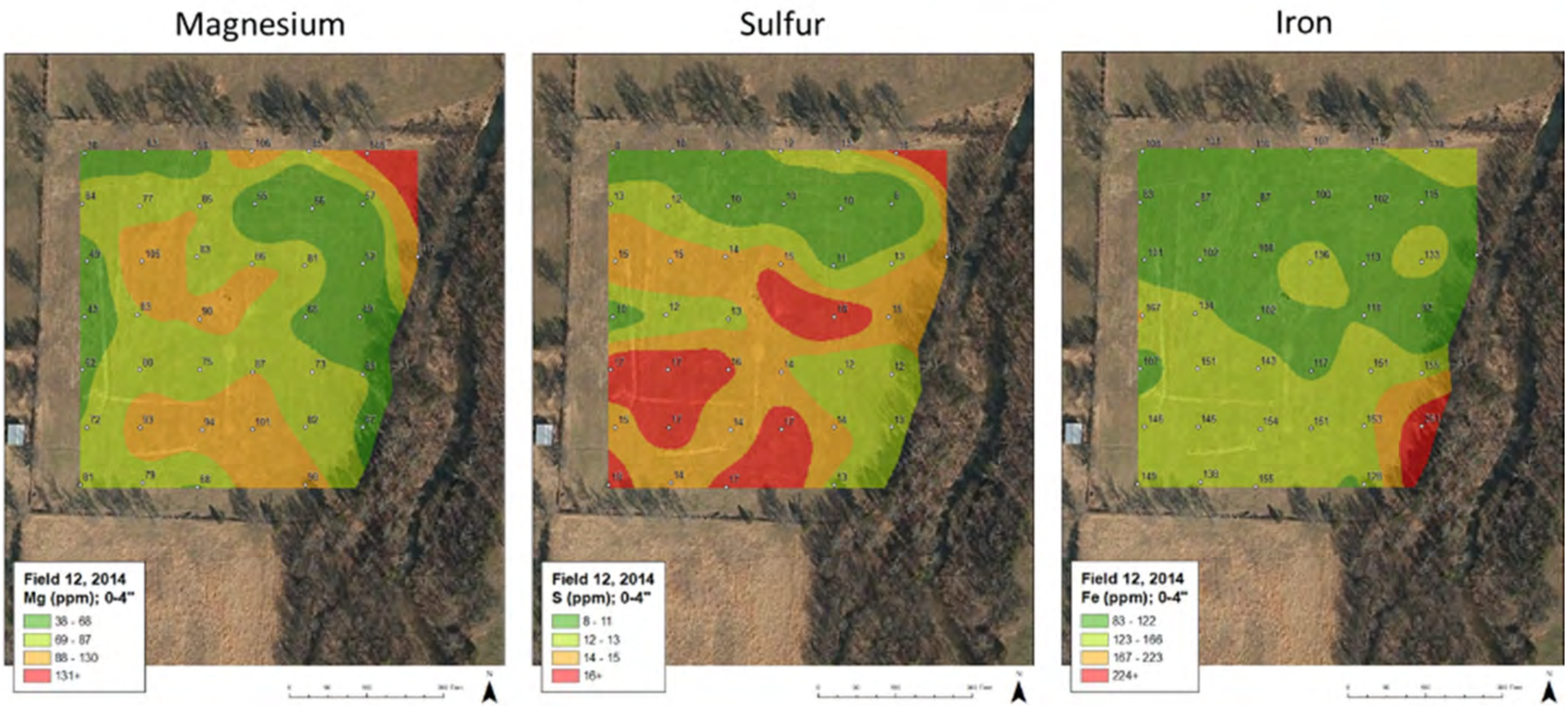

Figure 21. **Distribution of Mehlich-3 extractable Magnesium, Sulfur, and Iron for 0 to 4 inch depth of grid sampling of Field 12 in 2014.**

Field 12, 0 to 4 inch depth: 2018

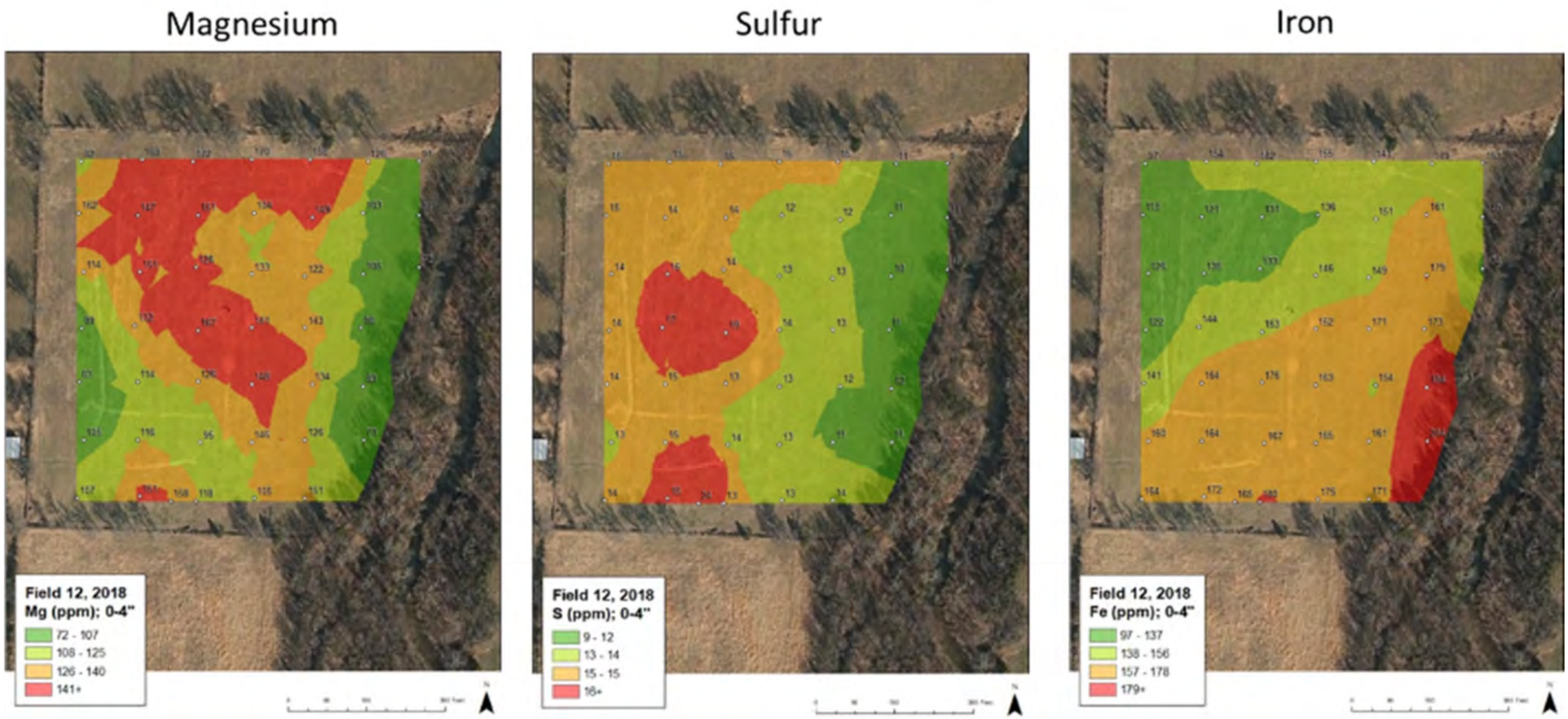

Figure 22. **Distribution of Mehlich-3 extractable Magnesium, Sulfur, and Iron for 0 to 4 inch depth of grid sampling of Field 12 in 2018.**

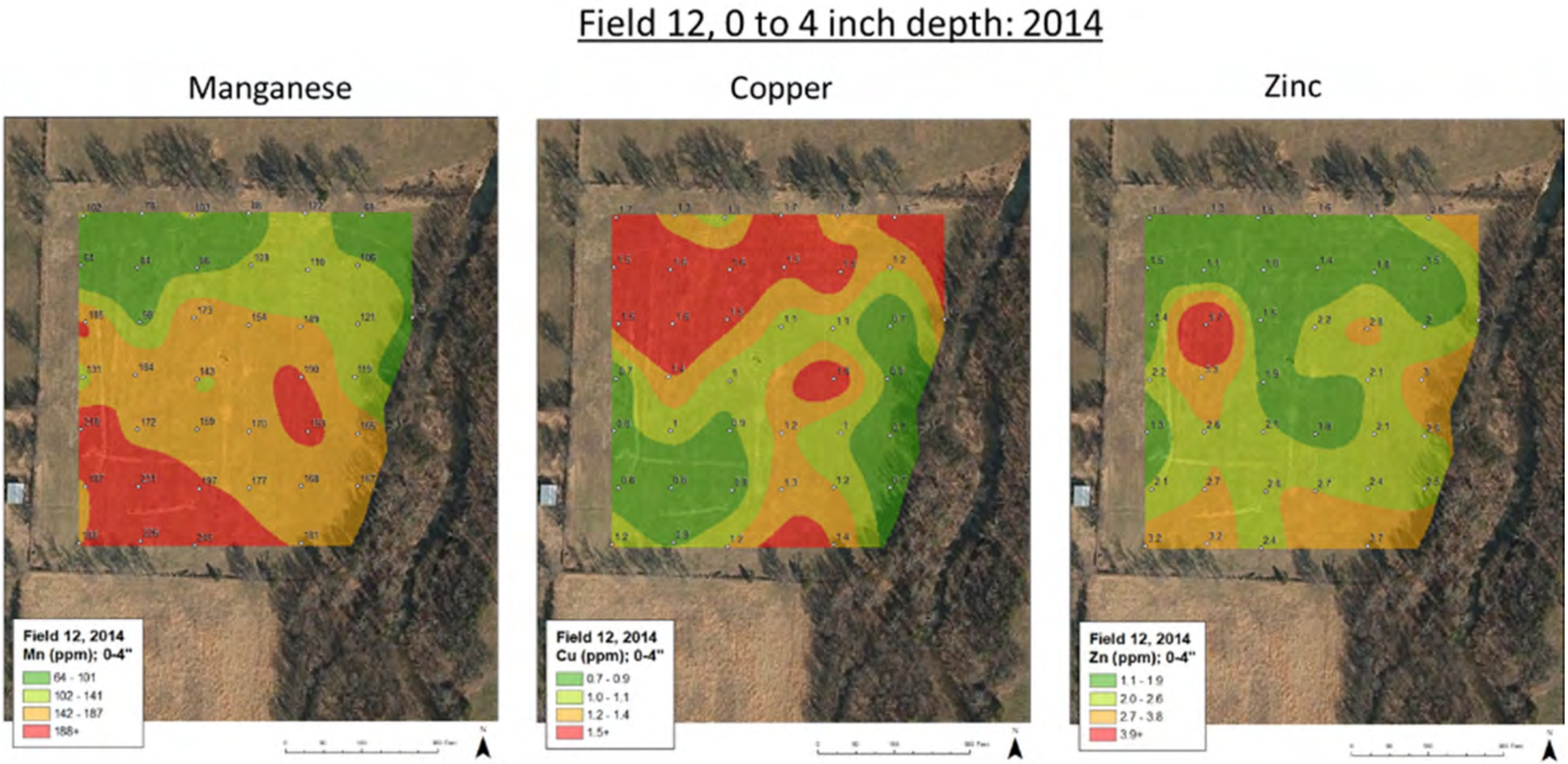

Figure 23. Distribution of Mehlich-3 extractable Manganese, Copper and Zinc for 0 to 4 inch depth of grid sampling of Field 12 in 2014.

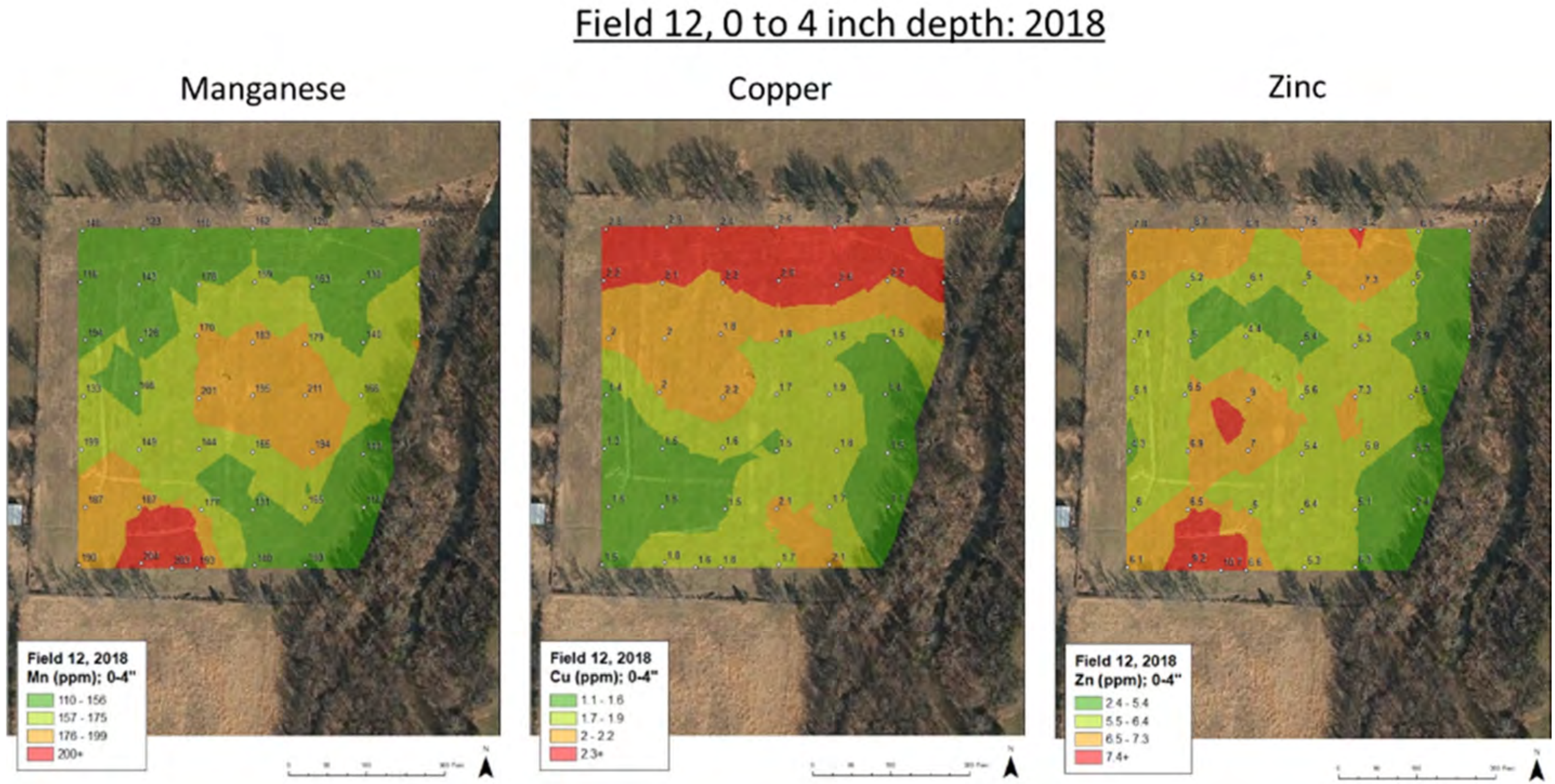

Figure 24. Distribution of Mehlich-3 extractable Manganese, Copper and Zinc for 0 to 4 inch depth of grid sampling of Field 12 in 2018.

APPENDIX F: SOIL P SORPTION SATURATION DATA

LIST OF TABLES

Table 1. Soil P sorption saturation and soil properties related to P sorption for 0 to 4 inch grid-soil samples from Field 1 for 2014.

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
			mg/L				%			
Whole field										
126	0-4"	7.3	30	8465	35	511	9.9	5.0	11.0	5.5
142	0-4"	7.8	32	5672	61	563	9.4	4.7	10.3	5.1
143	0-4"	6.7	99	1821	232	640	22.9	11.5	22.7	11.4
144	0-4"	7.8	18	7643	44	471	6.4	3.2	7.0	3.5
145	0-4"	6.5	28	2741	76	582	7.9	3.9	8.5	4.3
162	0-4"	6.1	83	1415	159	601	21.3	10.7	21.8	10.9
163	0-4"	6.3	98	2478	172	764	20.2	10.1	20.9	10.5
180	0-4"	6.5	22	1298	118	566	6.2	3.1	6.4	3.2
181	0-4"	7	100	2229	134	811	19.9	9.9	21.2	10.6
182	0-4"	6.6	59	2007	101	563	16.8	8.4	17.8	8.9
198	0-4"	6.6	82	2022	149	725	17.9	9.0	18.8	9.4
199	0-4"	6.9	50	1667	121	628	12.7	6.3	13.4	6.7
200	0-4"	6.1	57	1613	101	589	15.6	7.8	16.5	8.3
201	0-4"	6	44	1700	94	567	12.5	6.3	13.3	6.7
212	0-4"	4.4	49	456	188	524	13.9	6.9	13.8	6.9
213	0-4"	6	52	1398	70	567	15.1	7.5	16.3	8.2
214	0-4"	5.3	102	1072	107	586	27.9	13.9	29.4	14.7
215	0-4"	5.5	93	922	200	561	24.6	12.3	24.4	12.2
216	0-4"	6.6	50	1598	127	660	12.1	6.0	12.7	6.4
217	0-4"	6.2	67	1290	148	612	17.1	8.5	17.6	8.8
218	0-4"	7	77	1310	128	635	19.3	9.6	20.2	10.1

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
219	0-4"	6.3	169	2073	128	597	44.7	22.3	46.6	23.3
221	0-4"	5.5	100	1357	141	617	25.4	12.7	26.4	13.2
231	0-4"	6.6	80	1454	117	603	21.1	10.6	22.2	11.1
232	0-4"	7	48	1898	78	588	13.4	6.7	14.4	7.2
233	0-4"	6.8	56	1503	110	576	15.5	7.8	16.3	8.2
234	0-4"	6.4	41	1200	116	568	11.4	5.7	12.0	6.0
235	0-4"	6.3	109	1502	170	587	28.4	14.2	28.8	14.4
236	0-4"	6.5	56	1442	105	577	15.5	7.8	16.4	8.2
237	0-4"	6.8	82	2051	124	563	22.9	11.5	23.9	11.9
238	0-4"	6.4	55	1730	95	579	15.3	7.7	16.3	8.2
240	0-4"	5.4	60	889	119	589	16.2	8.1	16.9	8.5
241	0-4"	6.3	71	1638	97	591	19.4	9.7	20.6	10.3
249	0-4"	6.3	66	1247	114	621	17.0	8.5	18.0	9.0
250	0-4"	7.5	39	2056	84	603	10.6	5.3	11.4	5.7
251	0-4"	5.8	35	675	115	611	9.1	4.6	9.6	4.8
252	0-4"	6.5	63	1149	118	614	16.4	8.2	17.2	8.6
253	0-4"	6.7	90	1649	111	564	25.4	12.7	26.7	13.3
254	0-4"	5.9	54	1275	153	620	13.6	6.8	14.0	7.0
255	0-4"	7.3	77	4064	52	566	22.7	11.3	24.9	12.5
256	0-4"	6.6	52	1591	109	576	14.4	7.2	15.2	7.6
257	0-4"	5.5	54	955	124	566	15.0	7.5	15.7	7.8
258	0-4"	6	30	1299	89	584	8.3	4.2	8.9	4.5
259	0-4"	5.7	81	941	110	579	22.3	11.2	23.5	11.8
260	0-4"	6.7	37	3098	64	574	10.7	5.3	11.6	5.8
268	0-4"	5.2	58	641	166	596	14.9	7.5	15.2	7.6
269	0-4"	5.5	44	801	96	607	11.7	5.9	12.5	6.3

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
270	0-4"	5.7	53	1046	89	613	14.1	7.0	15.1	7.5
271	0-4"	6.4	33	1230	86	600	9.0	4.5	9.6	4.8
272	0-4"	7	62	1767	90	580	17.3	8.7	18.5	9.3
273	0-4"	7.4	52	2717	70	567	15.1	7.5	16.3	8.2
274	0-4"	6.4	56	4822	40	599	15.8	7.9	17.5	8.8
275	0-4"	6.3	28	1665	94	580	7.8	3.9	8.3	4.2
276	0-4"	6.2	46	1510	95	575	12.9	6.5	13.7	6.9
278	0-4"	6.6	32	2359	79	567	9.2	4.6	9.9	5.0
287	0-4"	5.9	65	1231	144	603	16.8	8.4	17.4	8.7
288	0-4"	6.2	55	1620	129	604	14.4	7.2	15.0	7.5
289	0-4"	5.6	36	1337	96	610	9.6	4.8	10.2	5.1
291	0-4"	6.1	40	1284	130	605	10.4	5.2	10.9	5.4
292	0-4"	7	42	2258	80	628	11.0	5.5	11.9	5.9
293	0-4"	7	45	3777	45	600	12.6	6.3	14.0	7.0
294	0-4"	6.7	40	2241	86	597	10.9	5.5	11.7	5.9
295	0-4"	6.9	36	2385	92	589	9.9	5.0	10.6	5.3
296	0-4"	5.3	49	736	169	593	12.7	6.3	12.9	6.4
297	0-4"	6.8	30	2047	79	587	8.4	4.2	9.0	4.5
309	0-4"	5.4	66	848	115	601	17.5	8.8	18.4	9.2
310	0-4"	5.4	72	605	128	665	17.3	8.6	18.2	9.1
311	0-4"	5.8	88	1181	124	638	22.0	11.0	23.1	11.5
312	0-4"	6.2	37	1835	83	673	9.0	4.5	9.8	4.9
313	0-4"	7.5	70	4550	50	687	17.2	8.6	19.0	9.5
314	0-4"	6.4	51	1430	79	614	13.6	6.8	14.7	7.4
Mean, mg/kg		6.4	59	1936	109	600	15.6	7.8	16.4	8.2
Median, mg/kg		6.4	54	1591	109	593	15.0	7.5	15.7	7.8

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
Minimum, mg/kg		4.4	18	456	35	471	6.2	3.1	6.4	3.2
Maximum, mg/kg		7.8	169	8465	232	811	44.7	22.3	46.6	23.3
Standard deviation, mg/kg		0.7	25	1423	38	49	6.3	3.1	6.5	3.2
C.V., %		10.4	43	73	35	56	56	58	57	58
Count		71								
Application zone										
126	0-4"	7.3	30	8465	35	511	9.9	5.0	11.0	5.5
142	0-4"	7.8	32	5672	61	563	9.4	4.7	10.3	5.1
143	0-4"	6.7	99	1821	232	640	22.9	11.5	22.7	11.4
144	0-4"	7.8	18	7643	44	471	6.4	3.2	7.0	3.5
145	0-4"	6.5	28	2741	76	582	7.9	3.9	8.5	4.3
162	0-4"	6.1	83	1415	159	601	21.3	10.7	21.8	10.9
163	0-4"	6.3	98	2478	172	764	20.2	10.1	20.9	10.5
180	0-4"	6.5	22	1298	118	566	6.2	3.1	6.4	3.2
181	0-4"	7.0	100	2229	134	811	19.9	9.9	21.2	10.6
182	0-4"	6.6	59	2007	101	563	16.8	8.4	17.8	8.9
198	0-4"	6.6	82	2022	149	725	17.9	9.0	18.8	9.4
199	0-4"	6.9	50	1667	121	628	12.7	6.3	13.4	6.7
200	0-4"	6.1	57	1613	101	589	15.6	7.8	16.5	8.3
201	0-4"	6.0	44	1700	94	567	12.5	6.3	13.3	6.7
215	0-4"	5.5	93	922	200	561	24.6	12.3	24.4	12.2
216	0-4"	6.6	50	1598	127	660	12.1	6.0	12.7	6.4
217	0-4"	6.2	67	1290	148	612	17.1	8.5	17.6	8.8
218	0-4"	7.0	77	1310	128	635	19.3	9.6	20.2	10.1
219	0-4"	6.3	169	2073	128	597	44.7	22.3	46.6	23.3

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
221	0-4"	5.5	100	1357	141	617	25.4	12.7	26.4	13.2
231	0-4"	6.6	80	1454	117	603	21.1	10.6	22.2	11.1
232	0-4"	7.0	48	1898	78	588	13.4	6.7	14.4	7.2
233	0-4"	6.8	56	1503	110	576	15.5	7.8	16.3	8.2
234	0-4"	6.4	41	1200	116	568	11.4	5.7	12.0	6.0
235	0-4"	6.3	109	1502	170	587	28.4	14.2	28.8	14.4
236	0-4"	6.5	56	1442	105	577	15.5	7.8	16.4	8.2
237	0-4"	6.8	82	2051	124	563	22.9	11.5	23.9	11.9
240	0-4"	5.4	60	889	119	589	16.2	8.1	16.9	8.5
241	0-4"	6.3	71	1638	97	591	19.4	9.7	20.6	10.3
250	0-4"	7.5	39	2056	84	603	10.6	5.3	11.4	5.7
251	0-4"	5.8	35	675	115	611	9.1	4.6	9.6	4.8
252	0-4"	6.5	63	1149	118	614	16.4	8.2	17.2	8.6
253	0-4"	6.7	90	1649	111	564	25.4	12.7	26.7	13.3
254	0-4"	5.9	54	1275	153	620	13.6	6.8	14.0	7.0
255	0-4"	7.3	77	4064	52	566	22.7	11.3	24.9	12.5
259	0-4"	5.7	81	941	110	579	22.3	11.2	23.5	11.8
269	0-4"	5.5	44	801	96	607	11.7	5.9	12.5	6.3
270	0-4"	5.7	53	1046	89	613	14.1	7.0	15.1	7.5
271	0-4"	6.4	33	1230	86	600	9.0	4.5	9.6	4.8
Mean, mg/kg		6.5	65	2046	116	602	17.0	8.5	17.8	8.9
Median, mg/kg		6.5	59	1598	116	591	16.2	8.1	16.9	8.5
Minimum, mg/kg		5.4	18	675	35	471	6.2	3.1	6.4	3.2
Maximum, mg/kg		7.8	169	8465	232	811	44.7	22.3	46.6	23.3
Standard deviation, mg/kg		0.6	30	1673	40	59	7.3	3.7	7.5	3.8

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
C.V., %		9.4	46	82	34	9	10	12	11	13
Count		39								
Buffer Zone										
212	0-4"	4.4	49	456	188	524	13.9	6.9	13.8	6.9
213	0-4"	6.0	52	1398	70	567	15.1	7.5	16.3	8.2
214	0-4"	5.3	102	1072	107	586	27.9	13.9	29.4	14.7
238	0-4"	6.4	55	1730	95	579	15.3	7.7	16.3	8.2
249	0-4"	6.3	66	1247	114	621	17.0	8.5	18.0	9.0
256	0-4"	6.6	52	1591	109	576	14.4	7.2	15.2	7.6
257	0-4"	5.5	54	955	124	566	15.0	7.5	15.7	7.8
258	0-4"	6.0	30	1299	89	584	8.3	4.2	8.9	4.5
260	0-4"	6.7	37	3098	64	574	10.7	5.3	11.6	5.8
268	0-4"	5.2	58	641	166	596	14.9	7.5	15.2	7.6
272	0-4"	7.0	62	1767	90	580	17.3	8.7	18.5	9.3
273	0-4"	7.4	52	2717	70	567	15.1	7.5	16.3	8.2
274	0-4"	6.4	56	4822	40	599	15.8	7.9	17.5	8.8
275	0-4"	6.3	28	1665	94	580	7.8	3.9	8.3	4.2
276	0-4"	6.2	46	1510	95	575	12.9	6.5	13.7	6.9
278	0-4"	6.6	32	2359	79	567	9.2	4.6	9.9	5.0
287	0-4"	5.9	65	1231	144	603	16.8	8.4	17.4	8.7
288	0-4"	6.2	55	1620	129	604	14.4	7.2	15.0	7.5
289	0-4"	5.6	36	1337	96	610	9.6	4.8	10.2	5.1
291	0-4"	6.1	40	1284	130	605	10.4	5.2	10.9	5.4
292	0-4"	7.0	42	2258	80	628	11.0	5.5	11.9	5.9
293	0-4"	7.0	45	3777	45	600	12.6	6.3	14.0	7.0
294	0-4"	6.7	40	2241	86	597	10.9	5.5	11.7	5.9

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
295	0-4"	6.9	36	2385	92	589	9.9	5.0	10.6	5.3
296	0-4"	5.3	49	736	169	593	12.7	6.3	12.9	6.4
297	0-4"	6.8	30	2047	79	587	8.4	4.2	9.0	4.5
309	0-4"	5.4	66	848	115	601	17.5	8.8	18.4	9.2
310	0-4"	5.4	72	605	128	665	17.3	8.6	18.2	9.1
311	0-4"	5.8	88	1181	124	638	22.0	11.0	23.1	11.5
312	0-4"	6.2	37	1835	83	673	9.0	4.5	9.8	4.9
313	0-4"	7.5	70	4550	50	687	17.2	8.6	19.0	9.5
314	0-4"	6.4	51	1430	79	614	13.6	6.8	14.7	7.4
Mean, mg/kg		6.2	52	1803	101	598	13.9	6.9	14.7	7.4
Median, mg/kg		6.3	52	1551	95	595	14.1	7.1	14.9	7.4
Minimum, mg/kg		4.4	28	456	40	524	7.8	3.9	8.3	4.2
Maximum, mg/kg		7.5	102	4822	188	687	27.9	13.9	29.4	14.7
Standard deviation, mg/kg		0.7	17	1052	35	33	4.3	2.1	4.5	2.2
C.V., %		11	32	58	35	9	10	12	11	13
Count			32							

Table 2. Soil P sorption saturation and soil properties related to P sorption for 4 to 8 inch grid-soil samples from Field 1 for 2014.

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
			mg/L				%			
Whole field										
180	4-8"	6.4	11	1002	108	685	2.6	1.3	2.8	1.4
199	4-8"	6.6	25	1024	104	705	5.8	2.9	6.2	3.1
218	4-8"	6.6	24	861	141	689	5.5	2.8	5.8	2.9
256	4-8"	6.6	22	1226	94	694	5.2	2.6	5.6	2.8
275	4-8"	6.6	14	1440	86	693	3.3	1.7	3.6	1.8
294	4-8"	6.9	22	1853	77	725	5.0	2.5	5.5	2.7
Mean, mg/kg		6.6	20	1234	102	699	4.6	2.3	4.9	2.5
Median, mg/kg		6.6	22	1125	99	694	5.1	2.6	5.5	2.8
Minimum, mg/kg		6.4	11	861	77	685	2.6	1.3	2.8	1.4
Maximum, mg/kg		6.9	25	1853	141	725	5.8	2.9	6.2	3.1
Standard deviation, mg/kg		0.2	6	364	22	15	1.3	0.6	1.4	0.7
C.V., %		2	29	29	22	25	26	28	27	28
Count			6							
Application zone										
180	4-8"	6.4	11	1002	108	685	2.6	1.3	2.8	1.4
199	4-8"	6.6	25	1024	104	705	5.8	2.9	6.2	3.1
218	4-8"	6.6	24	861	141	689	5.5	2.8	5.8	2.9
Mean, mg/kg		6.5	20	962	118	693	4.6	2.3	4.9	2.5
Median, mg/kg		6.6	24	1002	108	689	5.5	2.8	5.8	2.9
Minimum, mg/kg		6.4	11	861	104	685	2.6	1.3	2.8	1.4
Maximum, mg/kg		6.6	25	1024	141	705	5.8	2.9	6.2	3.1

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
Standard deviation, mg/kg		0.1	8	88	20	11	1.8	0.9	1.9	0.9
C.V., %		2	39	9	17	2	38	38	38	38
Count			3							
Buffer zone										
256	4-8"	6.6	22	1226	94	694	5.2	2.6	5.6	2.8
275	4-8"	6.6	14	1440	86	693	3.3	1.7	3.6	1.8
294	4-8"	6.9	22	1853	77	725	5.0	2.5	5.5	2.7
Mean, mg/kg		6.7	19	1506	86	704	4.5	2.3	4.9	2.4
Median, mg/kg		6.6	22	1440	86	694	5.0	2.5	5.5	2.7
Minimum, mg/kg		6.6	14	1226	77	693	3.3	1.7	3.6	1.8
Maximum, mg/kg		6.9	22	1853	94	725	5.2	2.6	5.6	2.8
Standard deviation, mg/kg		0.2	5	319	9	18	1.0	0.5	1.1	0.6
C.V., %		3	24	21	10	3	23	23	23	23
Count			3							

Table 3. Soil P sorption saturation and soil properties related to P sorption for 0 to 4 inch grid-soil samples from Field 1 for 2016.

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
			mg/L				%			
Whole field										
126	0-4"	7.2	17	9104	38	626	4.6	2.3	5.1	2.6
142	0-4"	7.5	29	9064	26	606	8.2	4.1	9.2	4.6
143	0-4"	6.8	123	2895	199	589	31.3	15.6	31.2	15.6
144	0-4"	7.4	32	7008	69	643	8.2	4.1	9.0	4.5
145	0-4"	6.7	65	5045	77	560	19.0	9.5	20.4	10.2
162	0-4"	6.9	77	2813	121	584	20.9	10.4	21.8	10.9
163	0-4"	6.4	121	2031	147	589	31.9	16.0	32.9	16.4
180	0-4"	6.7	44	1552	109	606	11.6	5.8	12.3	6.2
181	0-4"	6.8	89	1988	117	602	23.5	11.8	24.8	12.4
182	0-4"	6.1	74	2028	145	634	18.3	9.2	19.0	9.5
198	0-4"	6.1	63	1602	127	626	16.0	8.0	16.7	8.4
199	0-4"	6.0	45	1360	124	613	11.7	5.8	12.2	6.1
200	0-4"	5.8	54	1334	106	624	13.9	7.0	14.8	7.4
201	0-4"	5.3	72	1311	140	606	18.6	9.3	19.3	9.7
212	0-4"	5.2	43	494	195	600	10.8	5.4	10.8	5.4
213	0-4"	5.7	21	896	117	624	5.4	2.7	5.7	2.8
214	0-4"	5.2	45	776	166	579	11.9	5.9	12.1	6.0
215	0-4"	5.2	59	828	205	589	14.9	7.5	14.9	7.4
216	0-4"	6.0	55	1395	147	597	14.3	7.2	14.8	7.4
217	0-4"	5.6	70	870	149	600	18.1	9.1	18.7	9.3
218	0-4"	6.1	85	1646	152	589	22.4	11.2	22.9	11.5

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
219	0-4"	5.8	96	2035	160	576	25.6	12.8	26.1	13.0
221	0-4"	5.5	31	724	108	598	8.3	4.2	8.8	4.4
234	0-4"	6.0	93	1255	137	601	24.3	12.1	25.2	12.6
232	0-4"	5.8	83	1148	143	624	20.9	10.4	21.6	10.8
233	0-4"	5.7	274	1927	250	633	63.3	31.7	62.1	31.0
234	0-4"	6.0	31	715	109	621	8.0	4.0	8.5	4.2
235	0-4"	6.4	77	1037	135	613	19.8	9.9	20.6	10.3
236	0-4"	6.3	130	2061	115	610	34.0	17.0	35.9	17.9
237	0-4"	5.8	87	1736	131	600	22.9	11.4	23.8	11.9
238	0-4"	6.3	56	1769	98	634	14.3	7.2	15.3	7.7
240	0-4"	5.5	109	986	149	657	26.1	13.0	27.0	13.5
241	0-4"	6.2	33	1075	90	662	8.2	4.1	8.8	4.4
249	0-4"	5.1	38	695	103	647	9.5	4.8	10.1	5.1
250	0-4"	6.9	49	1924	104	653	12.1	6.1	12.9	6.5
251	0-4"	5.1	28	748	102	642	7.1	3.5	7.5	3.8
252	0-4"	5.6	115	1064	132	600	30.2	15.1	31.4	15.7
253	0-4"	6.0	126	1904	115	579	34.6	17.3	36.3	18.2
254	0-4"	5.6	90	1461	153	573	24.2	12.1	24.8	12.4
255	0-4"	5.4	66	2463	104	587	18.0	9.0	19.1	9.6
256	0-4"	5.7	103	1799	167	549	28.5	14.3	28.8	14.4
257	0-4"	5.4	67	1293	110	579	18.5	9.2	19.4	9.7
258	0-4"	6.0	16	1960	84	567	4.6	2.3	4.9	2.5
259	0-4"	5.4	51	1140	101	577	14.2	7.1	15.0	7.5
260	0-4"	6.3	19	3467	75	583	5.3	2.7	5.8	2.9
268	0-4"	5.0	44	568	143	572	12.0	6.0	12.3	6.2
269	0-4"	5.3	29	975	115	581	7.9	4.0	8.3	4.2

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
270	0-4"	5.4	33	739	121	589	8.9	4.4	9.3	4.6
271	0-4"	5.3	49	1124	105	602	13.1	6.5	13.9	6.9
272	0-4"	5.8	58	1361	120	586	15.7	7.8	16.4	8.2
273	0-4"	6.3	74	2235	103	572	20.7	10.4	21.9	11.0
274	0-4"	6.0	84	3299	80	585	23.5	11.7	25.3	12.6
275	0-4"	6.2	40	1643	128	594	10.6	5.3	11.1	5.5
276	0-4"	5.5	31	1102	155	597	8.0	4.0	8.2	4.1
278	0-4"	5.8	19	1956	87	601	5.1	2.6	5.5	2.8
287	0-4"	4.9	36	656	115	583	9.8	4.9	10.3	5.2
288	0-4"	5.6	27	1005	118	588	7.3	3.6	7.6	3.8
289	0-4"	4.9	20	649	108	594	5.4	2.7	5.7	2.8
291	0-4"	5.8	17	900	104	595	4.6	2.3	4.9	2.4
292	0-4"	5.7	40	1555	106	579	11.1	5.5	11.7	5.8
293	0-4"	6.1	25	2516	69	599	6.9	3.4	7.5	3.7
294	0-4"	5.8	26	1832	77	604	7.1	3.5	7.6	3.8
295	0-4"	5.9	26	1478	103	579	7.2	3.6	7.6	3.8
296	0-4"	5.3	24	950	132	584	6.5	3.2	6.7	3.4
297	0-4"	6.0	22	2273	74	588	6.1	3.1	6.6	3.3
309	0-4"	4.9	25	528	115	598	6.7	3.3	7.0	3.5
310	0-4"	4.9	25	590	115	586	6.8	3.4	7.1	3.6
311	0-4"	5.6	55	1206	109	576	15.2	7.6	16.1	8.0
312	0-4"	5.5	27	1490	86	587	7.5	3.7	8.0	4.0
313	0-4"	6.5	22	4371	49	594	6.2	3.1	6.8	3.4
314	0-4"	5.4	28	1547	90	600	7.6	3.8	8.1	4.1
Mean, mg/kg		5.9	57	1845	118	599	15.0	7.5	15.6	7.8
Median, mg/kg		5.8	45	1461	115	597	12.0	6.0	12.6	6.3

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
Minimum, mg/kg		4.9	16	494	26	549	4.6	2.3	4.9	2.4
Maximum, mg/kg		7.5	274	9104	250	662	63.3	31.7	62.1	31.0
Standard deviation, mg/kg		0.6	40	1635	37	23	10.0	5.0	10.0	5.0
C.V., %		10	71	89	31	4	66	66	64	64
Count		71								
Application zone										
126	0-4"	7.2	17	9104	38	626	4.6	2.3	5.1	2.6
142	0-4"	7.5	29	9064	26	606	8.2	4.1	9.2	4.6
143	0-4"	6.8	123	2895	199	589	31.3	15.6	31.2	15.6
144	0-4"	7.4	32	7008	69	643	8.2	4.1	9.0	4.5
145	0-4"	6.7	65	5045	77	560	19.0	9.5	20.4	10.2
162	0-4"	6.9	77	2813	121	584	20.9	10.4	21.8	10.9
163	0-4"	6.4	121	2031	147	589	31.9	16.0	32.9	16.4
180	0-4"	6.7	44	1552	109	606	11.6	5.8	12.3	6.2
181	0-4"	6.8	89	1988	117	602	23.5	11.8	24.8	12.4
182	0-4"	6.1	74	2028	145	634	18.3	9.2	19.0	9.5
198	0-4"	6.1	63	1602	127	626	16.0	8.0	16.7	8.4
199	0-4"	6.0	45	1360	124	613	11.7	5.8	12.2	6.1
200	0-4"	5.8	54	1334	106	624	13.9	7.0	14.8	7.4
201	0-4"	5.3	72	1311	140	606	18.6	9.3	19.3	9.7
215	0-4"	5.2	59	828	205	589	14.9	7.5	14.9	7.4
216	0-4"	6.0	55	1395	147	597	14.3	7.2	14.8	7.4
217	0-4"	5.6	70	870	149	600	18.1	9.1	18.7	9.3
218	0-4"	6.1	85	1646	152	589	22.4	11.2	22.9	11.5
219	0-4"	5.8	96	2035	160	576	25.6	12.8	26.1	13.0

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
221	0-4"	5.5	31	724	108	598	8.3	4.2	8.8	4.4
234	0-4"	6.0	93	1255	137	601	24.3	12.1	25.2	12.6
232	0-4"	5.8	83	1148	143	624	20.9	10.4	21.6	10.8
233	0-4"	5.7	274	1927	250	633	63.3	31.7	62.1	31.0
234	0-4"	6.0	31	715	109	621	8.0	4.0	8.5	4.2
235	0-4"	6.4	77	1037	135	613	19.8	9.9	20.6	10.3
236	0-4"	6.3	130	2061	115	610	34.0	17.0	35.9	17.9
237	0-4"	5.8	87	1736	131	600	22.9	11.4	23.8	11.9
240	0-4"	5.5	109	986	149	657	26.1	13.0	27.0	13.5
241	0-4"	6.2	33	1075	90	662	8.2	4.1	8.8	4.4
250	0-4"	6.9	49	1924	104	653	12.1	6.1	12.9	6.5
251	0-4"	5.1	28	748	102	642	7.1	3.5	7.5	3.8
252	0-4"	5.6	115	1064	132	600	30.2	15.1	31.4	15.7
253	0-4"	6.0	126	1904	115	579	34.6	17.3	36.3	18.2
254	0-4"	5.6	90	1461	153	573	24.2	12.1	24.8	12.4
255	0-4"	5.4	66	2463	104	587	18.0	9.0	19.1	9.6
259	0-4"	5.4	51	1140	101	577	14.2	7.1	15.0	7.5
269	0-4"	5.3	29	975	115	581	7.9	4.0	8.3	4.2
270	0-4"	5.4	33	739	121	589	8.9	4.4	9.3	4.6
271	0-4"	5.3	49	1124	105	602	13.1	6.5	13.9	6.9
Mean, mg/kg		6.0	73	2106	125	607	19.0	9.5	19.7	9.8
Median, mg/kg		6.0	66	1461	121	602	18.1	9.1	19.0	9.5
Minimum, mg/kg		5.1	17	715	26	560	4.6	2.3	5.1	2.6
Maximum, mg/kg		7.5	274	9104	250	662	63.3	31.7	62.1	31.0
Standard deviation, mg/kg		0.6	45	2021	40	24	10.9	5.5	10.8	5.4

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
C.V., %		10	62	96	32	4	58	58	55	55
Count			39							
Buffer zone										
212	0-4"	5.2	43	494	195	600	10.8	5.4	10.8	5.4
213	0-4"	5.7	21	896	117	624	5.4	2.7	5.7	2.8
214	0-4"	5.2	45	776	166	579	11.9	5.9	12.1	6.0
238	0-4"	6.3	56	1769	98	634	14.3	7.2	15.3	7.7
249	0-4"	5.1	38	695	103	647	9.5	4.8	10.1	5.1
256	0-4"	5.7	103	1799	167	549	28.5	14.3	28.8	14.4
257	0-4"	5.4	67	1293	110	579	18.5	9.2	19.4	9.7
258	0-4"	6.0	16	1960	84	567	4.6	2.3	4.9	2.5
260	0-4"	6.3	19	3467	75	583	5.3	2.7	5.8	2.9
268	0-4"	5.0	44	568	143	572	12.0	6.0	12.3	6.2
272	0-4"	5.8	58	1361	120	586	15.7	7.8	16.4	8.2
273	0-4"	6.3	74	2235	103	572	20.7	10.4	21.9	11.0
274	0-4"	6.0	84	3299	80	585	23.5	11.7	25.3	12.6
275	0-4"	6.2	40	1643	128	594	10.6	5.3	11.1	5.5
276	0-4"	5.5	31	1102	155	597	8.0	4.0	8.2	4.1
278	0-4"	5.8	19	1956	87	601	5.1	2.6	5.5	2.8
287	0-4"	4.9	36	656	115	583	9.8	4.9	10.3	5.2
288	0-4"	5.6	27	1005	118	588	7.3	3.6	7.6	3.8
289	0-4"	4.9	20	649	108	594	5.4	2.7	5.7	2.8
291	0-4"	5.8	17	900	104	595	4.6	2.3	4.9	2.4
292	0-4"	5.7	40	1555	106	579	11.1	5.5	11.7	5.8
293	0-4"	6.1	25	2516	69	599	6.9	3.4	7.5	3.7
294	0-4"	5.8	26	1832	77	604	7.1	3.5	7.6	3.8

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
295	0-4"	5.9	26	1478	103	579	7.2	3.6	7.6	3.8
296	0-4"	5.3	24	950	132	584	6.5	3.2	6.7	3.4
297	0-4"	6.0	22	2273	74	588	6.1	3.1	6.6	3.3
309	0-4"	4.9	25	528	115	598	6.7	3.3	7.0	3.5
310	0-4"	4.9	25	590	115	586	6.8	3.4	7.1	3.6
311	0-4"	5.6	55	1206	109	576	15.2	7.6	16.1	8.0
312	0-4"	5.5	27	1490	86	587	7.5	3.7	8.0	4.0
313	0-4"	6.5	22	4371	49	594	6.2	3.1	6.8	3.4
314	0-4"	5.4	28	1547	90	600	7.6	3.8	8.1	4.1
Mean, mg/kg		5.6	38	1527	109	591	10.2	5.1	10.7	5.4
Median, mg/kg		5.7	28	1420	107	588	7.5	3.8	8.1	4.0
Minimum, mg/kg		4.9	16	494	49	549	4.6	2.3	4.9	2.4
Maximum, mg/kg		6.5	103	4371	195	647	28.5	14.3	28.8	14.4
Standard deviation, mg/kg		0.5	21	917	31	19	5.8	2.9	6.0	3.0
C.V., %		8	56	60	29	3	57	57	56	56
Count			32							

Table 4. Soil P sorption saturation and soil properties related to P sorption for 4 to 8 inch grid-soil samples from Field 1 for 2016.

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
			mg/L				%			
Whole field										
126	4-8"	7.1	11	8836	40	702	2.7	1.3	3.0	1.5
142	4-8"	7.9	29	9031	22	699	7.1	3.6	8.0	4.0
143	4-8"	6.8	118	1911	165	715	25.9	12.9	26.8	13.4
144	4-8"	7.7	18	7061	58	705	4.3	2.1	4.7	2.4
145	4-8"	7.0	53	5890	69	722	12.2	6.1	13.4	6.7
162	4-8"	7.1	36	2893	86	726	8.2	4.1	8.9	4.4
163	4-8"	6.1	83	1738	115	715	18.8	9.4	20.0	10.0
180	4-8"	6.4	25	1056	114	703	5.7	2.9	6.1	3.1
181	4-8"	6.6	52	1431	122	697	12.0	6.0	12.7	6.3
182	4-8"	6.1	54	1623	126	688	12.6	6.3	13.3	6.6
198	4-8"	6.3	42	1146	112	694	9.8	4.9	10.4	5.2
199	4-8"	6.3	26	1236	111	684	6.1	3.1	6.5	3.3
200	4-8"	6.0	17	1454	86	688	4.1	2.0	4.4	2.2
201	4-8"	5.8	36	1043	111	692	8.4	4.2	9.0	4.5
215	4-8"	6.0	44	1130	114	715	10.0	5.0	10.6	5.3
216	4-8"	6.0	49	907	144	719	10.8	5.4	11.4	5.7
217	4-8"	6.3	28	750	100	725	6.3	3.2	6.8	3.4
218	4-8"	5.7	27	2538	118	706	6.2	3.1	6.6	3.3
219	4-8"	6.0	28	806	102	713	6.4	3.2	6.9	3.4
231	4-8"	6.1	119	1767	172	700	26.5	13.2	27.3	13.6
233	4-8"	6.4	69	1564	95	705	16.0	8.0	17.3	8.6
234	4-8"	6.0	38	1763	95	716	8.7	4.3	9.4	4.7

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
235	4-8"	5.6	55	497	107	697	12.8	6.4	13.7	6.8
236	4-8"	6.4	22	1048	99	698	5.1	2.6	5.5	2.8
237	4-8"	6.5	21	1183	99	688	5.0	2.5	5.3	2.7
240	4-8"	6.1	51	819	101	711	11.7	5.8	12.6	6.3
241	4-8"	6.3	40	1056	94	726	9.0	4.5	9.8	4.9
250	4-8"	5.9	4	4646	43	694	1.0	0.5	1.1	0.5
251	4-8"	6.1	18	589	88	711	4.2	2.1	4.5	2.3
252	4-8"	5.8	6	721	94	698	1.4	0.7	1.5	0.8
253	4-8"	4.9	12	648	99	690	2.8	1.4	3.0	1.5
254	4-8"	5.4	10	561	109	702	2.3	1.2	2.5	1.2
255	4-8"	6.5	12	319	182	715	2.6	1.3	2.7	1.3
259	4-8"	5.3	18	412	83	684	4.3	2.2	4.7	2.3
269	4-8"	6.5	4	2430	68	704	0.9	0.5	1.0	0.5
270	4-8"	6.1	4	2689	69	710	0.9	0.5	1.0	0.5
271	4-8"	5.0	24	493	102	700	5.6	2.8	6.0	3.0
212	4-8"	5.0	43	547	193	705	9.4	4.7	9.6	4.8
213	4-8"	6.1	37	1008	123	697	8.5	4.3	9.0	4.5
214	4-8"	5.7	29	640	114	695	6.7	3.4	7.2	3.6
238	4-8"	5.6	8	554	93	702	1.9	0.9	2.0	1.0
249	4-8"	5.7	26	1469	117	705	5.9	3.0	6.3	3.2
256	4-8"	5.1	5	596	60	702	1.2	0.6	1.3	0.7
257	4-8"	5.3	24	510	132	711	5.4	2.7	5.7	2.8
258	4-8"	6.2	24	1053	80	702	5.6	2.8	6.1	3.1
260	4-8"	5.8	50	1746	100	692	11.8	5.9	12.6	6.3
268	4-8"	5.9	41	1083	134	697	9.4	4.7	9.9	4.9
272	4-8"	6.0	14	993	105	711	3.2	1.6	3.4	1.7

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
273	4-8"	6.4	16	1340	90	694	3.8	1.9	4.1	2.0
274	4-8"	6.6	22	5404	49	682	5.4	2.7	6.0	3.0
275	4-8"	6.0	13	1047	80	697	3.1	1.5	3.3	1.7
276	4-8"	5.5	10	961	85	703	2.3	1.2	2.5	1.3
278	4-8"	6.3	9	3113	84	684	2.2	1.1	2.3	1.2
287	4-8"	5.4	7	527	75	692	1.7	0.8	1.8	0.9
288	4-8"	5.6	9	851	92	681	2.2	1.1	2.3	1.2
289	4-8"	5.0	6	857	66	697	1.4	0.7	1.6	0.8
291	4-8"	5.4	4	765	107	700	0.9	0.5	1.0	0.5
292	4-8"	5.7	12	1138	102	715	2.7	1.4	2.9	1.5
293	4-8"	5.8	13	2471	70	706	3.1	1.5	3.4	1.7
294	4-8"	5.0	6	2601	53	694	1.5	0.7	1.6	0.8
295	4-8"	5.8	7	1045	85	697	1.7	0.8	1.8	0.9
296	4-8"	5.6	14	999	108	688	3.3	1.6	3.5	1.8
297	4-8"	5.9	8	2627	64	675	2.0	1.0	2.2	1.1
309	4-8"	4.8	6	531	60	725	1.4	0.7	1.5	0.8
310	4-8"	5.1	9	599	104	715	2.0	1.0	2.2	1.1
311	4-8"	5.8	28	846	98	709	6.5	3.2	6.9	3.5
312	4-8"	5.5	13	1391	87	722	3.0	1.5	3.2	1.6
313	4-8"	6.8	7	4178	40	698	1.7	0.9	1.9	0.9
314	4-8"	5.8	17	2181	77	704	4.0	2.0	4.4	2.2
Mean, mg/kg		6.0	27	1759	96	702	6.1	3.1	6.5	3.3
Median, mg/kg		6.0	21	1056	98	702	5.0	2.5	5.3	2.7
Minimum, mg/kg		4.8	4	319	22	675	0.9	0.5	1.0	0.5
Maximum, mg/kg		7.9	119	9031	193	726	26.5	13.2	27.3	13.6

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
Standard deviation, mg/kg		0.6	24	1808	32	12	5.3	2.6	5.5	2.8
C.V., %		10	89	103	33	2	86	86	84	84
Count			69							
Application zone										
126	4-8"	7.1	11	8836	40	702	2.7	1.3	3.0	1.5
142	4-8"	7.9	29	9031	22	699	7.1	3.6	8.0	4.0
143	4-8"	6.8	118	1911	165	715	25.9	12.9	26.8	13.4
144	4-8"	7.7	18	7061	58	705	4.3	2.1	4.7	2.4
145	4-8"	7.0	53	5890	69	722	12.2	6.1	13.4	6.7
162	4-8"	7.1	36	2893	86	726	8.2	4.1	8.9	4.4
163	4-8"	6.1	83	1738	115	715	18.8	9.4	20.0	10.0
180	4-8"	6.4	25	1056	114	703	5.7	2.9	6.1	3.1
181	4-8"	6.6	52	1431	122	697	12.0	6.0	12.7	6.3
182	4-8"	6.1	54	1623	126	688	12.6	6.3	13.3	6.6
198	4-8"	6.3	42	1146	112	694	9.8	4.9	10.4	5.2
199	4-8"	6.3	26	1236	111	684	6.1	3.1	6.5	3.3
200	4-8"	6.0	17	1454	86	688	4.1	2.0	4.4	2.2
201	4-8"	5.8	36	1043	111	692	8.4	4.2	9.0	4.5
215	4-8"	6.0	44	1130	114	715	10.0	5.0	10.6	5.3
216	4-8"	6.0	49	907	144	719	10.8	5.4	11.4	5.7
217	4-8"	6.3	28	750	100	725	6.3	3.2	6.8	3.4
218	4-8"	5.7	27	2538	118	706	6.2	3.1	6.6	3.3
219	4-8"	6.0	28	806	102	713	6.4	3.2	6.9	3.4
231	4-8"	6.1	119	1767	172	700	26.5	13.2	27.3	13.6
233	4-8"	6.4	69	1564	95	705	16.0	8.0	17.3	8.6

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
234	4-8"	6.0	38	1763	95	716	8.7	4.3	9.4	4.7
235	4-8"	5.6	55	497	107	697	12.8	6.4	13.7	6.8
236	4-8"	6.4	22	1048	99	698	5.1	2.6	5.5	2.8
237	4-8"	6.5	21	1183	99	688	5.0	2.5	5.3	2.7
240	4-8"	6.1	51	819	101	711	11.7	5.8	12.6	6.3
241	4-8"	6.3	40	1056	94	726	9.0	4.5	9.8	4.9
250	4-8"	5.9	4	4646	43	694	1.0	0.5	1.1	0.5
251	4-8"	6.1	18	589	88	711	4.2	2.1	4.5	2.3
252	4-8"	5.8	6	721	94	698	1.4	0.7	1.5	0.8
253	4-8"	4.9	12	648	99	690	2.8	1.4	3.0	1.5
254	4-8"	5.4	10	561	109	702	2.3	1.2	2.5	1.2
255	4-8"	6.5	12	319	182	715	2.6	1.3	2.7	1.3
259	4-8"	5.3	18	412	83	684	4.3	2.2	4.7	2.3
269	4-8"	6.5	4	2430	68	704	0.9	0.5	1.0	0.5
270	4-8"	6.1	4	2689	69	710	0.9	0.5	1.0	0.5
271	4-8"	5.0	24	493	102	700	5.6	2.8	6.0	3.0
Mean, mg/kg		6.2	35	2046	100	704	8.1	4.0	8.6	4.3
Median, mg/kg		6.1	28	1183	100	703	6.3	3.2	6.8	3.4
Minimum, mg/kg		4.9	4	319	22	684	0.9	0.5	1.0	0.5
Maximum, mg/kg		7.9	119	9031	182	726	26.5	13.2	27.3	13.6
Standard deviation, mg/kg		0.6	28	2211	33	12	6.1	3.1	6.4	3.2
C.V., %		10	78	108	33	2	76	76	74	74
Count			37							
Buffer zone										
212	4-8"	5.0	43	547	193	705	9.4	4.7	9.6	4.8

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
213	4-8"	6.1	37	1008	123	697	8.5	4.3	9.0	4.5
214	4-8"	5.7	29	640	114	695	6.7	3.4	7.2	3.6
238	4-8"	5.6	8	554	93	702	1.9	0.9	2.0	1.0
249	4-8"	5.7	26	1469	117	705	5.9	3.0	6.3	3.2
256	4-8"	5.1	5	596	60	702	1.2	0.6	1.3	0.7
257	4-8"	5.3	24	510	132	711	5.4	2.7	5.7	2.8
258	4-8"	6.2	24	1053	80	702	5.6	2.8	6.1	3.1
260	4-8"	5.8	50	1746	100	692	11.8	5.9	12.6	6.3
268	4-8"	5.9	41	1083	134	697	9.4	4.7	9.9	4.9
272	4-8"	6.0	14	993	105	711	3.2	1.6	3.4	1.7
273	4-8"	6.4	16	1340	90	694	3.8	1.9	4.1	2.0
274	4-8"	6.6	22	5404	49	682	5.4	2.7	6.0	3.0
275	4-8"	6.0	13	1047	80	697	3.1	1.5	3.3	1.7
276	4-8"	5.5	10	961	85	703	2.3	1.2	2.5	1.3
278	4-8"	6.3	9	3113	84	684	2.2	1.1	2.3	1.2
287	4-8"	5.4	7	527	75	692	1.7	0.8	1.8	0.9
288	4-8"	5.6	9	851	92	681	2.2	1.1	2.3	1.2
289	4-8"	5.0	6	857	66	697	1.4	0.7	1.6	0.8
291	4-8"	5.4	4	765	107	700	0.9	0.5	1.0	0.5
292	4-8"	5.7	12	1138	102	715	2.7	1.4	2.9	1.5
293	4-8"	5.8	13	2471	70	706	3.1	1.5	3.4	1.7
294	4-8"	5.0	6	2601	53	694	1.5	0.7	1.6	0.8
295	4-8"	5.8	7	1045	85	697	1.7	0.8	1.8	0.9
296	4-8"	5.6	14	999	108	688	3.3	1.6	3.5	1.8
297	4-8"	5.9	8	2627	64	675	2.0	1.0	2.2	1.1
309	4-8"	4.8	6	531	60	725	1.4	0.7	1.5	0.8

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
310	4-8"	5.1	9	599	104	715	2.0	1.0	2.2	1.1
311	4-8"	5.8	28	846	98	709	6.5	3.2	6.9	3.5
312	4-8"	5.5	13	1391	87	722	3.0	1.5	3.2	1.6
313	4-8"	6.8	7	4178	40	698	1.7	0.9	1.9	0.9
314	4-8"	5.8	17	2181	77	704	4.0	2.0	4.4	2.2
Mean, mg/kg		5.7	17	1427	91	700	3.9	1.9	4.2	2.1
Median, mg/kg		5.7	13	1027	89	699	3.0	1.5	3.3	1.6
Minimum, mg/kg		4.8	4	510	40	675	0.9	0.5	1.0	0.5
Maximum, mg/kg		6.8	50	5404	193	725	11.8	5.9	12.6	6.3
Standard deviation, mg/kg		0.5	12	1131	30	11	2.8	1.4	2.9	1.5
C.V., %		8	73	79	33	2	72	72	71	71
Count			32							

Table 5. Soil P sorption saturation and soil properties related to P sorption for 0 to 4 inch grid-soil samples from Field 1 for 2018.

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
			mg/L				%			
Whole field										
126	0-4"	7.7	31	9224	30	624	8.5	4.2	9.5	4.7
142	0-4"	7.8	43	11512	33	587	12.4	6.2	13.9	6.9
143	0-4"	6.8	145	2552	189	611	36.0	18.0	36.3	18.1
144	0-4"	7.6	63	6629	48	593	17.8	8.9	19.7	9.8
145	0-4"	6.6	173	3091	118	578	47.5	23.7	49.7	24.9
162	0-4"	6.6	127	1631	143	604	32.9	16.4	34.0	17.0
163	0-4"	6.8	164	1600	159	605	41.9	21.0	42.9	21.5
180	0-4"	7.3	56	3021	82	589	15.5	7.8	16.7	8.3
181	0-4"	7.6	130	3646	91	589	35.8	17.9	38.2	19.1
182	0-4"	6.4	131	1972	135	608	33.9	17.0	35.3	17.6
198	0-4"	7.8	128	3584	106	589	34.8	17.4	36.8	18.4
199	0-4"	6.6	96	1902	130	574	26.3	13.1	27.3	13.6
200	0-4"	6.6	104	1929	103	578	28.9	14.4	30.5	15.3
201	0-4"	6.2	64	1698	117	588	17.3	8.7	18.2	9.1
212	0-4"	5.3	71	948	154	613	18.0	9.0	18.5	9.3
213	0-4"	6.1	60	1204	91	587	16.6	8.3	17.7	8.8
214	0-4"	6.2	79	1000	126	588	21.2	10.6	22.1	11.1
215	0-4"	6.0	84	822	193	596	21.2	10.6	21.3	10.6
216	0-4"	6.3	128	1499	219	586	32.2	16.1	31.8	15.9
217	0-4"	6.2	104	970	154	597	27.0	13.5	27.7	13.8
218	0-4"	6.3	147	1593	135	612	37.8	18.9	39.4	19.7
219	0-4"	6.6	189	1622	150	610	48.3	24.1	49.7	24.9

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
221	0-4"	6.0	247	1521	166	625	61.0	30.5	62.5	31.2
231	0-4"	6.7	135	1599	133	618	34.5	17.2	36.0	18.0
232	0-4"	6.1	92	1147	127	579	25.0	12.5	26.1	13.0
233	0-4"	6.2	76	933	109	599	20.3	10.2	21.5	10.7
234	0-4"	6.5	114	1212	128	587	30.6	15.3	31.9	15.9
235	0-4"	6.5	136	1388	135	598	35.7	17.9	37.1	18.6
236	0-4"	6.5	196	1788	108	579	54.1	27.1	57.1	28.5
237	0-4"	6.3	178	1660	129	599	46.9	23.4	48.9	24.5
238	0-4"	6.2	233	1670	122	596	62.0	31.0	64.9	32.5
240	0-4"	5.8	186	1308	137	612	47.8	23.9	49.7	24.8
241	0-4"	6.4	94	1568	100	603	25.1	12.6	26.7	13.4
249	0-4"	5.9	86	1042	107	579	23.8	11.9	25.1	12.5
250	0-4"	6.3	81	1144	98	615	21.3	10.7	22.7	11.4
251	0-4"	6.4	91	877	89	611	24.2	12.1	26.0	13.0
252	0-4"	6.2	120	851	108	615	31.3	15.7	33.2	16.6
253	0-4"	6.4	152	1169	119	604	40.0	20.0	42.0	21.0
254	0-4"	6.5	128	1237	134	608	33.2	16.6	34.5	17.3
255	0-4"	6.1	141	2259	101	609	37.3	18.7	39.7	19.9
256	0-4"	6.3	120	1462	146	584	31.9	16.0	32.9	16.4
257	0-4"	5.9	121	1141	115	601	32.1	16.1	33.8	16.9
258	0-4"	6.1	52	1310	91	611	13.8	6.9	14.8	7.4
259	0-4"	6.3	87	1429	107	600	23.3	11.6	24.6	12.3
260	0-4"	7.1	40	3487	49	623	10.8	5.4	11.9	6.0
268	0-4"	5.7	57	696	120	618	14.7	7.3	15.4	7.7
269	0-4"	6.1	39	741	83	597	10.7	5.3	11.5	5.7
270	0-4"	5.9	41	522	96	611	10.9	5.4	11.6	5.8

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
271	0-4"	6.8	27	1135	68	601	7.4	3.7	8.1	4.0
272	0-4"	6.8	105	1435	97	587	28.9	14.4	30.7	15.4
273	0-4"	6.9	98	1976	80	592	27.1	13.5	29.2	14.6
274	0-4"	6.9	105	4198	62	581	29.9	15.0	32.7	16.3
275	0-4"	6.3	52	1420	98	593	14.1	7.1	15.1	7.5
276	0-4"	6.0	43	904	93	620	11.3	5.6	12.1	6.0
278	0-4"	6.4	42	2182	64	614	11.3	5.7	12.4	6.2
287	0-4"	5.9	55	668	97	603	14.7	7.4	15.7	7.9
288	0-4"	6.2	47	1066	105	599	12.6	6.3	13.4	6.7
289	0-4"	6.4	18	1494	63	602	5.0	2.5	5.4	2.7
291	0-4"	6.4	30	910	92	596	8.2	4.1	8.7	4.4
292	0-4"	6.5	42	1496	78	611	11.3	5.6	12.2	6.1
293	0-4"	6.2	33	2236	63	601	9.1	4.6	9.9	5.0
294	0-4"	6.5	38	1796	76	622	10.1	5.0	10.9	5.4
295	0-4"	6.7	27	1599	77	597	7.4	3.7	8.0	4.0
296	0-4"	5.7	36	640	122	587	9.7	4.9	10.2	5.1
297	0-4"	6.3	29	1941	68	588	8.1	4.1	8.8	4.4
309	0-4"	5.9	58	632	113	600	15.4	7.7	16.3	8.1
310	0-4"	6.0	32	636	97	610	8.5	4.2	9.1	4.5
311	0-4"	6.7	64	1124	101	605	17.1	8.5	18.1	9.1
312	0-4"	6.4	31	1463	60	608	8.5	4.2	9.3	4.6
313	0-4"	7.2	33	4477	35	595	9.4	4.7	10.5	5.2
314	0-4"	6.0	38	1318	77	599	10.4	5.2	11.2	5.6
Mean, mg/kg		6.4	91	1909	106	600	24.1	12.0	25.3	12.7
Median, mg/kg		6.4	84	1463	105	600	21.3	10.7	22.7	11.4
Minimum, mg/kg		5.3	18	522	30	574	5.0	2.5	5.4	2.7

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
Maximum, mg/kg		7.8	247	11512	219	625	62.0	31.0	64.9	32.5
Standard deviation, mg/kg		0.5	54	1781	37	13	13.8	6.9	14.3	7.1
C.V., %		8	59	93	34	2	57	57	56	56
Count			71							
Application zone										
126	0-4"	7.7	31	9224	30	624	8.5	4.2	9.5	4.7
142	0-4"	7.8	43	11512	33	587	12.4	6.2	13.9	6.9
143	0-4"	6.8	145	2552	189	611	36.0	18.0	36.3	18.1
144	0-4"	7.6	63	6629	48	593	17.8	8.9	19.7	9.8
145	0-4"	6.6	173	3091	118	578	47.5	23.7	49.7	24.9
162	0-4"	6.6	127	1631	143	604	32.9	16.4	34.0	17.0
163	0-4"	6.8	164	1600	159	605	41.9	21.0	42.9	21.5
180	0-4"	7.3	56	3021	82	589	15.5	7.8	16.7	8.3
181	0-4"	7.6	130	3646	91	589	35.8	17.9	38.2	19.1
182	0-4"	6.4	131	1972	135	608	33.9	17.0	35.3	17.6
198	0-4"	7.8	128	3584	106	589	34.8	17.4	36.8	18.4
199	0-4"	6.6	96	1902	130	574	26.3	13.1	27.3	13.6
200	0-4"	6.6	104	1929	103	578	28.9	14.4	30.5	15.3
201	0-4"	6.2	64	1698	117	588	17.3	8.7	18.2	9.1
215	0-4"	6.0	84	822	193	596	21.2	10.6	21.3	10.6
216	0-4"	6.3	128	1499	219	586	32.2	16.1	31.8	15.9
217	0-4"	6.2	104	970	154	597	27.0	13.5	27.7	13.8
218	0-4"	6.3	147	1593	135	612	37.8	18.9	39.4	19.7
219	0-4"	6.6	189	1622	150	610	48.3	24.1	49.7	24.9
221	0-4"	6.0	247	1521	166	625	61.0	30.5	62.5	31.2

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
231	0-4"	6.7	135	1599	133	618	34.5	17.2	36.0	18.0
232	0-4"	6.1	92	1147	127	579	25.0	12.5	26.1	13.0
233	0-4"	6.2	76	933	109	599	20.3	10.2	21.5	10.7
234	0-4"	6.5	114	1212	128	587	30.6	15.3	31.9	15.9
235	0-4"	6.5	136	1388	135	598	35.7	17.9	37.1	18.6
236	0-4"	6.5	196	1788	108	579	54.1	27.1	57.1	28.5
237	0-4"	6.3	178	1660	129	599	46.9	23.4	48.9	24.5
240	0-4"	5.8	186	1308	137	612	47.8	23.9	49.7	24.8
241	0-4"	6.4	94	1568	100	603	25.1	12.6	26.7	13.4
250	0-4"	6.3	81	1144	98	615	21.3	10.7	22.7	11.4
251	0-4"	6.4	91	877	89	611	24.2	12.1	26.0	13.0
252	0-4"	6.2	120	851	108	615	31.3	15.7	33.2	16.6
253	0-4"	6.4	152	1169	119	604	40.0	20.0	42.0	21.0
254	0-4"	6.5	128	1237	134	608	33.2	16.6	34.5	17.3
255	0-4"	6.1	141	2259	101	609	37.3	18.7	39.7	19.9
259	0-4"	6.3	87	1429	107	600	23.3	11.6	24.6	12.3
269	0-4"	6.1	39	741	83	597	10.7	5.3	11.5	5.7
270	0-4"	5.9	41	522	96	611	10.9	5.4	11.6	5.8
271	0-4"	6.8	27	1135	68	601	7.4	3.7	8.1	4.0
Mean, mg/kg		6.6	115	2205	118	600	30.2	15.1	31.5	15.8
Median, mg/kg		6.4	120	1593	118	600	31.3	15.7	31.9	15.9
Minimum, mg/kg		5.8	27	522	30	574	7.4	3.7	8.1	4.0
Maximum, mg/kg		7.8	247	11512	219	625	61.0	30.5	62.5	31.2
Standard deviation, mg/kg		0.5	50	2220	39	13	12.8	6.4	13.2	6.6
C.V., %		8	44	101	33	2	43	43	42	42

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
Count			39							
Buffer zone										
212	0-4"	5.3	71	948	154	613	18.0	9.0	18.5	9.3
213	0-4"	6.1	60	1204	91	587	16.6	8.3	17.7	8.8
214	0-4"	6.2	79	1000	126	588	21.2	10.6	22.1	11.1
238	0-4"	6.2	233	1670	122	596	62.0	31.0	64.9	32.5
249	0-4"	5.9	86	1042	107	579	23.8	11.9	25.1	12.5
256	0-4"	6.3	120	1462	146	584	31.9	16.0	32.9	16.4
257	0-4"	5.9	121	1141	115	601	32.1	16.1	33.8	16.9
258	0-4"	6.1	52	1310	91	611	13.8	6.9	14.8	7.4
260	0-4"	7.1	40	3487	49	623	10.8	5.4	11.9	6.0
268	0-4"	5.7	57	696	120	618	14.7	7.3	15.4	7.7
272	0-4"	6.8	105	1435	97	587	28.9	14.4	30.7	15.4
273	0-4"	6.9	98	1976	80	592	27.1	13.5	29.2	14.6
274	0-4"	6.9	105	4198	62	581	29.9	15.0	32.7	16.3
275	0-4"	6.3	52	1420	98	593	14.1	7.1	15.1	7.5
276	0-4"	6.0	43	904	93	620	11.3	5.6	12.1	6.0
278	0-4"	6.4	42	2182	64	614	11.3	5.7	12.4	6.2
287	0-4"	5.9	55	668	97	603	14.7	7.4	15.7	7.9
288	0-4"	6.2	47	1066	105	599	12.6	6.3	13.4	6.7
289	0-4"	6.4	18	1494	63	602	5.0	2.5	5.4	2.7
291	0-4"	6.4	30	910	92	596	8.2	4.1	8.7	4.4
292	0-4"	6.5	42	1496	78	611	11.3	5.6	12.2	6.1
293	0-4"	6.2	33	2236	63	601	9.1	4.6	9.9	5.0
294	0-4"	6.5	38	1796	76	622	10.1	5.0	10.9	5.4
295	0-4"	6.7	27	1599	77	597	7.4	3.7	8.0	4.0

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
296	0-4"	5.7	36	640	122	587	9.7	4.9	10.2	5.1
297	0-4"	6.3	29	1941	68	588	8.1	4.1	8.8	4.4
309	0-4"	5.9	58	632	113	600	15.4	7.7	16.3	8.1
310	0-4"	6.0	32	636	97	610	8.5	4.2	9.1	4.5
311	0-4"	6.7	64	1124	101	605	17.1	8.5	18.1	9.1
312	0-4"	6.4	31	1463	60	608	8.5	4.2	9.3	4.6
313	0-4"	7.2	33	4477	35	595	9.4	4.7	10.5	5.2
314	0-4"	6.0	38	1318	77	599	10.4	5.2	11.2	5.6
Mean, mg/kg		6.3	62	1549	92	600	16.7	8.3	17.7	8.9
Median, mg/kg		6.3	50	1369	93	600	13.2	6.6	14.1	7.0
Minimum, mg/kg		5.3	18	632	35	579	5.0	2.5	5.4	2.7
Maximum, mg/kg		7.2	233	4477	154	623	62.0	31.0	64.9	32.5
Standard deviation, mg/kg		0.4	42	937	27	12	11.3	5.6	11.8	5.9
C.V., %		7	68	61	30	2	68	68	66	66
Count			32							

Table 6. Soil P sorption saturation and soil properties related to P sorption for 0 to 4 inch grid-soil samples from Field 5a for 2014.

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
			mg/L				%			
Whole field										
21	0-4"	6.4	17	2413	111	857	3.3	1.6	3.5	1.8
22	0-4"	5.6	35	1692	143	799	7.0	3.5	7.4	3.7
23	0-4"	5.4	55	1028	197	853	10.1	5.1	10.5	5.2
24	0-4"	5.9	40	1299	177	844	7.5	3.7	7.8	3.9
25	0-4"	5.2	47	448	196	840	8.7	4.3	9.0	4.5
32	0-4"	5.5	74	1040	230	826	13.8	6.9	14.0	7.0
33	0-4"	5.6	61	987	180	794	12.1	6.0	12.5	6.3
34	0-4"	6.4	29	1984	143	795	5.8	2.9	6.2	3.1
35	0-4"	6.1	23	2257	123	811	4.6	2.3	4.9	2.5
46	0-4"	5.4	50	840	192	790	9.9	4.9	10.2	5.1
47	0-4"	5.5	86	877	207	796	16.7	8.4	17.1	8.6
48	0-4"	5.3	59	922	188	804	11.5	5.7	11.9	5.9
49	0-4"	6.2	19	2055	135	811	3.8	1.9	4.0	2.0
50	0-4"	6.1	22	1776	130	822	4.3	2.2	4.6	2.3
59	0-4"	5.2	33	565	151	796	6.6	3.3	7.0	3.5
60	0-4"	5.0	51	584	170	790	10.2	5.1	10.6	5.3
61	0-4"	5.1	55	795	176	826	10.5	5.3	11.0	5.5
62	0-4"	5.3	69	846	161	834	13.2	6.6	13.9	6.9
73	0-4"	4.8	47	484	153	844	8.9	4.5	9.4	4.7
74	0-4"	5.3	51	513	148	825	9.9	5.0	10.5	5.2
75	0-4"	5.3	85	829	167	816	16.5	8.3	17.3	8.6
85	0-4"	5.0	54	350	118	807	10.9	5.4	11.7	5.8

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
86	0-4"	4.5	91	167	163	809	17.9	8.9	18.7	9.4
19	0-4"	6.6	34	3168	116	795	7.0	3.5	7.5	3.7
20	0-4"	7.0	36	3404	154	879	6.6	3.3	7.0	3.5
30	0-4"	6.3	27	2031	147	826	5.2	2.6	5.5	2.8
31	0-4"	6.0	26	1762	161	804	5.1	2.6	5.4	2.7
45	0-4"	6.6	32	2914	123	805	6.4	3.2	6.9	3.4
87	0-4"	6.4	18	2016	96	811	3.7	1.8	4.0	2.0
98	0-4"	4.6	51	359	155	798	10.2	5.1	10.7	5.4
99	0-4"	4.8	64	315	138	835	12.4	6.2	13.2	6.6
100	0-4"	6.4	20	2022	104	815	4.0	2.0	4.4	2.2
111	0-4"	5.0	23	644	118	827	4.5	2.3	4.9	2.4
Mean, mg/kg		5.6	45	1315	154	818	8.8	4.4	9.2	4.6
Median, mg/kg		5.5	47	987	153	811	8.7	4.3	9.0	4.5
Minimum, mg/kg		4.5	17	167	96	790	3.3	1.6	3.5	1.8
Maximum, mg/kg		7.0	91	3404	230	879	17.9	8.9	18.7	9.4
Standard deviation, mg/kg		0.7	21	881	32	22	4.0	2.0	4.1	2.1
C.V., %		12	46	67	21	3	46	46	45	45
Count			33							
Application Zone										
21	0-4"	6.4	17	2413	111	857	3.3	1.6	3.5	1.8
22	0-4"	5.6	35	1692	143	799	7.0	3.5	7.4	3.7
23	0-4"	5.4	55	1028	197	853	10.1	5.1	10.5	5.2
24	0-4"	5.9	40	1299	177	844	7.5	3.7	7.8	3.9
25	0-4"	5.2	47	448	196	840	8.7	4.3	9.0	4.5
32	0-4"	5.5	74	1040	230	826	13.8	6.9	14.0	7.0

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
33	0-4"	5.6	61	987	180	794	12.1	6.0	12.5	6.3
34	0-4"	6.4	29	1984	143	795	5.8	2.9	6.2	3.1
35	0-4"	6.1	23	2257	123	811	4.6	2.3	4.9	2.5
46	0-4"	5.4	50	840	192	790	9.9	4.9	10.2	5.1
47	0-4"	5.5	86	877	207	796	16.7	8.4	17.1	8.6
48	0-4"	5.3	59	922	188	804	11.5	5.7	11.9	5.9
49	0-4"	6.2	19	2055	135	811	3.8	1.9	4.0	2.0
50	0-4"	6.1	22	1776	130	822	4.3	2.2	4.6	2.3
59	0-4"	5.2	33	565	151	796	6.6	3.3	7.0	3.5
60	0-4"	5.0	51	584	170	790	10.2	5.1	10.6	5.3
61	0-4"	5.1	55	795	176	826	10.5	5.3	11.0	5.5
62	0-4"	5.3	69	846	161	834	13.2	6.6	13.9	6.9
73	0-4"	4.8	47	484	153	844	8.9	4.5	9.4	4.7
74	0-4"	5.3	51	513	148	825	9.9	5.0	10.5	5.2
75	0-4"	5.3	85	829	167	816	16.5	8.3	17.3	8.6
85	0-4"	5.0	54	350	118	807	10.9	5.4	11.7	5.8
86	0-4"	4.5	91	167	163	809	17.9	8.9	18.7	9.4
Mean, mg/kg		5.5	50	1076	163	817	10	5	10	5
Median, mg/kg		5.4	51	877	163	811	10	5	10	5
Minimum, mg/kg		4.5	17	167	111	790	3	2	4	2
Maximum, mg/kg		6.4	91	2413	230	857	18	9	19	9
Standard deviation, mg/kg		0.5	21	644	30	21	4	2	4	2
C.V., %		9	43	60	19	3	42	42	42	42
Count			23							
Buffer Zone										

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
19	0-4"	6.6	34	3168	116	795	7.0	3.5	7.5	3.7
20	0-4"	7.0	36	3404	154	879	6.6	3.3	7.0	3.5
30	0-4"	6.3	27	2031	147	826	5.2	2.6	5.5	2.8
31	0-4"	6.0	26	1762	161	804	5.1	2.6	5.4	2.7
45	0-4"	6.6	32	2914	123	805	6.4	3.2	6.9	3.4
87	0-4"	6.4	18	2016	96	811	3.7	1.8	4.0	2.0
98	0-4"	4.6	51	359	155	798	10.2	5.1	10.7	5.4
99	0-4"	4.8	64	315	138	835	12.4	6.2	13.2	6.6
100	0-4"	6.4	20	2022	104	815	4.0	2.0	4.4	2.2
111	0-4"	5.0	23	644	118	827	4.5	2.3	4.9	2.4
Mean, mg/kg		6.0	33	1864	131	820	6.5	3.3	6.9	3.5
Median, mg/kg		6.4	30	2019	131	813	5.8	2.9	6.2	3.1
Minimum, mg/kg		4.6	18	315	96	795	3.7	1.8	4.0	2.0
Maximum, mg/kg		7.0	64	3404	161	879	12.4	6.2	13.2	6.6
Standard deviation, mg/kg		0.9	14	1126	23	25	2.8	1.4	2.9	1.5
C.V., %		14	44	60	17	3	15	17	16	17
Count			10							

Table 7. Soil P sorption saturation and soil properties related to P sorption for 4 to 8 inch grid-soil samples from Field 5a for 2014.

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
			mg/L				%			
Whole field										
25	4-8"	6.4	42	2927	127	860	7.9	4.0	8.5	4.3
34	4-8"	6.6	45	1577	104	859	8.6	4.3	9.3	4.7
35	4-8"	6.4	33	2964	93	873	6.3	3.1	6.8	3.4
36	4-8"	6.1	36	3270	106	870	6.8	3.4	7.4	3.7
37	4-8"	5.8	49	2870	150	895	8.8	4.4	9.4	4.7
47	4-8"	6.3	22	1005	104	881	4.1	2.1	4.5	2.2
49	4-8"	6.7	41	4381	95	879	7.7	3.9	8.4	4.2
50	4-8"	6.1	30	2877	124	859	5.7	2.8	6.1	3.1
51	4-8"	5.9	33	2873	100	891	6.1	3.1	6.7	3.3
59	4-8"	6.3	49	921	113	899	9.0	4.5	9.7	4.8
61	4-8"	6	37	2754	143	882	6.8	3.4	7.2	3.6
62	4-8"	6.2	36	3093	111	859	6.9	3.4	7.4	3.7
73	4-8"	6.3	73	861	109	891	13.5	6.7	14.6	7.3
74	4-8"	6.2	67	2139	125	912	12.0	6.0	12.9	6.5
75	4-8"	6.4	28	3379	96	906	5.1	2.6	5.6	2.8
85	4-8"	6.4	57	981	122	897	10.4	5.2	11.2	5.6
86	4-8"	5.9	96	589	113	905	17.4	8.7	18.9	9.4
87	4-8"	6.4	41	2823	95	906	7.5	3.8	8.2	4.1
98	4-8"	6.8	17	2361	62	879	3.3	1.6	3.6	1.8
99	4-8"	6.4	46	1819	78	894	8.6	4.3	9.5	4.7
100	4-8"	6.3	98	1267	125	882	18.1	9.1	19.5	9.7
111	4-8"	6.3	14	3031	68	907	2.6	1.3	2.9	1.4

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
Mean, mg/kg		6.3	45	2307	107	886	8.3	4.2	9.0	4.5
Median, mg/kg		6.3	41	2789	108	887	7.6	3.8	8.3	4.2
Minimum, mg/kg		5.8	14	589	62	859	2.6	1.3	2.9	1.4
Maximum, mg/kg		6.8	98	4381	150	912	18.1	9.1	19.5	9.7
Standard deviation, mg/kg		0.3	22	1025	22	17	4.0	2.0	4.3	2.1
C.V., %		3.98	49.0	44.4	20.2	1.9	47.9	47.9	47.6	47.6
Count			22							
Application Zone										
25	4-8"	6.4	42	2927	127	860	7.9	4.0	8.5	4.3
34	4-8"	6.6	45	1577	104	859	8.6	4.3	9.3	4.7
35	4-8"	6.4	33	2964	93	873	6.3	3.1	6.8	3.4
36	4-8"	6.1	36	3270	106	870	6.8	3.4	7.4	3.7
37	4-8"	5.8	49	2870	150	895	8.8	4.4	9.4	4.7
47	4-8"	6.3	22	1005	104	881	4.1	2.1	4.5	2.2
49	4-8"	6.7	41	4381	95	879	7.7	3.9	8.4	4.2
50	4-8"	6.1	30	2877	124	859	5.7	2.8	6.1	3.1
51	4-8"	5.9	33	2873	100	891	6.1	3.1	6.7	3.3
59	4-8"	6.3	49	921	113	899	9.0	4.5	9.7	4.8
61	4-8"	6	37	2754	143	882	6.8	3.4	7.2	3.6
62	4-8"	6.2	36	3093	111	859	6.9	3.4	7.4	3.7
73	4-8"	6.3	73	861	109	891	13.5	6.7	14.6	7.3
74	4-8"	6.2	67	2139	125	912	12.0	6.0	12.9	6.5
75	4-8"	6.4	28	3379	96	906	5.1	2.6	5.6	2.8
85	4-8"	6.4	57	981	122	897	10.4	5.2	11.2	5.6
86	4-8"	5.9	96	589	113	905	17.4	8.7	18.9	9.4

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
Mean, mg/kg		6.2	46	2321	114	883	8.4	4.2	9.1	4.5
Median, mg/kg		6.3	41	2870	111	882	7.7	3.9	8.4	4.2
Minimum, mg/kg		5.8	22	589	93	859	4.1	2.1	4.5	2.2
Maximum, mg/kg		6.7	96	4381	150	912	17.4	8.7	18.9	9.4
Standard deviation, mg/kg		0.2	19	1117	16	18	3.3	1.7	3.6	1.8
C.V., %		4	41	48	14	2	40	40	40	40
Count			17							
Buffer Zone										
87	4-8"	6.4	41	2823	95	906	7.5	3.8	8.2	4.1
98	4-8"	6.8	17	2361	62	879	3.3	1.6	3.6	1.8
99	4-8"	6.4	46	1819	78	894	8.6	4.3	9.5	4.7
100	4-8"	6.3	98	1267	125	882	18.1	9.1	19.5	9.7
111	4-8"	6.3	14	3031	68	907	2.6	1.3	2.9	1.4
Mean, mg/kg		6.4	43	2260	86	894	8.0	4.0	8.7	4.4
Median, mg/kg		6.4	41	2361	78	894	7.5	3.8	8.2	4.1
Minimum, mg/kg		6.3	14	1267	62	879	2.6	1.3	2.9	1.4
Maximum, mg/kg		6.8	98	3031	125	907	18.1	9.1	19.5	9.7
Standard deviation, mg/kg		0.2	34	725	25	13	6.2	3.1	6.6	3.3
C.V., %		3	78	32	30	1	78	78	76	76
Count			5							

Table 8. Soil P sorption saturation and soil properties related to P sorption for 8 to 12 inch grid-soil samples from Field 5a for 2014.

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
			mg/L				%			
Whole field										
25	8-12"	6.1	33	3411	99	956	5.7	2.9	6.3	3.1
34	8-12"	6.7	36	1445	93	943	6.3	3.2	6.9	3.5
35	8-12"	6.5	21	4104	95	920	3.8	1.9	4.1	2.1
36	8-12"	6.1	23	3790	98	928	4.1	2.1	4.5	2.2
37	8-12"	5.4	42	3067	129	948	7.2	3.6	7.8	3.9
47	8-12"	6.6	24	1162	113	963	4.1	2.1	4.5	2.2
48	8-12"	6.6	23	4357	116	924	4.1	2.0	4.4	2.2
49	8-12"	7.1	11	4154	74	908	2.0	1.0	2.2	1.1
50	8-12"	6.2	22	3375	96	923	4.0	2.0	4.3	2.2
51	8-12"	5.7	30	3330	94	907	5.5	2.7	6.0	3.0
59	8-12"	6.6	30	824	118	914	5.4	2.7	5.8	2.9
61	8-12"	5.8	21	3024	95	922	3.8	1.9	4.1	2.1
62	8-12"	6.3	26	3266	100	956	4.5	2.3	4.9	2.5
73	8-12"	6.5	59	765	123	948	10.2	5.1	11.0	5.5
74	8-12"	6.3	36	2919	102	926	6.4	3.2	7.0	3.5
75	8-12"	6.2	28	3769	93	953	4.9	2.4	5.4	2.7
85	8-12"	6.5	46	910	139	915	8.2	4.1	8.7	4.4
87	8-12"	6.3	30	3392	89	928	5.4	2.7	5.9	2.9
98	8-12"	6.7	10	2474	70	951	1.8	0.9	2.0	1.0
99	8-12"	6.5	23	1979	78	920	4.2	2.1	4.6	2.3
111	8-12"	6.4	5	3016	55	935	0.9	0.5	1.0	0.5
Mean, mg/kg		6.3	28	2787	99	933	4.9	2.4	5.3	2.7

Median, mg/kg		6.4	26	3067	96	928	4.5	2.3	4.9	2.5
Minimum, mg/kg		5.4	5	765	55	907	0.9	0.5	1.0	0.5
Maximum, mg/kg		7.1	59	4357	139	963	10.2	5.1	11.0	5.5
Standard deviation, mg/kg		0.4	12	1152	20	17	2.1	1.1	2.3	1.1
C.V., %		6	45	41	20	2	12	14	13	14
Count			21							
Application zone										
25	8-12"	6.1	33	3411	99	956	5.7	2.9	6.3	3.1
34	8-12"	6.7	36	1445	93	943	6.3	3.2	6.9	3.5
35	8-12"	6.5	21	4104	95	920	3.8	1.9	4.1	2.1
36	8-12"	6.1	23	3790	98	928	4.1	2.1	4.5	2.2
37	8-12"	5.4	42	3067	129	948	7.2	3.6	7.8	3.9
47	8-12"	6.6	24	1162	113	963	4.1	2.1	4.5	2.2
48	8-12"	6.6	23	4357	116	924	4.1	2.0	4.4	2.2
49	8-12"	7.1	11	4154	74	908	2.0	1.0	2.2	1.1
50	8-12"	6.2	22	3375	96	923	4.0	2.0	4.3	2.2
51	8-12"	5.7	30	3330	94	907	5.5	2.7	6.0	3.0
59	8-12"	6.6	30	824	118	914	5.4	2.7	5.8	2.9
61	8-12"	5.8	21	3024	95	922	3.8	1.9	4.1	2.1
62	8-12"	6.3	26	3266	100	956	4.5	2.3	4.9	2.5
Mean, mg/kg		6.3	26	3024	102	932	4.7	2.3	5.1	2.5
Median, mg/kg		6.3	24	3330	98	924	4.1	2.1	4.5	2.2
Minimum, mg/kg		5.4	11	824	74	907	2.0	1.0	2.2	1.1
Maximum, mg/kg		7.1	42	4357	129	963	7.2	3.6	7.8	3.9
Standard deviation, mg/kg		0.5	8	1156	14	19	1.3	0.7	1.5	0.7
C.V., %		7	30	38	14	2	29	29	29	29
Count			13							
Buffer zone										

73	8-12"	6.5	59	765	123	948	10.2	5.1	11.0	5.5
74	8-12"	6.3	36	2919	102	926	6.4	3.2	7.0	3.5
75	8-12"	6.2	28	3769	93	953	4.9	2.4	5.4	2.7
85	8-12"	6.5	46	910	139	915	8.2	4.1	8.7	4.4
87	8-12"	6.3	30	3392	89	928	5.4	2.7	5.9	2.9
98	8-12"	6.7	10	2474	70	951	1.8	0.9	2.0	1.0
99	8-12"	6.5	23	1979	78	920	4.2	2.1	4.6	2.3
111	8-12"	6.4	5	3016	55	935	0.9	0.5	1.0	0.5
Mean, mg/kg		6.4	30	2403	94	935	5.2	2.6	5.7	2.8
Median, mg/kg		6.5	29	2697	91	932	5.1	2.6	5.6	2.8
Minimum, mg/kg		6.2	5	765	55	915	0.9	0.5	1.0	0.5
Maximum, mg/kg		6.7	59	3769	139	953	10.2	5.1	11.0	5.5
Standard deviation, mg/kg		0.2	18	1107	28	15	3.1	1.5	3.3	1.7
C.V., %		2	60	46	29	2	59	59	58	58
Count			8							

Table 9. Soil P sorption saturation and soil properties related to P sorption for 12 to 18 inch grid-soil samples from Field 5a for 2014.

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
			mg/L				%			
Whole field										
25	12-18"	6.3	35	3619	98	1025	5.7	2.8	6.2	3.1
34	12-18"	6.4	59	1896	92	1010	9.7	4.9	10.7	5.4
35	12-18"	6.7	16	4601	94	1058	2.5	1.3	2.8	1.4
36	12-18"	6.2	19	3892	83	1098	2.9	1.5	3.2	1.6
37	12-18"	5.2	48	3048	132	1125	7.0	3.5	7.6	3.8
47	12-18"	6.2	49	2014	108	1056	7.7	3.9	8.4	4.2
49	12-18"	7	9	3998	68	1068	1.4	0.7	1.6	0.8
50	12-18"	6.2	21	3248	93	1046	3.4	1.7	3.7	1.8
51	12-18"	5.8	31	3272	105	1058	4.9	2.4	5.3	2.7
59	12-18"	6.3	41	1027	143	1068	6.3	3.1	6.8	3.4
61	12-18"	5.9	26	3258	108	1025	4.2	2.1	4.6	2.3
62	12-18"	6	34	3110	141	1022	5.4	2.7	5.8	2.9
73	12-18"	6.3	41	697	136	1055	6.4	3.2	6.9	3.4
74	12-18"	6.4	19	3279	86	1024	3.1	1.6	3.4	1.7
75	12-18"	6.1	39	3336	94	1087	6.0	3.0	6.6	3.3
85	12-18"	6.6	53	707	139	1025	8.5	4.2	9.1	4.6
88	12-18"	6	17	3590	95	1067	2.7	1.3	2.9	1.5
98	12-18"	6.8	8	2268	79	1087	1.2	0.6	1.4	0.7
111	12-18"	6.5	5	3373	79	1098	0.8	0.4	0.8	0.4
Mean, mg/kg		6.3	30	2854	104	1058	4.7	2.4	5.2	2.6
Median, mg/kg		6.3	31	3258	95	1058	4.9	2.4	5.3	2.7
Minimum, mg/kg		5.2	5	697	68	1010	0.8	0.4	0.8	0.4

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
Maximum, mg/kg		7.0	59	4601	143	1125	9.7	4.9	10.7	5.4
Standard deviation, mg/kg		0.4	16	1116	23	31	2.6	1.3	2.8	1.4
C.V., %		6	54	39	23	3	29	31	30	31
Count			19							
Application zone										
25	12-18"	6.3	35	3619	98	1025	5.7	2.8	6.2	3.1
34	12-18"	6.4	59	1896	92	1010	9.7	4.9	10.7	5.4
35	12-18"	6.7	16	4601	94	1058	2.5	1.3	2.8	1.4
36	12-18"	6.2	19	3892	83	1098	2.9	1.5	3.2	1.6
37	12-18"	5.2	48	3048	132	1125	7.0	3.5	7.6	3.8
47	12-18"	6.2	49	2014	108	1056	7.7	3.9	8.4	4.2
49	12-18"	7	9	3998	68	1068	1.4	0.7	1.6	0.8
50	12-18"	6.2	21	3248	93	1046	3.4	1.7	3.7	1.8
51	12-18"	5.8	31	3272	105	1058	4.9	2.4	5.3	2.7
59	12-18"	6.3	41	1027	143	1068	6.3	3.1	6.8	3.4
61	12-18"	5.9	26	3258	108	1025	4.2	2.1	4.6	2.3
62	12-18"	6	34	3110	141	1022	5.4	2.7	5.8	2.9
73	12-18"	6.3	41	697	136	1055	6.4	3.2	6.9	3.4
74	12-18"	6.4	19	3279	86	1024	3.1	1.6	3.4	1.7
75	12-18"	6.1	39	3336	94	1087	6.0	3.0	6.6	3.3
85	12-18"	6.6	53	707	139	1025	8.5	4.2	9.1	4.6
Mean, mg/kg		6.2	34	2813	108	1053	5.3	2.7	5.8	2.9
Median, mg/kg		6.3	35	3253	102	1056	5.6	2.8	6.0	3.0
Minimum, mg/kg		5.2	9	697	68	1010	1.4	0.7	1.6	0.8
Maximum, mg/kg		7.0	59	4601	143	1125	9.7	4.9	10.7	5.4

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
Standard deviation, mg/kg		0.4	15	1190	24	32	2.3	1.2	2.5	1.2
C.V., %		6	43	42	22	3	29	31	30	31
Count			16							
Buffer zone										
88	12-18"	6	17	3590	95	1067	2.7	1.3	2.9	1.5
98	12-18"	6.8	8	2268	79	1087	1.2	0.6	1.4	0.7
111	12-18"	6.5	5	3373	79	1098	0.8	0.4	0.8	0.4
Mean, mg/kg		6.4	10	3077	84	1084	1.6	0.8	1.7	0.9
Median, mg/kg		6.5	8	3373	79	1087	1.2	0.6	1.4	0.7
Minimum, mg/kg		6.0	5	2268	79	1067	0.8	0.4	0.8	0.4
Maximum, mg/kg		6.8	17	3590	95	1098	2.7	1.3	2.9	1.5
Standard deviation, mg/kg		0.4	6	709	9	16	1.0	0.5	1.1	0.5
C.V., %		6	62	23	11	1	63	63	63	63
Count			3							

Table 10. Soil P sorption saturation and soil properties related to P sorption for 18 to 24 inch grid-soil samples from Field 5a for 2014.

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
			mg/L				%			
Whole field										
25	18-24"	6.5	42	3756	118	1258	5.6	2.8	6.1	3.1
34	18-24"	5.7	59	1401	106	1210	8.2	4.1	9.0	4.5
36	18-24"	6.5	20	4317	88	1120	3.0	1.5	3.3	1.7
47	18-24"	6.1	45	2011	95	1240	6.1	3.0	6.7	3.4
49	18-24"	7	8	4131	70	1226	1.1	0.6	1.2	0.6
51	18-24"	5.7	35	3653	107	1220	4.8	2.4	5.3	2.6
59	18-24"	6.2	51	1011	125	1258	6.7	3.4	7.4	3.7
61	18-24"	6.1	19	3450	108	1268	2.5	1.3	2.8	1.4
62	18-24"	5.8	34	3376	118	1197	4.7	2.4	5.2	2.6
88	18-24"	5.9	25	3288	110	1206	3.5	1.7	3.8	1.9
87	18-24"	6.4	16	3252	86	1246	2.2	1.1	2.4	1.2
98	18-24"	6.7	14	2148	61	1189	2.0	1.0	2.2	1.1
Mean, mg/kg		6.2	31	2983	99	1220	4.2	2.1	4.6	2.3
Median, mg/kg		6.2	30	3332	107	1223	4.1	2.0	4.5	2.2
Minimum, mg/kg		5.7	8	1011	61	1120	1.1	0.6	1.2	0.6
Maximum, mg/kg		7.0	59	4317	125	1268	8.2	4.1	9.0	4.5
Standard deviation, mg/kg		0.4	16	1075	20	41	2.2	1.1	2.4	1.2
C.V., %		7	53	36	20	3	16	18	17	18
Count			12							
Application zone										
25	18-24"	6.5	42	3756	118	1258	5.6	2.8	6.1	3.1

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
34	18-24"	5.7	59	1401	106	1210	8.2	4.1	9.0	4.5
36	18-24"	6.5	20	4317	88	1120	3.0	1.5	3.3	1.7
47	18-24"	6.1	45	2011	95	1240	6.1	3.0	6.7	3.4
49	18-24"	7	8	4131	70	1226	1.1	0.6	1.2	0.6
51	18-24"	5.7	35	3653	107	1220	4.8	2.4	5.3	2.6
59	18-24"	6.2	51	1011	125	1258	6.7	3.4	7.4	3.7
61	18-24"	6.1	19	3450	108	1268	2.5	1.3	2.8	1.4
62	18-24"	5.8	34	3376	118	1197	4.7	2.4	5.2	2.6
88	18-24"	5.9	25	3288	110	1206	3.5	1.7	3.8	1.9
Mean, mg/kg		6.2	34	3039	105	1220	4.6	2.3	5.1	2.5
Median, mg/kg		6.1	35	3413	108	1223	4.8	2.4	5.2	2.6
Minimum, mg/kg		5.7	8	1011	70	1120	1.1	0.6	1.2	0.6
Maximum, mg/kg		7.0	59	4317	125	1268	8.2	4.1	9.0	4.5
Standard deviation, mg/kg		0.4	16	1151	16	43	2.1	1.1	2.3	1.2
C.V., %		7	47	38	16	4	46	46	46	46
Count			10							
Buffer zone										
87	18-24"	6.4	16	3252	86	1246	2.2	1.1	2.4	1.2
98	18-24"	6.7	14	2148	61	1189	2.0	1.0	2.2	1.1
Mean, mg/kg		6.6	15	2700	74	1218	2.1	1.0	2.3	1.2
Median, mg/kg		6.6	15	2700	74	1218	2.1	1.0	2.3	1.2
Minimum, mg/kg		6.4	14	2148	61	1189	2.0	1.0	2.2	1.1
Maximum, mg/kg		6.7	16	3252	86	1246	2.2	1.1	2.4	1.2
Standard deviation, mg/kg		0.2	1	781	18	40	0.1	0.1	0.1	0.1

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation molarity with 0.5	P Saturation with 0.5	P Saturation
C.V., %		3	9	29	24	3	6	6	5	5
Count			2							

Table 11. Soil P sorption saturation and soil properties related to P sorption for 24 to 30 inch grid-soil samples from Field 5a for 2014.

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
			mg/L				%			
Whole field										
98	24-30"	6.5	21	2708	61	1280	2.8	3.1	1.4	1.6
102	24-30"	6.2	23	3624	94	1328	2.9	3.2	1.5	1.6
114	24-30"	6.6	35	3755	99	1458	4.0	4.5	2.0	2.2
115	24-30"	6.6	16	2861	104	1359	2.0	2.2	1.0	1.1
Mean, mg/kg		6.5	24	3237	90	1356	2.9	3.3	1.5	1.6
Median, mg/kg		6.6	22	3243	97	1344	2.9	3.2	1.4	1.6
Minimum, mg/kg		6.2	16	2708	61	1280	2.0	2.2	1.0	1.1
Maximum, mg/kg		6.6	35	3755	104	1458	4.0	4.5	2.0	2.2
Standard deviation, mg/kg		0.2	8	529	19	75	0.9	0.9	0.4	0.5
C.V., %		2.92	33.9	16.3	21.7	5.5	39	40	41	41
Count			4							
Application zone										
114	24-30"	6.6	35	3755	99	1458	4.0	4.5	2.0	2.2
115	24-30"	6.6	16	2861	104	1359	2.0	2.2	1.0	1.1
Mean, mg/kg		6.6	26	3308	102	1409	3.0	3.3	1.5	1.7
Median, mg/kg		6.6	26	3308	102	1409	3.0	3.3	1.5	1.7
Minimum, mg/kg		6.6	16	2861	99	1359	2.0	2.2	1.0	1.1
Maximum, mg/kg		6.6	35	3755	104	1458	4.0	4.5	2.0	2.2
Standard deviation, mg/kg		0.0	13	632	4	70	1.5	1.6	0.7	0.8
C.V., %		0	53	19	3	5	39	40	41	41
Count			2							

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
Buffer zone										
98	24-30"	6.5	21	2708	61	1280	2.8	3.1	1.4	1.6
102	24-30"	6.2	23	3624	94	1328	2.9	3.2	1.5	1.6
Mean, mg/kg		6.4	22	3166	78	1304	2.9	3.2	1.4	1.6
Median, mg/kg		6.4	22	3166	78	1304	2.9	3.2	1.4	1.6
Minimum, mg/kg		6.2	21	2708	61	1280	2.8	3.1	1.4	1.6
Maximum, mg/kg		6.5	23	3624	94	1328	2.9	3.2	1.5	1.6
Standard deviation, mg/kg		0.2	1	648	23	34	0.1	0.1	0.0	0.0
C.V., %		3	6	20	30	3	39	40	41	41
Count			2							

Table 12. Soil P sorption saturation and soil properties related to P sorption for 0 to 4 inch grid-soil samples from Field 5a for 2016.

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
			mg/L				%			
Whole field										
16	0-4"	4.6	49	260	114	820	9.8	10.5	4.9	5.2
17	0-4"	4.4	12	905	55	846	2.4	2.7	1.2	1.3
19	0-4"	5.9	10	2810	104	842	2.0	2.1	1.0	1.1
20	0-4"	6.7	20	3068	135	804	4.0	4.3	2.0	2.1
21	0-4"	5.9	16	2090	115	835	3.1	3.4	1.6	1.7
22	0-4"	5.4	24	1570	132	845	4.6	4.9	2.3	2.5
23	0-4"	5.5	37	1147	184	815	7.1	7.4	3.6	3.7
24	0-4"	5.2	33	987	164	820	6.4	6.7	3.2	3.4
25	0-4"	5.7	26	1212	159	849	4.9	5.2	2.4	2.6
30	0-4"	5.0	50	830	86	862	9.6	10.5	4.8	5.3
31	0-4"	4.6	84	441	107	843	16.4	17.7	8.2	8.8
32	0-4"	4.7	75	525	112	824	14.9	16.0	7.4	8.0
33	0-4"	5.9	29	2492	105	830	5.7	6.2	2.9	3.1
34	0-4"	5.2	30	980	147	844	5.7	6.1	2.9	3.0
35	0-4"	5.3	65	1161	187	825	12.4	12.8	6.2	6.4
36	0-4"	5.2	51	1130	196	837	9.5	9.9	4.8	4.9
37	0-4"	5.7	28	1287	143	841	5.4	5.7	2.7	2.8
38	0-4"	6.3	25	2198	142	820	4.9	5.2	2.5	2.6
45	0-4"	4.5	61	377	112	811	12.3	13.2	6.1	6.6
46	0-4"	6.3	34	3177	117	836	6.6	7.1	3.3	3.6
47	0-4"	5.1	47	778	174	859	8.7	9.1	4.3	4.5
48	0-4"	5.1	79	945	186	815	15.2	15.8	7.6	7.9

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
49	0-4"	5.4	43	874	183	861	7.9	8.2	3.9	4.1
50	0-4"	5.8	21	1834	143	827	4.1	4.3	2.0	2.2
57	0-4"	5.7	23	1953	138	840	4.4	4.7	2.2	2.4
58	0-4"	5.7	21	3059	146	843	4.0	4.2	2.0	2.1
59	0-4"	5.1	33	506	165	855	6.2	6.5	3.1	3.2
60	0-4"	5.2	49	756	178	873	8.9	9.3	4.5	4.7
61	0-4"	5.5	46	854	172	852	8.6	9.0	4.3	4.5
62	0-4"	5.0	58	841	165	862	10.7	11.3	5.4	5.6
71	0-4"	6.0	24	1785	142	825	4.7	5.0	2.3	2.5
72	0-4"	5.1	45	468	171	801	8.9	9.3	4.4	4.6
73	0-4"	5.0	47	622	171	843	8.8	9.3	4.4	4.6
74	0-4"	4.9	41	626	170	823	7.9	8.3	3.9	4.1
75	0-4"	5.2	39	905	136	815	7.7	8.2	3.9	4.1
84	0-4"	6.7	19	3128	121	824	3.8	4.0	1.9	2.0
85	0-4"	4.7	77	341	207	834	14.4	14.8	7.2	7.4
86	0-4"	5.9	46	1288	140	862	8.6	9.2	4.3	4.6
87	0-4"	5.2	44	609	138	833	8.5	9.1	4.3	4.5
98	0-4"	4.7	40	358	173	815	7.8	8.1	3.9	4.0
99	0-4"	4.9	39	457	165	822	7.5	7.9	3.8	4.0
100	0-4"	5.1	35	987	202	846	6.5	6.7	3.2	3.3
111	0-4"	6.1	12	1719	131	824	2.4	2.5	1.2	1.3
112	0-4"	4.9	30	1027	187	836	5.6	5.9	2.8	2.9
Mean, mg/kg		5.4	39	1258	148	835	7.49	7.9	3.7	4.0
Median, mg/kg		5.2	38	984	145	836	7.33	7.7	3.7	3.8
Minimum, mg/kg		4.4	10	260	55	801	1.95	2.1	1.0	1.1
Maximum, mg/kg		6.7	84	3177	207	873	16.36	17.7	8.2	8.8

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
Standard deviation, mg/kg		0.6	18	837	33	17	3.52	3.7	1.8	1.9
C.V., %		11	47	66	22	2	47	47	47	47
Count		44								
Application zone										
21	0-4"	5.9	16	2090	115	835	3.1	3.4	1.6	1.7
22	0-4"	5.4	24	1570	132	845	4.6	4.9	2.3	2.5
23	0-4"	5.5	37	1147	184	815	7.1	7.4	3.6	3.7
24	0-4"	5.2	33	987	164	820	6.4	6.7	3.2	3.4
25	0-4"	5.7	26	1212	159	849	4.9	5.2	2.4	2.6
32	0-4"	4.7	75	525	112	824	14.9	16.0	7.4	8.0
33	0-4"	5.9	29	2492	105	830	5.7	6.2	2.9	3.1
34	0-4"	5.2	30	980	147	844	5.7	6.1	2.9	3.0
35	0-4"	5.3	65	1161	187	825	12.4	12.8	6.2	6.4
36	0-4"	5.2	51	1130	196	837	9.5	9.9	4.8	4.9
37	0-4"	5.7	28	1287	143	841	5.4	5.7	2.7	2.8
38	0-4"	6.3	25	2198	142	820	4.9	5.2	2.5	2.6
46	0-4"	6.3	34	3177	117	836	6.6	7.1	3.3	3.6
47	0-4"	5.1	47	778	174	859	8.7	9.1	4.3	4.5
49	0-4"	5.4	43	874	183	861	7.9	8.2	3.9	4.1
48	0-4"	5.1	79	945	186	815	15.2	15.8	7.6	7.9
50	0-4"	5.8	21	1834	143	827	4.1	4.3	2.0	2.2
57	0-4"	5.7	23	1953	138	840	4.4	4.7	2.2	2.4
61	0-4"	5.5	46	854	172	852	8.6	9.0	4.3	4.5
62	0-4"	5.0	58	841	165	862	10.7	11.3	5.4	5.6
59	0-4"	5.1	33	506	165	855	6.2	6.5	3.1	3.2

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
58	0-4"	5.7	21	3059	146	843	4.0	4.2	2.0	2.1
60	0-4"	5.2	49	756	178	873	8.9	9.3	4.5	4.7
72	0-4"	5.1	45	468	171	801	8.9	9.3	4.4	4.6
73	0-4"	5.0	47	622	171	843	8.8	9.3	4.4	4.6
74	0-4"	4.9	41	626	170	823	7.9	8.3	3.9	4.1
75	0-4"	5.2	39	905	136	815	7.7	8.2	3.9	4.1
86	0-4"	5.9	46	1288	140	862	8.6	9.2	4.3	4.6
Mean, mg/kg		5.4	40	1295	155	838	7.6	8.0	3.8	4.0
Median, mg/kg		5.4	38	1059	162	839	7.4	7.8	3.7	3.9
Minimum, mg/kg		4.7	16	468	105	801	3.1	3.4	1.6	1.7
Maximum, mg/kg		6.3	79	3177	196	873	15.2	16.0	7.6	8.0
Standard deviation, mg/kg		0.4	16	741	25	18	3.1	3.2	1.5	1.6
C.V., %		8	40	57	16	2	40	40	40	40
Count		28								
Buffer zone										
16	0-4"	4.6	49	260	114	820	9.8	10.5	4.9	5.2
17	0-4"	4.4	12	905	55	846	2.4	2.7	1.2	1.3
19	0-4"	5.9	10	2810	104	842	2.0	2.1	1.0	1.1
20	0-4"	6.7	20	3068	135	804	4.0	4.3	2.0	2.1
30	0-4"	5.0	50	830	86	862	9.6	10.5	4.8	5.3
31	0-4"	4.6	84	441	107	843	16.4	17.7	8.2	8.8
45	0-4"	4.5	61	377	112	811	12.3	13.2	6.1	6.6
71	0-4"	6.0	24	1785	142	825	4.7	5.0	2.3	2.5
84	0-4"	6.7	19	3128	121	824	3.8	4.0	1.9	2.0
85	0-4"	4.7	77	341	207	834	14.4	14.8	7.2	7.4

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
87	0-4"	5.2	44	609	138	833	8.5	9.1	4.3	4.5
98	0-4"	4.7	40	358	173	815	7.8	8.1	3.9	4.0
99	0-4"	4.9	39	457	165	822	7.5	7.9	3.8	4.0
100	0-4"	5.1	35	987	202	846	6.5	6.7	3.2	3.3
111	0-4"	6.1	12	1719	131	824	2.4	2.5	1.2	1.3
112	0-4"	4.9	30	1027	187	836	5.6	5.9	2.8	2.9
Mean, mg/kg		5.3	38	1194	136	830	7.3	7.8	3.7	3.9
Median, mg/kg		5.0	37	868	133	829	7.0	7.3	3.5	3.6
Minimum, mg/kg		4.4	10	260	55	804	2.0	2.1	1.0	1.1
Maximum, mg/kg		6.7	84	3128	207	862	16.4	17.7	8.2	8.8
Standard deviation, mg/kg		0.8	22	1006	42	15	4.3	4.6	2.2	2.3
C.V., %		15	59	84	31	2	59	59	59	59
Count		16								

Table 13. Soil P sorption saturation and soil properties related to P sorption for 4 to 8 inch grid-soil samples from Field 5a for 2016.

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
			mg/L				%			
Whole field										
21	4-8"	6.1	8	2088	110	915	1.4	1.6	0.7	0.8
22	4-8"	5.5	15	2096	139	925	2.6	2.8	1.3	1.4
23	4-8"	5.6	32	1198	152	914	5.6	6.0	2.8	3.0
24	4-8"	5.5	34	918	184	903	6.0	6.3	3.0	3.1
25	4-8"	5.9	19	1176	137	915	3.4	3.6	1.7	1.8
32	4-8"	4.9	26	466	100	944	4.6	5.0	2.3	2.5
33	4-8"	5.8	13	2016	98	950	2.3	2.5	1.1	1.2
34	4-8"	5.2	18	1075	138	925	3.2	3.4	1.6	1.7
35	4-8"	5.3	50	1376	154	934	8.6	9.2	4.3	4.6
36	4-8"	5.5	43	1218	173	961	7.2	7.6	3.6	3.8
37	4-8"	5.8	21	1005	149	915	3.7	3.9	1.9	2.0
38	4-8"	6.5	18	1675	127	924	3.2	3.4	1.6	1.7
46	4-8"	6.6	12	3024	103	935	2.1	2.3	1.1	1.2
47	4-8"	5.1	30	802	156	928	5.2	5.5	2.6	2.8
49	4-8"	5.7	44	895	171	924	7.6	8.0	3.8	4.0
48	4-8"	5.4	65	1059	178	935	11.1	11.7	5.5	5.8
50	4-8"	6.0	12	2010	129	967	2.0	2.2	1.0	1.1
57	4-8"	6.0	17	1220	123	928	3.0	3.2	1.5	1.6
61	4-8"	5.5	33	936	148	922	5.8	6.2	2.9	3.1
62	4-8"	5.0	65	858	144	947	11.1	11.9	5.6	6.0
59	4-8"	4.9	22	498	155	935	3.8	4.0	1.9	2.0
58	4-8"	6.2	11	2596	123	925	1.9	2.1	1.0	1.0

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
60	4-8"	5.1	19	579	133	941	3.3	3.5	1.6	1.8
72	4-8"	5.2	26	480	150	925	4.5	4.8	2.3	2.4
73	4-8"	5.3	22	664	153	937	3.8	4.0	1.9	2.0
74	4-8"	5.3	24	814	165	968	4.0	4.2	2.0	2.1
75	4-8"	4.8	37	827	127	955	6.3	6.8	3.2	3.4
86	4-8"	6.0	26	1167	130	934	4.5	4.9	2.3	2.4
16	4-8"	4.7	22	212	108	930	3.9	4.2	2.0	2.1
17	4-8"	4.2	36	656	93	925	6.5	7.1	3.2	3.5
19	4-8"	5.9	19	2859	115	973	3.2	3.5	1.6	1.7
20	4-8"	6.3	10	2760	106	950	1.7	1.9	0.9	0.9
30	4-8"	4.9	32	477	97	935	5.7	6.2	2.8	3.1
31	4-8"	4.9	35	358	98	914	6.3	6.9	3.2	3.5
45	4-8"	4.5	37	381	104	944	6.5	7.1	3.2	3.5
71	4-8"	6.0	18	1694	138	933	3.1	3.4	1.6	1.7
84	4-8"	6.4	12	2310	120	948	2.1	2.2	1.0	1.1
85	4-8"	4.7	66	307	176	924	11.4	12.0	5.7	6.0
87	4-8"	5.0	36	645	143	933	6.3	6.7	3.1	3.3
98	4-8"	4.9	26	471	159	928	4.5	4.8	2.3	2.4
99	4-8"	4.9	21	564	137	946	3.6	3.9	1.8	1.9
100	4-8"	5.1	32	907	158	968	5.3	5.7	2.7	2.8
111	4-8"	6.0	22	1902	141	946	3.8	4.0	1.9	2.0
112	4-8"	4.8	14	805	150	955	2.4	2.5	1.2	1.3
Mean, mg/kg		5.4	27	1183	136	936	4.7	5.1	2.4	2.5
Median, mg/kg		5.4	23	927	138	934	3.9	4.2	2.0	2.1
Minimum, mg/kg		4.2	8	212	93	903	1.4	1.6	0.7	0.8
Maximum, mg/kg		6.6	66	3024	184	973	11.4	12.0	5.7	6.0

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
Standard deviation, mg/kg		0.6	14	749	25	16	2.5	2.6	1.2	1.3
C.V., %		11	53	63	18	2	52	51	52	51
Count		44								
Application zone										
21	4-8"	6.1	8	2088	110	915	1.4	1.6	0.7	0.8
22	4-8"	5.5	15	2096	139	925	2.6	2.8	1.3	1.4
23	4-8"	5.6	32	1198	152	914	5.6	6.0	2.8	3.0
24	4-8"	5.5	34	918	184	903	6.0	6.3	3.0	3.1
25	4-8"	5.9	19	1176	137	915	3.4	3.6	1.7	1.8
32	4-8"	4.9	26	466	100	944	4.6	5.0	2.3	2.5
33	4-8"	5.8	13	2016	98	950	2.3	2.5	1.1	1.2
34	4-8"	5.2	18	1075	138	925	3.2	3.4	1.6	1.7
35	4-8"	5.3	50	1376	154	934	8.6	9.2	4.3	4.6
36	4-8"	5.5	43	1218	173	961	7.2	7.6	3.6	3.8
37	4-8"	5.8	21	1005	149	915	3.7	3.9	1.9	2.0
38	4-8"	6.5	18	1675	127	924	3.2	3.4	1.6	1.7
46	4-8"	6.6	12	3024	103	935	2.1	2.3	1.1	1.2
47	4-8"	5.1	30	802	156	928	5.2	5.5	2.6	2.8
49	4-8"	5.7	44	895	171	924	7.6	8.0	3.8	4.0
48	4-8"	5.4	65	1059	178	935	11.1	11.7	5.5	5.8
50	4-8"	6.0	12	2010	129	967	2.0	2.2	1.0	1.1
57	4-8"	6.0	17	1220	123	928	3.0	3.2	1.5	1.6
61	4-8"	5.5	33	936	148	922	5.8	6.2	2.9	3.1
62	4-8"	5.0	65	858	144	947	11.1	11.9	5.6	6.0
59	4-8"	4.9	22	498	155	935	3.8	4.0	1.9	2.0

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
58	4-8"	6.2	11	2596	123	925	1.9	2.1	1.0	1.0
60	4-8"	5.1	19	579	133	941	3.3	3.5	1.6	1.8
72	4-8"	5.2	26	480	150	925	4.5	4.8	2.3	2.4
73	4-8"	5.3	22	664	153	937	3.8	4.0	1.9	2.0
74	4-8"	5.3	24	814	165	968	4.0	4.2	2.0	2.1
75	4-8"	4.8	37	827	127	955	6.3	6.8	3.2	3.4
86	4-8"	6.0	26	1167	130	934	4.5	4.9	2.3	2.4
Mean, mg/kg		5.6	27	1241	141	933	4.7	5.0	2.4	2.5
Median, mg/kg		5.5	23	1067	142	931	3.9	4.1	1.9	2.1
Minimum, mg/kg		4.8	8	466	98	903	1.4	1.6	0.7	0.8
Maximum, mg/kg		6.6	65	3024	184	968	11.1	11.9	5.6	6.0
Standard deviation, mg/kg		0.5	15	653	23	16	2.6	2.7	1.3	1.3
C.V., %		9	55	53	16	2	54	54	54	54
Count		28								
Buffer zone										
16	4-8"	4.7	22	212	108	930	3.9	4.2	2.0	2.1
17	4-8"	4.2	36	656	93	925	6.5	7.1	3.2	3.5
19	4-8"	5.9	19	2859	115	973	3.2	3.5	1.6	1.7
20	4-8"	6.3	10	2760	106	950	1.7	1.9	0.9	0.9
30	4-8"	4.9	32	477	97	935	5.7	6.2	2.8	3.1
31	4-8"	4.9	35	358	98	914	6.3	6.9	3.2	3.5
45	4-8"	4.5	37	381	104	944	6.5	7.1	3.2	3.5
71	4-8"	6.0	18	1694	138	933	3.1	3.4	1.6	1.7
84	4-8"	6.4	12	2310	120	948	2.1	2.2	1.0	1.1
85	4-8"	4.7	66	307	176	924	11.4	12.0	5.7	6.0

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
87	4-8"	5.0	36	645	143	933	6.3	6.7	3.1	3.3
98	4-8"	4.9	26	471	159	928	4.5	4.8	2.3	2.4
99	4-8"	4.9	21	564	137	946	3.6	3.9	1.8	1.9
100	4-8"	5.1	32	907	158	968	5.3	5.7	2.7	2.8
111	4-8"	6.0	22	1902	141	946	3.8	4.0	1.9	2.0
112	4-8"	4.8	14	805	150	955	2.4	2.5	1.2	1.3
Mean, mg/kg		5.9	29	1125	131	893	6.1	6.4	3.7	3.8
Median, mg/kg		4.9	24	651	129	940	4.2	4.5	2.1	2.3
Minimum, mg/kg		4.2	10	212	93	914	1.7	1.9	0.9	0.9
Maximum, mg/kg		6.4	66	2859	176	973	11.4	12.0	5.7	6.0
Standard deviation, mg/kg		0.7	14	909	26	16	2.4	2.5	1.2	1.3
C.V., %		12	48	81	20	2	39	40	32	33
Count		16								

Table 14. Soil P sorption saturation and soil properties related to P sorption for 0 to 4 inch grid-soil samples from Field 5a for 2018.

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
			mg/L				%			
Whole field										
21	0-4"	6.9	25	2630	105	826	5.0	5.4	2.5	2.7
22	0-4"	5.9	44	1628	121	835	8.6	9.2	4.3	4.6
23	0-4"	5.6	35	1071	148	825	6.8	7.2	3.4	3.6
24	0-4"	6.0	31	1119	139	830	6.0	6.4	3.0	3.2
25	0-4"	6.0	31	1250	141	860	5.8	6.2	2.9	3.1
32	0-4"	6.6	26	2395	95	814	5.3	5.7	2.6	2.9
33	0-4"	5.5	78	737	94	835	15.4	16.8	7.7	8.4
34	0-4"	6.6	31	1664	111	840	6.0	6.5	3.0	3.3
35	0-4"	5.6	59	919	153	830	11.4	12.0	5.7	6.0
36	0-4"	5.6	55	898	162	840	10.4	11.0	5.2	5.5
37	0-4"	6.0	24	1409	125	835	4.7	5.0	2.3	2.5
38	0-4"	6.3	27	1789	124	815	5.4	5.8	2.7	2.9
46	0-4"	6.9	44	3041	107	846	8.5	9.2	4.3	4.6
47	0-4"	5.6	50	724	156	855	9.4	9.9	4.7	4.9
48	0-4"	5.7	64	907	157	869	11.8	12.5	5.9	6.2
49	0-4"	5.8	77	1216	176	820	14.8	15.5	7.4	7.7
50	0-4"	6.1	20	1980	124	824	3.9	4.2	2.0	2.1
51	0-4"	6.2	25	1505	121	835	4.9	5.2	2.4	2.6
59	0-4"	5.3	34	619	144	861	6.4	6.8	3.2	3.4
60	0-4"	5.3	38	628	137	846	7.3	7.7	3.6	3.9
61	0-4"	5.8	51	919	147	856	9.6	10.2	4.8	5.1
62	0-4"	5.4	56	859	142	847	10.7	11.3	5.3	5.7

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
72	0-4"	5.4	55	524	148	811	10.9	11.5	5.4	5.7
73	0-4"	5.5	65	697	131	834	12.6	13.5	6.3	6.7
74	0-4"	5.5	43	621	128	813	8.6	9.1	4.3	4.6
75	0-4"	5.3	49	904	128	805	9.8	10.5	4.9	5.3
85	0-4"	5.2	62	421	165	824	12.0	12.5	6.0	6.3
86	0-4"	5.5	58	531	128	852	11.1	11.8	5.5	5.9
16	0-4"	4.9	66	408	87	812	13.5	14.7	6.7	7.3
17	0-4"	5.0	65	640	95	836	12.8	14.0	6.4	7.0
19	0-4"	6.8	29	3096	81	832	5.8	6.4	2.9	3.2
20	0-4"	6.9	28	3307	113	824	5.6	6.0	2.8	3.0
30	0-4"	5.2	150	587	127	856	28.5	30.5	14.2	15.3
31	0-4"	6.3	46	1376	78	846	9.1	10.0	4.5	5.0
45	0-4"	5.2	101	572	111	821	20.1	21.7	10.1	10.8
58	0-4"	6.5	35	2854	96	849	6.8	7.4	3.4	3.7
71	0-4"	7.0	31	2903	104	835	6.1	6.6	3.1	3.3
84	0-4"	7.2	20	4139	96	804	4.1	4.4	2.0	2.2
87	0-4"	5.3	40	595	129	837	7.7	8.3	3.9	4.1
98	0-4"	5.2	33	468	146	819	6.5	6.8	3.2	3.4
99	0-4"	5.3	78	432	148	816	15.3	16.2	7.7	8.1
100	0-4"	5.6	39	1030	168	827	7.5	7.8	3.7	3.9
111	0-4"	6.6	26	1906	113	819	5.2	5.6	2.6	2.8
112	0-4"	5.3	28	1099	166	833	5.3	5.6	2.7	2.8
Mean, mg/kg		5.9	47	1341	128	833	9.2	9.8	4.6	4.9
Median, mg/kg		5.6	42	975	128	834	8.1	8.7	4.1	4.4
Minimum, mg/kg		4.9	20	408	78	804	3.9	4.2	2.0	2.1
Maximum, mg/kg		7.2	150	4139	176	869	28.5	30.5	14.2	15.3

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
Standard deviation, mg/kg		0.6	24	932	25	16	4.7	5.0	2.3	2.5
C.V., %		11	52	69	20	2	51	51	51	51
Count		44								
Application zone										
21	0-4"	6.9	25	2630	105	826	5.0	5.4	2.5	2.7
22	0-4"	5.9	44	1628	121	835	8.6	9.2	4.3	4.6
23	0-4"	5.6	35	1071	148	825	6.8	7.2	3.4	3.6
24	0-4"	6.0	31	1119	139	830	6.0	6.4	3.0	3.2
25	0-4"	6.0	31	1250	141	860	5.8	6.2	2.9	3.1
32	0-4"	6.6	26	2395	95	814	5.3	5.7	2.6	2.9
33	0-4"	5.5	78	737	94	835	15.4	16.8	7.7	8.4
34	0-4"	6.6	31	1664	111	840	6.0	6.5	3.0	3.3
35	0-4"	5.6	59	919	153	830	11.4	12.0	5.7	6.0
36	0-4"	5.6	55	898	162	840	10.4	11.0	5.2	5.5
37	0-4"	6.0	24	1409	125	835	4.7	5.0	2.3	2.5
38	0-4"	6.3	27	1789	124	815	5.4	5.8	2.7	2.9
46	0-4"	6.9	44	3041	107	846	8.5	9.2	4.3	4.6
47	0-4"	5.6	50	724	156	855	9.4	9.9	4.7	4.9
48	0-4"	5.7	64	907	157	869	11.8	12.5	5.9	6.2
49	0-4"	5.8	77	1216	176	820	14.8	15.5	7.4	7.7
50	0-4"	6.1	20	1980	124	824	3.9	4.2	2.0	2.1
51	0-4"	6.2	25	1505	121	835	4.9	5.2	2.4	2.6
59	0-4"	5.3	34	619	144	861	6.4	6.8	3.2	3.4
60	0-4"	5.3	38	628	137	846	7.3	7.7	3.6	3.9
61	0-4"	5.8	51	919	147	856	9.6	10.2	4.8	5.1

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
62	0-4"	5.4	56	859	142	847	10.7	11.3	5.3	5.7
72	0-4"	5.4	55	524	148	811	10.9	11.5	5.4	5.7
73	0-4"	5.5	65	697	131	834	12.6	13.5	6.3	6.7
74	0-4"	5.5	43	621	128	813	8.6	9.1	4.3	4.6
75	0-4"	5.3	49	904	128	805	9.8	10.5	4.9	5.3
85	0-4"	5.2	62	421	165	824	12.0	12.5	6.0	6.3
86	0-4"	5.5	58	531	128	852	11.1	11.8	5.5	5.9
Mean, mg/kg		5.8	45	1200	134	835	8.7	9.2	4.3	4.6
Median, mg/kg		5.7	44	919	134	835	8.6	9.2	4.3	4.6
Minimum, mg/kg		5.2	20	421	94	805	3.9	4.2	2.0	2.1
Maximum, mg/kg		6.9	78	3041	176	869	15.4	16.8	7.7	8.4
Standard deviation, mg/kg		0.5	16	670	21	17	3.2	3.3	1.6	1.7
C.V., %		8	37	56	15	2	36	36	36	36
Count		28								
Buffer zone										
16	0-4"	4.9	66	408	87	812	13.5	14.7	6.7	7.3
17	0-4"	5.0	65	640	95	836	12.8	14.0	6.4	7.0
19	0-4"	6.8	29	3096	81	832	5.8	6.4	2.9	3.2
20	0-4"	6.9	28	3307	113	824	5.6	6.0	2.8	3.0
30	0-4"	5.2	150	587	127	856	28.5	30.5	14.2	15.3
31	0-4"	6.3	46	1376	78	846	9.1	10.0	4.5	5.0
45	0-4"	5.2	101	572	111	821	20.1	21.7	10.1	10.8
58	0-4"	6.5	35	2854	96	849	6.8	7.4	3.4	3.7
71	0-4"	7.0	31	2903	104	835	6.1	6.6	3.1	3.3
84	0-4"	7.2	20	4139	96	804	4.1	4.4	2.0	2.2

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
87	0-4"	5.3	40	595	129	837	7.7	8.3	3.9	4.1
98	0-4"	5.2	33	468	146	819	6.5	6.8	3.2	3.4
99	0-4"	5.3	78	432	148	816	15.3	16.2	7.7	8.1
100	0-4"	5.6	39	1030	168	827	7.5	7.8	3.7	3.9
111	0-4"	6.6	26	1906	113	819	5.2	5.6	2.6	2.8
112	0-4"	5.3	28	1099	166	833	5.3	5.6	2.7	2.8
Mean, mg/kg		5.9	51	1588	116	829	10.0	10.7	5.0	5.4
Median, mg/kg		5.5	37	1065	112	830	7.1	7.6	3.6	3.8
Minimum, mg/kg		4.9	20	408	78	804	4.1	4.4	2.0	2.2
Maximum, mg/kg		7.2	150	4139	168	856	28.5	30.5	14.2	15.3
Standard deviation, mg/kg		0.8	34	1256	29	14	6.6	7.1	3.3	3.6
C.V., %		14	68	79	25	2	66	66	66	66
Count		16								

Table 15. Soil P sorption saturation and soil properties related to P sorption for 4 to 8 inch grid-soil samples from Field 5a for 2018.

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
			mg/L				%			
Whole field										
21	4-8"	6.5	20	3004	115	925	3.6	3.8	1.8	1.9
22	4-8"	5.6	34	1490	142	936	5.9	6.3	2.9	3.2
23	4-8"	5.8	34	1122	149	915	6.0	6.4	3.0	3.2
24	4-8"	5.9	31	1002	170	928	5.3	5.6	2.7	2.8
25	4-8"	5.9	28	1037	167	948	4.7	5.0	2.4	2.5
32	4-8"	5.3	55	589	117	925	9.8	10.6	4.9	5.3
33	4-8"	6.6	17	3075	125	903	3.1	3.3	1.5	1.7
34	4-8"	6.6	19	1785	119	924	3.4	3.6	1.7	1.8
35	4-8"	5.6	53	1199	158	926	9.2	9.8	4.6	4.9
36	4-8"	5.8	60	938	178	935	10.2	10.8	5.1	5.4
37	4-8"	6.1	21	1213	145	941	3.6	3.9	1.8	1.9
38	4-8"	6.3	21	1972	144	925	3.7	3.9	1.8	2.0
46	4-8"	6.4	14	3281	103	935	2.5	2.7	1.2	1.3
47	4-8"	5.7	35	924	167	920	6.1	6.4	3.0	3.2
48	4-8"	5.6	80	1018	175	965	13.3	14.0	6.6	7.0
49	4-8"	5.7	40	1070	155	943	6.8	7.3	3.4	3.6
50	4-8"	6.2	13	2044	117	940	2.3	2.5	1.1	1.2
59	4-8"	5.3	24	373	133	941	4.2	4.5	2.1	2.2
60	4-8"	5.5	20	625	127	951	3.4	3.7	1.7	1.9
61	4-8"	5.7	40	895	146	935	6.9	7.4	3.5	3.7
62	4-8"	5.3	65	870	144	935	11.3	12.0	5.6	6.0
72	4-8"	5.3	31	476	137	929	5.4	5.8	2.7	2.9

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
73	4-8"	5.5	26	665	132	922	4.6	4.9	2.3	2.5
74	4-8"	5.5	27	668	147	923	4.7	5.0	2.4	2.5
75	4-8"	5.0	49	716	135	935	8.5	9.2	4.3	4.6
85	4-8"	5.2	38	354	152	928	6.6	7.0	3.3	3.5
86	4-8"	5.4	29	380	126	930	5.1	5.5	2.5	2.7
16	4-8"	4.9	42	211	105	912	7.6	8.3	3.8	4.1
17	4-8"	5.1	22	1015	90	948	3.9	4.2	1.9	2.1
19	4-8"	5.8	28	2405	122	953	4.8	5.2	2.4	2.6
20	4-8"	7.0	22	3648	138	943	3.8	4.1	1.9	2.0
30	4-8"	5.8	64	588	111	964	11.0	11.9	5.5	6.0
31	4-8"	5.1	76	500	125	910	13.6	14.7	6.8	7.3
45	4-8"	5.0	40	463	106	917	7.2	7.8	3.6	3.9
58	4-8"	6.3	13	2868	107	933	2.3	2.5	1.2	1.3
71	4-8"	5.1	38	551	131	944	6.6	7.1	3.3	3.5
84	4-8"	6.5	11	2168	117	941	1.9	2.1	1.0	1.0
87	4-8"	5.2	31	687	126	952	5.3	5.8	2.7	2.9
98	4-8"	5.0	28	415	144	921	4.9	5.3	2.5	2.6
99	4-8"	5.2	21	576	121	943	3.7	3.9	1.8	2.0
100	4-8"	5.5	23	935	149	915	4.1	4.3	2.0	2.2
111	4-8"	6.1	16	1425	115	922	2.9	3.1	1.4	1.5
112	4-8"	5.1	28	803	129	932	4.9	5.3	2.5	2.6
Mean, mg/kg		5.7	33	1210	134	933	5.8	6.2	2.9	3.1
Median, mg/kg		5.6	28	935	132	933	4.9	5.3	2.5	2.6
Minimum, mg/kg		4.9	11	211	90	903	1.9	2.1	1.0	1.0
Maximum, mg/kg		7.0	80	3648	178	965	13.6	14.7	6.8	7.3

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
Standard deviation, mg/kg		0.5	17	886	21	14	2.9	3.1	1.5	1.6
C.V., %		9	51	73	15	1	50	50	50	50
Count		43								
Application zone										
21	4-8"	6.5	20	3004	115	925	3.6	3.8	1.8	1.9
22	4-8"	5.6	34	1490	142	936	5.9	6.3	2.9	3.2
23	4-8"	5.8	34	1122	149	915	6.0	6.4	3.0	3.2
24	4-8"	5.9	31	1002	170	928	5.3	5.6	2.7	2.8
25	4-8"	5.9	28	1037	167	948	4.7	5.0	2.4	2.5
32	4-8"	5.3	55	589	117	925	9.8	10.6	4.9	5.3
33	4-8"	6.6	17	3075	125	903	3.1	3.3	1.5	1.7
34	4-8"	6.6	19	1785	119	924	3.4	3.6	1.7	1.8
35	4-8"	5.6	53	1199	158	926	9.2	9.8	4.6	4.9
36	4-8"	5.8	60	938	178	935	10.2	10.8	5.1	5.4
37	4-8"	6.1	21	1213	145	941	3.6	3.9	1.8	1.9
38	4-8"	6.3	21	1972	144	925	3.7	3.9	1.8	2.0
46	4-8"	6.4	14	3281	103	935	2.5	2.7	1.2	1.3
47	4-8"	5.7	35	924	167	920	6.1	6.4	3.0	3.2
48	4-8"	5.6	80	1018	175	965	13.3	14.0	6.6	7.0
49	4-8"	5.7	40	1070	155	943	6.8	7.3	3.4	3.6
50	4-8"	6.2	13	2044	117	940	2.3	2.5	1.1	1.2
59	4-8"	5.3	24	373	133	941	4.2	4.5	2.1	2.2
60	4-8"	5.5	20	625	127	951	3.4	3.7	1.7	1.9
61	4-8"	5.7	40	895	146	935	6.9	7.4	3.5	3.7
62	4-8"	5.3	65	870	144	935	11.3	12.0	5.6	6.0

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
72	4-8"	5.3	31	476	137	929	5.4	5.8	2.7	2.9
73	4-8"	5.5	26	665	132	922	4.6	4.9	2.3	2.5
74	4-8"	5.5	27	668	147	923	4.7	5.0	2.4	2.5
75	4-8"	5.0	49	716	135	935	8.5	9.2	4.3	4.6
85	4-8"	5.2	38	354	152	928	6.6	7.0	3.3	3.5
86	4-8"	5.4	29	380	126	930	5.1	5.5	2.5	2.7
Mean, mg/kg		5.8	34	1214	142	932	5.9	6.3	3.0	3.2
Median, mg/kg		5.7	31	1002	144	930	5.3	5.6	2.7	2.8
Minimum, mg/kg		5.0	13	354	103	903	2.3	2.5	1.1	1.2
Maximum, mg/kg		6.6	80	3281	178	965	13.3	14.0	6.6	7.0
Standard deviation, mg/kg		0.4	17	818	20	12	2.8	3.0	1.4	1.5
C.V., %		8	49	67	14	1	48	47	48	47
Count		27								
Buffer zone										
16	4-8"	4.9	42	211	105	912	7.6	8.3	3.8	4.1
17	4-8"	5.1	22	1015	90	948	3.9	4.2	1.9	2.1
19	4-8"	5.8	28	2405	122	953	4.8	5.2	2.4	2.6
20	4-8"	7.0	22	3648	138	943	3.8	4.1	1.9	2.0
30	4-8"	5.8	64	588	111	964	11.0	11.9	5.5	6.0
31	4-8"	5.1	76	500	125	910	13.6	14.7	6.8	7.3
45	4-8"	5.0	40	463	106	917	7.2	7.8	3.6	3.9
58	4-8"	6.3	13	2868	107	933	2.3	2.5	1.2	1.3
71	4-8"	5.1	38	551	131	944	6.6	7.1	3.3	3.5
84	4-8"	6.5	11	2168	117	941	1.9	2.1	1.0	1.0
87	4-8"	5.2	31	687	126	952	5.3	5.8	2.7	2.9

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
98	4-8"	5.0	28	415	144	921	4.9	5.3	2.5	2.6
99	4-8"	5.2	21	576	121	943	3.7	3.9	1.8	2.0
100	4-8"	5.5	23	935	149	915	4.1	4.3	2.0	2.2
111	4-8"	6.1	16	1425	115	922	2.9	3.1	1.4	1.5
112	4-8"	5.1	28	803	129	932	4.9	5.3	2.5	2.6
Mean, mg/kg		5.5	31	1204	121	934	5.5	6.0	2.8	3.0
Median, mg/kg		5.2	28	745	122	937	4.9	5.2	2.4	2.6
Minimum, mg/kg		4.9	11	211	90	910	1.9	2.1	1.0	1.0
Maximum, mg/kg		7.0	76	3648	149	964	13.6	14.7	6.8	7.3
Standard deviation, mg/kg		0.6	18	1018	15	17	3.1	3.4	1.6	1.7
C.V., %		11	56	85	13	2	57	57	57	57
Count		16								

Table 16. Soil P sorption saturation and soil properties related to P sorption for 0 to 4 inch grid-soil samples from Field 12 for 2014.

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
			mg/L				%			
Whole field										
9	0-4"	5.9	138	776	149	860	25.8	27.4	12.9	13.7
10	0-4"	6.0	143	763	138	857	27.0	28.7	13.5	14.4
11	0-4"	5.6	147	681	155	869	27.1	28.7	13.6	14.4
13	0-4"	6.0	65	1621	128	847	12.5	13.3	6.2	6.7
17	0-4"	5.7	117	721	146	826	22.7	24.1	11.4	12.0
18	0-4"	5.9	147	726	145	857	27.6	29.3	13.8	14.7
19	0-4"	5.7	126	608	154	869	23.3	24.6	11.6	12.3
20	0-4"	5.7	101	1169	151	893	18.2	19.3	9.1	9.7
21	0-4"	5.8	61	1367	153	855	11.4	12.1	5.7	6.1
22	0-4"	5.3	71	734	261	860	12.5	12.7	6.3	6.3
25	0-4"	5.5	60	788	107	815	12.1	13.0	6.0	6.5
26	0-4"	5.6	128	690	151	847	24.2	25.7	12.1	12.8
27	0-4"	5.8	109	956	143	825	21.2	22.5	10.6	11.3
28	0-4"	5.8	45	1441	117	889	8.3	8.9	4.1	4.5
29	0-4"	5.6	39	993	151	856	7.3	7.7	3.7	3.9
30	0-4"	5.6	53	873	155	814	10.4	10.9	5.2	5.5
33	0-4"	5.3	53	743	167	836	10.1	10.6	5.0	5.3
34	0-4"	6.1	43	1530	134	880	7.9	8.5	4.0	4.2
35	0-4"	6.0	37	1207	102	867	7.0	7.6	3.5	3.8
37	0-4"	5.8	63	1039	118	896	11.5	12.4	5.8	6.2
38	0-4"	5.8	52	828	92	847	10.2	11.1	5.1	5.5
41	0-4"	5.9	43	1318	101	869	8.2	8.9	4.1	4.4

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
42	0-4"	6.0	30	1781	102	834	5.9	6.4	3.0	3.2
43	0-4"	6.2	29	1767	108	875	5.4	5.9	2.7	3.0
44	0-4"	5.6	73	1048	136	826	14.3	15.2	7.1	7.6
45	0-4"	5.8	30	1143	113	867	5.7	6.1	2.8	3.1
46	0-4"	5.8	47	820	133	849	9.0	9.6	4.5	4.8
47	0-4"	5.9	42	1838	96	867	8.0	8.7	4.0	4.4
49	0-4"	6.1	24	1953	83	860	4.6	5.1	2.3	2.5
50	0-4"	5.9	19	1758	87	864	3.7	4.0	1.8	2.0
51	0-4"	6.3	17	1908	87	856	3.3	3.6	1.6	1.8
52	0-4"	6.3	30	1537	100	867	5.7	6.2	2.9	3.1
53	0-4"	6.1	33	1416	102	859	6.3	6.9	3.2	3.4
54	0-4"	6.1	32	970	115	863	6.1	6.5	3.0	3.3
57	0-4"	6.0	26	1120	108	896	4.8	5.2	2.4	2.6
58	0-4"	6.0	36	1338	101	878	6.8	7.4	3.4	3.7
59	0-4"	5.9	39	853	116	884	7.2	7.8	3.6	3.9
60	0-4"	6.0	52	1357	107	896	9.6	10.4	4.8	5.2
61	0-4"	6.0	34	1453	118	869	6.4	6.9	3.2	3.4
62	0-4"	6.0	97	1723	139	873	18.0	19.2	9.0	9.6
Mean, mg/kg		5.9	63	1184	127	860	11.9	12.7	6.0	6.4
Median, mg/kg		5.9	50	1132	118	862	9.3	10.0	4.6	5.0
Minimum, mg/kg		5.3	17	608	83	814	3.3	3.6	1.6	1.8
Maximum, mg/kg		6.3	147	1953	261	896	27.6	29.3	13.8	14.7
Standard deviation, mg/kg		0.2	40	405	32	21	7.4	7.8	3.7	3.9
C.V., %		4	63	34	25	2	62	61	62	61
Count		40								

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
Application zone										
17	0-4"	5.7	117	721	146	826	22.7	24.1	11.4	12.0
18	0-4"	5.9	147	726	145	857	27.6	29.3	13.8	14.7
19	0-4"	5.7	126	608	154	869	23.3	24.6	11.6	12.3
20	0-4"	5.7	101	1169	151	893	18.2	19.3	9.1	9.7
21	0-4"	5.8	61	1367	153	855	11.4	12.1	5.7	6.1
25	0-4"	5.5	60	788	107	815	12.1	13.0	6.0	6.5
26	0-4"	5.6	128	690	151	847	24.2	25.7	12.1	12.8
27	0-4"	5.8	109	956	143	825	21.2	22.5	10.6	11.3
28	0-4"	5.8	45	1441	117	889	8.3	8.9	4.1	4.5
29	0-4"	5.6	39	993	151	856	7.3	7.7	3.7	3.9
33	0-4"	5.3	53	743	167	836	10.1	10.6	5.0	5.3
34	0-4"	6.1	43	1530	134	880	7.9	8.5	4.0	4.2
35	0-4"	6.0	37	1207	102	867	7.0	7.6	3.5	3.8
37	0-4"	5.8	63	1039	118	896	11.5	12.4	5.8	6.2
41	0-4"	5.9	43	1318	101	869	8.2	8.9	4.1	4.4
42	0-4"	6.0	30	1781	102	834	5.9	6.4	3.0	3.2
43	0-4"	6.2	29	1767	108	875	5.4	5.9	2.7	3.0
44	0-4"	5.6	73	1048	136	826	14.3	15.2	7.1	7.6
45	0-4"	5.8	30	1143	113	867	5.7	6.1	2.8	3.1
46	0-4"	5.8	47	820	133	849	9.0	9.6	4.5	4.8
49	0-4"	6.1	24	1953	83	860	4.6	5.1	2.3	2.5
50	0-4"	5.9	19	1758	87	864	3.7	4.0	1.8	2.0
51	0-4"	6.3	17	1908	87	856	3.3	3.6	1.6	1.8
52	0-4"	6.3	30	1537	100	867	5.7	6.2	2.9	3.1
53	0-4"	6.1	33	1416	102	859	6.3	6.9	3.2	3.4

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
54	0-4"	6.1	32	970	115	863	6.1	6.5	3.0	3.3
57	0-4"	6.0	26	1120	108	896	4.8	5.2	2.4	2.6
58	0-4"	6.0	36	1338	101	878	6.8	7.4	3.4	3.7
59	0-4"	5.9	39	853	116	884	7.2	7.8	3.6	3.9
60	0-4"	6.0	52	1357	107	896	9.6	10.4	4.8	5.2
61	0-4"	6.0	34	1453	118	869	6.4	6.9	3.2	3.4
Mean, mg/kg		5.9	56	1210	121	862	10.5	11.2	5.3	5.6
Median, mg/kg		5.9	43	1169	116	864	7.9	8.5	4.0	4.2
Minimum, mg/kg		5.3	17	608	83	815	3.3	3.6	1.6	1.8
Maximum, mg/kg		6.3	147	1953	167	896	27.6	29.3	13.8	14.7
Standard deviation, mg/kg		0.2	36	384	23	22	6.8	7.1	3.4	3.6
C.V., %		4	64	32	19	3	64	63	64	63
Count		31								
Buffer zone										
9	0-4"	5.90	138	776	149	860	25.8	27.4	12.9	13.7
10	0-4"	6.00	143	763	138	857	27.0	28.7	13.5	14.4
11	0-4"	5.60	147	681	155	869	27.1	28.7	13.6	14.4
13	0-4"	6.00	65	1621	128	847	12.5	13.3	6.2	6.7
22	0-4"	5.30	71	734	261	860	12.5	12.7	6.3	6.3
30	0-4"	5.60	53	873	155	814	10.4	10.9	5.2	5.5
38	0-4"	5.80	52	828	92	847	10.2	11.1	5.1	5.5
47	0-4"	5.90	42	1838	96	867	8.0	8.7	4.0	4.4
62	0-4"	6.00	97	1723	139	873	18.0	19.2	9.0	9.6
Mean, mg/kg		5.8	90	1093	146	855	16.8	17.9	8.4	8.9
Median, mg/kg		5.9	71	828	139	860	12.5	13.3	6.3	6.7

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
Minimum, mg/kg		5.3	42	681	92	814	8.0	8.7	4.0	4.4
Maximum, mg/kg		6.0	147	1838	261	873	27.1	28.7	13.6	14.4
Standard deviation, mg/kg		0.2	43	482	49	18	7.8	8.3	3.9	4.2
C.V., %		4	47	44	34	2	47	47	47	47
Count		9								

Table 17. Soil P sorption saturation and soil properties related to P sorption for 4 to 8 inch grid-soil samples from Field 12 for 2014.

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
			mg/L				%			
Whole field										
9	4-8"	6.4	47	650	94	910	8.6	9.4	4.3	4.7
10	4-8"	5.8	73	663	110	958	12.6	13.7	6.3	6.8
11	4-8"	5.9	81	678	123	926	14.3	15.4	7.2	7.7
13	4-8"	6.0	32	1447	117	946	5.6	6.0	2.8	3.0
17	4-8"	5.8	69	670	100	910	12.5	13.7	6.3	6.8
18	4-8"	5.6	102	682	128	928	18.0	19.3	9.0	9.7
19	4-8"	5.7	62	601	108	900	11.3	12.3	5.7	6.2
20	4-8"	5.7	36	1307	106	927	6.4	7.0	3.2	3.5
21	4-8"	5.9	27	1489	105	948	4.7	5.1	2.4	2.6
22	4-8"	5.3	62	488	160	915	10.9	11.5	5.4	5.8
25	4-8"	5.8	32	713	80	936	5.7	6.3	2.9	3.1
26	4-8"	5.7	88	723	121	924	15.6	16.8	7.8	8.4
27	4-8"	5.9	77	879	116	905	14.0	15.1	7.0	7.5
28	4-8"	6.1	13	1778	90	910	2.4	2.6	1.2	1.3
29	4-8"	5.8	17	1315	119	927	3.0	3.3	1.5	1.6
30	4-8"	5.8	26	767	105	933	4.6	5.0	2.3	2.5
33	4-8"	6.0	38	675	121	948	6.6	7.1	3.3	3.6
34	4-8"	6.1	21	1670	111	935	3.7	4.0	1.9	2.0
35	4-8"	6.1	17	1297	97	922	3.1	3.3	1.5	1.7
37	4-8"	5.9	47	1171	98	918	8.5	9.3	4.2	4.6
38	4-8"	6.0	23	785	73	956	4.0	4.5	2.0	2.2
41	4-8"	6.3	32	1257	90	948	5.6	6.2	2.8	3.1

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
42	4-8"	5.9	18	2257	107	943	3.2	3.4	1.6	1.7
43	4-8"	6.4	15	1681	92	944	2.6	2.9	1.3	1.4
44	4-8"	5.3	39	926	110	940	6.8	7.4	3.4	3.7
45	4-8"	5.9	17	1404	103	937	3.0	3.3	1.5	1.6
46	4-8"	6.0	35	630	99	947	6.1	6.7	3.1	3.3
49	4-8"	6.1	15	2386	87	952	2.6	2.9	1.3	1.4
50	4-8"	5.9	12	1844	72	953	2.1	2.3	1.1	1.2
51	4-8"	6.3	9	2453	92	927	1.6	1.8	0.8	0.9
52	4-8"	6.2	22	1419	99	934	3.9	4.3	2.0	2.1
53	4-8"	6.2	16	1631	97	918	2.9	3.2	1.4	1.6
54	4-8"	6.2	19	1552	113	926	3.4	3.7	1.7	1.8
57	4-8"	6.1	33	1375	104	904	6.0	6.5	3.0	3.3
58	4-8"	6.1	28	1360	94	920	5.1	5.5	2.5	2.8
59	4-8"	6.0	24	848	108	943	4.2	4.6	2.1	2.3
60	4-8"	6.1	23	1432	101	911	4.2	4.5	2.1	2.3
61	4-8"	6.1	17	1440	95	920	3.1	3.3	1.5	1.7
62	4-8"	5.9	48	1841	100	948	8.4	9.2	4.2	4.6
Mean, mg/kg		6.0	36	1235	104	931	6.4	7.0	3.2	3.5
Median, mg/kg		6.0	28	1307	103	928	5.1	5.5	2.5	2.8
Minimum, mg/kg		5.3	9	488	72	900	1.6	1.8	0.8	0.9
Maximum, mg/kg		6.4	102	2453	160	958	18.0	19.3	9.0	9.7
Standard deviation, mg/kg		0.2	24	523	16	16	4.2	4.5	2.1	2.3
C.V., %		4	65	42	15	2	65	65	65	65
Count			39							
Application zone										

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
17	4-8"	5.80	69	670	100	910	12.5	13.7	6.3	6.8
18	4-8"	5.60	102	682	128	928	18.0	19.3	9.0	9.7
19	4-8"	5.70	62	601	108	900	11.3	12.3	5.7	6.2
20	4-8"	5.70	36	1307	106	927	6.4	7.0	3.2	3.5
21	4-8"	5.90	27	1489	105	948	4.7	5.1	2.4	2.6
25	4-8"	5.80	32	713	80	936	5.7	6.3	2.9	3.1
26	4-8"	5.70	88	723	121	924	15.6	16.8	7.8	8.4
27	4-8"	5.90	77	879	116	905	14.0	15.1	7.0	7.5
28	4-8"	6.10	13	1778	90	910	2.4	2.6	1.2	1.3
29	4-8"	5.80	17	1315	119	927	3.0	3.3	1.5	1.6
33	4-8"	6.00	38	675	121	948	6.6	7.1	3.3	3.6
34	4-8"	6.10	21	1670	111	935	3.7	4.0	1.9	2.0
35	4-8"	6.10	17	1297	97	922	3.1	3.3	1.5	1.7
37	4-8"	5.90	47	1171	98	918	8.5	9.3	4.2	4.6
41	4-8"	6.30	32	1257	90	948	5.6	6.2	2.8	3.1
42	4-8"	5.90	18	2257	107	943	3.2	3.4	1.6	1.7
43	4-8"	6.40	15	1681	92	944	2.6	2.9	1.3	1.4
44	4-8"	5.30	39	926	110	940	6.8	7.4	3.4	3.7
45	4-8"	5.90	17	1404	103	937	3.0	3.3	1.5	1.6
46	4-8"	6.00	35	630	99	947	6.1	6.7	3.1	3.3
49	4-8"	6.10	15	2386	87	952	2.6	2.9	1.3	1.4
50	4-8"	5.90	12	1844	72	953	2.1	2.3	1.1	1.2
51	4-8"	6.30	9	2453	92	927	1.6	1.8	0.8	0.9
52	4-8"	6.20	22	1419	99	934	3.9	4.3	2.0	2.1
53	4-8"	6.20	16	1631	97	918	2.9	3.2	1.4	1.6
54	4-8"	6.20	19	1552	113	926	3.4	3.7	1.7	1.8

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
57	4-8"	6.10	33	1375	104	904	6.0	6.5	3.0	3.3
58	4-8"	6.10	28	1360	94	920	5.1	5.5	2.5	2.8
59	4-8"	6.00	24	848	108	943	4.2	4.6	2.1	2.3
60	4-8"	6.10	23	1432	101	911	4.2	4.5	2.1	2.3
61	4-8"	6.10	17	1440	95	920	3.1	3.3	1.5	1.7
Mean, mg/kg		6.0	33	1318	102	929	5.9	6.4	2.9	3.2
Median, mg/kg		6.0	24	1360	101	927	4.2	4.6	2.1	2.3
Minimum, mg/kg		5.3	9	601	72	900	1.6	1.8	0.8	0.9
Maximum, mg/kg		6.4	102	2453	128	953	18.0	19.3	9.0	9.7
Standard deviation, mg/kg		0.2	23	511	12	15	4.2	4.5	2.1	2.3
C.V., %		4	71	39	12	2	71	71	71	71
Count			31							
Buffer zone										
9	4-8"	6.40	47	650	94	910	8.6	9.4	4.3	4.7
10	4-8"	5.80	73	663	110	958	12.6	13.7	6.3	6.8
11	4-8"	5.90	81	678	123	926	14.3	15.4	7.2	7.7
13	4-8"	6.00	32	1447	117	946	5.6	6.0	2.8	3.0
22	4-8"	5.30	62	488	160	915	10.9	11.5	5.4	5.8
30	4-8"	5.80	26	767	105	933	4.6	5.0	2.3	2.5
38	4-8"	6.00	23	785	73	956	4.0	4.5	2.0	2.2
62	4-8"	5.90	48	1841	100	948	8.4	9.2	4.2	4.6
Mean, mg/kg		5.9	49	915	110	937	8.6	9.3	4.3	4.7
Median, mg/kg		5.9	48	723	108	940	8.5	9.3	4.2	4.6
Minimum, mg/kg		5.3	23	488	73	910	4.0	4.5	2.0	2.2
Maximum, mg/kg		6.4	81	1841	160	958	14.3	15.4	7.2	7.7

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
Standard deviation, mg/kg		0.3	22	471	25	18	3.8	4.0	1.9	2.0
C.V., %		5	45	26	25	2	45	44	45	44
Count			8							

Table 18. Soil P sorption saturation and soil properties related to P sorption for 8 to 12 inch grid-soil samples from Field 12 for 2014.

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
			mg/L				%			
Whole field										
9	8-12"	6.0	82	713	101	938	14.5	15.8	7.2	7.9
10	8-12"	6.0	42	607	95	976	7.2	7.8	3.6	3.9
11	8-12"	6.2	44	716	107	983	7.4	8.1	3.7	4.0
13	8-12"	6.1	22	1755	103	982	3.7	4.1	1.9	2.0
17	8-12"	5.8	50	681	107	980	8.4	9.2	4.2	4.6
18	8-12"	5.8	53	673	101	983	8.9	9.8	4.5	4.9
19	8-12"	5.8	45	712	99	987	7.6	8.3	3.8	4.1
20	8-12"	5.9	21	1779	104	968	3.6	3.9	1.8	2.0
21	8-12"	5.8	32	1493	102	981	5.4	5.9	2.7	3.0
22	8-12"	5.2	39	481	126	982	6.5	7.0	3.3	3.5
25	8-12"	5.9	22	781	90	971	3.8	4.1	1.9	2.1
26	8-12"	5.7	46	681	94	955	8.0	8.8	4.0	4.4
27	8-12"	6.1	34	1121	93	967	5.9	6.4	2.9	3.2
28	8-12"	6.1	13	1787	103	938	2.3	2.5	1.1	1.2
29	8-12"	6.0	10	1760	104	980	1.7	1.8	0.8	0.9
30	8-12"	5.9	11	1297	89	933	2.0	2.2	1.0	1.1
33	8-12"	6.1	30	720	124	971	5.1	5.5	2.5	2.7
34	8-12"	6.1	14	2050	105	987	2.4	2.6	1.2	1.3
35	8-12"	6.3	10	1722	93	959	1.7	1.9	0.9	1.0
37	8-12"	5.9	28	1104	88	967	4.8	5.3	2.4	2.7
38	8-12"	6.0	19	643	69	983	3.3	3.6	1.6	1.8
41	8-12"	6.1	26	1505	91	972	4.5	4.9	2.2	2.4

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
42	8-12"	5.9	14	2443	103	970	2.4	2.6	1.2	1.3
43	8-12"	6.5	12	1849	90	968	2.1	2.3	1.0	1.1
44	8-12"	5.2	18	1219	106	965	3.1	3.4	1.5	1.7
45	8-12"	6.1	11	1752	108	948	1.9	2.1	1.0	1.0
46	8-12"	6.0	24	936	98	981	4.1	4.4	2.0	2.2
49	8-12"	6.1	16	2099	90	973	2.7	3.0	1.4	1.5
50	8-12"	5.9	10	2043	86	977	1.7	1.9	0.9	0.9
51	8-12"	6.3	7	2536	98	985	1.2	1.3	0.6	0.6
52	8-12"	6.0	20	1768	100	957	3.5	3.8	1.7	1.9
53	8-12"	6.1	18	1493	100	967	3.1	3.4	1.5	1.7
54	8-12"	6.2	13	1805	105	964	2.2	2.4	1.1	1.2
57	8-12"	5.9	39	1301	99	958	6.8	7.4	3.4	3.7
58	8-12"	6.1	31	1468	96	957	5.4	5.9	2.7	2.9
59	8-12"	6.1	25	942	120	950	4.3	4.7	2.2	2.3
60	8-12"	6.2	25	1559	105	933	4.4	4.8	2.2	2.4
61	8-12"	6.1	10	1899	87	975	1.7	1.9	0.9	0.9
62	8-12"	5.9	19	1848	88	952	3.3	3.7	1.7	1.8
Mean, mg/kg		6.0	26	1378	99	967	4.4	4.8	2.2	2.4
Median, mg/kg		6.0	22	1493	100	970	3.7	4.1	1.9	2.0
Minimum, mg/kg		5.2	7	481	69	933	1.2	1.3	0.6	0.6
Maximum, mg/kg		6.5	82	2536	126	987	14.5	15.8	7.2	7.9
Standard deviation, mg/kg		0.2	16	562	11	15	2.7	3.0	1.4	1.5
C.V., %		4	61	41	11	2	61	61	61	61
Count			39							
Application zone										

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
17	8-12"	5.8	50	681	107	980	8.4	9.2	4.2	4.6
18	8-12"	5.8	53	673	101	983	8.9	9.8	4.5	4.9
19	8-12"	5.8	45	712	99	987	7.6	8.3	3.8	4.1
20	8-12"	5.9	21	1779	104	968	3.6	3.9	1.8	2.0
21	8-12"	5.8	32	1493	102	981	5.4	5.9	2.7	3.0
25	8-12"	5.9	22	781	90	971	3.8	4.1	1.9	2.1
26	8-12"	5.7	46	681	94	955	8.0	8.8	4.0	4.4
27	8-12"	6.1	34	1121	93	967	5.9	6.4	2.9	3.2
28	8-12"	6.1	13	1787	103	938	2.3	2.5	1.1	1.2
29	8-12"	6.0	10	1760	104	980	1.7	1.8	0.8	0.9
33	8-12"	6.1	30	720	124	971	5.1	5.5	2.5	2.7
34	8-12"	6.1	14	2050	105	987	2.4	2.6	1.2	1.3
35	8-12"	6.3	10	1722	93	959	1.7	1.9	0.9	1.0
37	8-12"	5.9	28	1104	88	967	4.8	5.3	2.4	2.7
41	8-12"	6.1	26	1505	91	972	4.5	4.9	2.2	2.4
42	8-12"	5.9	14	2443	103	970	2.4	2.6	1.2	1.3
43	8-12"	6.5	12	1849	90	968	2.1	2.3	1.0	1.1
44	8-12"	5.2	18	1219	106	965	3.1	3.4	1.5	1.7
45	8-12"	6.1	11	1752	108	948	1.9	2.1	1.0	1.0
46	8-12"	6.0	24	936	98	981	4.1	4.4	2.0	2.2
49	8-12"	6.1	16	2099	90	973	2.7	3.0	1.4	1.5
50	8-12"	5.9	10	2043	86	977	1.7	1.9	0.9	0.9
51	8-12"	6.3	7	2536	98	985	1.2	1.3	0.6	0.6
52	8-12"	6.0	20	1768	100	957	3.5	3.8	1.7	1.9
53	8-12"	6.1	18	1493	100	967	3.1	3.4	1.5	1.7
54	8-12"	6.2	13	1805	105	964	2.2	2.4	1.1	1.2

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
57	8-12"	5.9	39	1301	99	958	6.8	7.4	3.4	3.7
58	8-12"	6.1	31	1468	96	957	5.4	5.9	2.7	2.9
59	8-12"	6.1	25	942	120	950	4.3	4.7	2.2	2.3
60	8-12"	6.2	25	1559	105	933	4.4	4.8	2.2	2.4
61	8-12"	6.1	10	1899	87	975	1.7	1.9	0.9	0.9
Mean, mg/kg		6.0	23	1474	100	968	4.0	4.4	2.0	2.2
Median, mg/kg		6.1	21	1505	100	968	3.6	3.9	1.8	2.0
Minimum, mg/kg		5.2	7	673	86	933	1.2	1.3	0.6	0.6
Maximum, mg/kg		6.5	53	2536	124	987	8.9	9.8	4.5	4.9
Standard deviation, mg/kg		0.2	13	533	9	14	2.2	2.4	1.1	1.2
C.V., %		4	55	36	9	1	54	54	54	54
Count			31							
Buffer zone										
9	8-12"	6.0	82	713	101	938	14.5	15.8	7.2	7.9
10	8-12"	6.0	42	607	95	976	7.2	7.8	3.6	3.9
11	8-12"	6.2	44	716	107	983	7.4	8.1	3.7	4.0
13	8-12"	6.1	22	1755	103	982	3.7	4.1	1.9	2.0
22	8-12"	5.2	39	481	126	982	6.5	7.0	3.3	3.5
30	8-12"	5.9	11	1297	89	933	2.0	2.2	1.0	1.1
38	8-12"	6.0	19	643	69	983	3.3	3.6	1.6	1.8
62	8-12"	5.9	19	1848	88	952	3.3	3.7	1.7	1.8
Mean, mg/kg		5.9	35	1008	97	966	6.0	6.5	3.0	3.3
Median, mg/kg		6.0	31	715	98	979	5.1	5.5	2.6	2.8
Minimum, mg/kg		5.2	11	481	69	933	2.0	2.2	1.0	1.1
Maximum, mg/kg		6.2	82	1848	126	983	14.5	15.8	7.2	7.9

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
Standard deviation, mg/kg		0.3	23	547	17	22	4.0	4.3	2.0	2.2
C.V., %		5	65	54	17	2	67	67	67	67
Count			8							

Table 19. Soil P sorption saturation and soil properties related to P sorption for 12 to 18 inch grid-soil samples from Field 12 for 2014.

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
			mg/L				%			
Whole field										
9	12-18"	6.1	50	674	107	1140	7.3	8.0	3.7	4.0
10	12-18"	6.1	40	656	103	1158	5.8	6.3	2.9	3.2
11	12-18"	6.3	59	817	121	1168	8.4	9.2	4.2	4.6
13	12-18"	6.1	19	1909	99	1147	2.8	3.0	1.4	1.5
17	12-18"	5.9	57	746	113	1169	8.1	8.9	4.1	4.4
19	12-18"	6.0	61	942	103	1178	8.7	9.5	4.3	4.8
20	12-18"	6.1	14	1699	93	1135	2.1	2.3	1.0	1.1
21	12-18"	5.3	38	1308	110	1148	5.5	6.0	2.8	3.0
22	12-18"	5.2	20	1151	118	1130	2.9	3.2	1.5	1.6
25	12-18"	5.9	28	616	89	1146	4.1	4.5	2.1	2.3
26	12-18"	5.8	33	646	90	1186	4.7	5.2	2.3	2.6
27	12-18"	6.2	24	1349	94	1128	3.6	3.9	1.8	2.0
28	12-18"	6.1	23	1630	100	1186	3.2	3.6	1.6	1.8
29	12-18"	6.3	12	1821	104	1170	1.7	1.9	0.9	0.9
30	12-18"	5.7	11	1674	93	1105	1.7	1.8	0.8	0.9
33	12-18"	6.1	29	1385	144	1130	4.2	4.6	2.1	2.3
34	12-18"	6.4	11	1934	107	1172	1.6	1.7	0.8	0.9
35	12-18"	6.1	11	1765	87	1135	1.6	1.8	0.8	0.9
37	12-18"	5.8	27	1622	87	1128	4.0	4.4	2.0	2.2
38	12-18"	5.6	40	644	94	1187	5.7	6.2	2.8	3.1
41	12-18"	6.0	20	1832	92	1158	2.9	3.2	1.4	1.6
42	12-18"	5.9	11	2372	100	1167	1.6	1.7	0.8	0.9

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
43	12-18"	6.6	18	1703	89	1174	2.6	2.9	1.3	1.4
44	12-18"	5.4	11	1457	97	1135	1.6	1.8	0.8	0.9
45	12-18"	6.0	9	1640	99	1140	1.3	1.5	0.7	0.7
46	12-18"	5.7	16	1440	103	1165	2.3	2.5	1.1	1.3
49	12-18"	5.8	11	1630	91	1128	1.6	1.8	0.8	0.9
50	12-18"	5.9	8	1711	87	1121	1.2	1.3	0.6	0.7
51	12-18"	6.2	9	2387	98	1111	1.4	1.5	0.7	0.7
52	12-18"	5.4	19	1671	111	1105	2.9	3.1	1.4	1.6
53	12-18"	5.6	18	1380	100	1187	2.5	2.8	1.3	1.4
54	12-18"	6.1	12	2121	105	1135	1.8	1.9	0.9	1.0
57	12-18"	5.9	44	1202	101	1168	6.3	6.9	3.2	3.5
58	12-18"	6.3	29	1186	85	1150	4.2	4.7	2.1	2.3
59	12-18"	5.9	14	1730	119	1157	2.0	2.2	1.0	1.1
60	12-18"	5.7	33	1334	106	1169	4.7	5.2	2.4	2.6
61	12-18"	6.1	8	1908	87	1135	1.2	1.3	0.6	0.7
62	12-18"	6.0	13	1740	84	1147	1.9	2.1	1.0	1.1
Mean, mg/kg		5.9	24	1459	100	1150	3.5	3.8	1.7	1.9
Median, mg/kg		6.0	19	1626	100	1148	2.8	3.1	1.4	1.5
Minimum, mg/kg		5.2	8	616	84	1105	1.2	1.3	0.6	0.7
Maximum, mg/kg		6.6	61	2387	144	1187	8.7	9.5	4.3	4.8
Standard deviation, mg/kg		0.3	15	478	12	23	2.2	2.4	1.1	1.2
C.V., %		5	63	33	12	2	62	62	62	62
Count			38							
Application zone										
17	12-18"	5.9	57	746	113	1169	8.1	8.9	4.1	4.4

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
19	12-18"	6.0	61	942	103	1178	8.7	9.5	4.3	4.8
20	12-18"	6.1	14	1699	93	1135	2.1	2.3	1.0	1.1
21	12-18"	5.3	38	1308	110	1148	5.5	6.0	2.8	3.0
25	12-18"	5.9	28	616	89	1146	4.1	4.5	2.1	2.3
26	12-18"	5.8	33	646	90	1186	4.7	5.2	2.3	2.6
27	12-18"	6.2	24	1349	94	1128	3.6	3.9	1.8	2.0
28	12-18"	6.1	23	1630	100	1186	3.2	3.6	1.6	1.8
29	12-18"	6.3	12	1821	104	1170	1.7	1.9	0.9	0.9
33	12-18"	6.1	29	1385	144	1130	4.2	4.6	2.1	2.3
34	12-18"	6.4	11	1934	107	1172	1.6	1.7	0.8	0.9
35	12-18"	6.1	11	1765	87	1135	1.6	1.8	0.8	0.9
37	12-18"	5.8	27	1622	87	1128	4.0	4.4	2.0	2.2
41	12-18"	6.0	20	1832	92	1158	2.9	3.2	1.4	1.6
42	12-18"	5.9	11	2372	100	1167	1.6	1.7	0.8	0.9
43	12-18"	6.6	18	1703	89	1174	2.6	2.9	1.3	1.4
44	12-18"	5.4	11	1457	97	1135	1.6	1.8	0.8	0.9
45	12-18"	6.0	9	1640	99	1140	1.3	1.5	0.7	0.7
46	12-18"	5.7	16	1440	103	1165	2.3	2.5	1.1	1.3
49	12-18"	5.8	11	1630	91	1128	1.6	1.8	0.8	0.9
50	12-18"	5.9	8	1711	87	1121	1.2	1.3	0.6	0.7
51	12-18"	6.2	9	2387	98	1111	1.4	1.5	0.7	0.7
52	12-18"	5.4	19	1671	111	1105	2.9	3.1	1.4	1.6
53	12-18"	5.6	18	1380	100	1187	2.5	2.8	1.3	1.4
54	12-18"	6.1	12	2121	105	1135	1.8	1.9	0.9	1.0
57	12-18"	5.9	44	1202	101	1168	6.3	6.9	3.2	3.5
58	12-18"	6.3	29	1186	85	1150	4.2	4.7	2.1	2.3

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
59	12-18"	5.9	14	1730	119	1157	2.0	2.2	1.0	1.1
60	12-18"	5.7	33	1334	106	1169	4.7	5.2	2.4	2.6
61	12-18"	6.1	8	1908	87	1135	1.2	1.3	0.6	0.7
Mean, mg/kg		6.0	22	1539	100	1151	3.2	3.5	1.6	1.7
Median, mg/kg		6.0	18	1630	100	1149	2.6	2.8	1.3	1.4
Minimum, mg/kg		5.3	8	616	85	1105	1.2	1.3	0.6	0.7
Maximum, mg/kg		6.6	61	2387	144	1187	8.7	9.5	4.3	4.8
Standard deviation, mg/kg		0.3	14	435	12	23	2.0	2.2	1.0	1.1
C.V., %		5	64	28	12	2	62	62	62	62
Count			30							
Buffer zone										
9	12-18"	6.1	50	674	107	1140	7.3	8.0	3.7	4.0
10	12-18"	6.1	40	656	103	1158	5.8	6.3	2.9	3.2
11	12-18"	6.3	59	817	121	1168	8.4	9.2	4.2	4.6
13	12-18"	6.1	19	1909	99	1147	2.8	3.0	1.4	1.5
22	12-18"	5.2	20	1151	118	1130	2.9	3.2	1.5	1.6
30	12-18"	5.7	11	1674	93	1105	1.7	1.8	0.8	0.9
38	12-18"	5.6	40	644	94	1187	5.7	6.2	2.8	3.1
62	12-18"	6.0	13	1740	84	1147	1.9	2.1	1.0	1.1
Mean, mg/kg		5.9	32	1158	102	1148	4.5	5.0	2.3	2.5
Median, mg/kg		6.0	30	984	101	1147	4.3	4.7	2.1	2.4
Minimum, mg/kg		5.2	11	644	84	1105	1.7	1.8	0.8	0.9
Maximum, mg/kg		6.3	59	1909	121	1187	8.4	9.2	4.2	4.6
Standard deviation, mg/kg		0.4	18	539	13	25	2.6	2.8	1.3	1.4

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
C.V., %		6	57	47	12	2	56	56	56	56
Count			8							

Table 20. Soil P sorption saturation and soil properties related to P sorption for 18 to 24 inch grid-soil samples from Field 12 for 2014.

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
			mg/L				%			
Whole field										
9	18-24"	6.1	63	641	117	1298	8.1	8.9	4.1	4.5
10	18-24"	6.3	58	761	103	1276	7.6	8.4	3.8	4.2
11	18-24"	6.1	90	847	119	1350	11.1	12.3	5.6	6.1
13	18-24"	6.2	16	1586	88	1321	2.0	2.3	1.0	1.1
17	18-24"	5.9	62	763	104	1315	7.9	8.7	4.0	4.4
21	18-24"	5.2	38	1153	112	1294	4.9	5.4	2.5	2.7
22	18-24"	5.5	13	1419	100	1311	1.7	1.8	0.8	0.9
27	18-24"	6.3	28	1337	94	1298	3.6	4.0	1.8	2.0
28	18-24"	6.1	12	1877	95	1257	1.6	1.8	0.8	0.9
29	18-24"	6.3	14	1857	101	1245	1.9	2.1	0.9	1.0
30	18-24"	5.7	17	1781	93	1236	2.3	2.6	1.2	1.3
33	18-24"	6.2	20	1646	130	1205	2.7	3.0	1.4	1.5
34	18-24"	6.1	12	1697	92	1274	1.6	1.8	0.8	0.9
35	18-24"	5.9	16	1608	95	1258	2.1	2.4	1.1	1.2
37	18-24"	6.0	19	1479	92	1269	2.5	2.8	1.3	1.4
38	18-24"	4.9	46	443	102	1287	6.0	6.6	3.0	3.3
41	18-24"	5.9	21	1837	90	1299	2.7	3.0	1.4	1.5
42	18-24"	6.1	9	2005	95	1287	1.2	1.3	0.6	0.7
43	18-24"	6.5	29	1659	84	1312	3.7	4.2	1.9	2.1
44	18-24"	5.3	13	1342	98	1306	1.7	1.9	0.8	0.9
45	18-24"	6.0	10	1622	95	1311	1.3	1.4	0.6	0.7
46	18-24"	5.7	11	1700	107	1297	1.4	1.6	0.7	0.8

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
49	18-24"	5.7	36	1682	105	1284	4.7	5.2	2.3	2.6
50	18-24"	6.0	44	1867	101	1287	5.7	6.3	2.9	3.2
51	18-24"	6.2	54	1643	117	1280	7.0	7.7	3.5	3.9
52	18-24"	5.8	83	1329	136	1238	11.1	12.1	5.5	6.0
53	18-24"	5.7	54	968	154	1289	6.9	7.5	3.5	3.7
54	18-24"	6.0	35	1351	121	1258	4.6	5.1	2.3	2.5
57	18-24"	5.9	55	1143	114	1261	7.3	8.0	3.6	4.0
58	18-24"	5.7	70	1064	140	1238	9.3	10.2	4.7	5.1
59	18-24"	6.1	101	1408	134	1291	13.0	14.2	6.5	7.1
61	18-24"	5.8	8	1569	91	1288	1.0	1.2	0.5	0.6
62	18-24"	5.8	11	1558	84	1250	1.5	1.6	0.7	0.8
Mean, mg/kg		5.9	35	1413	106	1281	4.6	5.1	2.3	2.5
Median, mg/kg		6.0	28	1558	101	1287	3.6	4.0	1.8	2.0
Minimum, mg/kg		4.9	8	443	84	1205	1.0	1.2	0.5	0.6
Maximum, mg/kg		6.5	101	2005	154	1350	13.0	14.2	6.5	7.1
Standard deviation, mg/kg		0.3	26	397	17	30	3.4	3.7	1.7	1.8
C.V., %		6	74	28	16	2	73	72	73	72
Count			33							
Application zone										
17	18-24"	5.9	62	763	104	1315	7.9	8.7	4.0	4.4
21	18-24"	5.2	38	1153	112	1294	4.9	5.4	2.5	2.7
22	18-24"	5.5	13	1419	100	1311	1.7	1.8	0.8	0.9
27	18-24"	6.3	28	1337	94	1298	3.6	4.0	1.8	2.0
28	18-24"	6.1	12	1877	95	1257	1.6	1.8	0.8	0.9
29	18-24"	6.3	14	1857	101	1245	1.9	2.1	0.9	1.0

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
33	18-24"	6.2	20	1646	130	1205	2.7	3.0	1.4	1.5
34	18-24"	6.1	12	1697	92	1274	1.6	1.8	0.8	0.9
35	18-24"	5.9	16	1608	95	1258	2.1	2.4	1.1	1.2
37	18-24"	6.0	19	1479	92	1269	2.5	2.8	1.3	1.4
41	18-24"	5.9	21	1837	90	1299	2.7	3.0	1.4	1.5
42	18-24"	6.1	9	2005	95	1287	1.2	1.3	0.6	0.7
43	18-24"	6.5	29	1659	84	1312	3.7	4.2	1.9	2.1
44	18-24"	5.3	13	1342	98	1306	1.7	1.9	0.8	0.9
45	18-24"	6.0	10	1622	95	1311	1.3	1.4	0.6	0.7
46	18-24"	5.7	11	1700	107	1297	1.4	1.6	0.7	0.8
49	18-24"	5.7	36	1682	105	1284	4.7	5.2	2.3	2.6
50	18-24"	6.0	44	1867	101	1287	5.7	6.3	2.9	3.2
51	18-24"	6.2	54	1643	117	1280	7.0	7.7	3.5	3.9
52	18-24"	5.8	83	1329	136	1238	11.1	12.1	5.5	6.0
53	18-24"	5.7	54	968	154	1289	6.9	7.5	3.5	3.7
54	18-24"	6.0	35	1351	121	1258	4.6	5.1	2.3	2.5
57	18-24"	5.9	55	1143	114	1261	7.3	8.0	3.6	4.0
58	18-24"	5.7	70	1064	140	1238	9.3	10.2	4.7	5.1
59	18-24"	6.1	101	1408	134	1291	13.0	14.2	6.5	7.1
61	18-24"	5.8	8	1569	91	1288	1.0	1.2	0.5	0.6
Mean, mg/kg		5.9	33	1501	108	1279	4.4	4.8	2.2	2.4
Median, mg/kg		6.0	25	1589	101	1287	3.2	3.5	1.6	1.8
Minimum, mg/kg		5.2	8	763	84	1205	1.0	1.2	0.5	0.6
Maximum, mg/kg		6.5	101	2005	154	1315	13.0	14.2	6.5	7.1
Standard deviation, mg/kg		0.3	25	308	18	27	3.3	3.6	1.6	1.8

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
C.V., %		5	76	20	17	2	76	75	76	75
Count			26							
Buffer zone										
9	18-24"	6.1	63	641	117	1298	8.1	8.9	4.1	4.5
10	18-24"	6.3	58	761	103	1276	7.6	8.4	3.8	4.2
11	18-24"	6.1	90	847	119	1350	11.1	12.3	5.6	6.1
13	18-24"	6.2	16	1586	88	1321	2.0	2.3	1.0	1.1
17	18-24"	5.7	17	1781	93	1236	2.3	2.6	1.2	1.3
21	18-24"	4.9	46	443	102	1287	6.0	6.6	3.0	3.3
22	18-24"	5.8	11	1558	84	1250	1.5	1.6	0.7	0.8
Mean, mg/kg		5.9	43	1088	101	1288	5.5	6.1	2.8	3.0
Median, mg/kg		6.1	46	847	102	1287	6.0	6.6	3.0	3.3
Minimum, mg/kg		4.9	11	443	84	1236	1.5	1.6	0.7	0.8
Maximum, mg/kg		6.3	90	1781	119	1350	11.1	12.3	5.6	6.1
Standard deviation, mg/kg		0.5	30	537	14	39	3.7	4.0	1.8	2.0
C.V., %		8	69	49	13	3	67	66	67	66
Count			7							

Table 21. Soil P sorption saturation and soil properties related to P sorption for 0 to 4 inch grid-soil samples from Field 12 for 2016.

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
			mg/L				%			
Whole field										
8	0-4"	5.4	148	961	214	890	26.0	26.8	13.0	13.4
9	0-4"	5.5	190	981	211	897	33.1	34.3	16.6	17.1
10	0-4"	5.3	160	912	175	886	28.7	30.2	14.4	15.1
11	0-4"	5.4	178	795	196	884	31.7	33.0	15.8	16.5
12	0-4"	5.2	172	766	206	887	30.4	31.5	15.2	15.7
13	0-4"	5.8	97	1830	215	896	16.9	17.5	8.5	8.7
17	0-4"	5.2	193	864	215	915	33.0	34.2	16.5	17.1
18	0-4"	5.1	167	751	192	878	30.0	31.2	15.0	15.6
19	0-4"	5.2	168	883	206	853	30.7	31.7	15.4	15.9
20	0-4"	5.5	73	1176	162	897	13.0	13.8	6.5	6.9
21	0-4"	5.6	49	1307	157	901	8.7	9.3	4.4	4.6
22	0-4"	5.4	40	991	143	879	7.4	7.8	3.7	3.9
25	0-4"	5.3	115	661	149	899	20.6	21.9	10.3	11.0
26	0-4"	4.9	186	739	185	925	31.9	33.5	16.0	16.8
27	0-4"	5.7	112	1297	172	915	19.6	20.6	9.8	10.3
28	0-4"	5.6	101	1568	204	911	17.4	18.1	8.7	9.1
29	0-4"	5.3	123	1316	227	902	21.2	21.8	10.6	10.9
30	0-4"	5.3	64	976	241	906	10.9	11.2	5.5	5.6
33	0-4"	5.1	138	772	147	896	24.9	26.5	12.4	13.2
34	0-4"	5.2	103	1408	175	857	19.1	20.0	9.5	10.0
35	0-4"	5.1	123	1752	195	873	22.2	23.0	11.1	11.5
36	0-4"	6.0	76	1575	163	924	13.2	14.0	6.6	7.0

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
37	0-4"	5.5	97	1333	197	836	18.1	18.8	9.1	9.4
38	0-4"	5.5	81	962	255	983	12.8	13.1	6.4	6.5
41	0-4"	5.5	91	1225	153	882	16.6	17.6	8.3	8.8
42	0-4"	5.3	59	1848	170	876	10.7	11.3	5.4	5.6
43	0-4"	5.5	57	1479	161	942	9.7	10.3	4.9	5.2
44	0-4"	5.7	79	1393	187	887	14.1	14.7	7.0	7.4
45	0-4"	5.6	65	1135	183	891	11.6	12.1	5.8	6.1
46	0-4"	5.9	77	930	181	890	13.7	14.4	6.9	7.2
47	0-4"	6.1	27	1378	163	894	4.8	5.1	2.4	2.6
49	0-4"	5.8	65	2178	133	911	11.6	12.5	5.8	6.2
50	0-4"	5.4	72	1697	143	924	12.6	13.5	6.3	6.7
51	0-4"	5.9	65	2099	157	925	11.3	12.0	5.7	6.0
52	0-4"	5.4	76	1389	187	916	13.2	13.8	6.6	6.9
53	0-4"	5.3	77	1493	192	897	13.6	14.1	6.8	7.1
54	0-4"	5.5	117	941	234	901	20.1	20.6	10.1	10.3
55	0-4"	5.8	55	1386	177	905	9.7	10.2	4.8	5.1
57	0-4"	6.0	63	2593	136	906	11.3	12.1	5.6	6.0
58	0-4"	5.3	146	1791	178	882	26.3	27.5	13.1	13.8
59	0-4"	5.4	117	1737	166	876	21.3	22.5	10.7	11.2
60	0-4"	5.6	65	1632	161	894	11.7	12.3	5.8	6.2
61	0-4"	5.3	151	1326	165	889	27.2	28.7	13.6	14.3
62	0-4"	5.6	82	1464	159	885	14.9	15.7	7.4	7.9
63	0-4"	5.4	104	845	220	887	18.2	18.8	9.1	9.4
Mean, mg/kg		5.5	104	1301	182	897	18.3	19.2	9.2	9.6
Median, mg/kg		5.4	97	1316	178	896	16.9	17.6	8.5	8.8
Minimum, mg/kg		4.9	27	661	133	836	4.8	5.1	2.4	2.6

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
Maximum, mg/kg		6.1	193	2593	255	983	33.1	34.3	16.6	17.1
Standard deviation, mg/kg		0.3	45	433	29	24	7.9	8.2	3.9	4.1
C.V., %		5	43	33	16	3	43	43	43	43
Count				45						
Application zone										
11	0-4"	5.4	178	795	196	884	31.7	33.0	15.8	16.5
12	0-4"	5.2	172	766	206	887	30.4	31.5	15.2	15.7
17	0-4"	5.2	193	864	215	915	33.0	34.2	16.5	17.1
18	0-4"	5.1	167	751	192	878	30.0	31.2	15.0	15.6
19	0-4"	5.2	168	883	206	853	30.7	31.7	15.4	15.9
20	0-4"	5.5	73	1176	162	897	13.0	13.8	6.5	6.9
21	0-4"	5.6	49	1307	157	901	8.7	9.3	4.4	4.6
25	0-4"	5.3	115	661	149	899	20.6	21.9	10.3	11.0
26	0-4"	4.9	186	739	185	925	31.9	33.5	16.0	16.8
27	0-4"	5.7	112	1297	172	915	19.6	20.6	9.8	10.3
29	0-4"	5.3	123	1316	227	902	21.2	21.8	10.6	10.9
28	0-4"	5.6	101	1568	204	911	17.4	18.1	8.7	9.1
33	0-4"	5.1	138	772	147	896	24.9	26.5	12.4	13.2
34	0-4"	5.2	103	1408	175	857	19.1	20.0	9.5	10.0
36	0-4"	6.0	76	1575	163	924	13.2	14.0	6.6	7.0
37	0-4"	5.5	97	1333	197	836	18.1	18.8	9.1	9.4
43	0-4"	5.5	57	1479	161	942	9.7	10.3	4.9	5.2
35	0-4"	5.1	123	1752	195	873	22.2	23.0	11.1	11.5
41	0-4"	5.5	91	1225	153	882	16.6	17.6	8.3	8.8
42	0-4"	5.3	59	1848	170	876	10.7	11.3	5.4	5.6

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
44	0-4"	5.7	79	1393	187	887	14.1	14.7	7.0	7.4
45	0-4"	5.6	65	1135	183	891	11.6	12.1	5.8	6.1
49	0-4"	5.8	65	2178	133	911	11.6	12.5	5.8	6.2
50	0-4"	5.4	72	1697	143	924	12.6	13.5	6.3	6.7
51	0-4"	5.9	65	2099	157	925	11.3	12.0	5.7	6.0
52	0-4"	5.4	76	1389	187	916	13.2	13.8	6.6	6.9
53	0-4"	5.3	77	1493	192	897	13.6	14.1	6.8	7.1
54	0-4"	5.5	117	941	234	901	20.1	20.6	10.1	10.3
57	0-4"	6.0	63	2593	136	906	11.3	12.1	5.6	6.0
58	0-4"	5.3	146	1791	178	882	26.3	27.5	13.1	13.8
59	0-4"	5.4	117	1737	166	876	21.3	22.5	10.7	11.2
60	0-4"	5.6	65	1632	161	894	11.7	12.3	5.8	6.2
61	0-4"	5.3	151	1326	165	889	27.2	28.7	13.6	14.3
62	0-4"	5.6	82	1464	159	885	14.9	15.7	7.4	7.9
Mean, mg/kg		5.4	107	1364	177	895	18.9	19.8	9.5	9.9
Median, mg/kg		5.4	99	1361	174	897	17.8	18.4	8.9	9.2
Minimum, mg/kg		4.9	49	661	133	836	8.7	9.3	4.4	4.6
Maximum, mg/kg		6.0	193	2593	234	942	33.0	34.2	16.5	17.1
Standard deviation, mg/kg		0.3	43	454	25	22	7.5	7.7	3.7	3.9
C.V., %		5	40	33	14	3	40	39	40	39
Count				34						
Buffer zone										
8	0-4"	5.4	148	961	214	890	26.0	26.8	13.0	13.4
9	0-4"	5.5	190	981	211	897	33.1	34.3	16.6	17.1
10	0-4"	5.3	160	912	175	886	28.7	30.2	14.4	15.1

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
13	0-4"	5.8	97	1830	215	896	16.9	17.5	8.5	8.7
22	0-4"	5.4	40	991	143	879	7.4	7.8	3.7	3.9
30	0-4"	5.3	64	976	241	906	10.9	11.2	5.5	5.6
38	0-4"	5.5	81	962	255	983	12.8	13.1	6.4	6.5
46	0-4"	5.9	77	930	181	890	13.7	14.4	6.9	7.2
47	0-4"	6.1	27	1378	163	894	4.8	5.1	2.4	2.6
55	0-4"	5.8	55	1386	177	905	9.7	10.2	4.8	5.1
63	0-4"	5.4	104	845	220	887	18.2	18.8	9.1	9.4
Mean, mg/kg		5.6	95	1105	200	901	16.6	17.2	8.3	8.6
Median, mg/kg		5.5	81	976	211	894	13.7	14.4	6.9	7.2
Minimum, mg/kg		5.3	27	845	143	879	4.8	5.1	2.4	2.6
Maximum, mg/kg		6.1	190	1830	255	983	33.1	34.3	16.6	17.1
Standard deviation, mg/kg		0.3	52	300	34	28	9.2	9.5	4.6	4.7
C.V., %		5	55	27	17	3	55	55	55	55
Count				11						

Table 22. Soil P sorption saturation and soil properties related to P sorption for 4 to 8 inch grid-soil samples from Field 12 for 2016.

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
			mg/L				%			
Whole field										
8	4-8"	5.7	107	701	158	967	17.9	19.0	8.9	9.5
9	4-8"	5.6	142	814	154	930	24.6	26.2	12.3	13.1
10	4-8"	5.5	88	847	141	935	15.3	16.4	7.6	8.2
11	4-8"	5.6	118	883	163	946	20.1	21.3	10.0	10.6
12	4-8"	5.7	116	827	164	983	19.0	20.2	9.5	10.1
13	4-8"	5.7	49	1766	153	925	8.5	9.1	4.3	4.5
17	4-8"	5.6	106	799	165	921	18.5	19.5	9.2	9.8
18	4-8"	5.2	104	723	160	922	18.1	19.2	9.1	9.6
19	4-8"	5.8	73	763	131	928	12.8	13.8	6.4	6.9
20	4-8"	5.7	41	1356	133	935	7.1	7.7	3.6	3.8
21	4-8"	6.1	25	1491	119	947	4.3	4.7	2.2	2.3
22	4-8"	5.7	24	1009	106	935	4.2	4.6	2.1	2.3
25	4-8"	5.4	45	691	106	961	7.7	8.4	3.9	4.2
26	4-8"	5.2	120	756	149	944	20.6	22.0	10.3	11.0
27	4-8"	5.8	60	1483	140	945	10.3	11.1	5.2	5.5
28	4-8"	5.7	38	1575	146	946	6.5	7.0	3.3	3.5
29	4-8"	5.7	28	1639	133	947	4.8	5.2	2.4	2.6
30	4-8"	5.8	35	675	134	948	6.0	6.5	3.0	3.2
33	4-8"	5.1	33	653	95	949	5.8	6.3	2.9	3.2
34	4-8"	5.7	47	1108	106	950	8.2	8.9	4.1	4.5
35	4-8"	5.8	27	1547	115	951	4.7	5.1	2.3	2.5
36	4-8"	6.0	23	1472	134	952	3.9	4.2	2.0	2.1

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
37	4-8"	5.7	45	859	157	953	7.6	8.1	3.8	4.1
38	4-8"	6.2	19	1567	115	954	3.3	3.6	1.6	1.8
41	4-8"	5.6	50	1904	145	953	8.5	9.1	4.3	4.6
42	4-8"	5.9	34	1154	103	924	6.1	6.6	3.0	3.3
43	4-8"	5.6	23	2111	124	924	4.1	4.4	2.0	2.2
44	4-8"	5.6	26	1350	117	930	4.6	5.0	2.3	2.5
45	4-8"	5.8	32	1314	132	907	5.7	6.2	2.9	3.1
46	4-8"	5.5	21	1072	106	967	3.6	3.9	1.8	2.0
47	4-8"	6.1	27	1288	151	958	4.6	4.9	2.3	2.4
49	4-8"	5.8	35	1291	133	957	6.0	6.4	3.0	3.2
50	4-8"	5.9	22	2202	108	965	3.8	4.1	1.9	2.1
51	4-8"	5.8	19	2190	118	912	3.4	3.7	1.7	1.8
52	4-8"	6.1	20	2477	132	905	3.6	3.9	1.8	1.9
53	4-8"	5.7	37	1516	148	931	6.4	6.9	3.2	3.4
54	4-8"	5.8	28	1714	147	953	4.8	5.1	2.4	2.5
55	4-8"	5.6	36	962	142	946	6.2	6.6	3.1	3.3
57	4-8"	6.2	17	2600	108	968	2.9	3.2	1.5	1.6
58	4-8"	5.7	55	1864	145	926	9.6	10.3	4.8	5.1
59	4-8"	5.7	50	1810	135	976	8.4	9.0	4.2	4.5
60	4-8"	5.7	30	1592	124	944	5.2	5.6	2.6	2.8
61	4-8"	5.4	61	1272	137	957	10.4	11.2	5.2	5.6
62	4-8"	6.0	37	1381	131	987	6.1	6.6	3.1	3.3
63	4-8"	5.4	64	885	156	957	10.8	11.5	5.4	5.8
Mean, mg/kg		5.7	50	1332	134	945	8.6	9.2	4.3	4.6
Median, mg/kg		5.7	37	1314	134	947	6.2	6.6	3.1	3.3
Minimum, mg/kg		5.1	17	653	95	905	2.9	3.2	1.5	1.6

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
Maximum, mg/kg		6.2	142	2600	165	987	24.6	26.2	12.3	13.1
Standard deviation, mg/kg		0.2	33	509	19	19	5.6	5.9	2.8	3.0
C.V., %		4	66	38	14	2	65	65	65	65
Count			45							
Application zone										
11	4-8"	5.6	118	883	163	946	20.1	21.3	10.0	10.6
12	4-8"	5.7	116	827	164	983	19.0	20.2	9.5	10.1
17	4-8"	5.6	106	799	165	921	18.5	19.5	9.2	9.8
18	4-8"	5.2	104	723	160	922	18.1	19.2	9.1	9.6
19	4-8"	5.8	73	763	131	928	12.8	13.8	6.4	6.9
20	4-8"	5.7	41	1356	133	935	7.1	7.7	3.6	3.8
21	4-8"	6.1	25	1491	119	947	4.3	4.7	2.2	2.3
25	4-8"	5.4	45	691	106	961	7.7	8.4	3.9	4.2
26	4-8"	5.2	120	756	149	944	20.6	22.0	10.3	11.0
27	4-8"	5.8	60	1483	140	945	10.3	11.1	5.2	5.5
28	4-8"	5.7	38	1575	146	946	6.5	7.0	3.3	3.5
29	4-8"	5.7	28	1639	133	947	4.8	5.2	2.4	2.6
33	4-8"	5.1	33	653	95	949	5.8	6.3	2.9	3.2
34	4-8"	5.7	47	1108	106	950	8.2	8.9	4.1	4.5
35	4-8"	5.8	27	1547	115	951	4.7	5.1	2.3	2.5
36	4-8"	6.0	23	1472	134	952	3.9	4.2	2.0	2.1
37	4-8"	5.7	45	859	157	953	7.6	8.1	3.8	4.1
41	4-8"	5.6	50	1904	145	953	8.5	9.1	4.3	4.6
42	4-8"	5.9	34	1154	103	924	6.1	6.6	3.0	3.3
43	4-8"	5.6	23	2111	124	924	4.1	4.4	2.0	2.2

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
44	4-8"	5.6	26	1350	117	930	4.6	5.0	2.3	2.5
45	4-8"	5.8	32	1314	132	907	5.7	6.2	2.9	3.1
49	4-8"	5.8	35	1291	133	957	6.0	6.4	3.0	3.2
50	4-8"	5.9	22	2202	108	965	3.8	4.1	1.9	2.1
51	4-8"	5.8	19	2190	118	912	3.4	3.7	1.7	1.8
52	4-8"	6.1	20	2477	132	905	3.6	3.9	1.8	1.9
53	4-8"	5.7	37	1516	148	931	6.4	6.9	3.2	3.4
54	4-8"	5.8	28	1714	147	953	4.8	5.1	2.4	2.5
57	4-8"	6.2	17	2600	108	968	2.9	3.2	1.5	1.6
58	4-8"	5.7	55	1864	145	926	9.6	10.3	4.8	5.1
59	4-8"	5.7	50	1810	135	976	8.4	9.0	4.2	4.5
60	4-8"	5.7	30	1592	124	944	5.2	5.6	2.6	2.8
61	4-8"	5.4	61	1272	137	957	10.4	11.2	5.2	5.6
62	4-8"	6.0	37	1381	131	987	6.1	6.6	3.1	3.3
Mean, mg/kg		5.7	48	1423	132	944	8.2	8.8	4.1	4.4
Median, mg/kg		5.7	37	1427	133	947	6.3	6.7	3.1	3.4
Minimum, mg/kg		5.1	17	653	95	905	2.9	3.2	1.5	1.6
Maximum, mg/kg		6.2	120	2600	165	987	20.6	22.0	10.3	11.0
Standard deviation, mg/kg		0.2	30	524	19	20	5.2	5.5	2.6	2.7
C.V., %		4	64	37	14	2	63	62	63	62
Count			34							
Buffer zone										
8	4-8"	5.7	107	701	158	967	17.9	19.0	8.9	9.5
9	4-8"	5.6	142	814	154	930	24.6	26.2	12.3	13.1
10	4-8"	5.5	88	847	141	935	15.3	16.4	7.6	8.2

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
13	4-8"	5.7	49	1766	153	925	8.5	9.1	4.3	4.5
22	4-8"	5.7	24	1009	106	935	4.2	4.6	2.1	2.3
30	4-8"	5.8	35	675	134	948	6.0	6.5	3.0	3.2
38	4-8"	6.2	19	1567	115	954	3.3	3.6	1.6	1.8
46	4-8"	5.5	21	1072	106	967	3.6	3.9	1.8	2.0
47	4-8"	6.1	27	1288	151	958	4.6	4.9	2.3	2.4
55	4-8"	5.6	36	962	142	946	6.2	6.6	3.1	3.3
63	4-8"	5.4	64	885	156	957	10.8	11.5	5.4	5.8
Mean, mg/kg		5.7	56	1053	138	947	9.5	10.2	4.8	5.1
Median, mg/kg		5.7	36	962	142	948	6.2	6.6	3.1	3.3
Minimum, mg/kg		5.4	19	675	106	925	3.3	3.6	1.6	1.8
Maximum, mg/kg		6.2	142	1766	158	967	24.6	26.2	12.3	13.1
Standard deviation, mg/kg		0.2	41	351	20	15	7.0	7.4	3.5	3.7
C.V., %		4	73	33	14	2	73	72	73	72
Count			11							

Table 23. Soil P sorption saturation and soil properties related to P sorption for 0 to 4 inch grid-soil samples from Field 12 for 2018.

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
			mg/L				%			
Whole field										
8	0-4"	7.1	161	1332	165	895	28.8	30.4	14.4	15.2
9	0-4"	6.2	192	950	164	887	34.6	36.5	17.3	18.3
10	0-4"	6.2	256	986	172	876	46.5	48.9	23.3	24.4
11	0-4"	6.1	230	893	180	876	41.6	43.6	20.8	21.8
12	0-4"	6.2	198	850	175	897	35.1	36.9	17.6	18.5
13	0-4"	6.3	125	1900	171	901	22.1	23.3	11.1	11.7
17	0-4"	6.2	180	836	160	914	31.6	33.5	15.8	16.8
18	0-4"	6.0	198	713	164	888	35.7	37.6	17.8	18.8
19	0-4"	5.9	149	716	167	856	27.7	29.1	13.9	14.6
20	0-4"	6.0	144	1212	165	900	25.6	27.0	12.8	13.5
21	0-4"	6.2	91	1297	161	897	16.3	17.2	8.1	8.6
22	0-4"	5.8	59	674	204	886	10.4	10.8	5.2	5.4
25	0-4"	5.8	119	678	141	891	21.6	23.1	10.8	11.5
26	0-4"	6.1	201	731	164	934	34.6	36.6	17.3	18.3
27	0-4"	5.9	176	766	176	924	30.4	32.0	15.2	16.0
28	0-4"	6.0	101	1226	163	906	17.9	18.9	8.9	9.4
29	0-4"	6.1	108	1162	154	901	19.3	20.5	9.6	10.2
30	0-4"	6.2	97	986	194	897	17.1	17.8	8.5	8.9
33	0-4"	5.9	143	767	122	885	26.4	28.4	13.2	14.2
34	0-4"	5.7	137	1130	144	886	25.0	26.6	12.5	13.3
35	0-4"	5.8	150	1454	153	920	26.3	28.0	13.1	14.0
36	0-4"	6.2	99	1344	162	856	18.5	19.4	9.2	9.7

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
37	0-4"	6.1	100	1294	171	968	16.6	17.6	8.3	8.8
38	0-4"	5.9	91	912	173	932	15.6	16.5	7.8	8.2
41	0-4"	6.0	118	1027	126	887	21.7	23.3	10.8	11.6
42	0-4"	5.6	77	1593	135	892	14.0	15.0	7.0	7.5
43	0-4"	5.8	78	1268	133	867	14.6	15.6	7.3	7.8
44	0-4"	6.1	76	1303	146	879	13.9	14.8	7.0	7.4
45	0-4"	6.1	77	1073	149	883	14.0	14.9	7.0	7.5
46	0-4"	6.1	96	894	179	895	17.0	17.9	8.5	8.9
47	0-4"	5.9	31	1351	134	893	5.6	6.0	2.8	3.0
49	0-4"	5.9	90	1968	113	904	16.4	17.7	8.2	8.8
50	0-4"	6.0	74	1723	121	906	13.4	14.4	6.7	7.2
51	0-4"	5.8	78	1710	131	928	13.7	14.7	6.9	7.4
52	0-4"	6.2	81	1195	136	916	14.4	15.4	7.2	7.7
53	0-4"	5.9	120	1227	151	924	21.0	22.3	10.5	11.2
54	0-4"	5.9	93	944	161	908	16.4	17.4	8.2	8.7
55	0-4"	5.9	52	1417	140	896	9.4	10.0	4.7	5.0
57	0-4"	6.4	91	2674	97	905	16.7	18.2	8.3	9.1
58	0-4"	5.9	124	1660	154	876	22.7	24.1	11.4	12.0
59	0-4"	6.0	159	1585	142	883	29.1	31.0	14.6	15.5
60	0-4"	6.1	119	1501	155	879	21.7	23.0	10.9	11.5
61	0-4"	5.9	170	1369	141	876	31.4	33.4	15.7	16.7
62	0-4"	6.1	119	1231	149	874	21.9	23.3	11.0	11.6
63	0-4"	5.8	72	700	153	896	12.9	13.7	6.5	6.9
Mean, mg/kg		6.0	122	1205	154	896	21.9	23.3	11.0	11.6
Median, mg/kg		6.0	118	1212	154	895	21.0	22.3	10.5	11.2
Minimum, mg/kg		5.6	31	674	97	856	5.6	6.0	2.8	3.0

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
Maximum, mg/kg		7.1	256	2674	204	968	46.5	48.9	23.3	24.4
Standard deviation, mg/kg		0.2	50	407	21	21	8.9	9.3	4.4	4.7
C.V., %		4	41	34	14	2	41	40	41	40
Count				45						
Application zone										
11	0-4"	6.1	230	893	180	876	41.6	43.6	20.8	21.8
12	0-4"	6.2	198	850	175	897	35.1	36.9	17.6	18.5
17	0-4"	6.2	180	836	160	914	31.6	33.5	15.8	16.8
18	0-4"	6.0	198	713	164	888	35.7	37.6	17.8	18.8
19	0-4"	5.9	149	716	167	856	27.7	29.1	13.9	14.6
20	0-4"	6.0	144	1212	165	900	25.6	27.0	12.8	13.5
21	0-4"	6.2	91	1297	161	897	16.3	17.2	8.1	8.6
25	0-4"	5.8	119	678	141	891	21.6	23.1	10.8	11.5
26	0-4"	6.1	201	731	164	934	34.6	36.6	17.3	18.3
27	0-4"	5.9	176	766	176	924	30.4	32.0	15.2	16.0
28	0-4"	6.0	101	1226	163	906	17.9	18.9	8.9	9.4
29	0-4"	6.1	108	1162	154	901	19.3	20.5	9.6	10.2
33	0-4"	5.9	143	767	122	885	26.4	28.4	13.2	14.2
34	0-4"	5.7	137	1130	144	886	25.0	26.6	12.5	13.3
35	0-4"	5.8	150	1454	153	920	26.3	28.0	13.1	14.0
36	0-4"	6.2	99	1344	162	856	18.5	19.4	9.2	9.7
37	0-4"	6.1	100	1294	171	968	16.6	17.6	8.3	8.8
41	0-4"	6.0	118	1027	126	887	21.7	23.3	10.8	11.6
42	0-4"	5.6	77	1593	135	892	14.0	15.0	7.0	7.5
43	0-4"	5.8	78	1268	133	867	14.6	15.6	7.3	7.8

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
44	0-4"	6.1	76	1303	146	879	13.9	14.8	7.0	7.4
45	0-4"	6.1	77	1073	149	883	14.0	14.9	7.0	7.5
49	0-4"	5.9	90	1968	113	904	16.4	17.7	8.2	8.8
50	0-4"	6.0	74	1723	121	906	13.4	14.4	6.7	7.2
51	0-4"	5.8	78	1710	131	928	13.7	14.7	6.9	7.4
52	0-4"	6.2	81	1195	136	916	14.4	15.4	7.2	7.7
53	0-4"	5.9	120	1227	151	924	21.0	22.3	10.5	11.2
54	0-4"	5.9	93	944	161	908	16.4	17.4	8.2	8.7
57	0-4"	6.4	91	2674	97	905	16.7	18.2	8.3	9.1
58	0-4"	5.9	124	1660	154	876	22.7	24.1	11.4	12.0
59	0-4"	6.0	159	1585	142	883	29.1	31.0	14.6	15.5
60	0-4"	6.1	119	1501	155	879	21.7	23.0	10.9	11.5
61	0-4"	5.9	170	1369	141	876	31.4	33.4	15.7	16.7
62	0-4"	6.1	119	1231	149	874	21.9	23.3	11.0	11.6
Mean, mg/kg		6.0	126	1239	149	897	22.6	24.0	11.3	12.0
Median, mg/kg		6.0	119	1227	152	895	21.7	23.0	10.8	11.5
Minimum, mg/kg		5.6	74	678	97	856	13.4	14.4	6.7	7.2
Maximum, mg/kg		6.4	230	2674	180	968	41.6	43.6	20.8	21.8
Standard deviation, mg/kg		0.2	43	419	19	23	7.6	8.0	3.8	4.0
C.V., %		3	34	34	13	3	34	33	34	33
Count				34						
Buffer zone										
8	0-4"	7.1	161	1332	165	895	28.8	30.4	14.4	15.2
9	0-4"	6.2	192	950	164	887	34.6	36.5	17.3	18.3
10	0-4"	6.2	256	986	172	876	46.5	48.9	23.3	24.4

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
13	0-4"	6.3	125	1900	171	901	22.1	23.3	11.1	11.7
22	0-4"	5.8	59	674	204	886	10.4	10.8	5.2	5.4
30	0-4"	6.2	97	986	194	897	17.1	17.8	8.5	8.9
38	0-4"	5.9	91	912	173	932	15.6	16.5	7.8	8.2
46	0-4"	6.1	96	894	179	895	17.0	17.9	8.5	8.9
47	0-4"	5.9	31	1351	134	893	5.6	6.0	2.8	3.0
55	0-4"	5.9	52	1417	140	896	9.4	10.0	4.7	5.0
63	0-4"	5.8	72	700	153	896	12.9	13.7	6.5	6.9
Mean, mg/kg		6.1	112	1100	168	896	20.0	21.1	10.0	10.5
Median, mg/kg		6.1	96	986	171	895	17.0	17.8	8.5	8.9
Minimum, mg/kg		5.8	31	674	134	876	5.6	6.0	2.8	3.0
Maximum, mg/kg		7.1	256	1900	204	932	46.5	48.9	23.3	24.4
Standard deviation, mg/kg		0.4	67	364	21	14	12.2	12.9	6.1	6.4
C.V., %		6	60	33	12	2	61	61	61	61
Count				11						

Table 24. Soil P sorption saturation and soil properties related to P sorption for 4 to 8 inch grid-soil samples from Field 12 for 2018.

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
			mg/L				%			
Whole field										
21	4-8"	6.4	95	804	155	945	16.2	17.3	8.1	8.6
22	4-8"	6.3	24	1153	111	946	4.2	4.5	2.1	2.3
25	4-8"	5.9	52	840	109	966	8.9	9.7	4.4	4.8
26	4-8"	5.6	137	668	154	946	23.4	24.9	11.7	12.5
27	4-8"	5.8	79	914	138	928	13.8	14.8	6.9	7.4
28	4-8"	6.0	24	1560	118	933	4.2	4.6	2.1	2.3
29	4-8"	6.0	31	1363	125	946	5.4	5.8	2.7	2.9
30	4-8"	5.9	46	740	142	953	7.8	8.4	3.9	4.2
33	4-8"	5.7	50	809	101	963	8.6	9.4	4.3	4.7
34	4-8"	5.5	80	1187	141	962	13.5	14.5	6.8	7.3
35	4-8"	5.8	53	1830	133	935	9.2	9.9	4.6	5.0
36	4-8"	6.1	67	1113	186	966	11.1	11.6	5.5	5.8
37	4-8"	6.1	30	1540	130	948	5.2	5.6	2.6	2.8
38	4-8"	6.0	36	719	134	961	6.1	6.6	3.1	3.3
41	4-8"	6.2	45	1229	107	920	8.1	8.8	4.0	4.4
42	4-8"	6.3	30	1903	141	928	5.2	5.6	2.6	2.8
43	4-8"	6.2	43	1123	151	933	7.4	7.9	3.7	4.0
44	4-8"	6.0	26	1381	114	950	4.5	4.9	2.3	2.4
45	4-8"	6.0	31	1173	124	957	5.3	5.7	2.7	2.9
46	4-8"	6.0	32	802	126	954	5.5	5.9	2.7	3.0
47	4-8"	6.0	25	1171	129	943	4.3	4.7	2.2	2.3
49	4-8"	5.9	84	1267	175	962	14.0	14.8	7.0	7.4

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
50	4-8"	6.2	27	2038	106	936	4.8	5.2	2.4	2.6
51	4-8"	6.2	25	2238	117	958	4.3	4.7	2.1	2.3
52	4-8"	6.3	32	1497	130	962	5.4	5.9	2.7	2.9
53	4-8"	6.1	54	1687	141	940	9.3	10.0	4.7	5.0
54	4-8"	6.0	57	901	150	961	9.6	10.3	4.8	5.1
55	4-8"	6.1	28	1249	129	936	4.9	5.3	2.4	2.6
57	4-8"	6.5	44	2508	108	925	7.8	8.5	3.9	4.3
58	4-8"	5.9	76	1895	163	942	13.0	13.8	6.5	6.9
59	4-8"	6.2	51	1371	133	949	8.8	9.4	4.4	4.7
60	4-8"	6.0	39	1563	123	955	6.7	7.2	3.3	3.6
61	4-8"	6.0	139	1192	171	931	23.9	25.2	11.9	12.6
62	4-8"	6.5	52	1126	133	956	8.9	9.6	4.4	4.8
63	4-8"	5.9	60	801	146	931	10.4	11.1	5.2	5.6
Mean, mg/kg		6.0	52	1296	134	946	8.9	9.5	4.4	4.7
Median, mg/kg		6.0	45	1192	133	946	7.8	8.5	3.9	4.3
Minimum, mg/kg		5.5	24	668	101	920	4.2	4.5	2.1	2.3
Maximum, mg/kg		6.5	139	2508	186	966	23.9	25.2	11.9	12.6
Standard deviation, mg/kg		0.2	29	454	20	13	4.9	5.2	2.5	2.6
C.V., %		4	56	35	15	1	55	55	55	55
Count		36	35							
Application zone										
21	4-8"	6.4	95	804	155	945	16.2	17.3	8.1	8.6
25	4-8"	5.9	52	840	109	966	8.9	9.7	4.4	4.8
26	4-8"	5.6	137	668	154	946	23.4	24.9	11.7	12.5
27	4-8"	5.8	79	914	138	928	13.8	14.8	6.9	7.4

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
28	4-8"	6.0	24	1560	118	933	4.2	4.6	2.1	2.3
29	4-8"	6.0	31	1363	125	946	5.4	5.8	2.7	2.9
33	4-8"	5.7	50	809	101	963	8.6	9.4	4.3	4.7
34	4-8"	5.5	80	1187	141	962	13.5	14.5	6.8	7.3
35	4-8"	5.8	53	1830	133	935	9.2	9.9	4.6	5.0
36	4-8"	6.1	67	1113	186	966	11.1	11.6	5.5	5.8
37	4-8"	6.1	30	1540	130	948	5.2	5.6	2.6	2.8
41	4-8"	6.2	45	1229	107	920	8.1	8.8	4.0	4.4
42	4-8"	6.3	30	1903	141	928	5.2	5.6	2.6	2.8
43	4-8"	6.2	43	1123	151	933	7.4	7.9	3.7	4.0
44	4-8"	6.0	26	1381	114	950	4.5	4.9	2.3	2.4
45	4-8"	6.0	31	1173	124	957	5.3	5.7	2.7	2.9
49	4-8"	5.9	84	1267	175	962	14.0	14.8	7.0	7.4
50	4-8"	6.2	27	2038	106	936	4.8	5.2	2.4	2.6
51	4-8"	6.2	25	2238	117	958	4.3	4.7	2.1	2.3
52	4-8"	6.3	32	1497	130	962	5.4	5.9	2.7	2.9
53	4-8"	6.1	54	1687	141	940	9.3	10.0	4.7	5.0
54	4-8"	6.0	57	901	150	961	9.6	10.3	4.8	5.1
57	4-8"	6.5	44	2508	108	925	7.8	8.5	3.9	4.3
58	4-8"	5.9	76	1895	163	942	13.0	13.8	6.5	6.9
59	4-8"	6.2	51	1371	133	949	8.8	9.4	4.4	4.7
60	4-8"	6.0	39	1563	123	955	6.7	7.2	3.3	3.6
61	4-8"	6.0	139	1192	171	931	23.9	25.2	11.9	12.6
62	4-8"	6.5	52	1126	133	956	8.9	9.6	4.4	4.8
Mean, mg/kg		6.1	55	1383	135	947	9.5	10.2	4.8	5.1
Median, mg/kg		6.0	51	1315	133	947	8.7	9.4	4.3	4.7

Point	Depth	pH	P	Ca	Fe	Al	P Saturation molarity	P Saturation with 0.5	P Saturation molarity	P Saturation
Minimum, mg/kg		5.5	24	668	101	920	4.2	4.6	2.1	2.3
Maximum, mg/kg		6.5	139	2508	186	966	23.9	25.2	11.9	12.6
Standard deviation, mg/kg		0.2	30	457	22	14	5.2	5.5	2.6	2.7
C.V., %		4	55	33	16	1	54	54	54	54
Count		28								
Buffer zone										
22	4-8"	6.3	24	1153	111	946	4.2	4.5	2.1	2.3
30	4-8"	5.9	46	740	142	953	7.8	8.4	3.9	4.2
38	4-8"	6.0	36	719	134	961	6.1	6.6	3.1	3.3
46	4-8"	6.0	32	802	126	954	5.5	5.9	2.7	3.0
47	4-8"	6.0	25	1171	129	943	4.3	4.7	2.2	2.3
55	4-8"	6.1	28	1249	129	936	4.9	5.3	2.4	2.6
63	4-8"	5.9	60	801	146	931	10.4	11.1	5.2	5.6
Mean, mg/kg		6.0	36	948	131	946	6.2	6.6	3.1	3.3
Median, mg/kg		6.0	32	802	129	946	5.5	5.9	2.7	3.0
Minimum, mg/kg		5.9	24	719	111	931	4.2	4.5	2.1	2.3
Maximum, mg/kg		6.3	60	1249	146	961	10.4	11.1	5.2	5.6
Standard deviation, mg/kg		0.1	13	231	11	11	2.3	2.4	1.1	1.2
C.V., %		2	36	24	9	1	36	36	36	36
Count		7								

APPENDIX G: FIELD 5A AND 12 PIEZOMETERS

Summary

1. Piezometers and water sampling stations were installed in Fields 5a and 12 in these two fields, which are adjacent to Big Creek. The aim of these stations was to determine water table fluctuations and potential subsurface flow pathways, as a function of weather, Big Creek flow stage, and field management.
2. Piezometer functioning was problematic. While the belowground installation allowed routine field operations (i.e., grazing, slurry application, and cutting hay), we were not able to keep them watertight. Surface water seepage into the units, damaged data loggers with little data collected.
3. An additional unforeseen problem with data collection occurred when pasture height limited access to the stations, between May and October, due to landowner concerns of pastures damage and yield reductions.
4. Due to limited functioning of the piezometers, insufficient data was obtained to present any reliable findings in the Final Report.

List of Figures

Piezometer and Monitoring Well Installation

Water-level sensors (Water Logger WL-15 units from Global Water) were installed on Fields 5a and 12 to continuously monitor the water table depth along two transects in Field 12 and in several strategic locations in Field 5a (Figure 1). The soil water-level sensors determine the depth at which soil is saturated with water (or the water-table depth) at four-hour intervals down to average depths of 6 to 7 feet, with the deepest being 9.7 feet below the surface, which is the depth where soil was underlain by a cherty or discontinuous layer (i.e., point of refusal).

At each site, two piezometers were also installed that allow collection of an in-situ soil water sample. The piezometers consist of 5-cm (2-inch) diameter Schedule 40 PVC pipe, which were slotted in the bottom 10 cm of the pipe to facilitate water flow. Sand was placed in the bottom of the hole and along the outside of the PVC pipe up to the top level of the slots in the pipe. Bentonite chips were placed above the sand along the outside of the PVC pipe to the soil surface to ensure no preferential movement of water along the well casing. Piezometers were installed so that there was no piping or equipment above ground that could interfere with day-to-day farm operations on the field. Belowground construction of piezometers is depicted in Figures 2, 3, and 4.

Data will be downloaded from each unit using a laptop computer approximately once a month. One piezometer was located to collect water from just below the root zone (about 12 inches deep) and one from the deeper point of refusal, described above.

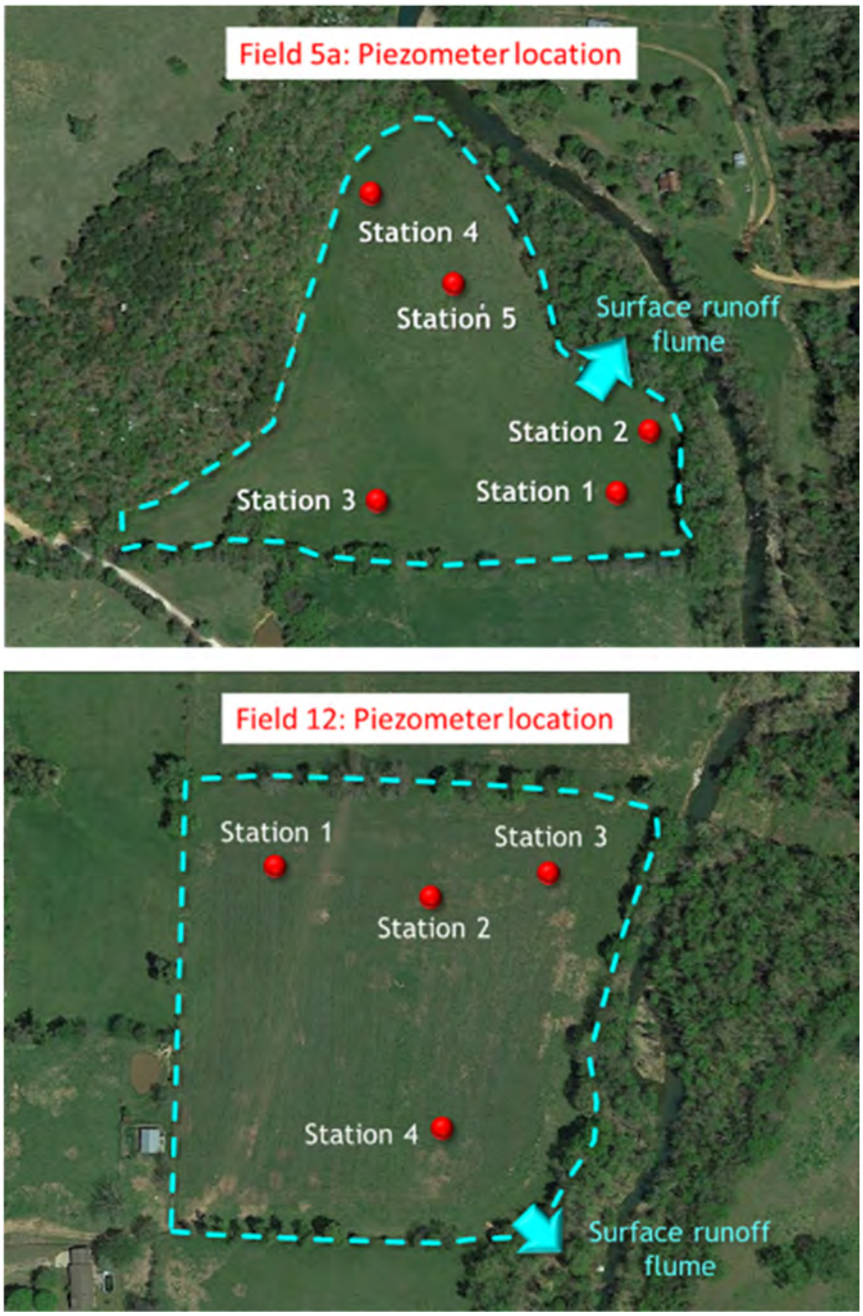

Figure 1. Location of piezometers in Fields 5a and 12.

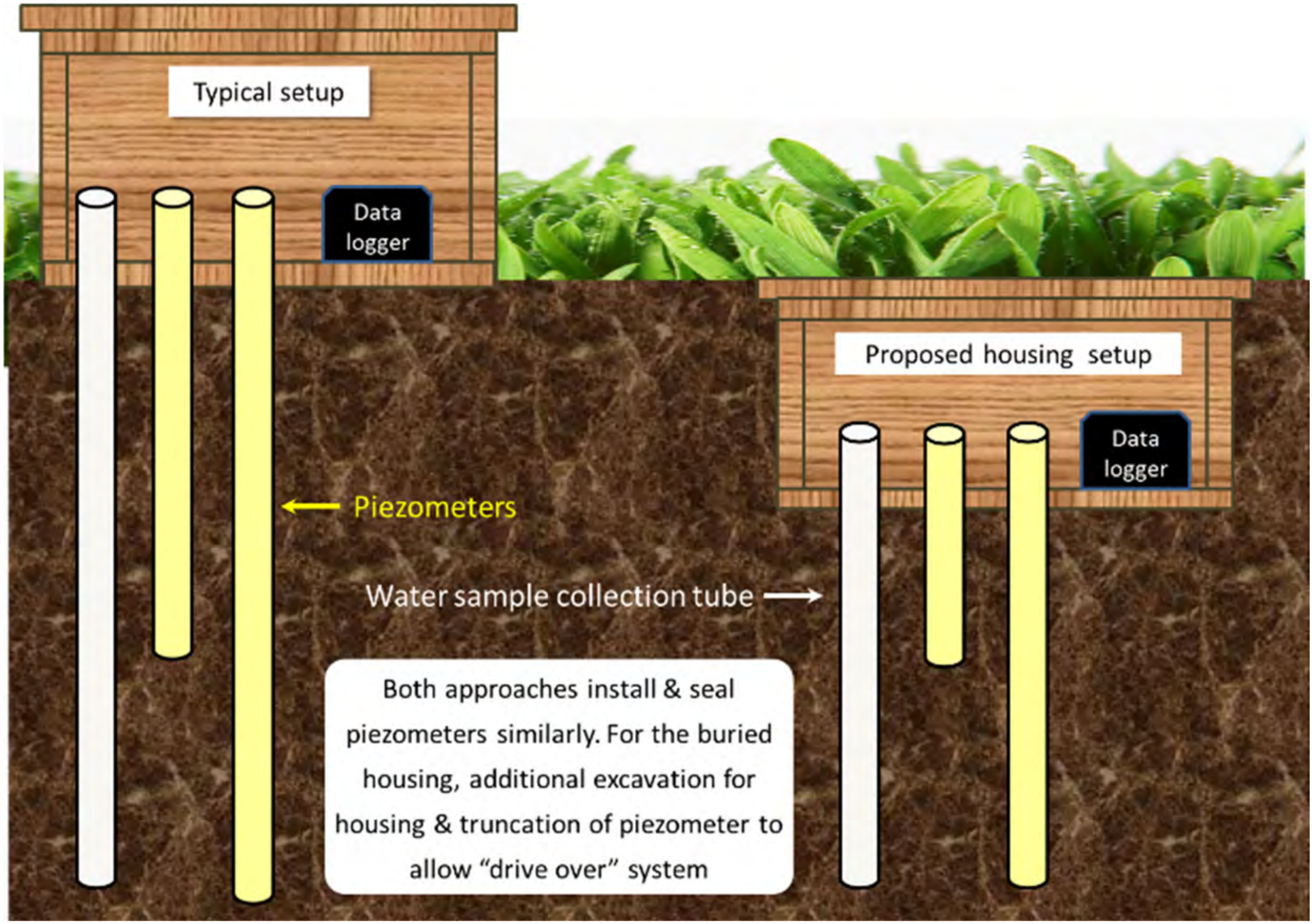

Figure 2. Schematic of belowground piezometer installation.

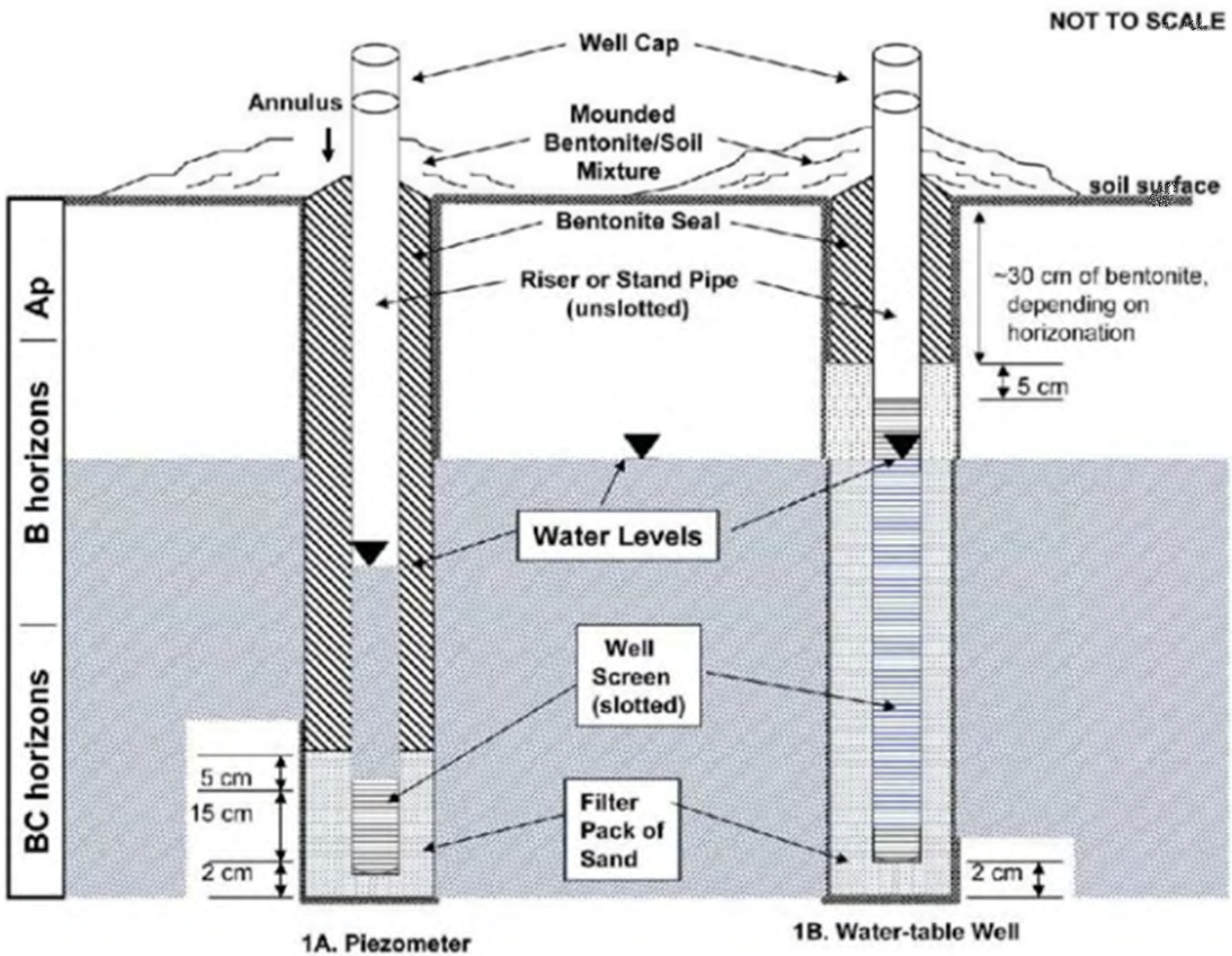

Figure 3. Standard installations for soil studies of (1A) a piezometer and (1B) a water-table well (see Sprecher, S.W. 2008. Installing monitoring wells in soils (Version 1.0). National Soil Survey Center, Natural Resources Conservation Service, USDA, Lincoln, NE).

Figure 4. Construction of belowground piezometer.

APPENDIX H: WATER QUALITY CHEMISTRY

Contents

Table 1. Water quality analyses at each sample site for the MOU monitoring period (September 12, 2013 to July 21, 2014).

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	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	0.37	0.50	3.0	N.D.	6.3	>2420
11:15	15:30	Upstream barn	0.010	0.032	0.05	0.36	0.54	5.8	N.D.	4.1	4040.0
11:50	15:30	Downstream barn	0.019	0.026	0.05	0.63	0.78	1.2	N.D.	1.0	488.4
13:00	15:30	Downstream farm	0.010	0.022	0.04	0.40	0.62	1.7	N.D.	16.0	>2420
9/20/2013	**9/20/2013**	**Base flow**									
10:50	16:08	Spring	0.006	0.020	0.03	0.38	0.50	4.7	N.D.	72.7	5040
11:15	16:08	Upstream farm	0.009	0.022	0.03	0.25	0.36	1.1	N.D.	80.9	9870
11:40	16:08	Upstream barn	0.015	0.024	0.04	0.36	0.42	1.2	N.D.	1203	26130
12:20	16:08	Downstream barn	0.024	0.032	0.06	0.76	0.85	1.3	N.D.	218.7	2430
12:50	16:08	Downstream farm	0.013	0.022	0.05	0.44	0.53	1.1	N.D.	548	17230

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
9/24/2013	**9/24/2013**	**Base flow**									
10:30	16:15	Spring	0.004	0.024	0.00	0.12	0.35	50.0	N.D.	8.5	>2420
10:45	16:15	Upstream farm	0.011	0.014	0.03	0.44	0.20	17.9	N.D.	39	1120
11:00	16:15	Upstream barn	0.007	0.024	0.00	0.33	0.41	1.6	N.D.	42	>2419
12:20	16:15	Downstream barn	0.017	0.032	0.01	0.79	0.82	0.7	N.D.	42	816
12:40	16:15	Downstream farm	0.007	0.028	0.01	0.51	0.58	1.5	N.D.	5	>2420
10/1/2013	**10/1/2013**	**Base flow**								N.D.	
9:45	14:42	Spring	0.001	0.162	0.00	0.11	0.41	89.2	N.D.	4	920
10:00	14:42	Upstream farm	0.011	0.038	0.02	0.24	0.34	2.2	N.D.	8	1300
10:15	14:42	Upstream barn	0.006	0.032	0.03	0.24	0.40	6.7	N.D.	82	5200
10:35	14:42	Downstream barn	0.018	0.032	0.00	0.8	0.92	1.1	N.D.	19	649
10:55	14:42	Downstream farm	0.009	0.034	0.02	0.51	0.65	3.6	N.D.	2620	10810
10/9/2013	**10/9/2013**	**Base flow**									
9:00	13:52	Spring	0.011	0.054	0.00	0.09	0.28	29.1	N.D.	3	1413
9:30	13:52	Upstream farm	0.016	0.034	0.00	0.50	0.73	7.1	N.D.	11	2419

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
9:45	13:52	Upstream barn	0.016	0.030	0.00	0.39	0.53	6.2	N.D.	194	4730
10:00	13:52	Downstream barn	0.017	0.02	0.00	0.87	0.89	0.4	N.D.	29	1986
10:20	13:52	Downstream farm	0.006	0.038	0.00	0.62	0.77	13.6	N.D.	28	3450
10/15/2013	**10/15/2013**	**Storm flow**									
11:13	15:47	Spring	0.010	0.250	0.15	0.09	0.58	66.9	N.D.	1401	19863
12:24	15:47	Upstream farm	0.018	0.026	0.00	1.02	1.03	1.1	N.D.	759	>2419
12:47	15:47	Upstream barn	0.019	0.036	0.06	0.84	0.99	2.1	N.D.	472	8664
13:13	15:47	Downstream barn	0.033	0.244	0.12	1.28	1.44	89.2	N.D.	959	12997
13:34	15:47	Downstream farm	0.067	0.316	0.20	0.68	1.07	101.1	N.D.	1334	19863
10/22/2013	**10/22/2013**	**Base flow**									
10:10	15:31	Spring	0.005	0.086	0.10	0.31	0.53	36.4	N.D.	1733	>2419
10:30	15:31	Upstream farm	0.014	0.034	0.00	0.35	0.32	0.3	N.D.	186	299
10:45	15:31	Upstream barn	0.016	0.024	0.03	0.58	0.60	1.2	N.D.	411	11190
11:00	15:31	Downstream barn	0.016	0.022	0.00	0.79	0.77	0.1	N.D.	150	2419

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
11:20	15:31	Downstream farm	0.012	0.020	0.04	0.72	0.76	0.7	N.D.	87	292
10/31/2013	**10/31/2013**	**Base flow**									
11:00	15:15	Spring	0.003	0.404	0.14	0.32	1.02	400.9	N.D.	91	32550
10:45	15:15	Upstream farm	0.012	0.032	0.00	0.24	0.32	1.1	N.D.	66	1986
10:15	15:15	Upstream barn	0.007	0.044	0.04	0.25	0.38	2.3	N.D.	261	6310
10:00	15:15	Downstream barn	0.018	0.022	0.11	0.52	0.66	0.9	N.D.	14	218
10:30	15:15	Downstream farm	0.012	0.024	0.03	0.44	0.45	1.4	N.D.	Leaked	Leaked
11/6/2013	**11/6/2013**	**Base flow**									
8:35	14:35	Spring	0.013	0.130	0.10	0.06	0.72	21.2	N.D.	8570	34480
9:00	14:35	Upstream farm	0.032	0.074	0.03	0.43	0.61	4.7	N.D.	4080	28510
9:10	14:35	Upstream barn	0.020	0.038	0.00	0.18	0.27	2.5	N.D.	579	13330
9:45	14:35	Downstream barn	0.040	0.164	0.12	0.41	0.67	32.9	N.D.	3180	36090
10:00	14:35	Downstream farm	0.041	0.154	0.12	0.29	0.60	28.4	N.D.	3500	43520
11/12/2013	**11/12/2013**	**Base flow**									

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
10:56	16:28	Spring	0.006	0.022	0.05	2.45	2.61	8.9	N.D.	48	2750
11:35	16:28	Upstream farm	0.011	0.010	0.00	0.17	0.22	1.0	N.D.	45	1986
12:15	16:28	Upstream barn	0.012	0.014	0.09	0.22	0.33	1.4	N.D.	36	1733
13:03	16:28	Downstream barn	0.012	0.012	0.00	0.30	0.34	0.5	N.D.	21	1046
13:35	16:28	Downstream farm	0.011	0.010	0.00	0.24	0.31	0.0	N.D.	24	>2419
11/19/2013	**11/19/2013**	**Base flow**									
9:20	14:35	Spring	0.007	0.022	0.02	3.06	3.06	4.4	N.D.	579	9880
9:45	14:35	Upstream farm	0.010	0.026	0.00	0.12	0.22	0.7	N.D.	435	2400
10:05	14:35	Upstream barn	0.011	0.028	0.00	0.18	0.32	0.3	N.D.	172	>2419
10:35	14:35	Downstream barn	0.011	0.028	0.00	0.23	0.34	0.5	N.D.	238	2419
10:55	14:35	Downstream farm	0.009	0.024	0.02	0.17	0.28	1.0	N.D.	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	N.D.	86	1553
10:45	14:40	Upstream farm	0.013	0.018	0.00	0.14	0.14	0.4	N.D.	77	1203
11:06	14:40	Upstream barn	0.014	0.016	0.00	0.19	0.20	0.7	N.D.	249	1986

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
11:30	14:40	Downstream barn	0.014	0.018	0.03	0.30	0.33	1.3	N.D.	40	613
11:45	14:40	Downstream farm	0.013	0.016	0.00	0.23	0.24	1.2	N.D.	36	2419
12/3/2013	**12/3/2013**	**Base flow**									
8:30	13:23	Spring	0.007	0.046	0.04	1.05	1.37	26.9	N.D.	25	1986
8:45	13:23	Upstream farm	0.007	0.012	0.00	0.15	0.25	0.5	N.D.	27	435
9:00	13:23	Upstream barn	0.009	0.012	0.00	0.21	0.28	0.3	N.D.	29	548
9:15	13:23	Downstream barn	0.010	0.018	0.00	0.30	0.35	0.6	N.D.	248	687
9:35	13:23	Downstream farm	0.006	0.012	0.00	0.23	0.28	0.5	N.D.	12	>2419
12/17/2013	**12/17/2013**	**After snow melt**									
9:35	14:03	Spring	0.007	0.042	0.05	0.37	0.65	2.0	N.D.	248.1	2419.2
10:00	14:03	Upstream farm	0.010	0.036	0.06	0.18	0.27	1.2	N.D.	248.1	2419.2
10:10	14:03	Upstream barn	0.011	0.032	0.02	0.38	0.48	0.7	N.D.	157.6	>2419.2
10:30	14:03	Downstream barn	0.008	0.032	0.03	0.39	0.50	1.6	N.D.	127.4	2419.2
10:50	14:03	Downstream farm	0.008	0.032	0.00	0.33	0.43	2.1	N.D.	148.3	>2419.2

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
1/2/2014	**1/2/2014**	**Base flow**									
10:45	14:19	Spring	0.006	0.024	0.05	3.35	3.24	0.5	N.D.	ND	ND
10:55	14:19	Upstream farm	0.009	0.022	0.01	0.22	0.25	0.7	N.D.	ND	ND
11:10	14:19	Upstream barn	0.012	0.024	0.00	0.44	0.47	0.3	N.D.	ND	ND
11:25	14:19	Downstream barn	0.012	0.024	0.00	0.54	0.58	0.8	N.D.	ND	ND
11:50	14:19	Downstream farm	0.012	0.036	0.00	0.49	0.54	0.8	N.D.	ND	ND
1/7/2014	**1/7/2014**	**Base flow**									
10:10	13:43	Spring	0.008	0.024	0.00	2.36	2.32	1.3	N.D.	20.9	1413.6
10:20	13:43	Upstream farm	0.014	0.022	0.02	0.20	0.27	0.8	N.D.	66.3	307.6
10:30	13:43	Upstream barn	0.017	0.022	0.00	0.36	0.43	0.3	N.D.	24.3	344.8
10:50	13:43	Downstream barn	0.015	0.022	0.00	0.50	0.54	1.1	N.D.	21.1	290.9
11:10	13:43	Downstream farm	0.015	0.028	0.00	0.41	0.46	0.2	N.D.	18.3	325.5
1/14/2014	**1/14/2014**	**Base flow**									
11:35	15:35	Spring	0.010	0.042	0.00	1.97	2.09	2.3	N.D.	24.3	1732.9
12:15	15:35	Upstream farm	0.008	0.028	0.01	0.16	0.25	0.3	N.D.	151.5	980.4

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
11:50	15:35	Upstream barn	0.008	0.030	0.03	0.21	0.73	0.9	N.D.	238.2	920.8
12:50	15:35	Downstream barn	0.008	0.028	0.02	0.33	0.43	0.5	N.D.	156.5	1119.9
13:15	15:35	Downstream farm	0.008	0.026	0.05	0.31	0.39	0.5	N.D.	95.9	1299.7
1/21/2014	**1/21/2014**	**Base flow**									
8:10	15:00	Spring	0.008	0.006	0.02	2.11	2.10	0.9	N.D.	5.2	613.1
8:30	15:00	Upstream farm	0.009	0.010	0.00	0.13	0.22	0.0	N.D.	55.7	290.9
8:20	15:00	Upstream barn	0.010	0.010	0.01	0.21	0.28	0.3	N.D.	51.2	488.4
8:45	15:00	Downstream barn	0.011	0.012	0.01	0.34	0.45	1.0	N.D.	49.6	249.9
9:05	15:00	Downstream farm	0.010	0.014	0.01	0.30	0.36	0.5	N.D.	131.3	410.6
1/29/2014	**1/29/2014**	**Base flow**									
10:20	14:15	Spring	0.009	0.024	0.00	0.85	0.86	1.4	N.D.	3.1	325.5
10:40	14:15	Upstream farm	0.007	0.028	0.00	0.13	0.15	0.6	N.D.	10.9	248.1
10:30	14:15	Upstream barn	0.007	0.024	0.01	0.20	0.24	0.0	N.D.	28.2	290.9
11:00	14:15	Downstream farm	0.007	0.024	0.00	0.28	0.28	0.0	N.D.	<1	275.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
2/13/2014	**2/13/2014**	**Base flow**									
8:30	13:22	Spring	0.009	0.024	0.00	0.65	0.73	5.1	N.D.	<1	461.1
8:50	13:22	Upstream farm	0.009	0.016	0.00	0.11	0.15	0.9	N.D.	68.9	238.2
8:40	13:22	Upstream barn	0.011	0.014	0.00	0.14	0.23	0.9	N.D.	31.4	260.2
9:10	13:22	Downstream farm	0.009	0.014	0.00	0.24	0.28	0.4	N.D.	9.8	290.9
2/19/2014	**2/19/2014**	**Base flow**									
9:15	14:36	Spring	0.006	0.020	0.02	0.57	0.62	0.8	N.D.	1.0	365.4
10:17	14:36	Upstream farm	0.008	0.018	0.00	0.05	0.10	0.4	N.D.	111.9	325.5
9:30	14:36	Upstream barn	0.009	0.018	0.00	0.07	0.15	0.5	N.D.	45.5	235.9
11:30	14:36	Downstream farm	0.007	0.016	0.00	0.11	0.17	0.3	N.D.	8.5	272.3
2/27/14	**2/27/14**	**Base flow**									
10:40	15:10	Spring	0.007	0.106	0.06	0.59	0.82	70	N.D.	<1	307.6
11:03	15:10	Upstream farm	0.008	0.022	0.02	0.07	0.22	2.1	N.D.	29.5	209.8
11:40	15:10	Upstream barn	0.008	0.016	0.00	0.08	0.11	0.3	N.D.	14.8	235.9
12:22	15:10	Downstream farm	0.007	0.014	0.00	0.11	0.16	0.6	N.D.	2.00	547.5

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
3/10/2014	**3/10/2014**	**Base flow/Snow melt**									
10:30	15:08	Spring	0.006	0.048	0.02	0.37	0.53	19.9	3.8	6.3	517.2
10:55	15:08	Upstream farm	0.005	0.026	0.06	0.09	0.12	0.9	1.4	52.1	275.5
11:40	15:08	Upstream barn	0.007	0.020	0.04	0.10	0.13	1.3	1.3	59.4	547.5
12:15	15:08	Downstream farm	0.004	0.026	0.04	0.12	0.21	6.1	1.2	27.8	579.4
3/18/2014	**3/18/2014**	**Storm flow**									
12:08	15:24	Spring	0.011	0.026	0.00	0.90	0.99	1.7	2.5	21.1	>2419.2
12:48	15:24	Upstream farm	0.010	0.038	0.08	0.19	0.24	2.1	1.2	50.4	435.2
12:20	15:24	Upstream barn	0.012	0.040	0.04	0.24	0.76	3.1	1.2	63.7	648.8
13:03	15:24	Downstream farm	0.014	0.040	0.06	0.31	0.38	3.4	1.7	78.8	866.4
12:36	15:24	Culvert	0.009	0.028	0.05	0.64	0.63	1.0	0.7	19.3	365.4
3/26/2014	**3/26/2014**	**Base flow**									
10:40	14:06	Spring	0.010	0.026	0.01	1.00	1.13	3.0	1.4	8.4	980.4
10:22	14:06	Upstream farm	0.010	0.024	0.00	0.12	0.19	0.6	0.8	43.5	517.2
10:32	14:06	Upstream barn	0.011	0.024	0.00	0.17	0.22	0.5	0.5	48.7	579.4

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
11:31	14:06	Downstream farm	0.011	0.026	0.00	0.25	0.30	1.2	0.7	21.8	866.4
9:55	14:06	Culvert	0.007	0.028	0.00	0.61	0.62	11.0	1.2	260.2	>2419.2
3/29/2014	**3/31/2014**	**Storm flow**									
9:40	8:42	Spring	0.006	0.044	0.00	0.29	0.51	3.3	8.1	ND	ND
10:00	8:42	Upstream farm	0.006	0.042	0.06	0.07	0.14	2.1	2.1	ND	ND
9:50	8:42	Upstream barn	0.007	0.036	0.00	0.09	0.16	1.5	2.3	ND	ND
10:35	8:42	Downstream farm	0.008	0.038	0.00	0.13	0.19	2.5	2.2	ND	ND
10:24	8:42	Culvert	0.004	0.042	0.00	0.69	0.81	3.3	4.9	ND	ND
4/2/2014	**4/2/2014**	**Base flow**									
11:15	14:30	Spring	0.011	0.020	0.00	0.60	0.67	0.6	2.1	3.1	307.6
10:14	14:30	Upstream farm	0.011	0.026	0.00	0.05	0.09	1.0	0.5	60.5	613.1
10:21	14:30	Upstream barn	0.012	0.028	0.00	0.08	0.11	0.7	1.4	12.1	1732.1
12:11	14:30	Downstream farm	0.010	0.024	0.00	0.11	0.14	0.8	0.6	29.5	1553.1
9:30	14:30	House well	0.014	0.024	0.00	0.50	0.50	0.1	0.8	7.5	117.2
9:30	14:30	House well, duplicate	0.014	0.020	0.04	0.50	0.49	0.3	0.7	ND	ND

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
9:47	14:30	Culvert	0.009	0.020	0.00	0.48	0.54	2.1	1.1	44.3	517.2
4/4/2014	**4/4/2014**	**Storm flow**									
9:07	12:19	Spring	0.014	0.052	0.02	0.39	0.59	3.9	4.9	N.D.	**N.D.**
9:40	12:19	Upstream farm	0.012	0.056	0.05	0.11	0.19	3.3	2.3	N.D.	**N.D.**
9:30	12:19	Upstream barn	0.013	0.044	0.04	0.08	0.21	5.2	2.6	N.D.	**N.D.**
10:08	12:19	Downstream farm	0.016	0.052	0.05	0.16	0.32	6.3	2.7	N.D.	**N.D.**
9:50	12:19	Culvert	0.026	0.262	0.46	0.85	2.36	908.8	6.5	N.D.	**N.D.**
4/3/2014, 4:04	12:19	Field 1	0.181	0.638	0.25	0.11	2.08	207.0	14.7	N.D.	**N.D.**
4/8/2014	**4/8/2014**	**Storm flow**									
9:15	15:24	Spring	0.016	0.018	0.00	0.53	0.59	0.7	4.7	74.9	488.4
10:25	15:24	Upstream farm	0.012	0.026	0.02	0.09	0.13	0.8	1.4	110.6	1299.7
9:58	15:24	Upstream barn	0.012	0.024	0.02	0.10	0.16	2.1	1.2	179.3	1299.7
9:05	15:24	Downstream farm	0.014	0.024	0.03	0.17	0.23	2.2	1.5	155.3	1413.6
10:15	15:24	Culvert	0.011	0.022	0.04	0.47	0.53	2.5	2.7	70.8	770.1
4/14/2014	**4/14/2014**	**Storm flow**									

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
9:47	13:57	Spring	0.006	0.038	0.01	0.43	0.54	0.9	4.4	172.2	>2419.2
11:17	13:57	Upstream farm	0.005	0.034	0.04	0.10	0.17	3.7	2.1	387.3	3090.0
10:38	13:57	Upstream barn	0.009	0.040	0.06	0.11	0.19	5.0	3.1	517.2	2980.0
9:35	13:57	Downstream farm	0.007	0.050	0.08	0.14	0.25	8.7	3.1	613.1	5210.0
4/13/2014, 9:57	13:57	Culvert, ISCO	0.003	0.016	0.00	0.46	0.49	4.7	1.8	8.5	195.6
10:50	13:57	Culvert	0.007	0.032	0.03	0.48	0.56	1.9	2.0	547.5	4320.0
4/22/2014	**4/22/2014**	**Base flow**									
9:40	13:57	Spring	0.013	0.020	0.00	0.59	0.66	1.7	0.9	11.0	>2419.2
10:21	13:57	Upstream farm	0.074	0.888	0.00	0.00	0.09	1.2	0.5	126.6	1203.3
10:10	13:57	Upstream barn	0.009	0.022	0.01	0.09	0.10	0.8	0.5	95.9	>2419.2
9:25	13:57	Downstream farm	0.020	0.024	0.01	0.13	0.17	1.6	0.6	66.3	>2419.2
11:00	13:57	House well	0.008	0.022	0.00	0.49	0.55	0.3	0.0	9.8	770.1
10:47	13:57	Culvert	0.004	0.012	0.00	0.45	0.50	1.0	0.0	47.9	>2419.2
5/1/2014	**5/1/2014**	**Base flow**									
10:09	13:05	Spring	0.007	0.012	0.00	0.51	0.57	1.4	1.0	52.1	1986.3

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
10:29	13:05	Upstream farm	0.006	0.018	0.00	0.07	0.09	1.9	1.0	96.0	3050.0
10:19	13:05	Upstream barn	0.007	0.014	0.04	0.10	0.10	2.2	0.4	73.8	4310.0
9:58	13:05	Downstream farm	0.007	0.008	0.05	0.12	0.11	1.5	0.9	62.4	3990.0
10:49	13:05	House well	0.012	0.012	0.08	0.47	0.52	0.7	0.5	<1	116.9
10:44	13:05	Culvert	0.005	0.010	0.00	0.45	0.50	1.5	0.6	90.5	4790.0
5/8/2014	**5/8/2014**	**Base flow**									
13:00	15:32	Spring	0.009	0.020	0.00	0.39	0.48	11.1	1.0	8.6	5560.0
12:45	15:32	Upstream farm	0.013	0.020	0.06	0.09	0.09	1.2	0.9	57.3	5120.0
12:53	15:32	Upstream barn	0.008	0.016	0.01	0.12	0.14	1.4	0.9	34.1	5760.0
13:13	15:32	Downstream farm	0.008	0.028	0.03	0.16	0.55	4.7	1.0	19.9	14760.0
12:34	15:32	House well	0.008	0.010	0.18	0.44	0.68	0.3	1.4	<1	<1
5/9/2014	**5/9/2014**	**Storm flow**									
10:05	13:54	Spring	0.009	0.030	0.02	0.16	0.36	5.8	4.0	ND	ND
10:42	13:54	Upstream farm	0.008	0.030	0.00	0.07	0.10	1.5	0.7	ND	ND
11:22	13:54	Upstream barn	0.008	0.020	0.06	0.10	0.10	2.0	0.7	ND	ND

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
9:52	13:54	Downstream farm	0.008	0.018	0.00	0.15	0.17	2.1	0.6	ND	ND
5/8/2014, 13:54	13:54	Field 1	0.079	0.312	0.17	0.21	1.63	125.9	9.6	ND	ND
5/13/2014	**5/13/2014**	**Storm flow**									
9:33	13:15	Spring	0.008	0.062	0.06	0.25	0.45	3.8	4.3	435.2	7280.0
10:38	13:15	Upstream farm	0.008	0.062	0.00	0.10	0.23	10.1	2.9	920.8	13130.0
10:05	13:15	Upstream barn	0.008	0.074	0.06	0.11	0.30	11.8	5.7	1046.2	15290.0
9:22	13:15	Downstream farm	0.010	0.086	0.07	0.13	0.38	19.4	5.6	1553.1	29090.0
10:13	13:15	House well	0.008	0.020	0.06	0.46	0.49	0.5	0.5	<1	18.9
10:20	13:15	Culvert	0.007	0.060	0.12	0.51	0.70	5.1	2.6	307.6	10760.0
5/12/2014, 16:26	13:15	Field 1	0.190	0.366	0.10	0.13	1.33	42.1	10.2	ND	ND
5/19/2014	**5/19/2014**	**Base flow**									
13:17	15:38	Spring	0.007	0.018	0.00	0.64	0.70	3.7	0.8	27.5	>2419.2
12:11	15:38	Upstream farm	0.006	0.024	0.05	0.10	0.16	1.9	0.5	133.3	2419.2
13:10	15:38	Upstream barn	0.008	0.020	0.00	0.00	0.10	1.5	0.5	95.9	4710.0
13:30	15:38	Downstream farm	0.008	0.018	0.00	0.11	0.14	2.0	0.3	53.7	4220.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
12:46	15:38	House well	0.011	0.016	0.03	0.49	0.49	0.2	0.4	11.0	123.6
12:41	15:38	Culvert	0.008	0.020	0.08	0.52	0.55	0.8	0.3	204.6	5940
5/28/2014	**5/28/2014**	**Storm flow**									
9:34	14:00	Spring	0.010	0.036	0.00	0.353	0.58	7.3	2.8	1986.3	16740.0
11:06	14:00	Upstream farm	0.007	0.022	0.00	0.124	0.10	2.1	0.7	290.9	15760.0
10:13	14:00	Upstream barn	0.007	0.020	0.03	0.154	0.14	1.9	0.7	198.9	12660.0
9:16	14:00	Downstream farm	0.008	0.020	0.03	0.221	0.21	1.9	0.7	209.8	8390.0
10:35	14:00	House well	0.009	0.012	0.06	0.495	0.51	0.1	0.3	<1	<1
10:28	14:00	Culvert	0.011	0.020	0.10	0.799	0.85	1.7	0.2	517.2	14830.0
9:55	14:00	Field 1	0.235	0.310	N.D.	N.D.	N.D.	56.1	164.7	N.D.	N.D.
6/5/2014	**6/5/2014**	**Base flow**									
13:03	15:37	Spring	0.022	0.030	0.08	0.350	0.46	4.5	0.9	33.2	4280.0
12:50	15:37	Upstream farm	0.012	0.022	0.01	0.136	0.14	1.2	1.0	307.6	18500.0
13:16	15:37	Downstream farm	0.012	0.026	0.05	0.219	0.28	4.3	0.8	201.4	13330.0
11:37	15:37	House well	0.008	0.028	0.12	0.444	0.59	0.0	1.4	<1	<1
6/9/2014	**6/9/2014**	**Storm flow**									

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
9:06	13:02	Spring	0.009	0.048	0.15	0.163	0.39	7.2	5.15	770.1	173290.0
10:22	13:02	Upstream farm	0.006	0.030	0.00	0.176	0.19	3.3	1.95	410.6	2419.2
9:34	13:02	Upstream barn	0.006	0.034	0.00	0.213	0.31	3.9	2.66	1119.9	29870.0
8:51	13:02	Downstream farm	0.006	0.026	0.02	0.256	0.26	4.3	1.33	517.2	11690.0
9:54	13:02	House well	0.005	0.016	0.14	0.501	0.57	0.2	0.90	<1	<1
6/19/2014	**6/19/2014**	**Base flow**									
9:10	13:27	Spring	0.008	0.024	0.06	0.320	0.43	3.7	0.20	28.8	2419.2
9:55	13:27	Upstream farm	0.008	0.028	0.09	0.154	0.22	0.3	0.3	36.4	3790.0
9:24	13:27	Upstream barn	0.009	0.026	0.10	0.180	0.25	0.1	0.40	49.6	5120.0
8:55	13:27	Downstream farm	0.010	0.020	0.03	0.246	0.32	0.9	0.33	61.3	4960.0
9:32	13:27	House well	0.009	0.028	0.06	0.442	0.57	0.0	0.33	<1	<1
6/24/2014	**6/24/2014**	**Storm flow**									
9:46	14:56	Spring	0.007	0.046	0.04	0.201	0.38	4.8	5.14	10810.0	275.5
12:17	14:56	Upstream farm	0.014	0.056	0.03	0.219	0.27	4.3	2.63	28510.0	980.4
10:17	14:56	Upstream barn	0.010	0.052	0.04	0.228	0.30	30.1	2.45	17270.0	1046.2

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
9:27	14:56	Downstream farm	0.009	0.068	0.05	0.245	0.35	7.2	3.81	24950.0	1046.2
10:47	14:56	House well	0.006	0.036	0.03	0.504	0.53	0.2	0.61	<1	<1
6/22/14, 8:02	14:56	Culvert, ISCO	0.005	0.090	0.68	4.562	7.16	2096	4.09	N.D.	N.D.
6/20/14, 14:31	14:56	Field 1	0.228	0.498	0.18	0.114	2.39	23.2	20.15	N.D.	N.D.
6/27/2014	**6/27/2014**	**Storm flow**									
10:03	14:25	Spring	0.012	0.010	0.00	0.378	0.51	3.3	3.86	N.D.	N.D.
6/26/14, 4:52	14:25	Upstream farm, ISCO	0.007	0.014	0.01	0.117	0.14	5.1	3.34	N.D.	N.D.
10:10	14:25	Upstream barn	0.017	0.026	0.02	0.248	0.29	3.5	0.54	N.D.	N.D.
12:17	14:25	Downstream farm	0.017	0.022	0.01	0.379	0.42	5.5	1.26	N.D.	N.D.
11:00	14:25	Culvert	0.017	0.022	0.00	0.550	0.60	1.7	0.83	N.D.	N.D.
6/25/14, 14:29	14:25	Field 1	1.166	1.374	0.10	0.333	1.18	12.3	7.80	N.D.	N.D.
6/25/14, 15:29	14:25	Field 5a	0.506	0.656	0.06	0.000	0.53	39.7	5.82	N.D.	N.D.
7/7/2014	**7/7/2014**	**Storm flow**									
9:28	15:15	Spring	0.009	0.132	0.33	0.352	0.66	18.7	2.97	10190.0	111990.0
11:00	15:15	Upstream farm	0.009	0.040	0.00	0.266	0.28	3.9	1.08	1732.9	69100.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
9:38	15:15	Upstream barn	0.013	0.040	0.00	0.322	0.33	3.7	0.67	2419.2	48840.0
9:12	15:15	Downstream farm	0.010	0.034	0.00	0.398	0.40	3.5	0.67	649.8	15760.0
9:51	15:15	House well	0.007	0.020	0.11	0.483	0.57	0.2	0.50	<1	<1
7/8/2014	**7/10/2014**	**Storm flow**									
17:10	**8:38**	Culvert, ISCO	0.023	0.054	0.37	0.759	2.89	1252.1	6.96	N.D.	N.D.
7/15/2014	**7/15/2014**	**Base flow**									
9:33	14:38	Spring	0.005	0.014	0.01	0.353	0.43	2.7	1.39	129.6	2810.0
10:20	14:38	Upstream farm	0.010	0.046	0.04	0.215	0.30	5.2	1.73	686.7	26130.0
10:10	14:38	Upstream barn	0.013	0.048	0.04	0.245	0.34	7.8	1.98	1119.9	26130.0
11:32	14:38	Downstream farm	0.009	0.050	0.03	0.270	0.40	9.1	1.92	816.4	27550.0
10:46	14:38	House well	0.009	0.012	0.08	0.476	0.60	0.4	0.70	<1	<1
7/18/2014	**7/18/2014**	**Storm flow**									
12:34	15:00	Spring	0.012	0.022	0.07	0.410	0.49	1.9	0.83	N.D.	N.D.
7/15/14, 18:52	15:00	Upstream farm, ISCO	0.006	0.032	0.04	0.004	0.20	4.4	1.83	N.D.	N.D.
12:13	15:00	Upstream farm	0.012	0.028	0.00	0.200	0.19	1.5	0.66	N.D.	N.D.

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
12:42	15:00	Upstream barn	0.013	0.028	0.03	0.249	0.25	2.1	0.68	N.D.	N.D.
10:45	15:00	Downstream farm	0.014	0.030	0.09	0.292	0.30	2.6	0.77	N.D.	N.D.
7/16/14, 12:18	15:00	Culvert, ISCO	0.006	0.032	0.06	0.601	0.67	16.8	0.56	N.D.	N.D.
7/23/2014	**7/23/2014**	**Base flow**									
10:27	13:11	Spring	0.015	0.024	0.05	0.342	0.37	2.5	1.42	14.6	1413.6
12:21	13:11	Upstream farm	0.021	0.020	0.05	0.103	0.11	1.3	1.13	142.1	2419.2
10:53	13:11	Upstream barn	0.018	0.026	0.04	0.217	0.21	1.8	1.08	344.8	5540.0
10:09	13:11	Downstream farm	0.019	0.032	0.09	0.280	0.31	3.7	1.12	95.9	6010.0
11:19	13:11	House well	0.013	0.016	0.26	0.469	0.67	0.2	0.70	<1	<1
7/25/2014	**7/25/2014**	**Storm flow**									
7/23/14, 15:41	15:59	Upstream farm, ISCO	0.081	0.476	0.09	0.004	0.86	447.1	5.55	N.D.	N.D.
11:33	15:59	Upstream farm	0.010	0.036	0.05	0.087	0.11	2.6	1.21	N.D.	N.D.
10:39	15:59	Upstream barn	0.012	0.034	0.04	0.134	0.19	2.7	1.31	N.D.	N.D.
9:55	15:59	Downstream farm	0.013	0.040	0.00	0.196	0.29	5.9	1.30	N.D.	N.D.

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
7/23/14, 14:42	15:59	Culvert, ISCO	0.016	1.018	0.98	0.875	2.69	2642.0	5.09	N.D.	N.D.
7/23/14, 15:06	15:59	Field 1	0.648	0.794	0.16	0.388	1.65	5.6	8.84	N.D.	N.D.
7/23/14, 16:09	15:59	Field 5a	0.625	0.754	0.09	0.004	0.61	9.0	5.81	N.D.	N.D.
7/31/2014	**7/31/2014**	**Storm flow**									
10:56	13:32	Upstream farm	0.015	0.022	0.00	0.116	0.13	1.2	0.76	275.5	6370.0
9:32	13:32	Downstream farm	0.018	0.030	0.00	0.250	0.30	3.3	0.77	224.7	23590.0
10:38	13:32	Culvert	0.017	0.042	0.20	1.204	1.23	4.9	1.03	1732.9	30760.0

N.D. is No Data.

Table 2. Water quality analyses at each sample site for the MOU monitoring period (August 12, 2014 to June 30, 2019).

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
			- -			mg/L	- -			- - MPN/100 mL - -	
8/12/2014	**8/12/2014**	**Base flow**									
10:09	13:23	Spring	0.009	0.032	0.03	0.217	0.26	7.0	0.56	40.4	2419
10:52	13:23	Upstream farm	0.012	0.026	<0.03	0.108	0.13	1.7	0.30	98.8	1986
9:54	13:23	Downstream farm	0.012	0.036	0.04	0.232	0.23	8.3	0.40	125.0	9870
10:37	13:23	House well	0.009	0.020	0.20	0.418	0.62	0.5	0.35	<1	<1
8/20/2014	**8/20/2014**	**Base flow**									
10:28	14:05	Spring	0.010	0.036	<0.03	0.285	0.45	7.5	1.09	307.6	40830
11:23	14:05	Upstream farm	0.014	0.040	<0.03	0.214	0.32	8.3	0.52	88.4	3000
10:14	14:05	Downstream farm	0.011	0.032	0.01	0.319	0.37	3.4	0.44	69.7	7380
10:53	14:05	House well	0.010	0.020	0.15	0.412	0.61	0.3	0.28	<1	<1
8/22/2014	**8/25/2014**	**Base flow**									
14:06	9:25	Trench, South	0.007	0.008	<0.03	0.523	0.69	5.7	1.79	N.D.	N.D.
8/26/2014	**8/26/2014**	**Base flow**									
11:38	14:23	Spring	0.007	0.078	0.05	0.256	0.42	38.6	0.35	51.2	4650

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
12:08	14:23	Upstream farm	0.005	0.064	0.09	0.075	0.42	6.5	1.21	3.1	4370
11:14	14:23	Downstream farm	0.013	0.018	0.01	0.398	0.46	1.4	0.22	19.7	5120
11:56	14:23	House well	0.008	0.022	0.26	0.378	0.66	0.4	0.18	<1	<1
9/3/2014	**9/3/2014**	**Storm flow**									
10:24	13:28	Spring	0.008	0.022	<0.03	0.227	0.37	10.9	0.61	1870.0	21430
11:15	13:28	Upstream farm	0.010	0.030	0.04	0.303	0.52	5.3	0.67	270	8570
9:39	13:28	Downstream farm	0.015	0.018	<0.03	0.500	0.60	3.5	0.09	65.7	4040
10:40	13:28	House well	0.011	0.008	0.17	0.475	0.68	2.9	0.02	56.3	59.1
11:36	13:28	Trench 1	0.004	0.003	0.04	0.937	1.22	3.7	0.68	N.D.	N.D.
9/11/2014	**9/11/2014**	**Storm flow**									
11:48	15:20	Spring	0.004	0.012	<0.03	0.564	0.65	1.3	0.16	35.4	7440
12:56	15:20	Upstream farm	0.001	0.040	0.06	0.198	0.53	6.2	2.28	2419.2	81640
11:31	15:20	Downstream farm	0.010	0.024	0.04	0.476	0.52	1.5	0.24	980.4	15970
12:43	15:20	House well	0.006	0.010	0.00	0.495	0.52	0.3	<0.18	<1.0	<1
12:35	15:20	Trench 1	0.001	0.018	0.03	1.580	1.86	1.0	0.54	1.0	57940
12:29	15:20	Trench 2	<0.002	0.010	0.03	2.033	2.31	3.2	0.70	81.3	27550

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
9/18/2014	**9/18/2014**	**Storm flow**									
10:42	13:42	Spring	0.007	0.200	0.17	0.170	0.6	54.7	3.12	12590.0	81640
11:25	13:42	Upstream farm	0.006	0.024	0.02	0.555	0.66	3.7	0.69	365.4	11720
9:54	13:42	Downstream farm	0.013	0.028	0.02	0.523	0.61	2.1	0.33	579.4	11530
11:06	13:42	House well	0.009	0.014	0.01	0.494	0.52	<6.6	<0.18	35.0	6940
9/23/2014	**9/23/2014**	**Base flow**									
1:05	15:28	Spring	0.001	0.024	<0.03	0.253	0.37	6.7	0.93	201.4	2750
12:45	15:28	Upstream farm	0.003	0.022	0.02	0.152	0.27	3.5	0.82	9.7	2419
10:59	15:28	Downstream farm	0.010	0.026	0.02	0.442	0.53	2.7	0.50	47.1	2620
12:27	15:28	House well	0.006	0.018	<0.03	0.494	0.53	0.5	0.33	8.5	866
9/30/2014	**9/30/2014**	**Base flow**									
10:56	14:36	Spring	0.002	0.138	<0.03	0.256	0.63	81.8	0.53	135.4	13960
12:20	14:36	Upstream farm	0.002	0.032	0.01	0.172	0.46	6.1	1.09	5.2	4320
9:57	14:36	Downstream farm	0.011	0.032	0.01	0.444	0.57	1.9	0.45	85.7	2560
11:10	14:36	House well	0.007	0.012	<0.03	0.501	0.56	0.3	0.17	2.0	43.5
10/8/2014	**10/8/2014**	**Base flow**									

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
10:24	14:46	Spring	0.001	0.050	<0.03	0.218	0.41	22.1	0.64	88.4	7330
12:11	14:46	Upstream farm	0.003	0.052	0.04	0.125	0.53	8.7	1.61	24.6	4260
9:31	14:46	Downstream farm	0.009	0.028	0.03	0.474	0.57	2.1	0.45	56.3	5630
11:01	14:46	House well	0.006	0.018	0.03	0.486	0.54	1.1	0.19	1.0	69.1
10/13/2014	**10/13/2014**	**Storm flow ISCO**									
10:07	13:45	Upstream farm	<0.005	0.072	0.03	0.124	0.46	20.8	3.36	N.D.	N.D.
9:21	13:45	Downstream farm	0.110	0.450	0.23	0.257	1.03	171.2	4.77	N.D.	N.D.
11:33	13:45	Culvert	0.004	0.068	0.08	0.996	1.37	11.2	3.28	N.D.	N.D.
9:55	13:45	Field 1	0.529	0.746	0.98	0.698	2.89	65.7	9.46	N.D.	N.D.
10:48	13:45	Field 5a	0.707	0.926	0.36	0.068	0.91	38.1	5.34	N.D.	N.D.
10/13/2014	**10/13/2014**	**Storm flow grab**									
9:38	13:45	Spring	0.005	0.126	0.12	0.083	0.62	46.5	6.55	19350	198630
10:11	13:45	Upstream farm	0.069	0.200	0.10	0.147	0.55	28.4	4.59	20140	173290
9:31	13:45	Downstream farm	0.015	0.058	0.05	0.379	0.51	7.0	2.30	1203.3	20120
11:00	13:45	House well	0.005	0.016	<0.03	0.496	0.56	0.3	0.23	28.1	2750
11:15	13:45	Trench 1	<0.002	0.024	<0.03	1.251	1.46	71.4	0.83	15650.0	61310

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
11:10	13:45	Trench 2	0.001	0.116	0.33	1.714	2.73	11.1	4.14	920.8	241920
10/22/2014	**10/22/2014**	**Base flow**									
10:24	15:23	Spring	0.006	0.058	<0.03	0.402	0.59	26.1	0.87	1046.2	5210
11:56	15:23	Upstream farm	0.010	0.026	<0.03	0.123	0.15	0.6	0.61	67.6	2430
10:09	15:23	Downstream farm	0.011	0.028	<0.03	0.380	0.47	2.0	0.59	200.0	4350
11:11	15:23	House well	0.007	0.016	<0.03	0.497	0.5	0.2	0.24	5.2	81
10/30/2014	**10/30/2014**	**Base flow**									
11:30	15:16	Spring	<0.002	0.048	0.04	0.360	0.58	23.5	0.61	110.0	3950
9:53	15:16	Upstream farm	0.005	0.016	<0.03	0.114	0.12	0.5	0.44	31.8	2419
11:47	15:16	Downstream farm	0.006	0.016	<0.03	0.368	0.42	1.8	0.42	20.1	2330
11/5/2014	**11/5/2014**	**Storm flow**									
9:29	15:26	Spring	0.013	0.088	0.11	0.145	0.50	13.4	3.91	579.4	11530
11:31	15:26	Upstream farm	0.018	0.032	<0.03	0.103	0.18	0.7	1.22	214.3	5040
9:10	15:26	Downstream farm	0.014	0.023	<0.03	0.353	0.48	2.1	0.78	153.9	4190
10:25	15:26	Trench 1	0.004	0.012	0.02	1.54	1.67	0.9	0.37	N.D.	N.D.
10:14	15:26	Trench 2	0.004	0.032	0.03	3.375	3.65	33.1	0.87	N.D.	N.D.

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
11/12/2014	**11/12/2014**	**Base flow**									
10:22	15:30	Spring	0.011	0.024	<0.03	0.095	0.16	<6.6	0.50	65	3310
10:38	15:30	Upstream farm	0.012	0.036	<0.03	0.065	0.10	0.5	0.40	57.3	3130
9:27	15:30	Downstream farm	0.012	0.026	<0.03	0.217	0.31	1.2	0.39	14.6	4350
11/24/2014	**11/24/2014**	**Storm flow**									
9:39	12:55	Spring	0.007	0.014	<0.03	0.271	0.48	4.1	4.71	40.2	2419
10:34	12:55	Upstream farm	0.013	0.013	<0.03	0.097	0.11	0.7	2.15	72.7	2419
9:23	12:55	Downstream farm	0.014	0.016	<0.03	0.297	0.38	1.5	2.11	14.8	2419
9:53	12:55	House well	0.010	0.010	<0.03	0.452	0.57	1.9	2.81	<1.0	5.2
12/4/2014	**12/4/2014**	**Base flow**									
10:49	15:25	Spring	0.007	0.024	<0.03	0.317	0.50	2.3	5.57	5.2	1120
11:10	15:25	Upstream farm	0.011	0.022	<0.03	0.103	0.13	0.7	2.94	45.7	1850
10:35	15:25	Downstream farm	0.013	0.024	<0.03	0.264	0.33	1.5	2.98	7.4	2990
12/4/2014	**12/4/2014**	**Base flow**									
10:49	15:25	Spring	0.007	0.024	<0.03	0.317	0.50	2.3	5.57	5.2	1120
11:10	15:25	Upstream farm	0.011	0.022	<0.03	0.103	0.13	0.7	2.94	45.7	1850

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
10:35	15:25	Downstream farm	0.013	0.024	<0.03	0.264	0.33	1.5	2.98	7.4	2990
11:05	15:25	Dry Creek	0.012	0.030	<0.03	0.167	0.21	0.7	2.30	27.8	1553.1
12/9/2014	**12/9/2014**	**Storm flow**									
10:00	14:00	Spring	0.008	0.024	<0.03	0.295	0.48	2.3	4.26	18.9	1203
10:33	14:00	Upstream farm	0.011	0.024	<0.03	0.057	0.09	0.5	1.60	36.4	1986
9:38	14:00	Downstream farm	0.013	0.022	<0.03	0.179	0.23	1.1	1.42	35	2650
12/15/2014	**12/15/2014**	**Storm flow**									
12:17	10:15	Spring	0.016	0.110	0.09	0.070	0.58	5.9	9.21	N.S.	N.S.
12:28	10:15	Upstream farm	0.026	0.070	0.06	0.067	0.26	21.6	3.17	N.S.	N.S.
12:09	10:15	Downstream farm	0.013	0.044	0.04	0.162	0.33	4.3	1.87	N.S.	N.S.
12:31	10:15	Dry Creek	0.011	0.030	0.03	0.071	0.15	1.4	1.01	N.S.	N.S.
12:44	10:15	Culvert	0.021	0.040	0.04	1.161	1.11	8.2	1.11	N.S.	N.S.
12/22/2014	**12/22/2014**	**Base flow**									
11:15	14:35	Spring	0.012	0.024	<0.03	0.459	0.70	1.1	2.93	28.5	1299.7
12:05	14:35	Upstream farm	0.010	0.028	0.06	0.096	0.12	0.9	1.05	155.3	1046.2
11:00	14:35	Downstream farm	0.011	0.052	<0.03	0.175	0.24	1.5	1.14	55.6	980.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
12:11	14:35	Dry Creek	0.014	0.036	<0.03	0.132	0.18	0.5	1.10	100.0	860.0
11:33	14:35	Culvert	0.011	0.026	<0.03	0.416	0.58	6.3	1.54	770.1	3550.0
11:45	14:35	Trench	0.005	0.018	<0.03	0.881	0.83	6.1	1.09	<1.0	630.0
1/8/2015	**1/8/2015**	**Base flow**									
11:05	15:05	Spring	0.010	0.014	<0.03	0.376	0.56	2.0	3.80	14.8	686.7
11:25	15:05	Upstream farm	0.009	0.022	<0.03	0.187	0.21	2.3	1.41	30.9	547.5
10:53	15:05	Downstream farm	0.011	0.024	<0.03	0.376	0.39	2.5	1.22	42.6	980.4
11:40	15:05	Ephemeral stream	0.008	0.022	<0.03	0.448	0.59	2.4	1.73	25.6	1203.3
12:00	15:05	Trench 1	0.005	0.022	<0.03	0.769	0.75	4.7	0.88	1.0	13130.0
1/14/2015	**1/14/2015**	**Base flow**									
11:30	15:20	Spring	0.010	0.028	<0.03	0.473	0.66	1.1	10.20	21.6	613.1
11:45	15:20	Upstream farm	0.012	0.032	<0.03	0.135	0.19	1.1	3.02	88.2	727.0
11:15	15:20	Downstream farm	0.011	0.020	<0.03	0.388	0.34	1.0	2.03	25.6	613.1
12:00	15:20	Ephemeral stream	0.007	0.028	<0.03	0.469	0.55	1.9	0.55	7.4	1413.6
1/21/2015	**1/21/2015**	**Base flow**									
11:15	15:28	Spring	0.009	0.020	<0.03	0.552	0.69	1.5	2.29	9.8	461.1

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
11:52	15:28	Upstream farm	0.008	0.018	<0.03	0.089	0.12	1.1	0.95	70.3	579.4
11:05	15:28	Downstream farm	0.010	0.026	0.06	0.197	0.30	1.1	1.60	37.4	613.1
11:25	15:28	Ephemeral stream	0.005	0.016	<0.03	0.370	0.46	1.0	2.34	155.3	2419.2
1/29/2015	**1/29/2015**	**Base flow**									
10:40	15:28	Spring	0.010	0.018	0.03	0.886	0.74	2.3	4.27	1.0	2850.0
11:45	15:28	Upstream farm	0.006	0.060	<0.03	0.065	0.21	47.8	1.71	727.0	1413.6
1:20	15:28	Downstream farm	0.009	0.020	0.04	0.168	0.27	1.3	1.50	19.9	1046.2
2/3/2015	**2/3/2015**	**Base flow**									
11:05	15:40	Spring	0.008	0.018	<0.03	0.691	0.77	3.8	7.64	1.0	461.1
11:40	15:40	Upstream farm	0.006	0.022	<0.03	0.051	0.28	1.1	2.69	4.1	1203.3
10:50	15:40	Downstream farm	0.009	0.018	<0.03	0.140	0.29	4.1	2.66	1.0	547.5
2/10/2015	**2/10/2015**	**Base flow**									
10:38	15:08	Spring	0.010	0.010	<0.03	0.544	0.64	1.9	0.76	2.0	686.7
11:05	15:08	Upstream farm	0.009	0.012	<0.03	0.056	0.09	0.7	1.04	1119.1	2419.2
10:25	15:08	Downstream farm	0.011	0.012	<0.03	0.143	0.23	1.0	1.15	7.4	1553.1
2/26/2015	**2/26/2015**	**Base flow**									

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
10:45	15:30	Spring	0.009	0.042	0.02	0.237	0.38	5.0	3.97	37.3	2419.2
11:36	15:30	Upstream farm	0.006	0.024	<0.03	0.100	0.13	0.6	1.20	47.9	686.7
10:34	15:30	Downstream farm	0.008	0.026	0.02	0.200	0.25	0.8	1.17	48.7	866.4
10:55	15:30	Ephemeral stream	0.006	0.022	<0.03	0.530	0.57	1.3	1.38	16.1	4790.0
11:15	15:30	Trench 1	0.004	0.028	0.01	0.712	0.76	46.0	0.60	1.0	41063.0
3/3/2015	**3/3/2015**	**Base flow**									
11:07	15:33	Spring	0.008	0.052	<0.03	0.124	0.35	13.5	4.90	N.S. §	N.S.
11:50	15:33	Upstream farm	0.006	0.026	0.02	0.048	0.11	2.3	1.50	N.S.	N.S.
10:55	15:33	Downstream farm	0.007	0.028	<0.03	0.138	0.23	1.3	1.50	N.S.	N.S.
11:18	15:33	Ephemeral stream	0.006	0.020	<0.03	0.477	0.52	2.0	1.84	N.S.	N.S.
11:30	15:33	Trench 1	0.003	0.024	<0.03	0.867	0.89	14.9	0.95	N.S.	N.S.
3/11/2015	**3/11/2015**	**Storm Flow**									
11:30	14:58	Spring	0.009	0.030	<0.03	0.242	2.37	5.5	14.79	19.5	111.9
12:30	14:58	Upstream farm	0.005	0.026	0.02	0.118	0.16	2.1	3.38	34.5	579.4
11:20	14:58	Downstream farm	0.007	0.030	0.02	0.209	0.27	1.8	1.44	66.3	770.1
11:45	14:58	Ephemeral stream	0.006	0.022	0.04	0.567	0.60	0.5	2.20	6.3	410.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
12:10	14:58	Trench 1	0.003	0.014	0.07	0.989	0.97	0.3	2.00	<1.0	2419.2
12:15	14:58	Trench 2	0.003	0.056	0.04	1.443	1.59	1.2	3.51	<1.0	2419.2
3/19/2015	**3/19/2015**	**Base flow**									
10:59	15:10	Spring	0.010	0.028	0.03	0.184	0.29	10.6	7.37	38.9	79.4
12:00	15:10	Upstream farm	0.007	0.024	0.04	0.111	0.20	1.7	2.53	42.6	866.4
11:13	15:10	Downstream farm	0.009	0.028	0.04	0.234	0.35	2.8	2.87	71.7	1119.9
11:08	15:10	Ephemeral stream	0.007	0.018	0.01	0.529	0.63	1.0	4.31	14.6	866.4
11:13	15:10	House well	0.009	0.020	0.02	0.467	0.55	1.2	4.93	1.0	31.3
11:30	15:10	Trench 1	0.003	0.012	0.01	0.849	0.93	<6.58	3.11	1.0	275.5
11:35	15:10	Trench 2	0.004	0.062	0.09	1.036	1.42	1.9	5.12	5.2	2419.2
3/25/2015	**3/25/2015**	**Base flow**									
11:45	15:20	Spring	0.006	0.014	0.02	0.197	0.39	1.6	1.45	23.1	275.5
13:30	15:20	Upstream farm	0.006	0.028	0.02	0.056	0.16	2.9	1.36	125.9	2419.2
11:30	15:20	Downstream farm	0.008	0.036	0.04	0.162	0.29	5.0	1.41	547.5	3410.0
12:00	15:20	Ephemeral stream	0.007	0.014	0.02	0.462	0.53	1.1	0.64	8.6	344.8
12:20	15:20	House well	0.007	0.016	<0.03	0.450	0.52	1.9	0.03	18.5	30.1
12:30	15:20	Trench 1	0.003	0.008	<0.03	0.838	0.88	0.2	0.59	<1.0	410.6

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
3/26/2015	**3/26/2015**	**Storm flow**									
13:10	15:25	Upstream farm	0.013	0.064	0.06	0.090	0.30	11.4	3.71	547.5	5200.0
13:35	15:25	Downstream farm	0.013	0.076	0.06	0.144	0.41	14.1	3.94	816.4	4960.0
12:55	15:25	Trench 1	0.004	0.026	0.02	0.904	1.00	15.4	0.69	<1.0	1553.1
12:50	15:25	Trench 2	0.004	0.126	0.13	0.873	1.44	22.2	4.63	105.4	6950.0
13:20	15:25	Field 1	0.143	0.346	0.41	0.216	2.68	65.5	15.65	N.S.	N.S.
12:30	15:25	Field 5a	0.813	1.330	0.39	0.225	2.59	72.3	15.95	N.S.	N.S.
4/2/2015	**4/2/2015**	**Base flow**									
11:50	15:25	Spring	0.008	0.042	0.04	0.173	0.35	3.5	10.47	248.1	1299.7
12:15	15:25	Upstream farm	0.007	0.040	0.02	0.045	0.14	3.1	3.61	166.9	2419.2
1:30	15:25	Downstream farm	0.007	0.042	0.02	0.139	0.22	2.5	2.71	121.1	1986.3
12:30	15:25	Ephemeral stream	0.006	0.032	0.02	0.467	0.46	1.8	4.41	5.2	547.5
12:48	15:25	House well	0.008	0.030	<0.03	0.477	0.50	0.7	6.05	39.3	9060.0
12:54	15:25	Trench 1	0.003	0.028	0.02	0.865	0.87	0.3	3.34	1.1	308.6
4/9/2015	**4/9/2015**	**Base flow**									
11:45	15:30	Spring	0.011	0.034	0.01	0.257	0.42	4.9	9.11	7380.0	9040.0
12:30	15:30	Upstream farm	0.011	0.042	0.04	0.066	0.18	13.1	2.13	86.0	2650.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
12:50	15:30	Downstream farm	0.010	0.048	0.03	0.157	0.25	19.7	1.82	47.2	1986.3
12:00	15:30	House well	0.011	0.026	<0.03	0.499	0.50	1.5	0.74	4.1	325.5
12:10	15:30	Trench 1	0.006	0.018	<0.03	0.790	0.83	0.8	2.99	<1.0	187.2
4/15/2015	**4/15/2015**	**Storm Flow**									
11:38	14:55	Spring	0.007	0.034	<0.03	0.210	0.39	7.7	4.70	275.5	2280.0
12:23	14:55	Upstream farm	0.007	0.040	0.03	0.090	0.16	3.5	3.24	648.8	4040.0
12:40	14:55	Downstream farm	0.009	0.048	0.03	0.166	0.26	4.4	2.67	344.8	2920.0
11:48	14:55	Ephemeral stream	0.005	0.026	0.03	0.472	0.56	0.8	1.26	305.0	2430.0
11:58	14:55	House well	0.008	0.022	0.02	0.475	0.60	1.2	3.72	9.6	80.9
12:10	14:55	Trench 1	0.003	0.020	<0.03	0.857	0.93	1.3	4.29	<1.0	3180.0
4/23/2015	**4/23/2015**	**Base Flow**									
12:23	15:30	Spring	0.008	0.034	<0.03	0.264	0.36	7.4	3.64	71.7	648.8
13:00	15:30	Upstream farm	0.007	0.032	0.03	0.083	0.18	4.0	5.11	104.6	2419.2
12:15	15:30	Downstream farm	0.007	0.032	0.03	0.162	0.25	2.6	2.51	65.7	2419.2
11:55	15:30	Ephemeral stream	0.008	0.026	0.03	0.520	0.56	2.0	1.78	12.0	3270.0
11:35	15:30	House well	0.008	0.082	<0.03	0.496	0.53	1.4	1.69	18.5	35.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
11:48	15:30	Trench 1	0.003	0.034	<0.03	0.877	0.97	1.2	1.18	3.1	2690.0
4/29/2015	**4/29/2015**	**Base flow**									
11:25	14:05	Spring	0.010	0.028	<0.03	0.419	0.59	9.0	4.28	25.6	1732.9
11:53	14:05	Upstream farm	0.010	0.020	0.03	0.082	0.13	2.7	1.58	58.3	1732.4
12:13	14:05	Downstream farm	0.012	0.018	0.03	0.189	0.82	2.1	1.64	58.6	1986.3
11:30	14:05	Ephemeral stream	0.012	0.018	0.02	0.569	0.61	3.5	1.98	14.3	4080.0
11:35	14:05	House well	0.010	0.006	<0.03	0.517	0.51	0.7	2.26	248.1	5040.0
5/7/2015	**5/7/2015**	**Base flow**									
11:10	14:10	Spring	0.011	0.036	0.02	0.499	0.58	9.9	44.04	135.4	980.4
11:43	14:10	Upstream farm	0.008	0.032	0.01	0.110	0.16	7.5	10.16	77.6	3280.0
12:05	14:10	Downstream farm	0.009	0.034	<0.03	0.267	0.36	4.5	7.70	27.8	2280.0
11:18	14:10	Ephemeral stream	0.013	0.066	0.02	0.628	0.71	3.2	16.41	71.7	7170.0
11:23	14:10	House well	0.008	0.022	0.01	0.512	0.49	<6.58	28.63	3.1	59.4
5/8/2015	**5/8/2015**	**Storm flow**									
13:25	15:32	Upstream farm	0.134	0.354	0.16	0.340	1.12	51.4	9.30	N.S.	N.S.
13:25	15:32	Downstream farm	0.195	0.544	0.27	0.292	1.20	113.2	7.47	N.S.	N.S.

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
11:43	15:32	Ephemeral stream	0.005	0.254	0.41	2.287	3.23	127.1	6.45	N.S.	N.S.
13:00	15:32	Field 1	0.525	0.714	0.16	0.475	2.19	16.9	13.28	N.S.	N.S.
12:38	15:32	Field 12	0.675	0.956	0.14	0.303	1.82	57.0	16.00	N.S.	N.S.
5/11/2015	**5/12/2015**	**Storm Flow**									
11:35	8:30	Spring	0.008	0.058	0.01	0.339	0.49	8.7	3.67	N.S.	N.S.
11:28	8:30	Upstream farm	0.004	0.074	0.04	0.004	0.24	4.5	4.31	N.S.	N.S.
12:47	8:30	Downstream farm	0.031	0.530	0.11	0.071	1.12	277.5	8.48	N.S.	N.S.
12:05	8:30	Ephemeral stream	0.008	0.146	0.15	0.941	1.80	22.0	8.09	N.S.	N.S.
12:15	8:30	House well	0.009	0.038	0.02	0.541	0.55	4.2	0.89	N.S.	N.S.
12:25	8:30	Trench 1	0.003	0.060	0.02	0.916	0.97	27.6	1.78	N.S.	N.S.
12:35	8:30	Trench 2	0.003	0.042	0.05	0.553	0.76	8.8	3.44	N.S.	N.S.
11:25	8:30	Field 1	0.251	0.386	0.09	0.055	0.86	44.4	6.31	N.S.	N.S.
11:40	8:30	Field 5a	0.248	0.968	0.26	0.127	1.50	320.1	8.58	N.S.	N.S.
1:05	8:30	Field 12	0.194	0.364	0.09	0.135	0.83	36.7	7.03	N.S.	N.S.
5/14/2015	**5/14/2015**	**Base flow**									
12:35	15:12	Spring	0.009	0.062	0.02	0.222	0.35	41.5	2.84	121.1	2419.2
12:28	15:12	Upstream farm	0.011	0.046	0.02	0.177	0.23	2.8	1.35	145.5	2470.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
12:47	15:12	Downstream farm	0.015	0.050	0.02	0.326	0.39	6.1	1.16	128.1	4370.0
12:57	15:12	Left Fork	0.015	0.038	0.02	0.321	0.38	3.3	1.36	83.3	2690.0
12:15	15:12	Ephemeral stream	0.010	0.022	0.01	0.527	0.50	1.7	0.73	41.3	1986.3
12:05	15:12	Trench 1	0.005	0.042	0.02	0.904	0.94	29.9	1.20	81.6	1732.9
5/18/2015	**5/18/2015**	**Storm Flow**									
10:45	14:43	Spring	0.005	0.084	0.05	0.209	0.56	114.2	2.79	98.7	1413.6
11:57	14:43	Upstream farm	0.007	0.034	0.02	0.110	0.15	5.2	1.29	137.6	2419.2
12:17	14:43	Downstream farm	0.009	0.040	0.03	0.201	0.25	6.1	1.47	185.0	6770.0
12:29	14:43	Left Fork	0.011	0.040	0.04	0.209	0.29	4.1	1.90	167.4	8300.0
11:14	14:43	Ephemeral stream	0.007	0.028	0.03	0.525	0.55	0.7	1.18	90.7	7630.0
11:20	14:43	House well	0.008	0.018	<0.03	0.529	0.53	0.9	0.90	5.2	13.4
12:55	14:43	Trench 1	0.002	0.020	<0.03	0.897	0.93	0.3	1.28	32.3	1732.9
10:58	14:43	Field 1	0.208	0.512	0.54	0.410	3.59	53.7	26.12	N.S.	N.S.
5/26/2015	**5/26/2015**	**Base flow**									
11:49	15:48	Spring	0.021	0.020	<0.03	0.205	0.29	1.2	2.66	N.S.	N.S.
13:20	15:48	Upstream farm	0.012	0.044	0.04	0.080	0.19	6.4	1.50	N.S.	N.S.

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
13:32	15:48	Downstream farm	0.045	0.200	0.11	0.096	0.56	94.7	4.57	N.S.	N.S.
13:45	15:48	Left Fork	0.014	0.048	0.04	0.139	0.29	6.1	2.41	N.S.	N.S.
13:11	15:48	Ephemeral stream	0.017	0.030	0.03	0.514	0.60	0.9	1.12	N.S.	N.S.
12:43	15:48	House well	0.013	0.020	<0.03	0.514	0.54	2.7	0.87	N.S.	N.S.
12:55	15:48	Trench 1	0.007	0.012	0.01	0.752	0.80	1.0	0.78	N.S.	N.S.
1:00	15:48	Trench 2	0.007	0.112	0.04	1.190	1.44	131.9	1.23	N.S.	N.S.
12:09	15:48	Field 1	0.245	0.432	0.20	0.174	1.66	37.8	11.28	N.S.	N.S.
6/1/2015	**6/1/2015**	**Storm Flow**									
13:15	15:20	Downstream farm	0.006	0.050	0.05	0.109	0.25	13.7	1.80	N.S.	N.S.
12:00	15:20	Ephemeral stream	0.002	0.056	0.01	0.851	1.05	18.3	2.46	N.S.	N.S.
6/4/2015	**6/4/2015**	**Base Flow**									
12:50	15:20	Spring	0.010	0.028	<0.03	0.239	0.3	6.2	9.54	44.3	1413.8
12:00	15:20	Upstream farm	0.008	0.026	0.03	0.083	0.11	2.3	2.93	38.6	>2419.2
13:05	15:20	Downstream farm	0.009	0.034	<0.03	0.184	0.23	1.7	2.64	24.7	2419.2
13:13	15:20	Left Fork	0.008	0.022	<0.03	0.145	0.19	2.1	3.15	38.9	2560.0
11:40	15:20	Ephemeral stream	0.010	0.024	0.02	0.572	0.58	0.8	5.35	21.6	3890.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
11:35	15:20	House well	0.012	0.022	0.02	0.561	0.52	1.3	6.07	<1.0	14.6
6/8/2015	**6/8/2015**	**Base flow**									
11:36	15:30	House well	0.008	0.018	0.27	0.475	0.82	0.7	6.67	<1.0	<1.0
10:45	15:30	Spring	0.011	0.046	0.03	0.322	0.53	12.7	11.18	20.1	1986.3
12:26	15:30	Upstream farm	0.010	0.030	0.06	0.058	0.24	4.5	3.63	866.4	2780.0
13:12	15:30	Downstream farm	0.009	0.022	0.05	0.185	0.27	0.9	2.66	57.4	4640.0
13:25	15:30	Left Fork	0.006	0.024	0.02	0.102	0.23	1.1	2.78	32.7	4550.0
11:51	15:30	Ephemeral stream	0.009	0.020	0.03	0.560	0.62	0.6	2.81	65.7	9870.0
6/17/2015	**6/17/2015**	**Base flow**									
12:08	15:40	Spring	0.009	0.046	0.07	0.224	0.47	9.4	8.92	517.2	24890.0
10:10	15:40	Upstream farm	0.009	0.036	0.03	0.050	0.16	3.5	2.83	435.2	13130.0
12:49	15:40	Downstream farm	0.007	0.034	0.03	0.106	0.23	2.3	2.92	344.8	20980.0
13:01	15:40	Left Fork	0.005	0.026	0.04	0.112	0.22	2.8	1.62	26.2	8550.0
11:50	15:40	Ephemeral stream	0.009	0.032	0.04	0.948	1.04	6.7	0.97	770.1	8840.0
11:47	15:40	House well	0.010	0.028	0.03	0.466	0.52	0.06	3.08	488.4	15390.0
6/22/2015	**6/22/15**	**Storm flow**									
12:30	15:55	Spring	0.009	0.032	0.03	0.218	0.26	5.3	3.01	61.3	1413.6

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
12:15	15:55	Upstream farm	0.010	0.030	0.01	0.042	0.05	2.9	0.99	78.0	4960.0
12:55	15:55	Downstream farm	0.009	0.032	0.04	0.136	0.16	2.9	1.15	36.8	5040.0
13:10	15:55	Left Fork	0.011	0.030	0.02	0.147	0.18	2.5	1.59	35.4	5910.0
10:50	15:55	Ephemeral stream	0.011	0.026	0.05	0.563	0.61	1.3	1.21	37.9	2419.2
10:45	15:55	House well	0.010	0.032	0.02	0.459	0.43	0.4	1.85	27.2	1732.9
10:30	15:55	Trench 1	0.005	0.048	0.07	0.653	0.76	47.3	1.86	21.1	1986.3
6/29/2015	**6/29/2015**	**Storm flow**									
10:47	15:32	Spring	0.013	0.018	0.03	0.235	0.30	1.7	5.26	93.3	2419.2
12:30	15:32	Upstream farm	0.010	0.028	0.14	0.055	0.13	2.7	2.49	117.8	4710
13:22	15:32	Downstream farm	0.068	0.748	0.17	0.147	1.88	571	6.57	135.4	7540
13:30	15:32	Left Fork	0.010	0.026	0.02	0.189	0.26	2.9	2.80	53.6	10170
12:20	15:32	Ephemeral stream	0.067	1.268	0.34	0.580	3.42	1366.8	11.04	69.7	4040
12:15	15:32	Trench 1	0.008	0.022	0.05	0.394	0.42	56.8	4.17	82.3	11450
10:48	15:32	Field 1	0.354	0.524	0.37	0.226	1.64	11	11.32	N.S.	N.S.
7/6/2015	**7/7/2015**	**Storm flow**									
19:45	14:58	Downstream farm	0.275	0.380	0.22	0.204	1.03	19.1	7.91	N.S.	N.S.

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
17:10	14:58	Ephemeral stream	0.063	0.658	0.37	0.717	2.75	567.3	8.52	N.S	N.S.
13:25	14:58	Field 1	0.387	0.444	0.23	0.345	1.30	4.9	8.32	N.S.	N.S.
16:45	14:58	Field 12	0.796	0.910	0.13	0.567	1.58	29.0	7.67	N.S.	N.S.
18:25	14:58	Field 5a	0.094	0.448	0.13	0.172	1.01	261.3	4.38		
7/9/2015	**7/9/2015**	**Base flow**									
13:37	15:15	Spring	0.011	0.048	0.09	0.144	0.41	4.3	6.47	77.1	3050.0
12:25	15:15	Upstream farm	0.013	0.048	0.02	0.087	0.18	6.8	2.75	201.4	10140.0
12:55	15:15	Downstream farm	0.014	0.050	0.03	0.117	0.24	8.8	2.32	275.5	10760.0
13:15	15:15	Left Fork	0.015	0.058	0.04	0.138	0.31	11.4	2.67	387.3	12670.0
12:12	15:15	Ephemeral stream	0.010	0.034	<0.03	0.569	0.71	4.9	2.56	78.9	5560.0
12:07	15:15	House well	0.011	0.024	0.01	0.423	0.48	2.0	1.69	9.8	4160.0
12:00	15:15	Trench 1	0.007	0.030	<0.03	0.520	0.62	7.1	2.52	63.7	12330.0
7/16/2015	**7/16/2015**	**Base flow**									
12:15	15:10	Upstream farm	0.010	0.024	0.02	0.065	0.15	0.5	1.91	41.3	52.0
12:54	15:10	Downstream farm	0.011	0.030	<0.03	0.195	0.33	0.5	1.35	11.8	6310.0
13:03	15:10	Left Fork	0.010	0.042	0.01	0.181	0.28	0.9	1.64	21.6	9330.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
12:33	15:10	Ephemeral stream	0.011	0.046	0.01	0.517	0.61	0.4	2.16	45.7	14830.0
12:28	15:10	House well	0.012	0.024	0.01	0.471	0.47	0.0	4.00	2.0	727.0
12:42	15:10	Spring	0.010	0.024	0.01	0.303	0.41	5.7	5.54	22.8	1413.6
7/23/2015	**7/23/2015**	**Storm flow**									
10:55	15:20	Spring	0.010	0.026	<0.03	0.436	0.60	2.7	1.12	61.3	1046.2
11:15	15:20	Upstream farm	0.009	0.026	0.02	0.096	0.18	1.3	0.97	93.3	7490.0
12:40	15:20	Downstream farm	0.011	0.028	0.02	0.198	0.31	0.8	1.06	16.8	4870.0
13:02	15:20	Left Fork	0.009	0.028	0.04	0.239	0.40	1.4	1.21	35.4	8360.0
12:00	15:20	Ephemeral stream	0.011	0.034	<0.03	0.511	0.68	11.3	0.33	201.4	24950.0
12:23	15:20	House well	0.015	0.030	<0.03	0.442	0.52	1.0	0.89	8.5	35.0
7/30/2015	**7/30/2015**	**Base flow**									
12:28	15:20	Spring	0.011	0.026	0.03	0.479	0.65	6.3	4.73	6.3	920.8
12:17	15:20	Upstream farm	0.014	0.024	<0.03	0.101	0.15	0.9	1.61	27.2	2880.0
12:50	15:20	Downstream farm	0.012	0.022	0.02	0.268	0.38	1.9	2.16	11.9	6500.0
13:00	15:20	Left Fork	0.008	0.020	0.04	0.221	0.37	2.3	2.60	30.3	8160.0
11:58	15:20	House well	0.013	0.014	0.02	0.466	0.51	0.3	0.90	1.0	7.4
8/6/2015	**8/6/2015**	**Storm flow**									

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
12:05	14:50	Spring	0.008	0.240	0.07	0.265	0.97	<6.58	7.10	23.1	48840.0
11:36	14:50	Upstream farm	0.009	0.028	<0.03	0.147	0.24	1.8	3.37	488.4	13540.0
12:22	14:50	Downstream farm	0.010	0.028	0.03	0.406	0.52	1.7	3.06	40.2	10390.0
12:37	14:50	Left Fork	0.007	0.026	0.04	0.310	0.47	1.2	3.16	217.8	8130.0
10:37	14:50	House well	0.010	0.018	0.04	0.482	0.52	0.5	3.33	920.8	21870.0
8/13/2015	**8/13/2015**	**Base flow**									
11:40	15:30	Spring	0.009	0.360	0.15	0.735	1.12	254.9	7.29	21.6	3360.0
12:06	15:30	Upstream farm	0.013	0.018	0.04	0.124	0.16	0.3	4.32	13.4	2460.0
13:01	15:30	Downstream farm	0.011	0.024	<0.03	0.384	0.50	4.0	3.74	24.0	3310.0
13:12	15:30	Left Fork	0.007	0.016	0.03	0.192	0.52	1.4	4.50	13.2	4810.0
11:53	15:30	House well	0.025	0.012	0.03	0.498	0.58	0.5	6.15	4.1	228.2
8/20/2015	**8/20/2015**	**Storm flow**									
11:32	14:05	Spring	0.009	0.276	0.07	0.337	0.89	223.6	17.88	148.3	3270.0
11:49	14:05	Downstream farm	0.015	0.022	0.03	0.491	0.53	2.2	5.94	39.3	66.3
12:04	14:05	Left Fork	0.009	0.028	0.04	0.306	0.42	2.3	5.12	48.8	3930.0
10:52	14:05	House well	0.012	0.018	<0.03	0.545	0.56	0.9	6.63	1.0	29.5
8/27/2015	**8/27/2015**	**Base flow**									

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
12:48	15:35	Spring	0.007	0.158	0.04	0.329	0.69	103.7	9.07	27.2	7540.0
12:37	15:35	Upstream farm	0.005	0.028	0.04	0.084	0.28	2.9	4.30	104.6	7710.0
1:20	15:35	Downstream farm	0.013	0.024	<0.03	0.450	0.54	2.5	4.43	137.4	5730.0
1:30	15:35	Left Fork	0.008	0.024	0.02	0.218	0.33	2.0	3.79	7.4	3010.0
12:20	15:35	House well	0.012	0.018	<0.03	0.599	0.61	1.6	3.66	1.0	61.3
9/2/2015	**9/2/2015**	**Base flow**									
12:06	14:45	Spring	0.007	0.620	0.10	0.304	1.27	2.47	402.7	155.3	15530.0
11:50	14:45	Upstream farm	0.007	0.042	0.07	0.047	0.39	3.37	5.5	46.4	9070.0
12:19	14:45	Downstream farm	0.010	0.020	0.01	0.449	0.55	3.2	4.80	20.3	6630.0
12:30	14:45	Left Fork	0.010	0.020	0.01	0.449	0.55	3.19	4.8	20.3	6630.0
11:30	14:45	House well	0.007	0.020	0.03	0.109	0.33	1.67	3.8	26.9	5290.0
9/10/2015	**9/10/2015**	**Base flow**									
12:45	15:15	Spring	0.004	0.026	0.02	0.197	0.39	6.50	3.5	980.4	38730.0
12:59	15:15	Downstream farm	0.008	0.028	0.02	0.464	0.58	3.96	2.9	66.3	5470.0
13:10	15:15	Left Fork	0.006	0.026	<0.03	0.198	0.34	4.09	2.5	21.6	7230.0
11:56	15:15	House well	0.010	0.018	<0.03	0.576	0.60	3.21	0.3	8.6	727.0
9/16/2015	**9/16/2015**	**Base flow**									

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
11:41	14:40	Spring	0.004	0.176	<0.03	0.260	0.70	5.84	111.2	130.9	8330.0
12:06	14:40	Upstream farm	0.004	0.024	<0.03	0.104	0.30	4.62	2.1	50.4	3590.0
12:24	14:40	Downstream farm	0.009	0.030	0.01	0.404	0.62	4.59	1.4	6.2	4800.0
12:36	14:40	Left Fork	0.006	0.032	<0.03	0.146	0.48	2.49	1.3	38.2	6333.0
11:52	14:40	House well	0.009	0.020	<0.03	0.559	0.60	2.58	0.2	1.0	148.3
9/24/2015	**9/24/2015**	**Base flow**									
11:40	14:30	Spring	0.006	0.024	<0.03	0.216	0.42	10.59	12.3	8.6	1119.9
11:30	14:30	Upstream farm	0.006	0.078	<0.03	0.200	0.41	5.92	14.8	17.1	4570.0
12:07	14:30	Downstream farm	0.009	0.018	<0.03	0.449	0.56	5.58	1.2	29.9	7540.0
12:18	14:30	Left Fork	0.007	0.016	0.01	0.098	0.20	3.08	0.6	31.3	3410.0
11:19	14:30	House well	0.009	0.012	<0.03	0.543	0.58	7.72	0.3	<1.0	24.6
9/30/2015	**9/30/2015**	**Base flow**									
12:00	15:15	Spring	0.005	0.630	0.11	0.178	1.15	15.88	450.3	137.6	36540.0
11:50	15:15	Downstream farm	0.008	0.022	0.01	0.472	0.66	5.43	4.5	31.7	5290.0
11:42	15:15	Left Fork	0.007	0.018	<0.03	0.082	0.20	4.98	1.2	18.3	5940.0
12:43	15:15	House well	0.009	0.016	<0.03	0.499	0.60	4.20	0.5	<1.0	2.0
10/8/2015	**10/8/2015**	**Base flow**									

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
11:32	14:05	Spring	0.003	0.018	0.02	0.176	0.27	4.5	2.43	<1.0	686.7
11:20	14:05	Downstream farm	0.005	0.020	0.02	0.517	0.60	1.5	1.62	21.3	12360.0
11:10	14:05	Left Fork	0.003	0.020	0.02	0.069	0.15	1.5	1.58	59.8	3640.0
12:15	14:05	House well	0.008	0.020	0.02	0.518	0.53	0.5	1.54	<1.0	<1
10/14/2015	**10/14/2015**	**Base flow**									
11:42	14:40	Spring	0.008	0.056	0.03	0.193	0.36	27.5	1.50	<1.0	248.1
11:28	14:40	Downstream farm	0.010	0.056	0.03	0.603	0.76	12.4	1.33	7.3	8164.0
11:17	14:40	Left Fork	0.009	0.022	0.01	0.078	0.16	2.2	1.28	9.8	1986.3
12:10	14:40	House well	0.012	0.020	<0.03	0.490	0.63	0.3	0.94	<1.0	<1
10/22/2015	**10/22/2015**	**Base flow**									
12:35	13:45	Spring	0.005	0.028	0.03	0.173	0.33	11.4	6.99	<1.0	307.6
12:15	13:45	Downstream farm	0.008	0.018	0.07	0.548	0.69	2.3	3.64	17.8	3140.0
12:05	13:45	Left Fork	0.008	0.018	<0.03	0.069	0.13	1.9	3.57	3.1	1732.9
13:10	13:45	House well	0.010	0.014	0.04	0.478	0.50	0.4	1.93	<1.0	2.0
10/28/2015	**10/28/2015**	**Base flow**									
12:10	14:25	Spring	0.005	0.112	0.05	0.247	0.55	66.2	4.89	179.3	3950.0
11:56	14:25	Downstream farm	0.009	0.032	0.03	0.544	0.78	1.7	3.91	35.0	6700.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
11:46	14:25	Left Fork	0.007	0.024	0.02	0.060	0.24	1.9	2.90	61.3	3410.0
12:55	14:25	House well	0.008	0.016	0.01	0.391	0.54	<6.58	2.40	<1.0	<1
11/4/2015	**11/4/2015**	**Base flow**									
12:14	14:50	Spring	0.007	0.026	0.07	0.139	0.33	0.7	5.44	8.4	920.8
12:03	14:50	Downstream farm	0.010	0.038	<0.03	0.607	0.76	1.7	3.79	23.1	2880.0
11:54	14:50	Left Fork	0.007	0.018	<0.03	0.072	0.18	0.7	3.98	77.6	>2419.2
12:41	14:50	House well	0.010	0.016	<0.03	0.468	0.54	<6.58	2.62	<1.0	<1
11/12/2015	**11/12/2015**	**Base flow**									
12:15	15:00	Spring	0.007	0.064	<0.03	0.187	0.43	33.6	5.46	72.7	>2419.2
12:26	15:00	Upstream farm	0.015	0.022	<0.03	0.127	0.22	0.9	2.51	117.8	2620.0
12:03	15:00	Downstream farm	0.013	0.044	<0.03	0.439	0.64	6.9	2.14	75.9	>2419.2
11:54	15:00	Left Fork	0.005	0.016	<0.03	0.215	0.34	1.1	2.50	25.6	3360.0
12:42	15:00	House well	0.009	0.012	<0.03	0.501	0.55	0.3	3.71	<1.0	<1
11/18/2015	**11/18/2015**	**Base flow**									
11:37	15:05	Spring	0.011	0.030	0.01	0.168	0.43	1.8	5.47	461.1	13130.0
11:50	15:05	Upstream farm	0.013	0.046	0.06	0.229	0.41	4.0	2.55	517.2	5810.0
11:25	15:05	Downstream farm	0.017	0.050	0.09	0.334	0.56	4.5	2.88	435.2	14550.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
11:15	15:05	Left Fork	0.020	0.062	0.08	0.432	0.73	7.4	3.72	686.7	23590.0
12:15	15:05	Ephemeral stream	0.012	0.040	0.07	1.262	1.57	2.7	3.23	325.5	10710.0
12:28	15:05	Trench 1	0.005	0.030	0.02	0.264	0.52	1.9	1.74	65.7	17930.0
12:50	15:05	House well	0.009	0.014	<0.03	0.464	0.59	0.4	0.48	<1.0	<1
12/2/2015	**12/2/2015**	**Base flow**									
12:15	15:35	Spring	0.011	0.014	<0.03	1.262	1.63	1.9	2.51	109.2	2419.2
13:22	15:35	Upstream farm	0.010	0.020	0.03	0.135	0.22	1.4	0.98	55.6	1986.3
11:57	15:35	Downstream farm	0.012	0.022	0.02	0.266	0.39	1.6	0.94	48.0	9600.0
11:40	15:35	Left Fork	0.014	0.024	0.01	0.302	0.43	1.6	1.36	66.9	1986.3
12:27	15:35	Ephemeral stream	0.011	0.024	<0.03	0.613	0.89	1.0	1.01	145.0	1986.3
12:48	15:35	Trench 1	0.006	0.008	<0.03	0.218	0.33	1.3	1.10	6.3	5810.0
13:38	15:35	House well	0.011	0.014	0.02	0.480	0.60	0.9	1.38	1.0	1.0
12/14/2015	**12/14/2015**	**Base flow**									
12:45	16:00	Spring	0.007	0.024	<0.03	0.744	0.94	0.5	3.86	No Data	3230.0
13:00	16:00	Upstream farm	0.009	0.030	<0.03	0.364	0.58	3.4	11.89	118.7	2810.0
12:30	16:00	Downstream farm	0.009	0.034	0.05	0.181	0.27	4.1	4.10	410.6	4080.0
12:20	16:00	Left Fork	0.012	0.048	0.07	0.235	0.38	11.2	3.24	325.5	4520.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
15:15	16:00	Ephemeral stream	0.014	0.056	0.06	0.298	0.50	10.8	3.92	410.6	6010.0
13:30	16:00	Trench 1	0.004	0.012	<0.03	0.299	0.36	1.1	3.44	8.4	10460.0
13:38	16:00	House well	0.011	0.010	<0.03	0.545	0.57	0.1	10.15	<1.0	1.0
12/22/2015	**12/22/2015**	**Base flow**									
11:35	14:45	Spring	0.008	0.018	<0.03	0.531	0.58	0.7	1.23	146.7	1203.3
12:38	14:45	Upstream	0.010	0.020	<0.03	0.092	0.14	0.4	0.94	50.4	648.8
11:02	14:45	Downstream	0.011	0.020	<0.03	0.245	0.32	1.0	1.12	31.8	980.4
10:48	14:45	Left Fork	0.013	0.020	<0.03	0.267	0.35	0.1	1.36	26.5	1299.7
11:46	14:45	Ephemeral	0.010	0.016	<0.03	1.452	1.68	0.7	2.41	52.9	1299.7
12:14	14:45	Trench 1	0.005	0.010	<0.03	0.157	0.20	0.3	0.89	1.0	435.2
12:25	14:45	House well	0.010	0.016	<0.03	0.534	0.59	0.3	1.40	<1.0	<1.0
1/5/2016	1/5/2016	Grab sample									
11:52	15:29	Spring	0.007	0.024	<0.03	0.584	0.63	0.7	1.39	16.0	816.4
13:00	15:29	Upstream	0.008	0.026	<0.03	0.158	0.20	0.5	0.95	67.7	648.8
11:40	15:29	Downstream	0.011	0.026	<0.03	0.419	0.46	0.1	1.13	40.8	648.8
11:30	15:29	Left Fork	0.013	0.028	<0.03	0.427	0.48	0.7	1.51	34.1	686.7
12:02	15:29	Ephemeral	0.007	0.018	<0.03	0.883	1.00	1.2	2.15	32.7	686.7
12:13	15:29	Trench 1	0.003	0.016	<0.03	0.243	0.29	0.9	1.11	1.0	209.8

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
12:44	15:29	House well	0.008	0.020	<0.03	0.528	0.57	0.9	1.08	<1.0	1.0
1/25/2016	**1/25/2016**	**Grab sample**									
11:16	15:25	Spring	0.010	0.022	<0.03	0.565	0.60	0.3	1.27	34.5	1732.9
12:10	15:25	Upstream	0.010	0.022	<0.03	0.068	0.09	1.1	1.52	16.9	290.9
11:00	15:25	Downstream	0.011	0.022	<0.03	0.213	0.24	0.7	1.29	8.6	365.4
10:48	15:25	Left Fork	0.010	0.024	<0.03	0.198	0.25	1.0	1.30	21.1	435.2
11:28	15:25	Ephemeral	0.011	0.030	<0.03	0.762	0.87	9.8	3.10	1.0	816.4
11:42	15:25	House well	0.012	0.020	<0.03	0.602	0.55	0.5	2.36	<1.0	<1
2/10/2016	**2/10/2016**	**Grab sample**									
12:25	15:26	Spring	0.007	0.040	<0.03	0.634	0.80	17.7	2.70	1.0	325.5
11:15	15:26	Upstream	0.005	0.016	<0.03	0.048	0.11	0.5	1.11	14.5	178.5
11:04	15:26	Downstream	0.005	0.016	<0.03	0.198	0.24	0.9	0.99	4.1	218.7
11:29	15:26	Left Fork	0.003	0.012	<0.03	0.175	0.24	0.8	1.15	7.4	209.8
12:03	15:26	House well	0.007	0.014	<0.03	0.542	0.56	0.1	0.63	<1.0	<1.0
2/24/2016	**2/24/2016**	**Grab sample**									
11:05	14:45	Spring	0.010	0.052	<0.03	1.102	1.46	2.8	N.S.	209.8	3930.0
12:16	14:45	Upstream	0.014	0.052	<0.03	0.099	0.28	6.1	N.S.	1203.3	7330.0
10:52	14:45	Downstream	0.015	0.058	<0.03	0.142	0.37	8.3	N.S.	1986.3	6500.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
10:38	14:45	Left Fork	0.015	0.088	<0.03	0.249	0.63	15.6	N.S.	2780.0	14390.0
11:15	14:45	Ephemeral	0.010	0.056	<0.03	0.195	0.40	12.8	N.S.	387.3	4870.0
11:36	14:45	Trench 1	0.005	0.014	<0.03	0.345	0.39	2.1	N.S.	<1.0	9070.0
11:53	14:45	House well	0.010	0.010	<0.03	0.582	0.55	1.3	N.S.	<1.0	<1.0
3/10/2016	**3/10/2016**	**Grab sample**									
11:04	15:45	Spring	0.012	0.064	0.11	0.104	0.34	9.5	5.38	285.1	3230.0
13:13	15:45	Upstream	0.012	0.048	0.13	0.082	0.20	8.6	2.66	770.1	>2419.2
10:51	15:45	Downstream	0.010	0.044	0.11	0.118	0.25	6.2	2.28	298.7	>2419.2
11:32	15:45	Ephemeral stream	0.006	0.050	0.13	0.918	1.22	26.7	3.12	648.8	8840.0
10:38	15:45	Left Fork	0.013	0.046	0.01	0.154	0.38	8.7	2.64	367.3	2750.0
12:03	15:45	House well	0.011	0.020	0.02	0.562	0.59	0.9	1.19	<1.0	<1.0
11:50	15:45	Trench 1	0.005	0.036	0.10	0.264	0.45	3.5	2.87	2419.2	16690.0
11:46	15:45	Trench 2	0.005	0.054	0.14	1.716	2.35	6.8	6.77	613.1	34480.0
12:41	15:45	Field 12	0.411	0.522	1.17	0.852	4.49	621.5	12.58	410.6	>241920
3/16/2016	**3/16/2016**	**Grab sample**									
11:35	15:05	Spring	0.009	0.036	0.01	0.340	0.44	5.7	3.36	75.4	461.1
12:35	15:05	Upstream	0.008	0.034	<0.03	0.060	0.13	0.4	1.10	52.9	579.4
11:23	15:05	Downstream	0.006	0.028	0.01	0.170	0.24	0.9	1.17	81.3	>2419.2

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
11:50	15:05	Ephemeral stream	0.006	0.022	0.01	0.520	0.54	<6.58	1.75	88.0	461.1
11:13	15:05	Left Fork	0.009	0.032	<0.03	0.190	0.26	0.3	1.45	35.9	980.4
12:22	15:05	House well	0.009	0.022	<0.03	0.550	0.55	<6.58	1.55	<1.0	<1
12:01	15:05	Trench 1	0.003	0.032	0.02	0.331	0.37	<6.58	1.23	101.7	290.9
3/24/2016	**3/24/2016**	**Storm sample**									
11:50	15:10	Spring	0.015	0.046	0.06	0.172	0.42	13.1	4.95	N.S.	N.S.
12:50	15:10	Upstream	0.011	0.032	0.06	0.040	0.14	4.5	1.60	N.S.	N.S.
11:35	15:10	Downstream	0.011	0.024	<0.03	0.106	0.20	3.9	1.29	N.S.	N.S.
12:10	15:10	Ephemeral stream	0.010	0.012	<0.03	0.531	0.64	1.3	1.44	N.S.	N.S.
11:25	15:10	Left Fork	0.013	0.048	0.09	0.186	0.39	10.7	2.65	N.S.	N.S.
12:34	15:10	House well	0.012	0.014	<0.03	0.565	0.65	0.2	2.72	N.S.	N.S.
12:20	15:10	Trench 1	0.008	0.016	<0.03	0.208	0.20	2.8	1.33	N.S.	N.S.
3/31/2016	**3/31/3016**	**Grab sample**									
11:06	15:10	Spring	0.011	0.034	<0.03	0.319	0.52	7.4	25.32	71.7	1553.1
12:45	15:10	Upstream	0.008	0.042	0.08	0.100	0.22	6.1	2.49	186.0	>2419.2
10:45	15:10	Downstream	0.011	0.056	0.08	0.156	0.33	12.4	2.67	365.0	>2419.2
11:16	15:10	Ephemeral stream	0.013	0.656	0.68	1.211	3.05	375.0	12.14	16160.0	198630.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
10:33	15:10	Left Fork	0.013	0.056	0.09	0.199	0.40	11.9	2.59	172.0	3640.0
11:49	15:10	House well	0.010	0.018	<0.03	0.556	0.62	0.2	3.93	1.0	26.2
11:40	15:10	Trench 1	0.004	0.018	<0.03	0.347	0.49	5.5	4.76	4.1	2419.2
11:35	15:10	Trench 2	0.006	0.040	0.06	2.800	3.54	20.9	9.29	7.4	10810.0
12:02	15:10	Field 5a	1.154	1.352	0.27	0.302	1.67	26.5	32.74	24890.0	>241920
4/4/2016	**4/4/2016**	**Grab sample**									
11:58	15:20	Spring	0.009	0.028	<0.03	0.324	0.42	7.5	1.57	104.7	866.4
12:50	15:20	Upstream	0.008	0.026	<0.03	0.065	0.08	1.7	0.71	8.3	648.8
11:48	15:20	Downstream	0.010	0.026	<0.03	0.176	0.20	1.9	0.98	77.6	1046.2
12:08	15:20	Ephemeral stream	0.008	0.018	<0.03	0.462	0.48	1.3	1.79	12.0	727.0
11:38	15:20	Left Fork	0.009	0.022	<0.03	0.131	0.17	1.5	0.87	44.8	1119.9
12:35	15:20	House well	0.011	0.018	<0.03	0.466	0.48	<6.58	0.94	<1.0	1.0
12:26	15:20	Trench 2	0.004	0.012	<0.03	0.236	0.25	<6.58	0.85	1.0	>2419.2
4/20/2016	**4/20/2016**	**Grab sample**									
12:02	15:52	Spring	0.005	0.042	<0.03	0.410	0.55	22.4	1.04	3.1	195.6
13:20	15:52	Upstream	0.003	0.020	<0.03	0.047	0.06	1.9	0.61	185.0	1299.7
11:42	15:52	Downstream	0.004	0.018	<0.03	0.152	0.20	1.2	0.74	38.4	2920.0
12:11	15:52	Ephemeral stream	0.008	0.020	<0.03	0.517	0.66	4.1	0.68	44.3	21430.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
11:30	15:52	Left Fork	0.005	0.020	<0.03	0.157	0.21	2.1	0.84	35.0	6160.0
12:52	15:52	House well	0.005	0.014	<0.03	0.598	0.50	0.5	0.47	1.0	1.0
4/28/2016	**4/28/2016**	**Grab sample**									
11:55	15:17	Spring	0.010	0.024	<0.03	0.455	0.63	12.0	N.S.	25.6	>2419.2
13:00	15:17	Upstream	0.009	0.012	<0.03	0.035	0.12	1.2	N.S.	58.6	648.8
11:30	15:17	Downstream	0.010	0.012	<0.03	0.154	0.27	1.5	N.S.	36.4	2149.2
12:31	15:17	House well	0.011	0.008	<0.03	0.481	0.57	0.3	N.S.	<1.0	<1.0
11:25	15:17	Dry Creek	0.010	0.012	<0.03	0.152	0.27	1.0	N.S.	14.8	3050.0
5/2/2016	**5/3/2016**	**Grab sample**									
12:25	08:55	Spring	0.008	0.012	<0.03	0.338	0.36	2.2	5.08	88.2	>2419.2
14:29	08:55	Upstream	0.006	0.018	<0.03	0.039	0.10	6.7	1.76	185.0	2419.2
11:43	08:55	Downstream	0.008	0.016	<0.03	0.075	0.16	2.0	1.50	178.9	4720.0
12:38	08:55	Ephemeral stream	0.007	0.016	<0.03	0.468	0.59	1.7	2.56	118.7	5380.0
12:38	08:55	Ephemeral stream	0.008	0.112	0.15	1.794	2.62	61.8	4.07	1046.2	23590.0
11:24	08:55	Left Fork	0.009	0.020	<0.03	0.095	0.20	1.9	2.30	172.6	3640.0
13:27	08:55	House well	0.009	0.016	<0.03	0.551	0.56	0.1	1.94	<1.0	<1
5/10/2016	**5/10/2016**	**Grab sample**									
11:15	15:40	Spring	0.008	0.026	<0.03	0.281	0.45	2.9	7.58	410.6	2780.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
12:50	15:40	Upstream	0.007	0.044	0.01	0.070	0.20	6.1	3.10	613.1	4480.0
10:58	15:40	Downstream	0.011	0.060	0.01	0.101	0.31	11.6	2.95	1203.3	7490.0
11:28	15:40	Ephemeral stream	0.195	0.560	0.32	0.649	4.01	1346.7	11.94	579.4	>2419.2
10:35	15:40	Left Fork	0.011	0.072	0.02	0.121	0.37	17.2	3.35	980.4	8230.0
12:08	15:40	House well	0.009	0.008	<0.03	0.533	0.56	0.5	4.39	<1.0	24.9
11:55	15:40	Trench 1	0.002	0.016	<0.03	0.228	0.30	3.9	2.91	13.9	>2419.2
11:45	15:40	Trench 2	0.002	0.038	<0.03	1.706	2.18	5.2	3.72	38.7	>2419.2
12:26	15:40	Field 5a	1.114	1.458	1.69	2.894	6.35	79.9	12.82	22820.0	>2419.2
13:08	15:40	Field 12	0.370	0.666	0.12	0.062	1.03	96.7	6.92	663.0	>2419.2
5/18/2016	5/18/2016	Grab sample									
11:29	15:20	Spring	0.009	0.024	0.01	0.320	0.51	8.7	2.20	45.7	1413.6
13:08	15:20	Upstream	0.007	0.016	<0.03	0.043	0.13	1.4	1.00	85.5	1299.7
11:10	15:20	Downstream	0.009	0.020	0.02	0.117	0.25	1.2	0.98	107.1	>2419.2
11:43	15:20	Ephemeral stream	0.008	0.014	<0.03	0.479	0.63	3.0	0.84	34.1	2419.2
10:57	15:20	Left Fork	0.010	0.016	0.01	0.139	0.27	1.4	1.54	60.1	2620.0
12:50	15:20	House well	0.009	0.010	<0.03	0.488	0.64	0.4	0.95	<1.0	<1.0
12:05	15:20	Trench 1	0.006	0.006	<0.03	0.169	0.22	0.1	0.54	2.0	5200.0
5/26/2016	**5/26/2016**	**Grab sample**									

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
11:45	15:30	Spring	0.008	0.020	<0.03	0.219	0.35	6.2	4.15	344.8	3730.0
13:08	15:30	Upstream	0.007	0.030	<0.03	0.056	0.12	4.2	1.56	238.2	5290.0
11:30	15:30	Downstream	0.009	0.036	<0.03	0.094	0.20	4.6	1.75	547.5	3640.0
12:05	15:30	Ephemeral stream	0.052	0.424	0.39	0.858	2.20	350.6	8.58	22470.0	>2419.2
11:20	15:30	Left Fork	0.010	0.048	0.02	0.123	0.24	10.6	2.66	461.1	6890.0
12:51	15:30	House well	0.009	0.012	<0.03	0.564	0.57	0.7	0.93	1.0	7.4
12:38	15:30	Trench 1	0.008	0.006	<0.03	0.217	0.23	1.4	1.29	1.0	4260.0
6/2/2016	**6/2/2016**	**Grab sample**									
11:15	14:40	Spring	0.007	0.032	<0.03	0.330	0.47	10.8	2.38	64.1	1986.3
12:26	14:40	Upstream farm	0.007	0.018	<0.03	0.046	0.13	4.1	1.8	224.7	1986.3
11:04	14:40	Downstream farm	0.006	0.018	<0.03	0.106	0.20	1.4	1.8	104.6	3410
11:26	14:40	Ephemeral stream	0.008	0.022	<0.03	0.494	0.63	3.6	2.15	770.1	1986.3
10:52	14:40	Left Fork	0.007	0.022	<0.03	0.117	0.22	1.4	1.40	44.1	1986.3
12:06	14:40	House well	0.008	0.018	<0.03	0.597	0.62	0.7	0.99	<1.0	<1.0
11:35	14:40	Trench 1	0.002	0.018	<0.03	0.124	0.30	8.8	3.01	26.5	393.0
6/7/2016	**6/7/2016**	**Grab sample**									
11:25	14:30	Spring	0.011	0.026	<0.03	0.327	0.46	4.6	6.06	140.1	2460.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
12:16	14:30	Upstream farm	0.013	0.018	0.06	0.131	0.14	1.3	2.8	120.1	2720.0
11:10	14:30	Downstream farm	0.012	0.018	0.04	0.123	0.19	1.5	1.94	73.8	2980.0
11:37	14:30	Ephemeral stream	0.012	0.024	0.01	0.503	0.65	6.9	3.89	2419.2	7980.0
10:50	14:30	Left Fork	0.009	0.016	0.04	0.124	0.19	0.8	2.08	31.8	3180.0
12:00	14:30	House well	0.011	0.014	0.03	0.500	0.58	0.1	3.06	<1.0	<1.0
6/15/2016	**6/15/2016**	**Grab sample**									
11:40	15:00	Spring	0.010	0.016	0.03	0.466	0.65	4.2	<0.18	153.9	1553.1
12:40	15:00	Upstream farm	0.007	0.010	<0.03	0.097	0.15	1.6	0.02	69.1	2310.0
11:25	15:00	Downstream farm	0.008	0.050	0.05	0.181	0.42	25.4	0.38	33.2	4740.0
11:15	15:00	Left Fork	0.009	0.012	0.01	0.198	0.29	2.0	0.94	63.1	8860.0
12:15	15:00	House well	0.008	0.008	<0.03	0.506	0.59	0.7	<0.18	<1.0	<1.0
6/22/2016	**6/22/2016**	**Grab sample**									
10:40	14:35	Spring	0.008	0.012	<0.03	0.532	0.60	1.0	<0.18	38.2	1413.6
12:20	14:35	Upstream farm	0.008	0.016	0.02	0.237	0.33	2.3	0.20	455.0	547.5
10:23	14:35	Downstream farm	0.015	0.028	0.04	0.327	0.44	14.9	<0.18	46.4	4570.0
10:08	14:35	Left Fork	0.008	0.018	0.05	0.220	0.37	2.1	0.70	37.9	676.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
11:38	14:35	House well	0.009	0.008	<0.03	0.545	0.58	0.5	<0.18	<1.0	<1.0
6/29/2016	**6/29/2016**	**Grab sample**									
10:53	14:00	Spring	0.009	0.083	0.02	0.487	0.73	43.4	1.10	5.2	648.8
11:37	14:00	Upstream farm	0.006	0.029	0.06	0.186	0.34	4.6	0.92	55.4	9888.0
10:41	14:00	Downstream farm	0.010	0.021	0.03	0.395	0.47	2.5	0.46	41.3	6310.0
10:25	14:00	Left Fork	0.006	0.023	0.03	0.251	0.35	2.0	0.94	23.5	5200.0
11:12	14:00	House well	0.008	0.014	<0.03	0.569	0.56	0.0	0.23	<1.0	<1.0
7/6/2016	**7/6/2016**	**Grab sample**									
6:44	10:16	Spring	0.011	0.027	<0.03	0.465	0.53	9.8	1.15	25.3	4430
7:41	10:16	Upstream farm	0.009	0.023	<0.03	0.221	0.27	5.9	0.66	387.3	12230.0
6:26	10:16	Downstream farm	0.010	0.023	0.01	0.461	0.43	2.1	0.47	39.3	8570.0
6:08	10:16	Left Fork	0.006	0.020	0.04	0.271	0.36	2.7	0.96	248.1	12590.0
7:18	10:16	House well	0.009	0.013	<0.03	0.874	0.96	1.0	0.73	<1.0	13.5
7/13/2016	**7/13/2016**	**Grab sample**									
7:53	12:30	Spring	0.003	0.023	<0.03	0.355	0.42	12.3	0.90	71.7	2920
7:33	12:30	Downstream farm	0.006	0.017	<0.03	0.365	0.43	4.3	1.12	129.6	8390.0
7:15	12:30	Left Fork	0.005	0.017	<0.03	0.172	0.29	1.9	0.85	95.9	12360.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
8:34	12:30	House well	0.005	0.011	<0.03	0.627	0.63	0.5	0.09	<1.0	<1.0
7/20/2016	**7/20/2016**	**Grab sample**									
7:56	12:05	Spring	0.006	0.024	<0.03	0.298	0.35	9.4	0.55	N.S.	N.S.
7:39	12:05	Downstream farm	0.005	0.024	<0.03	0.356	0.44	5.1	3.93	N.S	N.S.
7:25	12:05	Left Fork	0.005	0.013	<0.03	0.197	0.76	2.3	2.21	N.S.	N.S.
8:30	12:05	House well	0.007	0.009	0.02	0.594	0.70	0.1	0.14	N.S.	N.S.
7/27/2016	**7/27/2016**	**Grab sample**									
7:38	14:15	Spring	0.001	0.043	<0.03	0.375	0.46	17.6	2.64	55.6	980.4
7:21	14:15	Downstream farm	0.007	0.027	<0.03	0.423	0.47	2.3	1.62	140.8	17260.0
7:02	14:15	Left Fork	0.004	0.021	<0.03	0.255	0.35	3.6	1.79	920.8	15000.0
8:14	14:15	House well	0.006	0.010	<0.03	0.650	0.67	0.1	1.41	<1.0	<1.0
8/3/2016	**8/3/2016**	**Grab sample**									
8:03	12:10	Spring	0.006	0.104	<0.03	0.201	0.49	64.8	7.41	65.7	2920
7:43	12:10	Downstream farm	0.013	0.014	<0.03	0.221	0.29	3.2	3.46	115.3	9320.0
7:28	12:10	Left Fork	0.007	0.016	<0.03	0.212	0.32	2.4	2.21	101.4	7430.0
8/16/2016	**8/16/2016**	**Grab sample**									
10:58	14:50	Spring	0.007	0.027	0.02	0.223	0.39	7.7	9.89	88.2	5380.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
12:16	14:50	Upstream farm	0.009	0.031	0.03	0.089	0.23	4.6	3.14	248.9	9330.0
10:41	14:50	Downstream farm	0.011	0.039	0.03	0.161	0.33	8.1	2.94	178.2	17820.0
11:25	14:50	Ephemeral stream	0.011	0.023	0.01	1.365	1.59	2.6	2.47	137.6	154945.0
10:28	14:50	Left Fork	0.012	0.082	0.07	0.118	0.30	19.5	3.64	201.4	14550.0
11:40	14:50	Trench 1	0.005	0.006	0.02	0.130	0.17	0.2	2.14	93.4	48840.0
11:50	14:50	Trench 2	0.004	0.036	0.05	0.344	0.99	1.5	8.98	290.9	198630.0
8/24/2016	**8/24/2016**	**Grab sample**									
11:29	15:30	Spring	0.004	0.046	<0.03	0.477	0.97	29.9	2.99	27.8	5630
12:40	15:30	Upstream farm	0.004	0.014	0.03	0.046	0.14	2.0	1.08	72.3	2620.0
10:53	15:30	Downstream farm	0.005	0.016	<0.03	0.122	0.22	3.2	0.85	72.8	7030.0
10:40	15:30	Left Fork	0.004	0.013	0.00	0.045	0.13	1.5	1.62	43.5	6690.0
8/24/2016	**8/24/2016**	**Storm sample**									
11:03	15:30	Downstream farm	<0.002	0.109	0.01	0.002	0.42	66.9	5.89	156.5	38730.0
12:05	15:30	Trench 1	<0.002	0.019	0.03	0.033	0.30	8.3	1.99	21.8	3450.0
8/30/2016	**8/30/2016**	**Grab sample**									
11:24	14:55	Spring	0.003	0.020	<0.03	0.501	0.58	2.9	3.28	195.6	9090.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
12:35	14:55	Upstream farm	0.003	0.020	<0.03	0.042	0.13	1.7	1.37	102.5	5210.0
11:10	14:55	Downstream farm	0.004	0.020	<0.03	0.116	0.21	1.7	1.19	30.1	5200.0
11:00	14:55	Left Fork	0.005	0.021	0.02	0.157	0.28	2.7	2.00	111.2	17850.0
9/7/2016	**9/7/2016**	**Grab sample**									
7:58	12:25	Spring	0.003	0.219	0.05	0.514	0.92	142.1	5.37	31.8	18500.0
9:03	12:25	Upstream farm	0.007	0.020	0.01	0.113	0.21	1.9	1.89	195.6	5380.0
7:38	12:25	Downstream farm	0.008	0.059	0.01	0.265	0.46	25.4	1.39	30.9	4790.0
7:23	12:25	Left Fork	0.006	0.021	<0.03	0.151	0.24	2.8	1.58	27.5	10170.0
9/15/2016	**9/15/2016**	**Grab sample**									
11:00	14:00	Spring	0.009	0.273	<0.03	0.345	0.83	190.9	13.99	ND	ND
11:20	14:00	Upstream farm	0.012	0.011	<0.03	0.119	0.21	3.2	6.12	ND	ND
10:45	14:00	Downstream farm	0.014	0.016	0.01	0.312	0.42	2.9	5.38	ND	ND
10:32	14:00	Left Fork	0.011	0.014	0.01	0.132	0.25	2.2	5.35	ND	ND
9/28/2016	**9/28/2016**	**Grab sample**									
11:25	14:25	Spring	0.005	0.043	0.01	0.427	0.62	22.0	2.70	7540.0	7590.0
12:26	14:25	Upstream farm	0.008	0.016	0.01	0.128	0.21	1.0	1.33	9330.0	2310.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
11:12	14:25	Downstream farm	0.011	0.017	0.01	0.293	0.42	1.6	2.15	7120.0	5210.0
11:00	14:25	Left Fork	0.006	0.011	0.02	0.101	0.22	1.8	1.31	2530.0	3410.0
10/5/2016	**10/5/2016**	**Grab sample**									
10:29	15:40	Spring	0.006	0.513	0.01	0.502	1.40	334.8	4.66	36.8	241920.0
12:01	15:40	Upstream farm	0.009	0.020	<0.03	0.120	0.25	2.1	2.85	770.1	13170.0
10:07	15:40	Downstream farm	0.014	0.043	0.02	0.413	0.58	29.3	3.00	547.1	11690.0
9:54	15:40	Left Fork	0.009	0.023	0.01	0.130	0.29	2.8	2.38	285.1	17820.0
10/13/2016	**10/13/2016**	**Grab sample**									
10:46	15:45	Spring	0.018	0.272	0.05	0.623	1.36	148.0	6.09	>2419.2	28090.0
12:46	15:45	Upstream farm	0.015	0.026	<0.03	0.147	0.28	2.7	2.32	3590.0	46110.0
10:29	15:45	Downstream farm	0.033	0.066	0.02	0.614	0.88	9.6	3.90	4640.0	129970.0
11:03	15:45	Ephemeral stream	0.018	0.047	0.03	1.760	1.97	9.7	5.17	>2419.2	21430.0
10:16	15:45	Left Fork	0.091	0.203	0.04	1.071	1.74	24.2	9.30	14010.0	>241920
12:30	15:45	House well	0.008	0.010	0.01	1.166	1.23	0.6	1.35	<1.0	23.3
10/13/2016	**10/13/2016**	**Storm sample**									
11:15	15:45	Ephemeral stream	0.067	0.213	0.12	2.732	3.83	61.7	11.10	ND	ND

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
13:10	15:45	Field 1	0.940	1.231	0.13	0.335	2.36	59.0	16.67	ND	ND
10/20/2016	**10/20/2016**	**Grab sample**									
11:05	15:05	Spring	0.010	0.044	<0.03	0.414	0.56	18.9	11.91	461.1	30760.0
12:03	15:05	Upstream farm	0.010	0.021	<0.03	0.076	0.13	1.1	4.43	3730.0	16640.0
10:48	15:05	Downstream farm	0.014	0.030	0.03	0.327	0.39	2.1	3.11	387.3	5690.0
10:20	15:05	Left Fork	0.008	0.026	0.01	0.146	0.27	1.3	3.95	33.5	17890.0
11:38	15:05	House well	0.009	0.020	0.02	0.739	0.79	0.1	4.56	<1.0	19.7
10/27/2016	**10/27/2016**	**Grab sample**									
11:05	15:25	Spring	0.007	0.253	0.03	0.265	0.88	161.1	14.84	61.7	13960.0
11:50	15:25	Upstream farm	0.010	0.021	<0.03	0.046	0.14	1.1	5.87	517.2	5450.0
10:42	15:25	Downstream farm	0.014	0.021	0.01	0.291	0.36	2.1	7.91	45.5	6440.0
10:27	15:25	Left Fork	0.008	0.016	0.02	0.132	0.26	1.9	7.76	48.8	9340.0
11:30	15:25	House well	0.009	0.010	0.01	0.664	0.74	0.9	8.95	<1.0	5.2
11/03/2016	**11/03/2016**	**Grab sample**									
9:55	14:20	Spring	0.001	0.483	0.03	0.235	0.89	281.7	15.21	3.1	2419.2
11:10	14:20	Upstream farm	0.003	0.031	0.01	0.071	0.20	2.1	6.81	22.6	3010.0
9:36	14:20	Downstream farm	0.008	0.022	0.03	0.388	0.47	1.7	6.07	1732.9	5200.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
9:14	14:20	Left Fork	0.004	0.026	0.03	0.117	0.26	1.5	9.24	33.1	7380.0
10:38	14:20	House well	0.004	0.010	0.02	0.719	0.75	0.4	9.48	1.0	2.0
11/10/2016	**11/10/2016**	**Grab sample**									
10:56	14:00	Spring	0.003	0.104	<0.03	0.255	0.50	53.0	3.30	17.1	13760.0
11:33	14:00	Upstream farm	0.011	0.013	0.01	0.073	0.12	1.0	2.29	53.7	>2419.2
10:38	14:00	Downstream farm	0.011	0.021	0.02	0.419	0.48	0.7	2.15	22.6	5040.0
10:18	14:00	Left Fork	0.005	0.013	0.01	0.161	0.23	4.1	2.07	7.4	2560.0
11:10	14:00	House well	0.005	0.009	<0.03	0.574	0.68	0.1	2.16	<1.0	1.0
11/17/2016	**11/17/2016**	**Grab sample**									
11:00	13:45	Spring	0.001	0.021	<0.03	0.209	0.32	4.9	2.42	2.0	574.8
11:40	13:45	Upstream farm	0.009	0.020	<0.03	0.057	0.13	0.6	1.84	58.1	3270.0
10:43	13:45	Downstream farm	0.011	0.020	0.01	0.412	0.49	2.5	1.37	18.5	>2419.2
10:20	13:45	Left Fork	0.005	0.011	<0.03	0.195	0.26	0.5	1.77	15.8	2400.0
11:10	13:45	House well	0.006	0.010	0.01	0.660	0.71	0.3	1.57	<1.0	1.0
11/21/2016	**11/21/2016**	**Grab sample**									
10:24	14:15	Spring	0.010	0.313	0.04	0.239	0.87	210.2	4.99	135.4	6770.0
11:15	14:15	Upstream farm	0.010	0.019	<0.03	0.125	0.17	1.3	0.68	178.9	3840.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
10:05	14:15	Downstream farm	0.012	0.021	0.01	0.466	0.52	1.3	1.23	26.9	>2419.2
9:40	14:15	Left Fork	0.004	0.011	0.01	0.239	0.31	0.4	3.35	11.9	2419.2
10:40	14:15	House well	0.007	0.011	<0.03	0.675	0.75	0.4	1.37	<1.0	<1.0
11/29/2016	**11/29/2016**	**Grab sample**									
11:42	15:15	Spring	0.009	0.100	<0.03	0.329	0.68	45.0	8.06	1046.2	13360.0
12:48	15:15	Upstream farm	0.008	0.026	0.01	0.063	0.12	2.1	2.38	235.9	3790.0
11:30	15:15	Downstream farm	0.007	0.027	<0.03	0.146	0.23	4.4	2.11	387.3	7380.0
11:20	15:15	Left Fork	0.004	0.014	<0.03	0.191	0.28	1.1	1.97	57.6	>2419.2
12:36	15:15	House well	0.004	0.011	<0.03	0.598	0.68	0.4	2.67	<1.0	<1.0
12/14/2016	**12/14/2016**	**Grab sample**									
11:15	14:10	Spring	0.009	0.024	0.12	0.384	0.50	7.2	14.25	10.9	1119.9
11:58	14:10	Upstream farm	0.009	0.017	0.03	0.064	0.08	0.9	4.43	67.6	2650.0
11:03	14:10	Downstream farm	0.013	0.024	0.02	0.199	0.27	1.3	2.05	5.2	>2419.2
10:45	14:10	Left Fork	0.007	0.017	0.02	0.144	0.21	0.9	3.77	13.4	2419.2
11:30	14:10	House well	0.010	0.014	0.03	0.678	0.70	0.3	6.19	<1.0	<1.0
1/5/2017	**1/25/2017**	**Grab sample**									
12:28	15:25	Spring	0.004	0.026	0.04	0.276	0.390	9.5	0.94	74.4	1413.6

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
13:12	15:25	Upstream farm	0.009	0.014	0.02	0.059	0.090	0.7	0.66	52.0	2419.2
12:00	15:25	Downstream farm	0.012	0.019	0.04	0.257	0.310	1.3	0.55	5.2	1986.3
11:42	15:25	Left Fork	0.006	0.011	0.03	0.229	0.260	0.7	0.85	6.2	1732.9
12:47	15:25	House well	0.008	0.014	0.04	0.610	0.660	0.3	0.30	<1.0	<1.0
1/19/2017	**1/19/2017**	**Grab sample**									
10:41	14:30	Spring	0.009	0.017	0.04	0.286	0.600	33.0	13.31	<1.0	2260.0
11:27	14:30	Upstream farm	0.010	0.016	0.03	0.050	0.140	1.9	4.22	137.6	>2419.2
10:30	14:30	Downstream farm	0.014	0.024	0.02	0.121	0.210	2.5	3.19	60.1	3990.0
10:10	14:30	Left Fork	0.010	0.019	0.03	0.243	0.360	2.6	4.25	55.4	>2419.2
11:00	14:30	House well	0.009	0.013	0.03	0.617	0.690	0.9	7.87	<1.0	<1.0
2/2/2017	**2/2/2017**	**Grab sample**									
10:45	14:30	Spring	0.011	0.030	<0.03	0.823	0.890	7.3	5.06	6.3	1732.9
11:20	14:30	Upstream farm	0.009	0.017	<0.03	0.056	0.070	1.1	1.72	41.9	>2419.2
10:30	14:30	Downstream farm	0.014	0.026	0.01	0.160	0.210	5.1	2.21	41.3	>2419.2
10:15	14:30	Left Fork	0.008	0.019	0.01	0.139	0.180	1.1	1.69	17.1	>2419.2
10:57	14:30	House well	0.011	0.031	0.01	0.614	0.780	0.4	2.22	<1.0	<1.0
2/15/2017	**2/15/2017**	**Grab sample**									

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
11:50	15:35	Spring	0.013	0.093	0.02	0.201	0.570	12.7	8.76	178.5	4350.0
13:30	15:35	Upstream farm	0.009	0.060	0.01	0.132	0.300	5.0	3.04	1986.3	6570.0
11:24	15:35	Downstream farm	0.012	0.082	0.03	0.159	0.420	9.0	3.46	1732.9	11000.0
12:08	15:35	Ephemeral stream	0.020	0.064	0.02	1.323	1.450	3.1	5.06	166.9	5630.0
11:11	15:35	Left Fork	0.015	0.080	0.03	0.314	0.600	17.7	4.66	648.8	11060.0
12:46	15:35	Trench 1	0.004	0.023	0.01	0.141	0.200	1.3	0.45	1.0	1299.7
12:56	15:35	Trench 2	0.004	0.087	0.04	0.486	1.120	6.1	5.99	19.7	42860.0
12:25	15:35	House well	0.008	0.023	0.02	0.649	0.720	0.5	2.07	<1.0	<1.0
3/1/2017	**3/1/2017**	**Grab sample**									
12:38	14:55	Upstream farm	0.009	0.044	0.03	0.069	0.240	4.7	3.93	2590.0	7940.0
11:18	14:55	Downstream farm	0.005	0.016	0.03	0.148	0.270	2.6	3.24	71.7	2430.0
11:43	14:55	Ephemeral stream	0.011	0.016	0.02	0.659	0.710	1.5	6.75	195.6	5730.0
11:00	14:55	Left Fork	0.008	0.024	0.02	0.136	0.280	4.3	2.46	1119.9	4260.0
12:16	14:55	Trench 2	0.002	0.050	0.04	0.345	0.760	11.6	4.90	98.8	34480.0
11:52	14:55	House well	0.012	0.040	0.03	0.620	0.720	0.5	5.85	<1.0	<1.0
3/16/2017	**3/16/2017**	**Grab sample**									
7:30	11:45	Spring	0.009	0.061	<0.03	0.729	0.990	15.5	2.69	24.0	>2419.2

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
8:38	11:45	Upstream farm	0.006	0.046	<0.03	0.118	0.290	1.7	1.08	75.9	1299.7
7:13	11:45	Downstream farm	0.010	0.031	<0.03	0.266	0.300	2.9	0.97	68.3	1986.3
7:38	11:45	Ephemeral stream	0.005	0.021	<0.03	0.738	0.800	0.8	2.99	14.8	2419.2
7:00	11:45	Left Fork	0.009	0.043	<0.03	0.300	0.410	3.1	1.77	45.5	>2419.2
8:00	11:45	Trench 1	0.006	0.020	<0.03	0.083	0.110	1.1	1.87	<1.0	179.3
7:46	11:45	House well	0.009	0.023	<0.03	0.856	0.880	0.1	1.52	<1.0	<1.0
3/27/2017	**3/27/2017**	**Grab sample**									
11:27	15:40	Spring	0.007	0.044	<0.03	0.213	0.600	7.2	9.58	770.1	8800.0
12:51	15:40	Upstream farm	0.012	0.122	0.06	0.181	0.740	131.4	5.72	1986.3	17850.0
10:51	15:40	Downstream farm	0.047	0.096	0.20	0.173	1.490	321.9	6.68	9840.0	72150.0
10:37	15:40	Left Fork	0.058	0.164	0.17	0.206	1.500	1005.1	8.51	9330.0	38770.0
11:50	15:40	Trench 1	0.004	0.048	0.03	0.129	0.390	3.1	4.36	387.3	17230.0
11:55	15:40	Trench 2	0.009	0.102	0.13	0.060	0.820	7.0	7.13	488.4	29240.0
12:38	15:40	House well	0.007	0.038	0.02	0.573	0.630	1.6	3.83	18.1	261.3
3/27/2017	**3/27/2017**	**Storm sample**									
11:40	15:40	Ephemeral stream	0.151	0.268	0.29	1.704	3.300	448.3	16.47	18500.0	66530.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
11:05	15:40	Field 1	0.420	0.670	0.43	0.090	1.870	124.4	9.29	8390.0	45690.0
12:15	15:40	Field 5a	2.980	3.232	1.40	0.122	1.800	30.2	32.01	2419.2	69100.0
13:06	15:40	Field 12	0.800	1.276	2.02	2.798	6.040	134.2	9.35	7120.0	96060.0
3/30/2017	**3/30/2017**	**Storm sample**									
11:15	14:15	Ephemeral stream	0.005	0.032	0.01	0.796	0.860	8.6	1.89	ND §	ND
4/6/2017	**4/6/2017**	**Grab sample**									
11:40	15:25	Spring	0.009	0.032	0.01	0.265	0.420	5.2	6.36	1413.6	1413.6
11:30	15:25	Upstream farm	0.007	0.038	0.01	0.099	0.210	2.3	2.53	72.0	>2419.2
11:55	15:25	Downstream farm	0.009	0.034	0.01	0.173	0.260	3.1	1.96	107.6	>2419.2
11:20	15:25	Ephemeral stream	0.008	0.022	<0.03	0.717	0.760	1.6	1.69	148.3	1986.3
11:50	15:25	Left Fork	0.010	0.048	0.01	0.222	0.410	4.7	2.32	135.4	2780.0
10:20	15:25	Trench 1	0.004	0.022	0.03	0.165	0.300	17.2	1.98	47.2	2750.0
4/6/2017	**4/6/2017**	**Storm sample**									
11:15	15:25	Ephemeral stream	0.018	0.080	0.06	0.807	1.140	19.9	4.14	ND	ND
4/13/2017	**4/13/2017**	**Grab sample**									
12:22	15:30	Spring	0.011	0.022	<0.03	0.600	0.630	3.6	15.57	8.6	816.4

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
13:05	15:30	Upstream farm	0.008	0.054	<0.03	0.026	0.110	2.5	4.64	83.6	2419.2
11:56	15:30	Downstream farm	0.009	0.028	0.01	0.092	0.170	1.1	2.33	135.4	>2419.2
12:50	15:30	Ephemeral stream	0.010	0.018	<0.03	0.593	0.600	1.5	7.73	71.7	6700.0
11:33	15:30	Left Fork	0.010	0.024	<0.03	0.123	0.210	1.6	2.75	22.3	>2419.2
12:35	15:30	House well	0.011	0.020	<0.03	0.564	0.590	0.1	6.22	<1.0	1.0
4/17/2017	**4/17/2017**	**Grab sample**									
12:02	14:55	Spring	0.007	0.044	0.02	0.154	0.400	5.3	6.46	1413.6	18420.0
11:45	14:55	Upstream farm	0.019	0.054	<0.03	0.025	0.120	5.3	1.55	1553.1	9330.0
10:51	14:55	Downstream farm	0.011	0.046	0.01	0.129	0.240	3.3	1.51	866.4	8360.0
11:10	14:55	Ephemeral stream	0.005	0.018	<0.03	0.651	0.680	0.9	1.71	410.6	7270.0
10:40	14:55	Left Fork	0.040	0.112	0.02	0.173	0.460	19.5	4.55	9090.0	129970.0
11:25	14:55	House well	0.006	0.016	0.01	0.563	0.570	0.2	1.94	<1.0	12.1
4/24/2017	**4/24/2017**	**Storm sample**									
11:50	15:30	Ephemeral stream	0.007	0.128	0.04	0.000	1.830	318.0	7.35	ND	ND
11:15	15:30	Field 1	0.395	0.592	0.13	0.143	1.500	43.1	7.25	ND	ND
11:35	15:30	Field 5a	0.961	1.212	0.12	0.321	1.530	11.7	11.53	ND	ND

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
12:15	15:30	Trench 1	0.005	0.040	21.95	0.133	22.760	18.5	7.04	ND	ND
12:20	15:30	Trench 2	0.010	0.084	0.04	0.087	0.930	8.2	8.78	ND	ND
4/27/2017	**4/27/2017**	**Grab sample**									
11:05	16:25	Spring	0.011	0.022	<0.03	0.380	0.440	3.1	2.58	165.8	>2419.2
12:10	16:25	Upstream farm	0.010	0.036	<0.03	0.117	0.120	7.1	1.34	172.3	2430.0
10:35	16:25	Downstream farm	0.014	0.042	<0.03	0.231	0.240	10.7	1.70	214.3	6090.0
10:20	16:25	Left Fork	0.016	0.046	<0.03	0.306	0.320	16.4	2.08	275.5	7230.0
11:30	16:25	House well	0.011	0.014	<0.03	0.532	0.530	0.1	0.69	5.1	52.8
11:43	16:25	Trench 2	0.006	0.046	0.04	0.029	0.420	2.4	4.95	115.3	2419.2
4/27/2017	**4/27/2017**	**Storm sample**									
11:52	16:25	Ephemeral stream	0.042	0.253	0.01	0.302	2.570	734.5	8.29	186.0	>2419.2
10:50	16:25	Field 1	0.550	0.784	0.08	0.107	1.320	52.2	8.46	ND	ND
11:15	16:25	Field 5a	0.686	0.846	0.07	0.063	0.860	11.3	7.26	ND	ND
13:40	16:25	Field 12	0.326	0.544	0.02	0.105	0.710	102.3	5.64	ND	ND
11:40	16:25	Trench 1	0.006	0.048	1.04	0.081	1.430	7.2	4.04	40.4	3990.0
5/1/2017	**5/1/2017**	**Grab sample**									
11:35	15:45	Spring	0.012	0.012	<0.03	0.343	0.480	0.3	4.34	127.4	2419.2

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
13:05	15:45	Upstream farm	0.013	0.026	<0.03	0.144	0.250	4.1	1.01	95.9	2280.0
11:01	15:45	Downstream farm	0.018	0.032	<0.03	0.279	0.390	6.9	1.22	187.2	3010.0
12:54	15:45	Ephemeral stream	0.014	0.018	<0.03	0.681	0.750	68.2	1.12	146.7	1986.3
10:50	15:45	Left Fork	0.019	0.068	<0.03	0.362	0.550	14.1	1.68	129.1	7430.0
12:15	15:45	House well	0.015	0.042	<0.03	0.529	0.650	1.8	1.59	4.1	3740.0
12:30	15:45	Trench 1	0.007	0.008	<0.03	0.124	0.180	2.3	1.05	435.2	12960.0
12:40	15:45	Trench 2	0.013	0.022	<0.03	0.000	0.230	3.4	3.02	435.2	3890.0
5/1/2017	**5/1/2017**	**Storm sample**									
11:20	15:45	Field 1	0.534	0.760	0.33	0.321	2.200	36.7	12.66	ND	ND
12:00	15:45	Field 5a	0.734	0.916	0.22	0.281	1.560	13.1	9.81	ND	ND
13:15	15:45	Field 12	0.224	0.374	0.03	0.166	1.060	40.6	7.25	ND	ND
12:30	15:45	Trench 1	0.009	0.050	0.61	0.076	2.400	10.7	4.56	ND	ND
12:40	15:45	Trench 2	0.008	0.066	0.02	0.010	0.810	11.2	8.31	ND	ND
5/11/2017	**5/11/2017**	**Grab sample**									
7:40	12:05	Spring	0.013	0.016	<0.03	0.406	0.410	0.9	4.97	30.5	1986.3
8:25	12:05	Upstream farm	0.009	0.022	<0.03	0.125	0.170	2.4	1.32	165.8	2419.2
7:24	12:05	Downstream farm	0.010	0.026	<0.03	0.397	0.400	2.4	1.18	93.3	3090.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
7:50	12:05	Ephemeral stream	0.009	0.018	<0.03	0.682	0.740	1.5	1.49	48.0	2419.2
7:13	12:05	Left Fork	0.012	0.024	<0.03	0.383	0.380	1.3	1.09	78.9	5460.0
7:55	12:05	House well	0.010	0.016	<0.03	1.023	1.080	0.6	1.19	<1.0	6.3
5/18/2017	**5/18/2017**	**Grab sample**									
10:55	15:00	Spring	0.006	0.018	<0.03	0.220	0.340	0.4	4.91	88.0	2419.2
11:40	15:00	Upstream farm	0.006	0.048	<0.03	0.067	0.190	2.9	1.50	260.2	>2419.2
10:45	15:00	Downstream farm	0.008	0.024	<0.03	0.189	0.300	1.9	1.10	129.6	3690.0
11:05	15:00	Ephemeral stream	0.012	0.020	<0.03	0.692	0.750	1.7	1.76	49.6	2419.2
10:30	15:00	Left Fork	0.009	0.022	<0.03	0.167	0.260	1.9	1.54	50.4	2419.2
11:15	15:00	House well	0.011	0.020	<0.03	0.431	0.600	0.6	5.05	1.0	3.1
5/25/2017	**5/25/2017**	**Grab sample**									
12:16	15:27	Spring	0.007	0.042	0.01	0.219	0.330	22.2	3.76	68.9	2419.2
13:06	15:27	Upstream farm	0.007	0.052	0.01	0.109	0.240	1.9	1.53	ND	ND
11:35	15:27	Downstream farm	0.008	0.020	0.01	0.295	0.300	1.7	1.41	101.7	>2419.2
12:25	15:27	Ephemeral stream	0.013	0.016	0.01	0.661	0.710	0.4	2.01	72.8	>2419.2
11:18	15:27	Left Fork	0.010	0.022	0.01	0.303	0.320	1.4	1.48	58.1	2419.2

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
12:48	15:27	House well	0.010	0.016	0.02	0.525	0.570	0.3	1.71	<1.0	613.1
5/25/2017	**5/25/2017**	**Storm sample**									
11:35	15:27	Downstream farm	0.006	0.050	<0.03	0.274	0.310	3.0	1.35	ND	ND
5/31/2017	**5/31/2017**	**Grab sample**									
10:38	13:50	Spring	0.007	0.036	<0.03	0.163	0.320	13.2	3.81	235.9	4280.0
11:05	13:50	Upstream farm	0.009	0.020	<0.03	0.053	0.140	1.9	1.34	157.6	2419.2
10:30	13:50	Downstream farm	0.008	0.052	<0.03	0.188	0.250	1.6	1.33	150.0	2419.2
10:55	13:50	Ephemeral stream	0.009	0.020	<0.03	0.769	0.790	2.5	1.53	275.5	3500.0
10:20	13:50	Left Fork	0.008	0.020	<0.03	0.156	0.220	1.5	1.58	260.2	4720.0
10:51	13:50	House well	0.019	0.026	<0.03	0.605	0.920	0.4	1.86	<1.0	22.1
6/5/2017	**6/5/2017**	**Grab sample**									
10:53	14:35	Spring	0.007	0.026	0.02	0.225	0.330	9.7	6.63	160.7	4640.0
11:51	14:35	Upstream farm	0.007	0.054	0.01	0.114	0.210	8.3	3.01	178.5	5040.0
10:35	14:35	Downstream farm	0.013	0.064	0.01	0.185	0.290	12.9	1.81	313.0	9330.0
11:03	14:35	Ephemeral stream	0.010	0.028	<0.03	0.706	0.710	1.5	2.38	613.1	5830.0
10:25	14:35	Left Fork	0.011	0.070	0.01	0.179	0.320	14.4	1.63	579.4	24000.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
11:09	14:35	House well	0.008	0.026	0.01	0.586	0.590	0.3	0.00	6.3	48.0
11:30	14:35	Trench 2	0.003	0.086	0.02	0.018	0.750	8.7	7.04	2780.0	>241920
6/6/2017	**6/6/2017**	**Storm sample**									
11:17	15:30	Field 1	0.747	0.998	0.51	0.438	2.340	56.0	10.39	ND	ND
12:12	15:30	Field 5a	1.000	1.430	0.05	1.861	2.380	<10.0	6.21	ND	ND
12:46	15:30	Field 12	0.316	0.470	0.03	0.166	1.660	280.8	6.65	ND	ND
11:30	15:30	Ephemeral stream	0.041	0.816	0.14	0.580	4.610	1788.2	9.24	ND	ND
11:02	15:30	Downstream farm	0.018	0.118	0.03	0.073	0.900	291.5	6.35	ND	ND
6/12/2017	**6/12/2017**	**Grab sample**									
10:27	14:25	Spring	0.006	0.084	0.01	0.193	0.400	53.3	2.57	29.5	155310.0
11:02	14:25	Upstream farm	0.008	0.026	0.01	0.105	0.130	2.0	1.01	121.1	6280.0
10:14	14:25	Downstream farm	0.009	0.020	0.01	0.256	0.270	1.6	0.77	119.8	4350.0
10:35	14:25	Ephemeral stream	0.010	0.882	<0.03	0.732	0.730	0.6	0.67	33.6	2419.2
10:05	14:25	Left Fork	0.006	0.016	<0.03	0.143	0.190	0.9	1.17	77.1	4350.0
10:40	14:25	House well	0.010	0.012	0.00	0.591	0.590	0.0	1.20	<1.0	3.1
6/19/2017	**6/19/2017**	**Grab sample**									
10:45	14:25	Spring	0.007	0.046	0.01	0.227	0.710	25.6	7.34	9.6	1986.3

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
11:17	14:25	Upstream farm	0.009	0.014	<0.03	0.089	0.120	1.4	2.99	60.1	3640.0
10:35	14:25	Downstream farm	0.007	0.016	0.01	0.256	0.300	1.9	2.75	75.9	7590.0
10:25	14:25	Left Fork	0.006	0.018	0.01	0.226	0.280	2.1	2.15	32.3	4130.0
11:00	14:25	House well	0.009	0.014	0.02	0.582	0.580	0.3	6.92	<1.0	<1.0
6/29/2017	**6/29/2017**	**Grab sample**									
11:47	14:55	Spring	0.006	0.016	0.01	0.244	0.280	5.0	9.08	9.8	866.4
12:19	14:55	Upstream farm	0.007	0.016	0.01	0.083	0.130	1.1	3.10	52.9	3950.0
11:35	14:55	Downstream farm	0.010	0.018	0.02	0.293	0.360	1.8	2.27	28.8	3410.0
11:24	14:55	Left Fork	0.010	0.016	0.02	0.236	0.320	1.3	2.77	29.8	3640.0
12:01	14:55	House well	0.009	0.014	0.01	0.574	0.640	0.3	4.39	1.0	2.0
7/5/2017	**7/5/2017**	**Grab sample**									
11:25	14:55	Spring	0.008	0.022	<0.03	0.107	0.250	1.9	9.11	90.7	4430.0
12:15	14:55	Upstream farm	0.011	0.028	<0.03	0.094	0.180	2.5	2.76	261.3	9060.0
11:05	14:55	Downstream farm	0.011	0.026	<0.03	0.169	0.270	3.1	2.29	185.0	18500.0
10:55	14:55	Left Fork	0.014	0.040	<0.03	0.220	0.390	8.7	3.37	387.3	28510.0
12:30	14:55	House well	0.009	0.010	<0.03	0.570	0.570	0.0	2.61	1.0	31.1
7/11/2017	**7/11/2017**	**Grab sample**									

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
10:40	13:48	Spring	0.004	0.008	<0.03	0.296	0.330	1.5	7.60	20.1	>2419.2
11:23	13:48	Upstream farm	0.004	0.026	0.01	0.064	0.110	1.5	2.56	585.0	5860.0
10:26	13:48	Downstream farm	0.006	0.014	<0.03	0.154	0.210	1.5	1.45	55.4	11120.0
10:17	13:48	Left Fork	0.005	0.020	0.02	0.125	0.210	3.0	2.52	73.8	12590.0
10:50	13:48	House well	0.006	0.012	0.03	0.573	0.570	0.3	3.50	<1.0	1.0
7/19/2017	**7/19/2017**	**Grab sample**									
10:51	15:30	Spring	0.002	0.214	0.03	0.295	0.770	156.7	0.75	4.1	1119.9
12:04	15:30	Upstream farm	0.003	0.030	0.01	0.105	0.130	1.3	0.92	27.2	7514.7
10:26	15:30	Downstream farm	0.005	0.016	0.01	0.232	0.280	1.7	0.53	35.0	9060.0
10:12	15:30	Left Fork	0.004	0.018	0.01	0.213	0.310	6.4	1.62	19.3	10810.0
11:40	15:30	House well	0.005	0.012	0.04	0.730	0.730	0.0	0.47	<1.0	<1.0
7/26/2017	**7/26/2017**	**Grab sample**									
7:28	11:40	Spring	0.001	0.248	0.02	0.209	0.760	174.7	3.47	2.0	>2419.2
8:08	11:40	Upstream farm	0.005	0.014	0.04	0.162	0.290	3.6	1.87	166.4	11530.0
7:05	11:40	Downstream farm	0.005	0.018	0.03	0.364	0.450	3.1	1.78	28.1	15660.0
6:51	11:40	Left Fork	0.003	0.016	0.05	0.223	0.370	2.7	1.89	27.8	14670.0
7:44	11:40	House well	0.004	0.012	0.01	0.779	0.820	0.1	2.62	<1.0	<1.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
8/3/2017	**8/3/2017**	**Grab sample**									
11:52	15:08	Spring	0.001	0.036	0.01	0.156	0.240	7.5	3.98	33.1	3680.0
12:32	15:08	Upstream Farm	0.005	0.022	<0.03	0.136	0.210	1.0	0.89	27.2	6500.0
11:25	15:08	Downstream Farm	0.007	0.026	0.02	0.297	0.390	1.5	0.84	43.2	12110.0
11:12	15:08	Left Fork	0.003	0.022	0.04	0.221	0.360	2.0	1.24	14.6	7800.0
12:09	15:08	House well	0.006	0.018	0.02	0.542	0.630	0.0	1.09	<1.0	1.0
8/3/2017	**8/3/2017**	**Storm sample**									
11:25	15:08	Downstream farm	0.000	0.032	0.01	0.185	0.250	1.1	7.88	ND	ND
8/9/2017	**8/9/2017**	**Grab sample**									
11:56	15:00	Spring	0.004	0.024	0.04	0.158	0.200	3.5	0.59	22.8	>2419.2
12:36	15:00	Upstream farm	0.008	0.022	0.04	0.162	0.210	1.0	0.50	177.9	7710.0
11:29	15:00	Downstream farm	0.010	0.036	0.02	0.351	0.440	1.5	0.38	23.1	7980.0
11:11	15:00	Left Fork	0.007	0.032	0.03	0.259	0.370	2.1	0.78	60.9	5300.0
12:10	15:00	House well	0.008	0.020	0.00	0.596	0.630	0.3	0.03	<1.0	<1.0
8/16/2017	**8/16/2017**	**Grab sample**									
7:04	11:50	Spring	0.005	0.094	0.01	0.111	0.470	40.7	7.99	816.4	16690.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
7:58	11:50	Upstream farm	0.010	0.030	<0.03	0.092	0.210	3.9	2.50	648.8	13540.0
6:47	11:50	Downstream farm	0.010	0.028	<0.03	0.216	0.320	3.3	1.66	157.6	12960.0
6:29	11:50	Left Fork	0.010	0.028	0.01	0.659	0.770	4.6	2.20	517.2	15530.0
7:24	11:50	House well	0.016	0.016	<0.03	0.652	0.650	0.3	1.83	<1.0	2.0
8/24/2016	**8/24/2016**	**Grab sample**									
11:58	14:55	Spring	0.005	0.064	<0.03	0.075	0.360	27.0	4.38	435.2	20140.0
12:38	14:55	Upstream farm	0.011	0.038	<0.03	0.132	0.280	3.3	2.35	344.8	18420.0
11:23	14:55	Downstream farm	0.012	0.040	0.01	0.192	0.330	3.5	2.37	261.3	31300.0
11:11	14:55	Left Fork	0.011	0.044	<0.03	0.175	0.330	5.3	2.14	461.1	17820.0
12:15	14:55	House well	0.014	0.018	<0.03	0.625	0.640	0.2	0.59	<1.0	4.1
8/24/2017	**8/24/2017**	**Storm sample**									
11:23	14:55	Downstream farm	0.007	0.126	<0.03	0.182	0.570	38.1	26.88	ND	ND
8/31/2017	**8/31/2017**	**Grab sample**									
11:28	14:15	Spring	0.008	0.084	0.16	0.299	0.520	42.3	2.77	101.7	7490.0
11:55	14:15	Upstream farm	0.009	0.024	0.02	0.075	0.150	1.5	0.73	105.0	5370.0
11:18	14:15	Downstream farm	0.010	0.026	<0.03	0.167	0.230	2.7	1.08	47.2	10460.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
11:00	14:15	Left Fork	0.008	0.024	<0.03	0.063	0.140	2.2	0.00	55.7	6570.0
11:41	14:15	House well	0.010	0.018	0.01	0.664	0.660	0.5	0.52	1.0	4.1
9/6/2017	**9/6/2017**	**Grab sample**									
8:41	12:15	Spring	0.006	0.116	<0.03	0.255	0.550	62.8	1.06	31.7	2419.2
9:20	12:15	Upstream farm	0.008	0.020	<0.03	0.126	0.180	1.1	0.50	66.3	4280.0
8:22	12:15	Downstream farm	0.019	0.019	0.01	0.246	0.330	1.7	0.51	51.2	6970.0
8:06	12:15	Left Fork	0.011	0.024	0.01	0.101	0.200	1.9	0.76	133.3	7800.0
8:57	12:15	House well	0.010	0.018	0.01	0.669	0.690	0.3	0.25	<1.0	<1.0
9/13/2017	**9/13/2017**	**Grab sample**									
10:02	13:25	Spring	0.007	0.132	0.01	0.193	0.400	80.0	0.85	8.6	6970.0
10:30	13:25	Upstream farm	0.011	0.022	0.01	0.132	0.220	2.3	0.87	410.6	16070.0
9:46	13:25	Downstream farm	0.015	0.024	0.02	0.355	0.430	2.5	0.52	18.7	7280.0
9:36	13:25	Left Fork	0.010	0.028	0.02	0.130	0.220	1.7	0.69	18.7	6270.0
10:15	13:25	House well	0.012	0.016	0.02	0.664	0.690	1.2	0.33	<1.0	<1.0
9/21/2017	**9/21/2017**	**Grab sample**									
10:50	14:40	Downstream farm	0.012	0.026	0.02	0.418	0.470	1.8	1.93	101.4	6240.0
10:34	14:40	Left Fork	0.007	0.026	<0.03	0.143	0.270	2.1	2.43	10.9	6380.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
11:25	14:40	House well	0.007	0.016	<0.03	0.671	0.680	0.0	1.33	<1.0	1.0
9/28/2017	**9/28/2017**	**Grab sample**									
11:29	14:19	Downstream farm	0.015	0.028	0.04	0.402	0.480	1.3	2.14	62.7	3320.0
11:17	14:19	Left Fork	0.010	0.026	0.02	0.106	0.200	1.8	2.64	3.1	7120.0
11:45	14:19	House well	0.014	0.018	0.03	0.623	0.680	0.6	2.16	<1.0	<1.0
10/5/2017	**10/5/2017**	**Grab sample**									
9:15	13:20	Downstream farm	0.014	0.022	0.01	0.478	0.560	2.1	0.76	99.1	7030.0
9:03	13:20	Left Fork	0.011	0.022	0.01	0.135	0.240	2.3	0.24	10.9	8570.0
9:46	13:20	House well	0.014	0.014	0.03	0.660	0.690	0.2	0.60	<1.0	17.5
10/12/2017	**10/12/2017**	**Grab sample**									
8:13	12:40	Downstream farm	0.012	0.024	0.02	0.511	0.580	0.7	0.55	72.7	3690.0
8:01	12:40	Left Fork	0.011	0.020	<0.03	0.122	0.180	0.8	0.80	17.3	4410.0
8:40	12:40	House well	0.010	0.016	<0.03	0.660	0.730	0.0	0.28	<1.0	<1.0
10/18/2017	**10/18/2017**	**Grab sample**									
12:12	15:00	Downstream farm	0.012	0.020	0.02	0.495	0.700	2.1	0.42	11.0	3010.0
11:59	15:00	Left Fork	0.010	0.018	0.01	0.129	0.270	2.3	1.14	4.1	3640.0
12:35	15:00	House well	0.009	0.010	0.01	0.632	0.780	0.5	0.04	<1.0	1.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
10/23/2017	**10/23/2017**	**Grab sample**									
12:00	15:20	Spring	0.011	0.220	0.04	0.402	1.100	124.4	4.37	1986.3	28090.0
12:52	15:20	Upstream farm	0.025	0.042	0.02	0.469	0.640	1.7	1.26	1046.2	39680.0
11:28	15:20	Downstream farm	0.017	0.044	0.02	1.056	1.370	4.5	2.25	1732.9	270.0
11:10	15:20	Left Fork	0.022	0.058	0.01	1.042	1.350	5.9	2.36	3090.0	39680.0
12:31	15:20	House well	0.010	0.012	<0.03	0.641	0.800	0.0	0.13	<1.0	6.3
10/23/2017	**10/23/2017**	**Storm sample**									
12:16	15:20	Ephemeral stream	0.109	0.348	0.70	5.834	9.820	538.3	13.53	ND	ND
11/1/2017	**11/1/2017**	**Grab sample**									
8:06	12:15	Downstream farm	0.017	0.024	0.02	0.510	0.650	1.5	0.22	20.1	4260.0
7:51	12:15	Left Fork	0.010	0.014	0.01	0.189	0.270	0.0	0.94	23.8	2419.2
8:43	12:15	House well	0.012	0.018	0.01	0.833	0.960	0.0	0.24	<1.0	<1.0
11/9/2017	**11/9/2017**	**Grab sample**									
7:59	12:05	Downstream farm	0.013	0.018	0.02	0.466	0.570	0.7	6.04	9.8	6440.0
7:42	12:05	Left Fork	0.009	0.016	0.01	0.130	0.250	0.6	6.44	16.9	4410.0
8:30	12:05	House well	0.009	0.012	0.01	0.770	0.860	0.3	7.98	<1.0	<1.0
11/15/2017	**11/15/2017**	**Grab sample**									

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
7:36	13:15	Downstream farm	0.013	0.022	0.04	0.475	0.660	4.1	0.63	6.3	4640.0
7:24	13:15	Left Fork	0.006	0.015	0.03	0.142	0.260	0.2	0.68	3.1	198630.0
8:54	13:15	House well	0.007	0.007	0.02	0.789	0.850	0.0	0.00	<1.0	1.0
9:10	13:15	Trench 2	0.009	0.275	0.06	5.959	8.280	23.0	4.20	9080.0	241960
11/15/2017	**11/15/2017**	**Storm grab sample**									
8:37	13:15	Downstream farm	0.036	0.085	0.04	0.443	0.770	18.5	2.04	4220.0	61310.0
8:27	13:15	Left Fork	0.012	0.021	0.04	0.155	0.340	1.1	1.01	124.6	7430.0
11/30/2017	**11/30/2017**	**Grab sample**									
7:45	12:20	Downstream farm	0.012	0.029	0.05	0.361	0.500	0.9	0.11	2.0	2419.2
7:28	12:20	Left Fork	0.005	0.016	0.05	0.122	0.230	1.1	0.48	10.0	1732.0
8:24	12:20	House well	0.009	0.024	0.04	0.717	0.850	0.0	0.00	<1.0	<1.0
12/13/2017	**12/13/2017**	**Grab sample**									
8:15	12:35	Upstream farm	0.007	0.164	0.01	0.067	0.100	0.3	0.41	10.8	>2419.2
7:25	12:35	Downstream farm	0.012	0.016	0.02	0.438	0.520	1.1	0.16	3.1	1553.1
7:04	12:35	Left Fork	0.005	0.007	0.01	0.256	0.300	0.1	0.34	8.4	1299.7
7:57	12:35	House well	0.010	0.011	0.03	0.683	0.840	0.3	0.00	<1.0	2.0
12/18/2017	**12/18/2017**	**Grab sample**									

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
12:02	14:43	Downstream farm	0.011	0.011	0.02	0.356	0.460	1.0	1.61	7.1	>2419.2
11:15	14:43	Left Fork	0.004	0.004	0.01	0.194	0.300	0.0	1.53	27.2	>2419.2
11:33	14:43	House well	0.010	0.010	0.02	0.683	0.810	0.5	1.76	<1.0	<1.0
1/4/2018	**1/4/2018**	**Grab sample**									
12:45	15:20	Upstream farm	0.006	0.006	0.01	0.165	0.270	1.3	2.19	18.3	2880.0
12:05	15:20	Downstream farm	0.009	0.009	0.01	0.300	0.410	0.5	2.22	2.0	613.1
11:52	15:20	Left Fork	0.004	0.005	0.01	0.228	0.310	0.7	1.58	1.0	461.1
12:22	15:20	House well	0.007	0.007	0.01	0.683	0.840	0.1	3.05	<1.0	1.0
1/18/2018	**1/18/2018**	**Grab sample**									
11:50	14:45	Upstream farm	0.005	0.005	0.02	0.125	0.180	0.5	2.14	24.7	>2419.2
11:01	14:45	Downstream farm	0.007	0.007	0.01	0.214	0.300	0.5	1.97	14.5	547.5
10:45	14:45	Left Fork	0.002	0.002	0.01	0.128	0.180	0.6	1.17	1.0	461.1
11:24	14:45	House well	0.006	0.006	0.03	0.670	0.820	0.3	0.72	<1.0	<1.0
1/30/2018	**1/30/2018**	**Grab sample**									
12:13	14:30	Upstream farm	0.006	0.007	0.00	0.143	0.210	1.1	2.40	18.9	613.1
11:36	14:30	Downstream farm	0.005	0.005	0.00	0.163	0.230	4.6	2.22	4.1	579.4

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
11:24	14:30	Left Fork	0.005	0.005	0.00	0.216	0.280	4.0	2.37	9.7	686.7
12:00	14:30	House well	0.009	0.009	0.00	0.642	0.800	0.4	4.84	<1.0	<1.0
2/14/2018	**2/14/2018**	**Grab sample**									
10:46	13:20	Upstream farm	0.006	0.006	0.01	0.064	0.090	0.7	0.82	53.0	613.1
10:00	13:20	Downstream farm	0.008	0.008	0.01	0.150	0.220	1.4	1.29	35.5	816.1
9:44	13:20	Left Fork	0.004	0.004	0.01	0.143	0.130	1.2	1.29	13.4	866.4
10:31	13:20	House well	0.008	0.008	0.04	0.711	0.820	0.6	1.27	<1.0	<1.0
2/21/2018	**2/21/2018**	**Storm sample**									
11:32	15:32	Field 5a	1.496	2.078	0.14	0.307	2.990	66.9	17.12	ND	ND
2/22/2018	**2/22/2018**	**Grab sample**									
11:16	14:35	Spring	0.010	0.032	0.02	0.560	0.780	1.1	8.28	86.0	>2419.2
12:16	14:35	Upstream farm	0.008	0.043	0.01	0.358	0.460	5.7	2.89	261.3	>2419.2
11:00	14:35	Downstream farm	0.011	0.050	0.03	0.499	0.720	6.5	3.19	387.3	2650.0
12:04	14:35	Ephemeral stream	0.009	0.037	0.01	1.869	2.030	1.4	4.22	90.6	2720.0
10:52	14:35	Left Fork	0.015	0.057	0.02	0.660	0.880	7.4	3.32	238.2	4130.0
11:38	14:35	House well	0.007	0.024	0.01	0.697	0.900	0.2	3.19	<1.0	<1.0
11:43	14:35	Trench 1	0.008	0.043	0.06	1.334	1.590	2.1	3.55	8.4	6113.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
2/26/2018	**2/26/2018**	**Storm sample**									
11:52	15:40	Ephemeral stream	0.061	0.173	0.04	1.735	2.720	56.5	6.34	ND	ND
12:05	15:40	Field 5a	0.735	1.495	0.12	0.087	2.280	175.5	7.22	ND	ND
3/1/2018	**3/1/2018**	**Grab sample**									
11:43	15:00	Spring	0.014	0.037	0.00	0.284	0.540	6.9	5.44	74.4	613.1
12:36	15:00	Upstream farm	0.009	0.032	0.01	0.226	0.370	0.0	1.94	325.5	1732.9
11:29	15:00	Downstream farm	0.008	0.035	0.01	0.337	0.460	2.9	2.17	142.1	1413.6
12:24	15:00	Ephemeral stream	0.010	0.029	0.00	1.078	1.310	0.9	5.62	90.7	>2419.2
11:20	15:00	Left Fork	0.011	0.037	0.01	0.349	0.490	2.6	2.26	137.6	1986.3
11:55	15:00	House well	0.014	0.031	0.02	0.655	0.770	0.5	3.77	8.5	16.0
12:06	15:00	Trench 1	0.007	0.024	0.01	1.668	1.850	0.5	1.89	1.0	235.9
3/7/2018	**3/7/2018**	**Grab sample**									
11:21	15:10	Spring	0.008	0.033	0.01	0.790	1.100	20.2	2.74	34.1	613.1
12:06	15:10	Upstream farm	0.006	0.009	0.00	0.177	0.260	1.6	1.02	35.5	344.8
11:03	15:10	Downstream farm	0.008	0.013	0.00	0.356	0.480	1.3	1.07	29.9	613.1
11:31	15:10	Ephemeral stream	0.008	0.010	0.01	0.764	0.980	1.5	0.72	101.4	5940.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
10:50	15:10	Left Fork	0.009	0.009	0.00	0.345	0.460	0.8	0.81	63.1	579.4
11:40	15:10	House well	0.012	0.012	0.04	0.679	0.840	0.7	0.81	<1.0	<1.0
3/14/2018	**3/14/2018**	**Grab sample**									
12:20	15:00	Upstream farm	0.006	0.006	0.00	0.072	0.160	0.6	0.69	118.3	461.1
11:38	15:00	Downstream farm	0.007	0.019	0.00	0.254	0.410	0.2	0.81	24.3	387.3
11:25	15:00	Left Fork	0.006	0.006	0.00	0.175	0.270	0.5	1.21	18.3	365.4
3/29/2018	**3/29/2018**	**Grab sample**									
12:13	15:50	Spring	0.007	0.035	0.00	0.127	0.470	7.3	6.01	1046.2	21430.0
13:30	15:50	Upstream farm	0.037	0.167	0.01	0.149	0.840	99.3	6.10	3840.0	30760.0
12:35	15:50	Ephemeral stream	0.039	0.075	0.02	0.870	1.430	8.6	4.64	5370.0	27550.0
11:45	15:50	Left Fork	0.066	0.275	0.03	0.141	0.950	147.9	7.90	10460.0	54750.0
12:40	15:50	House well	0.013	0.013	0.02	0.648	0.830	0.1	1.28	<1.0	5.2
12:50	15:50	Trench 1	0.003	0.040	0.02	1.014	1.600	3.8	5.22	770.1	32550.0
13:05	15:50	Field 5a	2.067	2.247	0.05	0.296	1.750	27.1	12.48	72700.0	>241920
3/29/2018	**3/29/2018**	**Storm sample**									
11:56	15:50	Downstream farm	0.003	0.079	0.01	0.016	0.590	44.1	27.16	ND	ND
4/5/2018	**4/5/2018**	**Grab sample**									

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
9:39	14:10	Spring	0.008	0.008	0.00	0.448	0.650	2.7	3.29	21.8	648.8
10:34	14:10	Upstream farm	0.006	0.006	0.00	0.115	0.190	1.3	1.17	62.0	727.0
9:19	14:10	Downstream farm	0.006	0.006	0.00	0.268	0.380	1.8	1.31	224.7	1046.2
9:54	14:10	Ephemeral stream	0.005	0.005	0.00	0.778	0.980	1.1	2.38	40.8	2419.2
9:01	14:10	Left Fork	0.007	0.007	0.00	0.277	0.410	2.0	1.63	104.6	1046.2
10:07	14:10	House well	0.007	0.007	0.00	0.524	0.810	0.7	2.38	<1.0	5.2
11:00	14:10	Trench 1	0.002	0.002	0.01	1.291	1.470	0.9	0.88	1.0	275.5
4/12/2018	**4/12/2018**	**Grab sample**									
8:31	13:15	Spring	0.008	0.008	0.00	0.848	1.050	0.9	12.16	8.4	410.6
9:21	13:15	Upstream farm	0.003	0.003	0.00	0.051	0.110	0.9	4.09	98.7	1119.9
8:13	13:15	Downstream farm	0.004	0.004	0.00	0.189	0.280	0.9	3.25	74.9	1119.9
8:46	13:15	Ephemeral stream	0.004	0.004	0.00	0.717	0.870	0.3	5.75	30.9	>2419.2
7:58	13:15	Left Fork	0.003	0.003	0.00	0.156	0.250	0.7	3.15	45.7	1203.3
4/16/2018	**4/16/2018**	**Storm sample**									
12:30	15:00	Ephemeral stream	0.009	0.038	0.04	0.920	1.230	7.2	2.20	ND	ND
4/19/2018	**4/19/2018**	**Grab sample**									

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
10:37	15:30	Spring	0.008	0.008	0.00	0.772	1.030	0.8	1.94	22.8	410.6
11:17	15:30	Upstream farm	0.006	0.009	0.00	0.076	0.170	0.9	0.99	88.0	866.4
10:15	15:30	Downstream farm	0.005	0.014	0.00	0.154	0.250	1.3	0.95	113.7	1553.1
10:51	15:30	Ephemeral stream	0.003	0.004	0.00	0.654	0.820	0.7	1.09	29.2	1986.3
10:01	15:30	Left Fork	0.004	0.007	0.00	0.113	0.230	1.3	1.17	127.4	2419.2
11:04	15:30	House well	0.006	0.006	0.01	0.642	0.830	0.1	7.41	<1.0	<1.0
4/23/2018	**4/23/2018**	**Storm sample**									
11:10	15:05	Ephemeral stream	0.002	0.014	0.02	0.680	0.940	10.4	7.70	ND	ND
4/26/2018	**4/26/2018**	**Grab sample**									
11:30	15:10	Spring	0.006	0.032	0.00	0.131	0.390	2.0	6.56	547.5	2419.2
12:23	15:10	Upstream farm	0.004	0.022	0.00	0.057	0.150	2.4	1.94	307.6	3500.0
11:15	15:10	Downstream farm	0.004	0.029	0.00	0.081	0.230	4.5	1.98	686.7	5120.0
11:42	15:10	Ephemeral stream	0.005	0.010	0.00	0.799	1.050	0.3	2.03	60.1	2419.2
11:05	15:10	Left Fork	0.003	0.014	0.00	0.069	0.210	2.5	1.86	292.4	2010.0
11:53	15:10	House well	0.008	0.009	0.00	0.628	0.770	0.3	1.60	<1.0	2.0
5/3/2018	**5/3/2018**	**Grab sample**									

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
10:00	13:44	Spring	0.007	0.058	0.00	0.115	0.500	4.9	6.06	1046.2	54750.0
11:04	13:44	Upstream farm	0.054	0.305	0.02	0.106	1.080	17.2	3.90	15000.0	173290
9:47	13:44	Downstream farm	0.010	0.065	0.01	0.095	0.400	74.9	5.62	3730.0	23820.0
10:28	13:44	Ephemeral stream	0.017	0.033	0.00	0.919	1.120	16.2	5.81	248.9	13790.0
9:38	13:44	Left Fork	0.023	0.150	0.01	0.167	0.850	20.9	6.38	7540.0	86640.0
10:38	13:44	House well	0.009	0.026	0.00	0.661	0.760	0.6	1.62	<1.0	2.0
10:45	13:44	Trench 1	0.004	0.048	0.00	0.636	0.880	5.9	2.52	135.4	54750.0
10:45	13:44	Trench 2	0.004	0.320	0.02	0.240	1.770	32.1	15.79	290.9	241920
10:15	13:44	Field 1	0.273	0.467	0.06	0.037	1.750	27.5	8.12	41060.0	241920
5/3/2018	**5/3/2018**	**Storm sample**									
10:28	13:44	Ephemeral stream	0.004	0.044	0.01	1.008	1.380	100.8	2.80	ND	ND
5/17/2018	**5/17/2018**	**Grab sample**									
8:09	12:30	Spring	0.005	0.023	0.01	0.673	0.870	13.1	3.78	16.0	579.4
8:53	12:30	Upstream farm	0.004	0.010	0.01	0.130	0.240	2.6	1.67	101.7	3500.0
7:48	12:30	Downstream farm	0.007	0.022	0.02	0.275	0.440	1.8	1.47	82.0	8200.0
7:33	12:30	Left Fork	0.006	0.012	0.02	0.268	0.430	2.0	2.12	26.9	2490.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
8:30	12:30	House well	0.005	0.006	0.01	0.814	0.930	0.3	1.13	1.0	2.0
5/24/2018	**5/24/2018**	**Grab sample**									
11:35	14:40	Spring	0.009	0.017	0.00	0.634	0.780	2.9	1.71	5.1	4260.0
12:25	14:40	Upstream farm	0.006	0.015	0.00	0.118	0.220	1.1	0.93	517.2	17890.0
11:25	14:40	Downstream farm	0.010	0.017	0.01	0.315	0.460	1.3	0.84	41.1	2419.2
11:15	14:40	Left Fork	0.008	0.015	0.02	0.318	0.510	2.5	1.07	33.7	4020.0
12:05	14:40	House well	0.009	0.012	0.01	0.666	0.770	0.5	0.96	<1.0	<1.0
5/31/2018	**5/31/2018**	**Grab sample**									
11:17	14:45	Spring	0.005	0.012	0.00	0.473	0.640	2.0	2.35	74.3	8360.0
11:43	14:45	Upstream farm	0.006	0.015	0.00	0.085	0.200	1.6	1.13	90.6	4080.0
11:05	14:45	Downstream farm	0.008	0.014	0.01	0.198	0.340	1.9	1.13	66.9	4570.0
11:00	14:45	Left Fork	0.006	0.014	0.01	0.146	0.290	3.1	1.22	60.9	3450.0
11:30	14:45	House well	0.007	0.010	0.01	0.661	0.780	0.1	0.55	<1.0	<1.0
6/7/2018	**6/7/2018**	**Grab sample**									
8:04	12:10	Spring	0.008	0.027	0.00	0.578	0.770	5.8	23.88	145.0	8300.0
8:31	12:10	Upstream farm	0.011	0.020	0.01	0.124	0.230	2.2	7.79	209.8	6630.0
7:51	12:10	Downstream farm	0.009	0.021	0.04	0.112	0.420	2.5	7.51	111.9	4880.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
7:39	12:10	Left Fork	0.009	0.024	0.06	0.189	0.390	3.4	7.93	58.1	8860.0
8:18	12:10	House well	0.008	0.012	0.01	0.825	0.940	0.7	12.33	<1.0	<1.0
6/13/2018	**6/13/2018**	**Grab sample**									
12:53	16:10	Spring	0.005	0.020	0.00	0.707	0.940	6.4	4.08	74.9	8130.0
12:44	16:10	Upstream farm	0.004	0.017	0.01	0.107	0.290	8.9	1.35	648.8	8300.0
10:51	16:10	Downstream farm	0.008	0.012	0.01	0.320	0.470	1.2	0.94	61.3	5040.0
10:40	16:10	Left Fork	0.006	0.014	0.02	0.213	0.440	2.9	1.46	38.2	6630.0
12:30	16:10	House well	0.006	0.006	0.00	0.669	0.800	0.1	0.52	<1.0	2.0
6/28/2018	**6/28/2018**	**Grab sample**									
12:38	15:00	Upstream farm	0.008	0.013	0.02	0.217	0.370	1.4	1.84	66.3	985.0
12:00	15:00	Downstream farm	0.008	0.023	0.02	0.375	0.580	8.4	1.96	8.6	374.0
11:45	15:00	Left Fork	0.003	0.013	0.02	0.129	0.350	2.4	2.06	5.2	798.0
12:12	15:00	House well	0.007	0.007	0.00	0.660	0.790	0.0	2.75	<1.0	<1.0
7/5/2018	**7/5/2018**	**Grab sample**									
11:38	15:40	Downstream farm	0.008	0.021	0.02	0.405	0.600	2.3	2.59	14.5	6840.0
11:28	15:40	Left Fork	0.002	0.019	0.01	0.152	0.390	1.8	3.09	1.0	10500.0
12:10	15:40	House well	0.005	0.014	0.00	0.677	0.820	1.1	2.15	0.0	6.3

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
7/12/2018	**7/12/2018**	**Grab sample**									
7:07	11:20	Downstream farm	0.008	0.008	0.02	0.480	0.660	1.7	2.79	93.3	7270.0
6:47	11:20	Left Fork	0.007	0.007	0.02	0.120	0.350	2.2	3.61	5.2	11060.0
7:36	11:20	House well	0.006	0.006	0.00	1.098	1.230	0.2	1.70	0.0	1.0
7/18/2018	**7/18/2018**	**Grab sample**									
6:44	11:00	Downstream farm	0.013	0.017	0.03	0.487	0.660	1.9	0.43	114.5	8570.0
6:31	11:00	Left Fork	0.011	0.016	0.03	0.120	0.320	1.7	1.27	13.2	11980.0
7:12	11:00	House well	0.010	0.017	0.01	1.587	1.670	1.1	1.23	<1.0	<1.0
7/25/2018	**7/25/2018**	**Grab sample**									
11:08	13:45	Downstream farm	0.008	0.008	0.00	0.418	0.590	1.7	1.10	13.2	7230.0
10:56	13:45	Left Fork	0.006	0.010	0.00	0.102	0.280	2.5	1.99	2.0	8600.0
11:22	13:45	House well	0.007	0.007	0.00	0.697	0.840	0.1	6.11	<1.0	<1.0
8/1/2018	**8/1/2018**	**Grab sample**									
11:35	15:00	Spring	0.007	0.028	0.02	2.471	2.990	8.5	4.60	920.8	155310
12:30	15:00	Upstream farm	0.020	0.036	0.03	0.832	1.200	4.0	4.09	1732.9	20460.0
11:17	15:00	Downstream farm	0.008	0.013	0.02	0.605	0.800	2.2	0.93	101.4	10711.0
11:03	15:00	Left Fork	0.006	0.015	0.02	0.482	0.730	3.6	1.44	95.9	9330.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
12:05	15:00	House well	0.009	0.009	0.02	0.697	0.790	0.8	0.54	<1.0	3.1
8/9/2018	**8/9/2018**	**Grab sample**									
11:38	14:15	Spring	0.008	0.008	0.00	0.367	0.460	2.0	1.21	43.7	28510.0
11:21	14:15	Downstream farm	0.012	0.012	0.01	0.418	0.560	1.5	0.48	74.9	5830.0
11:08	14:15	Left Fork	0.007	0.007	0.01	0.126	0.280	2.8	1.15	32.7	7380.0
11:53	14:15	House well	0.010	0.010	0.01	0.712	0.850	0.9	0.02	<1.0	<1.0
8/16/2018	**8/16/2018**	**Grab sample**									
12:33	15:15	Upstream farm	0.009	0.009	0.00	0.245	0.340	1.4	1.62	210.5	7540.0
12:43	15:15	Downstream farm	0.009	0.009	0.01	0.486	0.630	1.5	1.30	49.5	5650.0
13:01	15:15	Left Fork	0.006	0.006	0.01	0.413	0.630	36.6	2.02	10.9	4640.0
12:00	15:15	House well	0.008	0.008	0.00	0.682	0.770	0.0	2.37	<1.0	<1.0
8/23/2018	**8/23/2018**	**Grab sample**									
13:05	15:25	Upstream farm	0.009	0.010	0.01	0.110	0.160	1.5	1.39	75.4	4040.0
11:41	15:25	Downstream farm	0.008	0.011	0.02	0.245	0.320	1.7	1.43	44.3	3690.0
11:27	15:25	Left Fork	0.004	0.008	0.03	0.118	0.220	2.2	1.77	57.3	3310.0
12:50	15:25	House well	0.007	0.007	0.01	0.701	0.750	0.0	0.88	<1.0	<1.0
8/30/2018	**8/30/2018**	**Grab sample**									

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
13:20	15:30	Upstream farm	0.008	0.008	0.01	0.138	0.290	1.3	3.35	1203.3	10710.0
11:58	15:30	Downstream farm	0.018	0.041	0.02	0.474	0.810	20.1	2.15	1986.3	57940.0
11:40	15:30	Left Fork	0.010	0.022	0.01	0.302	0.580	7.1	2.27	248.9	10810.0
12:56	15:30	House well	0.007	0.007	0.00	0.686	0.840	0.3	11.68	<1.0	3.0
8/30/2018	**8/30/2018**	**Storm sample**									
12:20	15:30	Field 1	1.617	1.875	0.69	1.869	5.510	49.6	17.02	ND	ND
9/6/2018	**9/6/2018**	**Grab sample**									
7:27	11:50	Downstream farm	0.012	0.016	0.02	0.431	0.600	2.9	0.96	143.9	5380.0
7:10	11:50	Left Fork	0.007	0.007	0.02	0.174	0.350	3.6	1.02	45.7	7890.0
7:58	11:50	House well	0.006	0.006	0.00	0.732	0.820	0.5	0.32	<1.0	4.1
9/11/2018	**9/11/2018**	**Grab sample**									
9:42	13:10	Downstream farm	0.012	0.020	0.02	0.382	0.530	2.6	4.27	50.4	5040.0
9:30	13:10	Left Fork	0.007	0.014	0.01	0.162	0.290	2.9	4.38	27.8	5460.0
10:05	13:10	House well	0.007	0.011	0.00	0.747	0.860	0.5	5.46	<1.0	1.0
9/25/2018	**9/25/2018**	**Grab sample**									
11:40	15:00	Spring	0.010	0.034	0.00	1.386	1.840	17.8	17.41	290.9	14670.0
12:23	15:00	Upstream farm	0.016	0.024	0.00	0.202	0.320	3.2	5.90	1046.2	22820.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
11:17	15:00	Downstream farm	0.014	0.026	0.00	0.370	0.570	5.1	5.84	410.6	17250.0
11:05	15:00	Left Fork	0.009	0.013	0.00	0.363	0.500	3.8	4.50	172.2	10810.0
12:05	15:00	House well	0.009	0.010	0.00	0.725	0.800	0.9	3.12	<1.0	3.1
10/2/2018	**10/2/2018**	**Grab sample**									
7:04	11:20	Downstream farm	0.014	0.018	0.01	0.365	0.500	2.9	1.56	ND	ND
6:47	11:20	Left Fork	0.006	0.013	0.01	0.115	0.250	2.3	1.51	ND	ND
7:34	11:20	House well	0.008	0.012	0.00	1.080	1.180	0.7	2.08	ND	ND
10/11/2018	**10/11/2018**	**Grab sample**									
11:33	15:20	Spring	0.013	0.036	0.00	1.674	1.980	12.5	12.64	686.7	16160.0
12:40	15:20	Upstream farm	0.016	0.029	0.00	0.280	0.460	2.2	3.80	235.9	16310.0
11:18	15:20	Downstream farm	0.019	0.034	0.00	0.561	0.790	4.0	3.65	770.1	17250.0
11:00	15:20	Left Fork	0.013	0.028	0.00	0.772	1.040	6.4	4.02	488.4	13760.0
12:18	15:20	House well	0.008	0.008	0.00	0.722	0.820	0.2	5.39	<1.0	<1.0
10/11/2018	**10/11/2018**	**Storm sample**									
11:57	15:20	Ephemeral stream	0.075	0.166	0.00	2.223	2.910	59.5	6.79	ND	ND
11:45	15:20	Field 1	1.941	2.103	0.40	2.942	5.830	12.3	21.23	ND	ND
10/16/2018	**10/16/2018**	**Grab sample**									

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
7:19	11:40	Spring	0.008	0.031	0.00	1.342	1.790	19.1	4.94	410.6	12360.0
8:18	11:40	Upstream farm	0.011	0.023	0.00	0.183	0.390	3.5	1.94	195.6	7270.0
7:04	11:40	Downstream farm	0.013	0.019	0.00	0.273	0.470	5.1	1.60	198.9	11530.0
6:52	11:40	Left Fork	0.010	0.010	0.00	0.384	0.550	2.7	1.37	156.5	6690.0
7:47	11:40	Trench 1	0.002	0.002	0.00	0.156	0.240	0.4	8.02	12.1	2620.0
10/24/2018	**10/24/2018**	**Grab sample**									
7:19	11:30	Spring	0.009	0.027	0.01	1.670	1.880	14.3	2.78	29.4	2419.2
8:17	11:30	Upstream farm	0.008	0.015	0.01	0.223	0.300	2.3	0.91	40.4	2419.2
7:05	11:30	Downstream farm	0.011	0.015	0.01	0.434	0.550	2.8	0.96	57.6	2720.0
6:44	11:30	Left Fork	0.008	0.011	0.01	0.342	0.470	2.5	1.33	45.0	3130.0
7:33	11:30	House well	0.007	0.016	0.00	1.745	1.810	1.3	0.15	<1.0	214.3
11/1/2018	**11/1/2018**	**Grab sample**									
11:40	15:05	Spring	0.007	0.025	0.00	1.348	1.660	5.7	9.05	238.2	8330.0
12:40	15:05	Upstream farm	0.018	0.056	0.00	0.268	0.510	11.0	4.04	686.7	20140.0
11:12	15:05	Downstream farm	0.028	0.079	0.00	0.368	0.660	17.7	4.74	920.8	12220.0
11:53	15:05	Ephemeral stream	0.007	0.026	0.00	1.967	2.100	2.7	3.98	307.6	4620.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
11:00	15:05	Left Fork	0.028	0.082	0.00	0.435	0.770	16.7	5.06	866.4	19350.0
12:04	15:05	House well	0.008	0.008	0.01	0.744	0.790	1.6	4.97	6.3	49.6
12:15	15:05	Trench 1	0.002	0.050	0.00	0.465	0.930	4.0	5.29	488.4	43520.0
12:22	15:05	Trench 2	0.003	0.067	0.00	1.306	2.010	4.6	6.69	866.4	68670.0
11/1/2018	**11/1/2018**	**Storm sample**									
11:53	15:05	Ephemeral stream	0.022	0.094	0.01	2.207	2.790	49.0	6.08	ND	ND
11:30	15:05	Field 1	0.955	1.171	0.38	0.719	3.000	39.3	13.17	ND	ND
11/7/2018	**11/7/2018**	**Grab sample**									
8:00	12:30	Spring	0.010	0.011	0.01	1.354	1.460	5.5	0.61	47.1	2920.0
9:25	12:30	Upstream farm	0.011	0.015	0.02	0.177	0.250	4.3	1.21	41.6	>2419.2
7:42	12:30	Downstream farm	0.013	0.018	0.01	0.410	0.520	4.3	0.99	86.2	>2419.2
8:16	12:30	Ephemeral stream	0.009	0.009	0.01	0.862	1.510	2.5	1.61	35.0	1732.9
7:25	12:30	Left Fork	0.013	0.024	0.01	0.397	0.520	4.5	1.30	73.3	>2419.2
8:27	12:30	House well	0.008	0.008	0.00	0.863	0.940	2.8	0.36	<1.0	46.4
8:45	12:30	Trench 1	0.002	0.002	0.01	0.612	0.740	3.3	0.66	12.2	980.4
8:57	12:30	Trench 2	0.004	0.004	0.01	0.999	1.210	3.0	1.74	31.8	241920.0
11/20/2018	**11/20/2018**	**Grab sample**									

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
7:55	11:15	Spring	0.009	0.009	0.26	1.533	1.730	2.2	15.13	10.9	1119.9
8:34	11:15	Upstream farm	0.009	0.009	0.00	0.118	0.170	0.5	5.89	13.2	1299.7
7:41	11:15	Downstream farm	0.012	0.012	0.01	0.378	0.470	0.9	5.07	6.2	980.4
7:31	11:15	Left Fork	0.010	0.010	0.01	0.296	0.370	0.6	5.13	9.6	1986.3
8:12	11:15	House well	0.010	0.010	0.05	1.168	1.300	0.4	5.62	<1.0	10.9
12/5/2018	**12/5/2018**	**Grab sample**									
8:17	11:30	Spring	0.012	0.015	0.00	1.149	1.340	7.5	1.46	28.8	1413.6
8:51	11:30	Upstream farm	0.006	0.009	0.00	0.061	0.120	1.7	0.61	38.4	1119.9
8:01	11:30	Downstream farm	0.008	0.009	0.00	0.190	0.250	1.5	0.72	23.1	1413.9
7:50	11:30	Left Fork	0.006	0.009	0.00	0.171	0.270	1.1	0.83	25.9	1553.1
8:31	11:30	House well	0.006	0.012	0.00	0.821	1.250	1.1	0.40	<1.0	6.3
12/17/2018	**12/17/2018**	**Grab sample**									
11:45	14:45	Spring	0.007	0.035	0.00	0.956	1.300	22.3	10.13	34.5	1299.7
12:00	14:45	Upstream farm	0.005	0.018	0.00	0.203	0.310	1.7	2.93	28.8	1986.3
12:07	14:45	Downstream farm	0.008	0.018	0.00	0.374	0.500	2.1	2.40	36.4	1986.3
11:30	14:45	Ephemeral stream	0.006	0.010	0.00	1.167	1.350	0.8	6.28	32.7	>2419.2

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
12:20	14:45	Left Fork	0.010	0.021	0.00	0.443	0.580	1.5	2.81	55.7	2419.2
11:12	14:45	House well	0.007	0.007	0.00	0.738	0.880	0.5	18.42	<1.0	1.0
1/3/2019	**1/3/2019**	**Grab sample**									
11:45	14:30	Spring	0.007	0.013	<0.03	0.740	0.990	8.8	1.35	26.9	204.6
12:16	14:30	Upstream farm	0.006	0.006	0.01	0.182	0.240	2.3	0.46	47.9	816.4
11:34	14:30	Downstream farm	0.008	0.008	<0.03	0.323	0.400	2.1	0.47	50.4	980.4
11:56	14:30	Ephemeral stream	0.005	0.011	<0.03	1.091	1.220	1.5	0.24	10.9	1732.9
11:25	14:30	Left Fork	0.010	0.010	<0.03	0.358	0.450	2.3	0.58	32.7	1299.7
12:03	14:30	House well	0.007	0.007	<0.03	0.745	0.830	0.9	0.04	<1.0	<1.0
1/16/2019	**1/16/2019**	**Grab sample**									
11:45	15:30	Spring	0.009	0.014	<0.03	1.206	1.370	4.4	0.90	2.0	613.2
12:56	15:30	Upstream farm	0.005	0.010	0.01	0.147	0.200	1.1	0.39	155.3	727.0
11:32	15:30	Downstream farm	0.007	0.011	0.01	0.291	0.340	1.3	0.35	20.1	387.3
12:18	15:30	Ephemeral stream	0.009	0.010	0.02	0.991	1.080	2.5	0.34	3.0	>2419.2
11:16	15:30	Left Fork	0.009	0.010	0.01	0.327	0.400	1.1	0.50	26.2	517.2
12:25	15:30	House well	0.008	0.008	0.01	0.703	0.790	0.5	0.35	<1.0	<1.0
1/31/2019	**1/31/2019**	**Grab sample**									

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
11:32	14:30	Spring	0.009	0.009	<0.03	1.142	1.300	2.5	0.63	3.1	488.4
12:15	14:30	Upstream farm	0.006	0.006	<0.03	0.168	0.200	1.6	0.27	17.3	387.3
11:16	14:30	Downstream farm	0.008	0.008	0.01	0.320	0.390	1.1	0.36	10.9	179.3
11:45	14:30	Ephemeral stream	0.009	0.010	<0.03	1.015	1.140	1.9	0.28	6.3	2419.2
11:06	14:30	Left Fork	0.008	0.008	<0.03	0.316	0.390	0.5	0.43	10.9	325.5
12:01	14:30	House well	0.010	0.010	0.01	0.768	0.820	0.6	0.19	<1.0	<1.0
2/13/2019	**2/13/2019**	**Grab sample**									
11:30	15:15	Spring	0.008	0.027	<0.03	0.692	0.940	8.0	1.26	15.8	1119.9
13:00	15:15	Upstream farm	0.005	0.022	0.02	0.204	0.280	1.0	0.77	148.3	1203.3
10:51	15:15	Downstream farm	0.008	0.027	0.02	0.349	0.490	1.9	0.82	86.0	1553.1
11:43	15:15	Ephemeral stream	0.008	0.019	<0.03	1.131	1.250	2.4	0.33	24.3	1732.9
10:38	15:15	Left Fork	0.010	0.025	0.02	0.428	0.550	1.7	1.63	49.5	1553.1
12:00	15:15	House well	0.008	0.010	0.02	0.642	0.760	0.1	0.66	<1.0	8.4
12:17	15:15	Trench 1	0.001	0.007	0.01	0.595	0.720	0.4	0.70	13.2	9330.0
12:40	15:15	Trench 2	0.004	0.012	0.02	0.899	1.110	0.7	1.30	1.0	980.4
2/27/2019	**2/27/2019**	**Grab sample**									
11:25	14:40	Spring	0.007	0.014	<0.03	0.620	0.860	6.9	4.64	1.0	1732.9

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
12:23	14:40	Upstream farm	0.004	0.008	0.01	0.136	0.210	1.5	1.36	54.6	488.4
11:07	14:40	Downstream farm	0.006	0.010	0.02	0.273	0.370	1.5	0.89	62.0	410.6
11:48	14:40	Ephemeral stream	0.006	0.006	<0.03	0.967	1.120	1.3	1.87	18.5	1553.1
11:55	14:40	House well	0.006	0.006	<0.03	0.690	0.810	0.5	1.26	<1.0	<1.0
3/14/2019	**3/14/2019**	**Grab sample**									
11:54	15:25	Spring	0.007	0.023	<0.03	0.518	0.760	2.0	4.73	22.8	816.4
12:58	15:25	Upstream farm	0.005	0.032	0.02	0.124	0.220	2.5	1.70	135.4	1553.1
11:37	15:25	Downstream farm	0.006	0.036	0.01	0.180	0.320	4.5	1.84	325.5	>2419.2
12:10	15:25	Ephemeral stream	0.006	0.028	<0.03	0.967	1.200	1.8	22.00	52.9	1986.3
11:30	15:25	Left Fork	0.006	0.032	0.01	0.161	0.240	3.0	2.89	186.0	>2419.2
12:15	15:25	House well	0.008	0.012	<0.03	0.711	0.870	0.0	2.73	<1.0	<1.0
12:25	15:25	Trench 1	0.002	0.016	0.01	0.616	0.820	120.1	1.73	<1.0	435.2
12:43	15:25	Trench 2	0.002	0.025	0.01	0.839	1.200	0.2	2.99	<1.0	435.2
3/20/2019	**3/20/2019**	**Grab sample**									
8:01	11:30	Spring	0.007	0.027	0.01	0.735	1.050	18.1	1.05	5.2	298.7
8:42	11:30	Upstream farm	0.003	0.003	<0.03	0.098	0.160	2.1	0.45	344.8	1119.9

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
7:44	11:30	Downstream farm	0.004	0.004	<0.03	0.217	0.300	2.4	0.57	62.4	387.3
8:11	11:30	Ephemeral stream	0.006	0.006	<0.03	0.983	1.160	3.3	0.33	5.2	1119.9
7:34	11:30	Left Fork	0.002	0.002	<0.03	0.178	0.300	2.9	0.68	29.5	547.5
8:17	11:30	House well	0.008	0.008	<0.03	0.726	0.880	0.0	0.16	<1.0	2.0
3/28/2019	**3/28/2019**	**Grab sample**									
7:09	11:20	Spring	0.007	0.052	<0.03	0.703	1.040	35.1	3.39	1.0	365.4
7:55	11:20	Upstream farm	0.002	0.011	<0.03	0.069	0.130	2.0	2.22	123.6	866.4
6:51	11:20	Downstream farm	0.002	0.010	<0.03	0.136	0.210	2.5	1.01	93.3	666.7
7:21	11:20	Ephemeral stream	0.006	0.006	<0.03	0.966	1.130	1.6	7.37	7.4	>2419.2
6:35	11:20	Left Fork	0.001	0.007	<0.03	0.102	0.200	2.9	1.07	9.8	387.3
7:32	11:20	House well	0.006	0.009	<0.03	0.798	0.950	0.5	0.51	<1.0	<1.0
4/8/2019	**4/8/2019**	**Grab sample**									
12:00	15:00	Spring	0.006	0.011	<0.03	0.363	0.550	1.7	31.78	38.8	1046.2
12:40	15:00	Upstream farm	0.007	0.014	<0.03	0.060	0.130	3.6	4.39	193.5	1986.3
11:40	15:00	Downstream farm	0.004	0.022	<0.03	0.091	0.200	4.0	7.01	191.8	2419.2
12:10	15:00	Ephemeral stream	0.004	0.013	<0.03	0.792	0.920	1.7	18.32	37.3	1413.6

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
11:30	15:00	Left Fork	0.001	0.016	<0.03	0.064	0.200	5.1	10.61	178.9	>2419.2
12:25	15:00	House well	0.005	0.005	<0.03	0.678	0.770	0.9	23.13	<1.0	5.2
4/11/2019	**4/11/2019**	**Grab sample**									
11:20	14:10	Spring	0.007	0.012	0.01	0.639	0.800	1.8	1.01	16.1	613.1
11:47	14:10	Upstream farm	0.004	0.009	<0.03	0.048	0.110	2.9	0.47	146.7	1732.9
10:55	14:10	Downstream farm	0.007	0.019	<0.03	0.084	0.200	3.3	0.46	118.7	2419.2
11:28	14:10	Ephemeral stream	0.003	0.012	<0.03	0.823	1.010	5.6	0.34	19.9	>2419.2
10:45	14:10	Left Fork	0.004	0.010	<0.03	0.084	0.160	3.1	0.67	35.9	1203.2
11:33	14:10	House well	0.007	0.009	<0.03	0.671	0.800	0.2	1.58	<1.0	<1.0
4/18/2019	**4/18/2019**	**Grab sample**									
7:11	12:05	Spring	0.004	0.043	<0.03	0.399	0.700	12.7	2.01	866.4	16640.0
8:32	12:05	Upstream farm	0.018	0.104	<0.03	0.113	0.540	38.5	2.32	4130.0	23590.0
6:53	12:05	Downstream farm	0.006	0.046	<0.03	0.173	0.390	18.2	0.81	920.8	5630.0
7:24	12:05	Ephemeral stream	0.009	0.009	<0.03	0.920	1.080	2.8	0.35	31.7	>2419.2
6:35	12:05	Left Fork	0.006	0.020	<0.03	0.231	0.400	4.0	0.62	13960.0	>2419.2
8:01	12:05	Trench 1	0.001	0.062	<0.03	0.399	0.820	14.5	1.12	1046.2	241920
7:53	12:05	Trench 2	0.000	0.107	<0.03	0.120	0.910	20.9	0.14	6090.0	241920

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
4/25/2019	**4/25/2019**	**Grab sample**									
7:32	11:50	Spring	0.008	0.031	<0.03	0.641	1.080	8.7	3.19	1732.9	30760.0
8:47	11:50	Upstream farm	0.010	0.051	<0.03	0.109	0.360	18.8	1.73	2750.0	16640.0
7:11	11:50	Downstream farm	0.027	0.065	0.01	0.208	0.510	18.2	1.56	3270.0	34480.0
7:44	11:50	Ephemeral stream	0.009	0.010	<0.03	0.889	1.110	3.2	0.45	142.1	2490.0
6:49	11:50	Left Fork	0.016	0.043	<0.03	0.256	0.530	13.9	1.07	1986.3	22470.0
7:55	11:50	House well	0.009	0.009	0.01	0.670	0.840	0.3	0.14	1.0	6.3
8:05	11:50	Trench 2	0.002	0.031	0.02	0.155	0.470	4.2	1.47	204.6	48840.0
5/2/2019	**5/2/2019**	**Grab sample**									
12:59	15:35	Spring	0.013	0.027	0.05	0.465	0.720	6.0	1.94	325.5	3410.0
12:42	15:35	Upstream farm	0.009	0.047	0.04	0.103	0.270	11.3	1.77	727.0	9070.0
11:25	15:35	Downstream farm	0.010	0.056	0.04	0.145	0.750	14.9	1.66	613.1	9590.0
12:00	15:35	Ephemeral stream	0.007	0.024	0.03	0.957	1.120	2.7	0.55	159.7	1732.9
11:00	15:35	Left Fork	0.011	0.073	0.04	0.183	2.430	25.0	1.77	547.5	8160.0
12:05	15:35	House well	0.007	0.018	0.06	0.625	0.625	1.0	0.20	1.0	27.5
12:17	15:35	Trench 1	0.002	0.016	0.02	0.420	0.700	1.4	0.73	29.5	4960.0
12:23	15:35	Trench 2	0.003	0.034	0.05	0.150	0.660	3.2	2.03	77.1	19350.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
5/9/2019	**5/9/2019**	**Grab sample**									
6:45	11:25	Spring	0.010	0.017	0.01	0.459	0.660	12.1	1.64	93.3	2890.0
7:51	11:25	Upstream farm	0.006	0.020	0.01	0.158	0.260	5.7	0.91	435.1	2780.0
6:27	11:25	Downstream farm	0.009	0.024	0.02	0.262	0.390	6.9	1.17	275.5	5560.0
6:59	11:25	Ephemeral stream	0.006	0.014	0.01	0.944	1.100	1.2	0.73	167.0	2850.0
6:12	11:25	Left Fork	0.010	0.031	0.02	0.232	0.420	10.0	1.37	261.3	10140.0
7:11	11:25	House well	0.010	0.010	0.02	0.681	0.710	0.2	0.14	<1.0	13.4
7:21	11:25	Trench 1	0.001	0.003	0.01	0.489	0.600	0.9	0.45	115.3	7330.0
7:32	11:25	Trench 2	0.002	0.028	0.02	0.089	0.560	1.9	2.37	114.5	72700.0
5/16/2019	**5/16/2019**	**Grab sample**									
7:05	11:20	Spring	0.008	0.023	0.01	0.394	0.540	10.5	1.73	12.2	686.7
7:47	11:20	Upstream farm	0.005	0.014	0.01	0.136	0.210	3.9	0.73	104.3	2419.2
6:49	11:20	Downstream farm	0.007	0.012	0.05	0.303	0.380	2.3	0.73	81.3	2419.2
7:19	11:20	Ephemeral stream	0.008	0.008	0.04	0.996	1.120	1.1	0.53	23.3	2590.0
6:37	11:20	Left Fork	0.006	0.013	0.03	0.302	0.430	1.8	0.93	118.7	>2419.2
5/22/2019	**5/22/2019**	**Grab sample**									
6:49	11:50	Spring	0.010	0.028	0.01	0.572	0.760	6.9	3.64	547.5	5200.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
8:29	11:50	Upstream farm	0.007	0.068	0.01	0.166	0.380	11.9	2.49	980.4	20350.0
6:24	11:50	Downstream farm	0.010	0.045	0.01	0.254	0.450	10.7	2.29	1299.7	72700.0
7:05	11:50	Ephemeral stream	0.010	0.035	0.01	1.328	1.520	2.5	1.35	517.2	29090.0
6:01	11:50	Left Fork	0.011	0.059	0.02	0.238	0.480	17.3	3.18	1413.6	19350.0
7:16	11:50	House well	0.014	0.014	0.01	0.780	0.970	1.2	0.21	<1.0	5.2
7:29	11:50	Trench 2	0.005	0.006	0.01	0.127	0.200	1.0	1.18	30.9	23820.0
5/30/2019	**5/30/2019**	**Grab sample**									
6:33	11:40	Spring	0.010	0.045	0.02	0.409	0.700	8.9	2.17	1299.7	21870.0
7:46	11:40	Upstream farm	0.015	0.123	0.02	0.115	0.490	68.2	2.86	1553.1	30760.0
6:11	11:40	Downstream farm	0.031	0.179	0.02	0.138	0.700	90.7	3.67	3790.0	141360.0
7:01	11:40	Ephemeral stream	0.013	0.052	0.01	1.381	1.570	10.9	2.05	3800.0	77010.0
5:55	11:40	Left Fork	0.030	0.167	0.02	0.150	0.650	81.7	3.78	>2419.2	51720.0
7:15	11:40	Trench 1	0.004	0.056	0.01	0.366	0.860	5.8	2.49	1553.1	241920.0
7:24	11:40	Trench 2	0.005	0.079	0.02	0.183	1.040	11.4	4.55	17930.0	>241920
6/6/2019	**6/6/2019**	**Grab sample**									
6:51	11:10	Spring	0.014	0.025	0.02	0.426	0.620	8.4	1.07	41.3	1553.1

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
7:41	11:10	Upstream farm	0.007	0.015	0.01	0.115	0.190	2.9	0.62	307.8	2620.0
6:33	11:10	Downstream farm	0.009	0.017	0.02	0.279	0.370	3.3	0.68	204.6	3770.0
7:04	11:10	Ephemeral stream	0.011	0.019	0.02	1.138	1.260	1.2	0.41	2.0	3790.0
6:12	11:10	Left Fork	0.009	0.016	0.02	0.277	0.380	2.7	0.64	79.4	4350.0
7:15	11:10	House well	0.008	0.019	0.01	0.673	0.750	0.9	0.18	<1.0	5.2
6/12/2019	**6/12/2019**	**Grab sample**									
11:55	15:15	Spring	0.011	0.019	0.01	0.328	0.490	8.0	1.43	28.8	1299.7
12:56	15:15	Upstream farm	0.008	0.015	0.01	0.140	0.190	2.5	0.52	59.8	5980.0
11:41	15:15	Downstream farm	0.010	0.014	<0.03	0.356	0.420	2.6	0.51	86.2	5120.0
12:06	15:15	Ephemeral stream	0.012	0.013	0.01	1.244	1.310	1.0	0.31	101.7	3320.0
11:23	15:15	Left Fork	0.009	0.011	0.01	0.277	0.350	1.4	0.64	35.0	4350.0
12:24	15:15	House well	0.009	0.009	0.01	0.713	0.760	0.2	0.44	<1.0	3.1
6/20/2019	**6/20/2019**	**Grab sample**									
6:39	10:50	Spring	0.011	0.020	0.01	0.536	0.770	5.9	0.91	9.8	727.0
7:25	10:50	Upstream farm	0.007	0.008	0.02	0.123	0.240	1.7	0.50	49.5	2419.2
6:22	10:50	Downstream farm	0.008	0.008	0.02	0.296	0.450	1.3	0.51	75.4	3690.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
6:55	10:50	Ephemeral stream	0.011	0.015	0.01	1.073	1.290	11.5	0.23	1986.3	13540.0
6:03	10:50	Left Fork	0.005	0.005	0.02	0.228	0.400	1.3	0.62	63.8	4800.0
6/25/2019	**6/25/2019**	**Grab sample**									
7:54	12:30	Spring	0.012	0.017	0.01	0.335	0.550	5.1	1.46	101.4	5120.0
9:19	12:30	Upstream farm	0.008	0.023	0.01	0.144	0.230	4.3	0.73	127.4	5650.0
7:33	12:30	Downstream farm	0.012	0.032	<0.03	0.255	0.400	4.9	0.82	275.5	8130.0
8:19	12:30	Ephemeral stream	0.009	0.014	<0.03	1.088	1.260	1.7	0.24	114.5	5200.0
7:14	12:30	Left Fork	0.014	0.031	0.01	0.325	0.470	5.7	1.02	235.9	9850.0
8:29	12:30	House well	0.010	0.012	0.01	0.652	0.800	0.4	0.07	<1.0	54.5
8:55	12:30	Trench 1	0.004	0.004	<0.03	0.325	0.430	0.4	0.38	24.6	3130.0

¶ Values proceeded by ‘<’ were reported by the analytical laboratory as zero and the minimum detection limit is given.
§ ND is No Data, due to coliform not measured on water samples collected automatically by non-sterilized ISCO sampler.

Water pH, Alkalinity, Chloride, Electrical Conductivity, and Total Dissolved Solids for Several Big Creek Sites

The pH, alkalinity, chloride concentration, electrical conductivity, and total dissolved solids were determined on water samples collected at the upstream and downstream sites, spring, house well, and trenches, to build a database that will enable to eventually source track the major water source pathways at these sites. These values are given below in Table 3.

Table 3. The pH, Chloride concentration, and electrical conducting of water samples collected at upstream, downstream, spring, ephemeral stream, house well and trench sites.

Date	pH	Chloride	Electrical conductivity
		mg/L	µS/cm
Upstream			
1/8/2015	7.3	1.80	90
1/14/2015		2.09	105
1/21/2015	7.6	1.85	121
1/29/2015		2.09	140
2/3/2015	7.7	2.40	129
2/10/2015		2.51	132
2/26/2015	7.6	1.98	107
3/3/2015		2.08	112
3/11/2015	7.8	1.88	85
3/19/2015		1.55	98
3/25/2015	8.0	1.77	110
3/26/2015		1.33	115
4/2/2015	8.0	1.57	110
4/9/2015		1.73	116
4/15/2015	7.7	1.38	91
4/23/2015		1.65	95
4/29/2015	8.1	1.56	85
5/7/2015		1.40	123

Date	pH	Chloride	Electrical conductivity
5/8/2015		1.80	157
5/11/2015	7.5	1.63	131
5/14/2015		1.55	143
5/18/2015		1.20	107
5/26/2015	7.7	1.10	90
6/4/2015		1.08	78
6/8/2015	8.2	2.03	149
6/17/2015		1.51	128
6/22/2015	8.2	1.36	114
6/29/2015		1.74	55
7/9/2015	7.7	1.53	90
7/16/2015		1.33	161
7/23/2015	7.9	1.63	180
7/30/2015		1.75	224
8/6/2015	7.7	1.84	218
8/13/2015		1.91	210
8/20/2015	7.3	2.15	219
8/27/2015		2.11	240
9/2/2015	7.1	2.50	262
9/16/2015	7.6	3.05	272
9/24/2015		2.74	271
11/12/2015	8.0	2.13	228
11/18/2015		1.36	84
12/2/2015		1.52	83
12/14/2015	7.5	1.21	63
12/22/2015	8.3	1.78	107
1/5/2016	7.5	1.34	102

Date	pH	Chloride	Electrical conductivity
1/25/2016	8.2	1.50	115
2/10/2016	8.6	1.69	141
2/24/2016	7.2	1.20	102
3/10/2016	7.6	1.268	84.5
3/16/2016	6.7	1.252	88.3
3/24/2016	7.7	1.825	103.3
3/31/2016	7.3	0.933	65.8
4/4/2016	7.4	1.163	86.9
4/20/2016	8.0	1.405	125.7
4/29/2016	8.1	1.373	134.8
5/3/2016	7.7	1.150	83.7
5/10/2016	7.6	0.914	67.6
518/2016	8.0	1.228	102.8
5/26/2016	7.8	1.045	78.4
6/2/2016	7.9	1.298	105.4
6/7/2016	8.1	2.722	128.3
6/15/2016	8.3	1.471	150.3
6/22/2016	8.1	1.695	182.3
6/29/2016	7.4	2.176	203.0
7/6/2016	7.5	1.821	212.0
8/16/2016	7.7	1.092	88.1
8/24/2016	8.3	1.513	121.7
8/30/2016	8.2	1.088	143.3
9/7/2016	7.9	1.601	176.0
9/15/2016	8.0	1.287	206.0
9/28/2016	8.1	1.804	217.0
10/5/2016	7.9	1.831	230.0

Date	pH	Chloride	Electrical conductivity
10/13/2016	7.8	2.540	225.0
10/20/2016	7.9	2.017	235.0
10/27/2016	8.0	2.139	299.0
11/3/2016	7.6	2.330	260.0
11/10/2016	8.0	2.446	233.0
11/17/2016	8.0	2.455	272.0
11/21/2016	8.0	2.314	101.0
11/29/2016	8.1	2.087	115.0
12/14/2016	8.3	2.140	129.0
1/5/2017	8.8	2.264	142.0
1/19/2017	7.9	2.089	125.0
2/2/2017	8.4	2.044	112.0
2/15/2017	7.9	2.022	128.0
3/1/2017	8.4	1.696	115.0
3/16/2017	7.8	1.508	88.0
3/27/2017	7.6	0.997	50.0
4/6/2017	7.5	1.436	72.0
4/13/2017	7.8	1.392	76.0
4/17/2017	7.9	1.372	95.8
4/27/2017	7.7	1.003	68.0
5/18/2017	8.3	1.518	110.0
5/31/2017	8.0	1.296	122.0
6/5/2017	7.9	0.781	75.0
6/12/2017	8.0	1.231	120.0
6/19/2017	7.8	1.379	146.0
6/29/2017	7.8	1.554	170.0
7/5/2017	7.6	1.235	109.0

Date	pH	Chloride	Electrical conductivity
7/11/2017	8.2	1.543	113.0
7/19/2017	8.4	1.415	174.0
7/26/2017	7.8	1.664	193.0
8/3/2017	7.9	1.690	206.0
8/9/2017	8.0	1.930	206.0
8/16/2017	7.4	1.199	163.0
8/24/2017	8.1	1.381	133.0
8/31/2017	8.2	1.461	161.0
9/6/2017	8.0	1.697	184.0
9/13/2017	7.9	2.009	194.0
10/23/2017	7.9	2.082	253.0
12/13/2017	8.0	2.126	168.0
1/4/2018	8.1	1.771	153.0
1/18/2018	8.3	2.198	143.0
1/30/2018	7.8	2.148	111.0
2/14/2018	8.5	4.213	129.0
2/22/2018	7.5	1.430	66.0
3/1/2018	8.1	1.378	63.0
3/7/2018	8.1	1.535	89.0
3/14/2018	8.2	1.692	103.0
3/29/2018	8.2	0.932	100.0
4/5/2018	8.2	1.354	102.0
4/12/2018	8.0	1.546	107.0
4/19/2018	8.1	1.338	88.0
4/26/2018	8.0	1.113	93.0
5/3/2018	7.7	1.095	95.0
5/17/2018	7.9	1.444	156.0

Date	pH	Chloride	Electrical conductivity
5/24/2018	8.3	1.600	162.0
5/31/2018	8.3	1.373	139.0
6/7/2018	8.0	1.912	112.0
6/13/2018	8.4	1.482	179.0
6/28/2018	8.4	1.625	222.0
8/1/2018	7.7	2.841	256.0
8/16/2018	8.0	1.315	180.0
8/23/2018	8.3	1.591	159.0
8/30/2018	7.8	1.933	205.0
9/25/2018	7.8	1.602	216.0
10/11/2018	7.5	1.737	203.0
10/16/2018	7.6	1.752	122.0
10/24/2018	7.7	1.972	166.0
11/1/2018	7.4	1.227	81.0
11/7/2018	7.8	1.600	107.0
11/20/2018	7.8	1.823	135.0
12/5/2018	7.7	1.792	113.0
12/17/2018	7.6	1.617	96.0
1/3/2019	7.8	1.418	86.0
1/16/2019	7.9	1.472	94.0
1/31/2019	7.8	1.564	91.0
2/13/2019	7.7	1.181	74.0
2/27/2019	7.6	1.426	38.0
3/14/2019	7.6	1.531	67.0
3/20/2019	7.9	1.484	92.0
3/28/2019	7.7	1.365	82.0
4/8/2019	8.1	1.417	80.0

Date	pH	Chloride	Electrical conductivity
4/11/2019	8.5	1.415	91.0
4/18/2019	7.6	1.174	84.0
4/25/2019	7.8	1.116	88.0
5/2/2019	7.8	0.954	67.0
5/9/2019	7.6	1.341	82.0
5/16/2019	7.6	1.180	76.0
5/22/2019	7.6	1.232	84.0
5/30/2019	7.4	0.799	60.0
6/6/2019	7.6	1.231	115.0
6/12/2019	8.0	1.212	117.0
6/20/2019	7.6	1.345	139.0
6/25/2019	7.6	0.932	82.0
Downstream			
1/8/2015	7.6	2.02	144
1/14/2015		2.76	166
1/21/2015	7.6	2.44	191
1/29/2015		2.51	205
2/3/2015	7.7	2.82	196
2/10/2015		3.01	204
2/26/2015	7.8	2.27	162
3/3/2015		2.39	170
3/11/2015	7.8	2.02	128
3/19/2015		1.75	148
3/25/2015	7.8	2.07	158
3/26/2015		1.46	83
4/2/2015	8.1	1.95	163

Date	pH	Chloride	Electrical conductivity
4/9/2015		2.08	168
4/15/2015	7.8	1.54	130
4/23/2015		1.81	142
4/29/2015	8.0	2.15	150
5/7/2015		1.84	185
5/8/2015		2.50	225
5/11/2015	7.5	1.73	149
5/14/2015		1.06	103
5/18/2015		1.55	150
5/26/2015	7.7	1.25	137
6/1/2015		1.20	125
6/8/2015	8.0	1.44	163
6/17/2015		2.14	216
6/22/2015	7.9	1.76	204
7/7/2015		1.55	177
7/9/2015	7.7	1.63	116
7/16/2015		1.50	124
7/23/2015	7.8	1.84	223
7/30/2015		2.18	248
8/6/2015	7.6	2.31	286
8/13/2015		2.78	283
8/20/2015	7.2	2.83	287
8/27/2015		3.01	300
9/2/2015	7.5	3.13	322
9/10/2015		3.47	309
9/16/2015	7.4	3.87	310
9/24/201		3.46	308

Date	pH	Chloride	Electrical conductivity
9/30/2015	7.6	3.98	322
10/8/2015		3.42	344
10/14/2015	7.8	3.72	362
10/22/2015		3.45	362
10/28/2015	7.8	3.40	351
11/4/2015		4.05	358
11/12/2015	7.9	2.80	281
11/18/2015		1.55	120
12/2/2015		1.86	127
12/14/2015	7.7	1.26	93
12/22/2015	7.7	1.99	157
1/5/2016	7.5	2.17	158
1/25/2016	8.0	2.00	191
2/10/2016	8.0	2.36	214
2/22/2016	7.5	1.48	156
3/10/2016	7.3	1.481	126.1
3/16/2016	7.1	1.500	137.6
3/24/2016	7.3	1.827	156.8
3/31/2016	7.3	1.043	95.9
4/4/2016	7.4	1.563	138.6
4/20/2016	7.3	1.903	187.0
4/29/2016	7.7	2.052	199.1
5/3/2016	7.8	1.197	130.5
5/10/2016	7.6	0.856	93.5
518/2016	7.8	1.482	154.5
5/26/2016	7.7	0.941	114.1
6/2/2016	8.0	1.447	154.8

Date	pH	Chloride	Electrical conductivity
6/7/2016	7.8	1.698	176.8
6/15/2016	7.9	2.525	205.0
6/22/2016	7.8	2.406	230.0
6/29/2016	7.5	2.971	259.0
7/6/2016	7.4	2.960	262.0
7/13/2016	7.4	2.549	289.0
7/20/2016	7.7	2.726	305.0
7/27/2016	7.5	2.599	286.0
8/3/2016	7.9	1.845	258.0
8/16/2016	7.7	1.255	128.9
8/24/2016	7.8	1.368	174.8
8/24/2016	7.8	1.152	122.8
8/30/2016	7.8	1.435	193.5
9/7/2016	7.9	2.143	240.0
9/15/2016	7.9	1.918	265.0
9/28/2016	7.8	2.272	281.0
10/5/2016	7.8	2.708	288.0
10/13/2016	7.6	2.799	264.0
10/20/2016	7.2	2.791	314.0
10/27/2016	7.6	2.805	304.0
11/3/2016	7.2	3.074	313.0
11/10/2016	7.8	3.330	311.0
11/17/2016	7.8	3.203	366.0
11/21/2016	7.8	3.272	139.0
11/29/2016	7.8	2.481	180.0
12/14/2016	7.8	2.597	206.0
1/5/2017	8.1	5.692	220.0

Date	pH	Chloride	Electrical conductivity
1/19/2017	7.6	2.390	200.0
2/2/2017	7.9	2.414	171.0
2/15/2017	8.2	2.199	119.0
3/1/2017	7.8	2.926	162.0
3/16/2017	7.5	1.792	128.0
3/27/2017	7.5	1.113	69.0
4/6/2017	7.5	1.649	106.0
4/13/2017	7.7	1.665	114.0
4/17/2017	7.8	1.849	162.9
4/27/2017	7.6	1.160	102.0
5/18/2017	7.7	2.009	172.0
5/31/2017	8.0	1.714	171.0
6/5/2017	7.7	1.810	178.0
6/12/2017	7.9	1.942	225.0
6/19/2017	7.9	2.643	224.0
6/29/2017	7.6	2.652	231.0
7/5/2017	7.7	2.841	246.0
7/11/2017	7.8	1.716	201.0
7/19/2017	7.8	1.350	161.0
7/26/2017	7.3	1.690	213.0
8/3/2017	7.9	1.810	178.0
8/9/2017	7.9	1.942	225.0
8/16/2017	7.6	2.643	224.0
8/24/2017	7.9	2.652	231.0
8/31/2017	8.0	2.841	246.0
9/6/2017	7.7	2.132	214.0
9/13/2017	7.7	2.517	251.0

Date	pH	Chloride	Electrical conductivity
9/21/2017	7.5	2.788	282.0
9/28/2017	7.8	2.882	281.0
10/5/2017	7.5	3.041	292.0
10/12/2017	7.5	3.305	272.0
10/18/2017	7.8	3.391	307.0
10/23/2017	7.6	3.722	292.0
11/1/2017	7.5	3.016	262.0
11/9/2017	7.6	3.640	268.0
11/15/2017	7.8	3.114	217.0
11/30/2017	7.6	3.163	176.0
12/13/2017	7.8	3.041	280.0
12/18/2017	7.9	3.288	258.0
1/4/2018	8.3	2.288	210.0
1/18/2018	8.1	2.516	224.0
1/30/2018	8.0	2.330	160.0
2/14/2018	7.9	2.598	178.0
2/22/2018	7.4	1.559	96.0
3/1/2018	7.8	1.548	99.0
3/7/2018	7.7	1.864	136.0
3/14/2018	8.0	2.176	164.0
3/29/2018	8.1	1.392	112.0
4/5/2018	7.7	1.655	149.0
4/12/2018	7.6	2.000	166.0
4/19/2018	7.6	1.619	132.0
4/26/2018	7.9	1.246	131.0
5/3/2018	7.7	1.586	148.0
5/17/2018	7.6	1.981	225.0

Date	pH	Chloride	Electrical conductivity
5/24/2018	8.0	2.319	226.0
5/31/2018	8.0	1.795	189.0
6/7/2018	7.9	1.362	207.0
6/13/2018	7.9	2.285	260.0
6/28/2018	8.0	2.615	284.0
7/5/2018	7.8	2.944	283.0
7/12/2018	7.4	2.948	234.0
7/18/2018	7.4	3.050	285.0
7/25/2018	7.7	3.085	301.0
8/1/2018	7.6	3.467	316.0
8/9/2018	7.7	2.812	303.0
8/16/2018	7.6	2.939	282.0
8/23/2018	7.9	1.991	224.0
8/30/2018	7.7	2.560	263.0
9/6/2018	7.5	2.561	276.0
9/11/2018	7.6	2.677	271.0
9/25/2018	7.7	2.256	297.0
10/2/2018	7.5	2.504	294.0
10/11/2018	7.5	2.197	272.0
10/16/2018	7.6	1.983	191.0
10/24/2018	7.6	2.342	203.0
11/1/2018	7.4	1.340	113.0
11/7/2018	7.5	1.884	183.0
11/20/2018	7.6	2.402	204.0
12/5/2018	7.6	2.155	177.0
12/17/2018	7.6	1.805	148.0
1/3/2019	7.7	1.693	134.0

Date	pH	Chloride	Electrical conductivity
1/16/2019	8.0	1.797	196.0
1/31/2019	7.7	1.988	151.0
2/13/2019	7.7	1.473	117.0
2/27/2019	7.5	1.803	124.0
3/14/2019	7.5	1.665	105.0
3/20/2019	7.6	1.835	140.0
3/28/2019	7.5	1.700	125.0
4/8/2019	8.0	1.633	124.0
4/11/2019	8.0	1.684	140.0
4/18/2019	7.5	1.456	130.0
4/25/2019	7.5	1.454	143.0
5/2/2019	7.8	1.117	90.0
5/9/2019	7.4	1.557	128.0
5/16/2019	7.4	1.698	157.0
5/22/2019	7.4	1.380	134.0
5/30/2019	7.5	0.843	109.0
6/6/2019	7.4	1.679	175.0
6/12/2019	7.8	2.325	170.0
6/20/2019	7.5	2.035	198.0
6/25/2019	7.4	1.143	120.0
Left Fork			
5/4/2015	2.433	231.0	2.433
5/14/2015	2.037	212.0	2.037
5/18/2015	1.960	201.0	1.960
5/26/2015	1.840	196.3	1.840
6/4/2015	2.433	231.0	2.433
6/8/2015	2.785	264.0	2.785

Date	pH	Chloride	Electrical conductivity
6/17/2015	2.576	252.0	2.576
6/22/2015	1.982	220.0	1.982
6/29/2015	2.241	250.0	2.241
7/9/2015	1.984	193.7	1.984
7/16/2015	2.548	281.0	2.548
7/23/2015	3.037	307.0	3.037
8/6/2015	3.721	272.0	3.721
8/20/2015	3.897	279.0	3.897
8/27/2015	3.546	281.0	3.546
9/2/2015	3.732	285.0	3.732
9/10/2015	4.121	273.0	4.121
9/16/2015	5.830	289.0	5.830
9/24/2015	4.141	286.0	4.141
9/30/2015	3.826	287.0	3.826
10/8/2015	3.865	295.0	3.865
10/14/2015	4.622	318.0	4.622
10/22/2015	4.370	292.0	4.370
10/28/2015	4.451	296.0	4.451
11/4/2015	4.922	296.0	4.922
11/12/2015	3.389	326.0	3.389
11/18/2015	1.920	172.5	1.920
12/2/2015	2.443	171.4	2.443
12/14/2015	1.680	129.3	1.680
12/22/2015	2.712	211.0	2.712
1/5/2016	7.6	2.552	209.0
1/25/2016	8.3	2.713	235.0
2/10/2016	8.3	3.045	246.0

Date	pH	Chloride	Electrical conductivity
2/24/2016	7.5	2.045	188.3
3/10/2016	8.0	1.952	179.7
3/16/2016	7.5	2.086	194.5
3/24/2016	7.6	2.833	233.0
3/31/2016	7.5	1.479	136.3
4/4/2016	7.6	1.837	184.6
4/20/2016	7.7	2.701	235.0
5/2/2016	8.0	1.606	187.4
5/10/2016	7.8	1.157	137.4
5/18/2016	8.0	2.000	211.0
5/26/2016	7.7	1.526	166.0
6/2/2016	8.0	2.208	219.0
6/7/2016	8.0	2.206	239.0
6/15/2016	7.9	2.022	247.0
6/22/2016	8.0	3.166	260.0
6/29/2016	7.8	3.885	264.0
7/6/2016	7.6	3.429	268.0
7/13/2016	7.8	3.219	451.0
7/20/2016	7.8	3.104	287.0
7/27/2016	7.7	3.369	274.0
8/3/2016	7.8	2.828	308.0
8/16/2016	7.9	1.509	196.5
8/24/2016	8.0	1.636	239.0
8/30/2016	7.9	1.869	193.5
9/7/2016	8.0	2.604	288.0
9/15/2016	7.9	2.341	280.0
9/28/2016	8.0	2.546	293.0

Date	pH	Chloride	Electrical conductivity
10/5/2016	7.9	3.036	287.0
10/13/2016	7.7	3.351	224.0
10/20/2016	7.3	3.877	340.0
10/27/2016	7.5	3.767	326.0
11/3/2016	7.1	3.866	326.0
11/10/2016	7.9	4.183	323.0
11/17/2016	7.9	4.040	371.0
11/21/2016	7.8	4.092	362.0
11/29/2016	7.8	2.801	325.0
12/14/2016	7.8	3.117	242.0
1/5/2017	8.4	3.803	247.0
1/19/2017	7.7	3.462	225.0
2/2/2017	8.4	3.059	205.0
2/15/2017	8.1	3.385	200.0
3/1/2017	7.8	2.081	218.0
3/16/2017	7.8	2.540	176.0
3/27/2017	7.6	1.488	95.0
4/6/2017	7.7	2.234	153.0
4/13/2017	7.8	2.559	186.0
4/17/2017	7.8	2.487	192.0
4/27/2017	7.7	1.778	127.0
5/1/2017	7.8	2.001	152.0
5/11/2017	7.9	3.070	212.0
5/18/2017	7.8	2.536	210.0
5/25/2017	7.9	1.984	193.0
5/31/2017	8.1	2.393	206.0
6/5/2017	7.8	0.972	147.0

Date	pH	Chloride	Electrical conductivity
6/12/2017	8.1	2.297	222.0
6/19/2017	8.0	2.748	260.0
6/29/2017	7.7	3.141	269.0
7/5/2017	7.8	1.815	215.0
7/11/2017	8.0	2.061	214.0
7/19/2017	8.0	2.631	251.0
7/26/2017	7.6	3.431	253.0
8/3/2017	8.0	3.504	261.0
8/9/2017	7.9	3.570	263.0
8/16/2017	7.5	2.775	301.0
8/24/2017	8.0	1.330	169.0
8/31/2017	8.0	1.822	224.0
9/6/2017	8.0	2.363	239.0
9/13/2017	7.9	2.766	254.0
9/21/2017	7.5	3.167	276.0
9/28/2017	7.8	3.571	275.0
10/5/2017	7.6	3.732	259.0
10/12/2017	7.5	4.034	247.0
10/18/2017	7.6	4.119	276.0
10/23/2017	7.7	3.141	251.0
11/1/2017	7.8	3.238	278.0
11/9/2017	7.6	3.696	280.0
11/15/2017	7.9	3.658	261.0
11/15/2017	7.8	3.311	287.0
11/30/2017	7.9	3.615	261.0
12/13/2017	7.7	3.581	256.0
12/18/2017	8.0	3.983	230.0

Date	pH	Chloride	Electrical conductivity
1/4/2018	8.6	2.735	217.0
1/18/2018	8.0	3.029	203.0
1/30/2018	8.3	2.829	201.0
2/14/2018	7.9	5.810	192.0
2/22/2018	7.4	2.251	95.0
3/1/2018	7.9	2.202	137.0
3/7/2018	7.7	2.652	177.0
3/14/2018	8.2	2.841	192.0
3/29/2018	8.0	1.121	181.0
4/5/2018	7.6	2.244	179.0
4/12/2018	7.9	2.731	205.0
4/19/2018	7.9	2.363	187.0
4/26/2018	8.3	1.907	146.0
5/3/2018	7.8	1.843	178.0
5/17/2018	7.9	2.745	267.0
5/24/2018	8.0	3.191	265.0
5/31/2018	8.0	2.029	211.0
6/7/2018	8.0	2.511	249.0
6/13/2018	7.8	2.839	273.0
6/28/2018	7.9	3.451	266.0
7/5/2018	7.9	3.406	273.0
7/12/2018	7.5	3.786	172.0
7/18/2018	7.5	3.954	246.0
7/25/2018	7.7	4.067	255.0
8/1/2018	7.8	3.824	288.0
8/9/2018	7.7	3.181	278.0
8/16/2018	8.1	3.710	264.0

Date	pH	Chloride	Electrical conductivity
8/23/2018	8.0	2.323	245.0
8/30/2018	7.7	2.985	244.0
9/6/2018	7.8	2.704	200.0
9/11/2018	7.9	2.524	269.0
9/25/2018	8.0	2.930	315.0
10/2/2018	7.7	2.658	279.0
10/11/2018	7.6	3.263	327.0
10/16/2018	7.9	2.681	322.0
10/24/2018	7.9	2.674	249.0
11/1/2018	7.5	1.649	149.0
11/7/2018	7.7	2.478	149.0
11/20/2018	8.0	3.113	233.0
12/5/2018	7.9	3.115	236.0
12/17/2018	7.9	2.524	197.0
1/3/2019	7.9	2.367	183.0
1/16/2019	7.9	2.651	146.0
1/31/2019	8.1	2.729	193.0
2/13/2019	7.7	2.083	164.0
3/14/2019	7.9	2.135	161.0
3/20/2019	7.8	2.562	126.0
3/28/2019	7.6	2.542	199.0
4/8/2019	8.4	2.270	181.0
4/11/2019	8.2	1.674	199.0
4/18/2019	7.7	2.197	196.0
4/25/2019	7.6	2.533	206.0
5/2/2019	7.8	1.359	127.0
5/9/2019	7.6	1.924	158.0

Date	pH	Chloride	Electrical conductivity
5/16/2019	7.7	2.643	205.0
5/22/2019	7.7	1.817	190.0
5/30/2019	7.6	1.058	122.0
6/6/2019	7.8	2.333	226.0
6/12/2019	8.1	2.149	219.0
6/20/2019	7.7	2.838	229.0
6/25/2019	7.6	1.586	170.0
Ephemeral Stream			
1/5/2016		2.908	368.0
1/25/2016		3.454	392.0
2/24/2016		2.427	264.0
3/10/2016		2.530	288.0
3/16/2016		2.427	356.0
3/24/2016		3.467	399.0
3/31/2016		3.366	153.2
4/4/2016		2.544	330.0
4/20/2016		2.758	380.0
5/2/2016		2.068	329.0
5/2/2016		2.571	241.0
5/10/2016		1.617	143.3
5/18/2016		2.726	360.0
5/26/2016		2.031	194.5
6/2/2016		2.733	359.0
6/7/2016		2.930	344.0
8/16/2016		3.309	357.0
10/13/2016		3.546	393.0

Date	pH	Chloride	Electrical conductivity
2/15/2017	7.7	3.366	270.0
3/1/2017	7.8	4.328	396.0
3/16/2017	7.5	3.415	354.0
3/27/2017	7.4	4.373	180.0
3/30/2017	7.8	2.705	224.0
4/6/2017	7.3	3.154	223.0
4/13/2017	7.7	3.585	377.0
4/17/2017	7.5	3.997	394.0
4/23/2017	7.5	2.221	321.0
4/27/2017	7.5	1.414	109.0
5/18/2017	7.6	3.247	346.0
5/31/2017	8.0	3.161	380.0
6/5/2017	7.3	1.834	230.0
6/12/2017	8.1	2.961	363.0
10/23/2017	7.7	2.149	152.0
2/22/2018	7.1	2.460	236.0
3/1/2018	8.2	2.945	269.0
3/7/2018	7.7	3.517	370.0
3/29/2018	7.5	2.077	369.0
4/5/2018	7.5	2.700	361.0
4/12/2018	7.6	3.235	400.0
4/16/2018	7.8	2.779	261.0
4/19/2018	7.6	2.831	337.0
4/23/2018	8.1	3.285	334.0
4/26/2018	7.5	2.810	381.0
5/3/2018	7.4	3.157	412.0
10/11/2018	7.5	2.620	254.0

Date	pH	Chloride	Electrical conductivity
11/1/2018	6.6	1.986	220.0
11/7/2018	7.5	5.041	381.0
12/17/2018	7.3	2.758	319.0
1/3/2019	7.4	2.764	331.0
1/16/2019	7.6	3.128	372.0
1/31/2019	7.9	3.190	374.0
2/13/2019	7.3	2.328	198.0
2/27/2019	7.7	2.842	395.0
3/14/2019	7.4	2.525	263.0
3/20/2019	7.7	2.878	375.0
3/28/2019	8.0	3.189	407.0
4/8/2019	7.7	2.733	347.0
4/11/2019	8.0	2.777	387.0
4/18/2019	7.3	2.468	350.0
4/25/2019	7.2	2.851	374.0
5/2/2019	7.2	2.012	250.0
5/9/2019	7.1	2.551	252.0
5/16/2019	7.3	2.684	391.0
5/22/2019	7.4	2.820	359.0
5/30/2019	7.0	1.661	229.0
6/6/2019	7.5	2.914	439.0
6/12/2019	7.7	2.781	424.0
6/20/2019	7.8	3.064	460.0
6/25/2019	7.5	1.975	245.0
Spring			
1/8/2015		2.27	534

Date	pH	Chloride	Electrical conductivity
1/14/2015		2.79	517
1/21/2015		2.27	553
2/3/2015		2.20	562
2/10/2015		2.44	581
2/26/2015		1.74	491
3/3/2015		1.57	430
3/11/2015		1.63	495
3/19/2015		1.54	474
3/25/2015		2.08	544
4/2/2015		1.78	515
4/9/2015		2.03	509
4/15/2015		1.76	480
4/23/2015		1.93	512
4/29/2015		2.55	564
5/4/2015		1.57	554
5/7/2015		2.29	623
5/11/2015		1.11	408
5/14/2015		1.35	507
5/18/2015		1.17	508
5/26/2015		1.08	516
6/8/2015		1.95	615
6/17/2015		1.65	532
6/22/2015		1.79	601
7/9/2015		1.43	542
7/16/2015		2.02	629
7/23/2015		2.17	656
7/30/2015		2.26	648

Date	pH	Chloride	Electrical conductivity
8/6/2015		0.92	606
8/13/2015		2.71	522
8/20/2015		2.09	554
8/27/2015		2.01	575
9/2/2015		2.08	581
9/10/2015		1.99	485
9/16/2015		0.00	557
9/24/2015		1.95	574
9/30/2015		2.00	573
10/8/2015		1.92	581
10/14/2015		1.94	610
10/22/2015		1.86	581
10/28/201		1.81	537
11/4/2015		2.11	572
11/12/2015		2.20	565
11/18/2015		1.80	395
12/2/2015		4.14	487
3/10/2016		1.109	359.0
3/16/2016		2.038	516.0
3/24/2016		1.939	446.0
3/31/2016		1.324	414.0
4/4/2016		1.971	506.0
4/20/2016		2.111	554.0
4/29/2016		2.234	522.0
5/3/2016		1.879	486.0
5/10/2016		1.190	417.0
5/18/2016		2.206	493.0

Date	pH	Chloride	Electrical conductivity
5/26/2016		1.370	450.0
6/2/2016		2.111	512.0
6/7/2016		2.348	503.0
6/15/2016		2.523	526.0
6/22/2016		2.659	543.0
6/29/2016		2.864	545.0
7/6/2016		2.749	533.0
7/13/2016		2.661	272.0
7/20/2016		2.271	594.0
7/27/2016		2.424	593.0
8/3/2016		2.151	541.0
8/16/2016		1.435	434.0
8/24/2016		2.644	556.0
8/30/2016		2.710	604.0
9/7/2016		2.822	598.0
9/15/2016		2.040	590.0
9/28/2016		2.785	652.0
10/5/2016		2.272	644.0
10/13/2016		1.899	455.0
10/20/2016	6.9	2.528	674.0
10/27/2016	7.2	2.525	637.0
11/3/2016	6.9	2.361	619.0
11/10/2016	7.2	2.402	605.0
11/17/2016	7.1	2.367	695.0
11/21/2016	7.0	2.433	259.0
11/29/2016	7.0	2.472	450.0
12/14/2016	6.9	2.320	519.0

Date	pH	Chloride	Electrical conductivity
1/5/2017	7.2	2.462	504.0
1/19/2017	7.1	2.397	520.0
2/2/2017	7.1	3.099	546.0
2/15/2017	7.3	2.305	353.0
3/16/2017	7.4	2.618	602.0
3/27/2017	7.3	1.223	373.0
4/6/2017	7.1	2.010	486.0
4/13/2017	7.1	2.810	547.0
4/17/2017	7.2	1.720	445.0
4/27/2017	7.4	1.565	476.0
5/18/2017	7.0	1.988	474.0
5/31/2017	7.5	1.305	471.0
6/5/2017	7.5	1.042	469.0
6/12/2017	8.0	1.532	482.0
6/19/2017	7.5	1.766	527.0
6/29/2017	7.2	1.982	451.0
7/5/2017	7.0	1.265	438.0
7/11/2017	7.1	1.972	521.0
7/19/2017	7.1	2.299	567.0
7/26/2017	6.8	2.394	559.0
8/3/2017	7.4	2.349	539.0
8/9/2017	7.4	2.129	518.0
8/16/2017	7.5	1.590	430.0
8/24/2017	7.2	1.690	459.0
8/31/2017	7.5	2.068	560.0
9/6/2017	7.1	2.276	570.0
9/13/2017	7.0	2.133	317.0

Date	pH	Chloride	Electrical conductivity
10/23/2017	7.0	2.784	409.0
2/22/2018	7.2	2.067	371.0
3/1/2018	8.3	1.794	362.0
3/7/2018	7.2	2.808	493.0
3/29/2018	7.4	0.903	489.0
4/5/2018	7.3	1.933	481.0
4/12/2018	7.1	2.974	533.0
4/19/2018	7.1	2.810	489.0
4/26/2018	7.3	1.057	387.0
5/3/2018	7.1	1.236	413.0
5/17/2018	7.1	2.812	593.0
5/24/2018	7.3	2.852	564.0
5/31/2018	7.3	2.539	557.0
6/7/2018	7.6	2.575	523.0
6/13/2018	7.8	3.107	511.0
8/1/2018	7.1	3.846	610.0
8/9/2018	7.2	2.405	588.0
9/25/2018	7.3	3.950	558.0
10/11/2018	6.9	4.113	649.0
10/16/2018	7.3	3.706	565.0
10/24/2018	7.1	4.685	589.0
11/1/2018	6.7	1.868	475.0
11/7/2018	7.0	3.734	514.0
11/20/2018	7.0	4.655	567.0
12/5/2018	7.2	3.821	551.0
12/17/2018	7.0	2.463	518.0
1/3/2019	7.2	2.383	513.0

Date	pH	Chloride	Electrical conductivity
1/16/2019	7.2	3.648	534.0
1/31/2019	7.2	3.573	561.0
2/13/2019	7.1	2.087	492.0
2/27/2019	7.3	2.568	543.0
3/14/2019	7.1	1.983	469.0
3/20/2019	7.2	3.042	545.0
3/28/2019	7.2	3.199	559.0
4/8/2019	7.3	2.084	552.0
4/11/2019	7.2	2.926	594.0
4/18/2019	7.0	1.832	498.0
4/25/2019	7.0	1.474	478.0
5/2/2019	7.2	1.459	488.0
5/9/2019	7.0	1.865	534.0
5/16/2019	7.0	2.145	569.0
5/22/2019	7.0	1.964	566.0
5/30/2019	6.9	0.940	476.0
6/6/2019	7.1	2.913	604.0
6/12/2019	7.1	2.211	582.0
6/20/2019	7.0	2.962	636.0
6/25/2019	7.0	1.917	483.0
House Well			
3/19/2015		4.787	458.0
3/25/2015		5.270	453.0
4/2/2015		4.908	453.0
4/9/2015		5.100	419.0
4/15/2015		5.023	426.0
4/23/2015		4.826	414.0

Date	pH	Chloride	Electrical conductivity
4/29/2015		4.960	436.0
5/4/2015		5.080	458.0
5/7/2015		5.104	452.0
5/11/2015		5.189	484.0
5/18/2015		4.817	481.0
5/26/2015		5.018	488.0
6/4/2015		5.080	458.0
6/8/2015		7.087	437.0
6/17/2015		5.134	493.0
6/22/2015		5.172	481.0
7/9/2015		5.856	481.0
7/16/2015		5.378	495.0
7/23/2015		5.423	481.0
7/30/2015		5.852	499.0
8/6/2015		5.738	449.0
8/13/2015		4.888	448.0
8/20/2015		4.647	427.0
8/27/2015		4.808	441.0
9/2/2015		4.989	465.0
9/10/2015		5.206	447.0
9/16/2015		4.878	448.0
9/24/2015		5.191	448.0
9/30/2015		7.307	446.0
10/8/2015		5.782	455.0
10/14/2015		5.235	461.0
10/22/2015		5.845	453.0
10/28/2015		4.837	456.0

Date	pH	Chloride	Electrical conductivity
11/4/2015		5.159	455.0
11/12/2015		5.590	458.0
11/18/2015		4.657	458.0
12/2/2015		5.557	422.0
12/14/2015		4.545	460.0
12/22/2015		5.455	458.0
1/5/2016		4.855	439
1/25/2016		5.278	462
2/10/2016		5.273	468
2/24/2016		5.237	447
3/10/2016		5.366	458
3/16/2016		4.993	482
3/24/2016		5.265	484
3/31/2016		5.023	409
4/4/2016		4.735	414
4/20/2016		5.475	417
4/28/2016		4.671	417
5/2/2016		5.316	441
5/10/2016		5.234	411
5/18/2016		4.450	420
5/26/2016		5.649	426
6/2/2016		5.450	409
6/7/2016		4.670	416
6/15/2016		4.394	414
6/22/2016		5.173	424
6/29/2016		5.557	432
7/6/2016		5.811	391

Date	pH	Chloride	Electrical conductivity
7/13/2016		5.021	561
7/20/2016		5.561	447
7/27/2016		5.230	467
10/13/2016		6.988	476
10/20/2016	7.6	6.421	495
10/27/2016	7.9	6.132	501
11/3/2016	7.6	5.560	479
11/10/2016	7.6	5.858	473
11/17/2016	7.6	5.655	544
11/21/2016	7.5	5.576	209
11/29/2016	7.5	5.721	350
12/14/2016	7.4	5.724	411
7/5/2016	7.36	5.105	417
7/11/2017	7.65	5.136	389
7/19/2017	7.45	12.717	430
7/26/2017	7.34	5.722	402
8/3/2017	7.75	5.085	419
8/9/2017	7.75	5.107	419
8/16/2017	8.00	5.121	413
8/24/2016	7.80	5.115	314
8/31/2017	7.75	4.910	419
9/13/2017	7.6	5.198	426.0
9/21/2017	7.4	5.065	440.0
9/28/2017	7.5	5.555	442.0
10/5/2017	7.2	5.461	433.0
10/12/2017	7.5	5.544	429.0
10/18/2017	7.5	5.149	436.0

Date	pH	Chloride	Electrical conductivity
10/23/2017	7.6	5.143	427.0
11/1/2017	7.3	5.622	457.0
11/9/2017	7.4	5.375	464.0
11/15/2017	7.7	5.431	446.0
11/30/2017	7.4	6.020	334.0
12/13/2017	7.4	7.786	434.0
12/18/2017	7.6	5.410	380.0
1/4/2018	7.8	5.025	321.0
1/18/2018	8.3	5.282	450.0
1/30/2018	7.7	5.334	436.0
2/14/2018	7.5	5.684	405.0
2/22/2018	7.3	5.088	317.0
3/1/2018	8.4	5.576	413.0
3/7/2018	7.4	5.197	446.0
3/29/2018	7.4	5.315	422.0
4/5/2018	7.5	1.647	460.0
4/19/2018	7.4	4.955	440.0
4/26/2018	7.6	5.106	450.0
5/3/2018	7.4	5.160	468.0
5/17/2018	7.4	4.861	464.0
5/24/2018	7.4	4.960	442.0
5/31/2018	7.7	4.840	283.0
6/7/2018	7.9	5.340	421.0
6/13/2018	7.9	4.949	425.0
6/28/2018	7.5	4.906	455.0
7/5/2018	7.6	5.001	455.0
7/12/2018	7.3	5.380	424.0

Date	pH	Chloride	Electrical conductivity
7/18/2018	7.2	6.588	443.0
7/25/2018	7.4	5.005	446.0
8/1/2018	7.5	5.347	445.0
8/9/2018	7.5	5.080	440.0
8/16/2018	7.5	4.874	415.0
8/23/2018	7.5	5.008	428.0
8/30/2018	7.5	5.010	447.0
9/6/2018	7.5	5.007	436.0
9/11/2018	7.4	5.083	434.0
9/25/2018	7.5	4.886	304.0
10/2/2018	7.3	5.022	391.0
10/11/2018	7.4	4.969	479.0
10/24/2018	7.4	5.956	428.0
11/1/2018	7.1	4.614	450.0
11/7/2018	7.5	5.099	456.0
11/20/2018	7.2	5.093	427.0
12/5/2018	7.5	5.057	428.0
12/17/2018	7.5	4.709	441.0
1/3/2019	7.4	4.824	445.0
1/16/2019	7.3	4.885	446.0
1/31/2019	7.4	4.807	445.0
2/13/2019	7.4	4.561	450.0
2/27/2019	8.2	4.737	508.0
3/14/2019	7.4	5.060	426.0
3/20/2019	7.5	4.680	439.0
3/28/2019	7.5	4.974	454.0
4/8/2019	7.6	5.031	450.0

Date	pH	Chloride	Electrical conductivity
4/11/2019	7.7	4.801	459.0
4/25/2019	7.4	4.661	479.0
5/2/2019	7.6	4.475	437.0
5/9/2019	7.3	4.766	458.0
5/22/2019	7.3	4.647	480.0
6/6/2019	7.3	4.611	478.0
6/12/2019	7.6	4.719	496.0
6/25/2019	7.3	4.587	404.0
Trench 1			
1/8/2015		2.01	154
1/14/2015		2.81	166
2/26/2015		2.08	171
3/3/2015		2.11	177
3/11/2015		1.95	193
3/19/2015		1.70	209
3/25/2015		2.13	238
3/26/2015		1.64	209
4/2/2015		1.94	261
4/9/2015		1.99	260
4/15/2015		1.80	260
4/23/2015		2.06	231
5/11/2015		2.09	262
5/14/2015		1.86	299
5/18/2015		1.57	346
5/26/2015		1.65	297
6/22/2015		1.99	341

Date	pH	Chloride	Electrical conductivity
6/29/2015		2.63	342
7/9/2015		2.08	171
11/18/2015		1.15	152
12/2/2015		1.47	162
12/14/2015		1.59	157
12/22/2015		1.70	180
1/5/2016		1.61	161
2/24/2016		1.16	162
3/10/2016		1.019	173.7
3/16/2016		1.451	226.0
3/24/2016		1.732	229.0
3/31/2016		1.280	167.9
5/10/2016		1.122	226.0
5/19/2016		0.405	196.5
5/18/2016		1.653	234.0
5/26/2016		1.421	262.0
6/2/2016		1.229	320
8/16/2016		2.051	293
8/24/2016		1.259	318
2/15/2017	8.0	2.344	397.0
3/16/2017	7.8	1.483	164.0
3/27/2017	7.4	1.018	164.0
4/6/2017	7.4	1.877	168.0
4/24/2017	7.4	0.895	160.0
4/27/2017	7.8	0.557	150.0
5/1/2017	7.7	1.193	172.0
2/22/2018	7.2	1.094	134.0

Date	pH	Chloride	Electrical conductivity
3/1/2018	8.2	1.224	152.0
3/29/2018	7.8	0.966	179.0
4/5/2018	7.7	1.365	192.0
5/3/2018	7.3	1.208	335.0
10/16/2018	7.9	1.032	132.0
11/1/2018	6.6	1.035	152.0
11/7/2018	7.6	1.304	272.0
2/13/2019	7.5	1.239	185.0
3/14/2019	7.2	1.151	147.0
4/18/2019	7.1	0.943	227.0
5/2/2019	6.7	0.846	179.0
5/9/2019	6.6	1.049	207.0
5/30/2019	6.3	1.405	193.0
6/25/2019	6.8	1.129	259.0
Trench 2			
3/11/2015		1.77	159
3/19/2015		1.04	168
3/26/2015		0.78	135
5/11/2015		0.41	165
5/26/2015		0.93	284
3/11/2015		1.77	159
3/19/2015		1.04	168
3/26/2015		0.78	135
5/11/2015		0.41	165
5/26/2015		0.93	284
12/14/2016		1.00	148

Date	pH	Chloride	Electrical conductivity
2/24/2016		0.99	144
3/10/2016		0.349	106.8
3/31/2016		0.424	134.5
4/4/2016		1.4	192.1
8/16/2016		0.597	219
2/15/2017	8.0	1.164	135.0
3/1/2017	7.3	0.808	159.0
3/27/2017	7.1	0.376	90.0
4/6/2017	7.0	0.325	175.0
4/24/2017	7.3	0.322	134.0
4/27/2017	7.5	0.217	129.0
5/1/2017	7.7	0.340	157.0
6/5/2017	7.0	0.298	160.0
11/15/2017	7.7	3.490	264.0
5/3/2018	7.0	0.456	111.0
11/1/2018	6.5	1.233	133.0
11/7/2018	6.8	1.560	208.0
2/13/2019	7.5	0.957	184.0
3/14/2019	6.6	0.706	117.0
4/18/2019	6.8	0.292	158.0
4/25/2019	6.7	0.341	221.0
5/2/2019	6.4	0.319	154.0
5/9/2019	6.3	0.375	171.0
5/22/2019	8.1	0.482	273.0
5/30/2019	6.2	1.226	158.0

APPENDIX I: BIG CREEK DISSOLVED OXYGEN

Contents

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Introduction

Dissolved oxygen is an important indicator of aquatic ecosystem health and as such is a key water-quality parameter measured in many water studies and is a guiding regulatory standard for evaluating and protecting stream health. Arkansas Pollution Control and Ecology Commission Regulation 2.505 establishes the standards for surface-water dissolved oxygen values.

Regulation 2.505 Establishing Dissolved Oxygen Standards for Surface Waters of the State of Arkansas

Arkansas Pollution Control and Ecology Commission Regulation No. 2, as amended by the Pollution Control and Ecology Commission # 014.00-002 from Arkansas Department of Environmental Quality (ADEQ), 2018, pages 45-48 of "Assessment methodology: For the Preparation of the 2016 Integrated Water Quality Monitoring and Assessment Report pursuant to the Clean Water Act Sections 303(d) and 305(b). Final Draft 2017." 72 pages total. Available at https://www.adeq.state.ar.us/water/planning/integrated/assessment/pdfs/final-draft-2018-am_10oct2017-(2).pdf provides the specific dissolved oxygen standard for surface waters in the State.

Dissolved oxygen levels are specified in water quality standards. In the 2 to 5 mg/L range, most fish and aquatic life will survive, but will not thrive. At less than 2 mg/L, mortality begins.

The following dissolved oxygen standards are applicable for rivers and streams (Table 1).

Table 1. Dissolved oxygen standards relevant to the Big Creek Watershed region.

Watershed area, mi^2	Ozark Highlands		Boston Mountains	
	Primary [1]	Critical [2]	Primary [1]	Critical [2]
	- - - - - - - - - - - - - - - - - mg/L - - - - - - - - - - - - - - - - - -			
<10 mi^2 watershed	6	2	6	2
10 to 100 mi^2 watershed	6	5	None	None
>100 mi^2 watershed	6	6	6	6

1. Primary season is defined as when water temperatures are at or below 22 °C.
2. Critical season is defined as when water temperatures are greater 22 °C.

In streams with watersheds of less than 10 mi^2, it is assumed that insufficient water exists to support aquatic life during the critical season. During this time, a dissolved oxygen standard of 2 mg/L will apply to prevent nuisance conditions. However, field verification is required in areas suspected of having significant groundwater flows or enduring pools, which may support unique aquatic biota. In such waters, the critical season standard for the next size category of stream shall apply.

All streams with watersheds of less than 10 mi^2 are expected to support aquatic life during the primary season when stream flows, including discharges, equal or exceed 1 cubic foot per second (cfs). However, when site verification indicates that aquatic life exists at flows below 1 cfs, such aquatic biota will be protected by the primary standard (refer to the State of Arkansas Continuing Planning Process for field verification requirements).

Also, in these streams with watersheds of less than 10 mi^2, where waste discharges are 1 cfs or more, they are assumed to provide sufficient water to support aquatic life and, therefore, must meet the dissolved oxygen standards of the next size category of streams.

For purposes of determining effluent discharge limits, the following conditions apply:

A. The primary season dissolved oxygen standard is to be met at a water temperature of 22°C (71.5°F) and at the minimum stream flow for that season. At water temperatures of 10°C (50°F), the dissolved oxygen standard is 6.5 mg/L.

B. During March, April and May, when background stream flows are 15 cfs or higher, the dissolved oxygen standard is 6.5 mg/L in all areas except the Delta Ecoregion, where the primary season dissolved oxygen standard will remain at 5 mg/L.

C. The critical season dissolved oxygen standard is to be met at maximum allowable water temperatures and at Q7-10 flows. However, when water temperatures exceed 22°C (71.6°F), a 1 mg/L diurnal depression will be allowed below the applicable critical standard for no more than 8 hours during any 24-hour period.

Field Determination and Methodology

Dissolved oxygen and temperature are determined *in-situ* using a luminescent dissolved oxygen sensor integrated to a Hydrolab HL4 sonde[1]. In-situ measurement entails no holding time for samples, and the act of collecting a sample can change the oxygen level, a direct probe reading is often the preferred method. The probe is air calibrated at monthly intervals when data are downloaded from the sonde data logger. Data quality are assured through recording calibration accuracy and conducting a field duplicate to determine precision. See U.S. EPA Field Measurement of Dissolved Oxygen for details https://www.epa.gov/sites/production/files/2017-07/documents/field_do_measurement106_af.r4.pdf. Sonde readings were recorded every hour for the time they were deployed in Big Creek.

Big Creek Dissolved Oxygen

The following tables and Figures detail the dissolved oxygen concentration in Big Creek upstream of the C&H farm October 22 to November 13, 2014 and downstream of the farm from September 9 to November 11, 2014, April 10 to October 16, 2015, and May 16 to December 11, 2017.

Measurements upstream of the farm were not taken after 2014 due to the sonde probe being dislodged and lost during a large storm even in the spring of 2015. It was not replaced until early 2018, when a secure site on the low-water bridge at the upstream site on Big Creek was made available.

[1] Mention of trade names does not imply endorsement by the Division of Agriculture, University of Arkansas Systems. Information on the Hydrolab HL4 sonde is available at http://www.ott.com/products/water-quality-2/hydrolab-hl4-multiparameter-sonde-54/

Measurements at the downstream site were not taken in 2016, again due to loss of the sonde at that site during an early spring storm event. Loss of the two sonde units are indicative of the significant amount of scouring and stream bed modification that can take place in large storm events. Also, measurements were not recorded between September 16 and October 17, 2017 due the sonde malfunctioning.

Diurnal and seasonal fluctuations in dissolved oxygen concentrations are apparent from measurements in Big Creek. See Figures 1 through 8. The diurnal fluctuations in dissolved oxygen concentration are typically a function of photosynthesis during daylight hours (which releases oxygen); removal of dissolved oxygen by microbial respiration (satisfying microbial and chemical oxygen demands, either in the water column or through interaction with the bed sediments); and exchange of oxygen at the water surface (i.e., reaeration) (O'Connor and Di Toro, 1970[2]; Williams et al., 2000[3]).

The diurnal and seasonal fluctuations of dissolved oxygen concentration are clearly dependent on many factors (Williams et al., 2000[3]). The influence of water column temperature on oxygen solubility can be eliminated by converting dissolved oxygen concentration in mg/L to % saturation. See Figures 9 to 12. Additional breaks in dissolved oxygen concentrations were determined with flow less and greater than 15 cfs for monitoring in 2014, 2015, and 2017 and given in Table 2.

Dissolved oxygen was measured at both upstream and downstream from October 22 to November 13, 2014 and is presented in Figures 13 to 18. Finally, dissolved oxygen at the USGS Carver gaging station is presented in Figure 19 for June 3, 2014 to May 1, 2017.

The information on dissolved oxygen in Big Creek downstream of the C&H Farm at USGS 07055790 Big Creek near Mt. Judea, given here is made available to ADEQ and on the BCRET website. Interpretation of dissolved oxygen concentrations in terms of water quality standards is deferred to ADEQ.

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[2] O'Connor, D.J., and D.M. Di Toro. 1970. Photosynthesis and oxygen balance in streams. J. Sanit. Eng. Div. ASCE, 98:547-571.

[3] Williams, R.J., C. White, M.L. Harrow, and C. Neal. 2000. Temporal and small-scale spatial variations of dissolved oxygen in the River Thames, Pang and Kennet, UK. Sci. Total. Environ. 251/252:497-510.

Table 2. Big Creek Dissolved Oxygen concentrations.

Metric	Upstream [1]	Downstream [2]				
	10/22/2014 – 11/13/2014	10/22/2014 – 11/13/2014	9/9/2014 – 11/13/2014	4/8/2015 – 10/16/2015	5/16/2017 - 12/11/2017	9/9/2014 – 12/11/2017
Average	9.36	8.92	8.57	8.73	8.63	8.66
Minimum	6.78	6.67	5.73	5.01	5.84	5.01
Maximum	11.58	12.42	12.42	12.92	14.04	14.04
Median	9.49	8.57	8.27	8.53	8.44	8.44
Observations	525		1,557	4,524	4,093	10,175

1. Watershed area is 27.01 $miles^2$.
2. Watershed area is 40.89 $miles^2$.

Table 3. Big Creek Dissolved Oxygen concentrations downstream of C&H, as a function of stream temperature.

Metric	9/9/2014 – 11/13/2014		4/10/2015 – 10/16/2015		5/16/2017 - 12/11/2017		9/9/2014 – 12/11/2017	
	Temperature	Dissolved oxygen	Temperature	Dissolved oxygen	Temperature	Dissolved oxygen	Temperature	Dissolved oxygen
	°C	mg/L	°C	mg/L	°C	mg/L	°C	mg/L
All observed water temperatures								
Average	16.87	8.57	17.98	8.73	18.38	8.63	17.97	8.66
Minimum	7.46	5.73	8.53	5.01	8.49	5.84	7.46	5.01
Maximum	26.46	12.42	26.69	12.92	26.42	14.04	26.69	14.04
Median	16.98	8.28	18.50	8.53	18.65	8.44	18.19	8.45
Observations	1,557		4,525		4,093		10,175	
Observations <6 mg/L DO	8		47		21		74	
Observations <6 mg/L DO, %	0.51		1.04		0.51		0.73	
Water temperature > 22 °C								
Average	23.03	10.78	23.32	9.62	23.16	9.40	23.23	9.56
Minimum	22.04	7.68	22.00	6.09	22.00	6.15	22.00	6.09
Maximum	26.46	11.62	26.69	12.26	26.42	13.19	26.69	13.13
Median	22.66	10.85	23.11	9.87	22.85	9.73	22.95	9.86
Observations	48		523		519		1,090	
Observations <6 mg/L DO	0		0		0		0	

Metric	9/9/2014 – 11/13/2014		4/10/2015 – 10/16/2015		5/16/2017 - 12/11/2017		9/9/2014 – 12/11/2017	
	Flow	Dissolved oxygen	Flow	Dissolved oxygen	Flow	Dissolved oxygen	Flow	Dissolved oxygen
	cfs	mg/L	cfs	mg/L	cfs	mg/L	cfs	mg/L
	Stream flow <15 cfs							
Average	5.08	8.54	3.51	8.48	4.80	8.44	4.43	8.48
Minimum	2.41	5.73	1.44	5.74	1.06	5.72	1.06	5.72
Maximum	14.10	12.42	14.10	12.90	14.60	14.04	14.60	14.04
Median	3.62	8.27	2.79	8.20	3.40	8.15	3.19	8.19
Observations	1340		2006		2634		5980	
	Stream flow >15 cfs							
Average	64.40	8.75	190.63	8.92	127.61	8.97	162.18	8.93
Minimum	15.00	6.96	15.00	5.01	15.50	6.61	15.00	5.01
Maximum	369.00	11.67	14600.00	12.92	10600.00	13.75	14600.00	13.75
Median	45.40	8.28	84.00	8.89	44.70	8.86	58.30	8.85
Observations	217		2519		1459		4195	

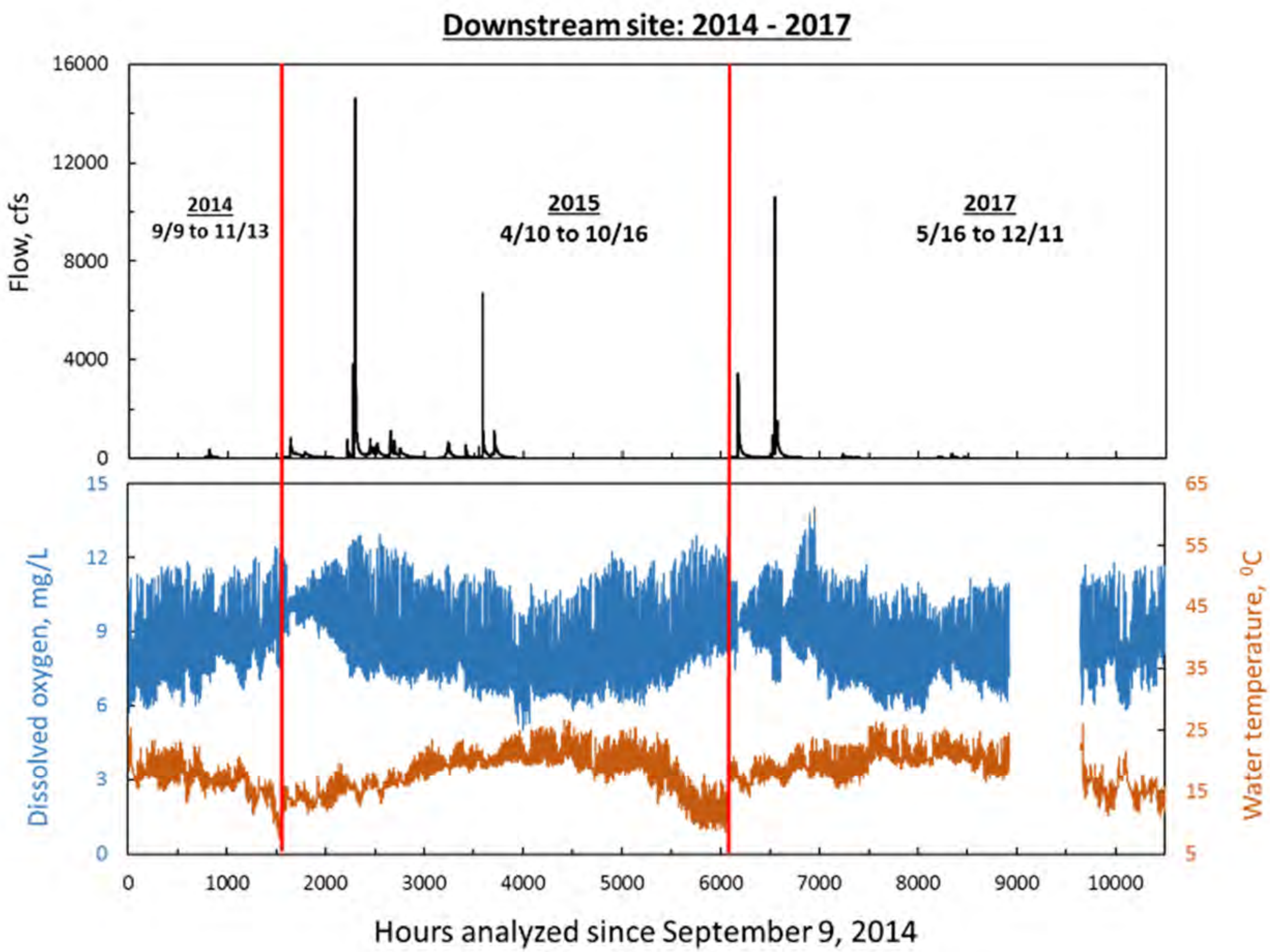

Figure 1. Flow, water temperature, and dissolved oxygen concentration downstream of the C&H Farm between September 9, 2014 and December 11, 2017.

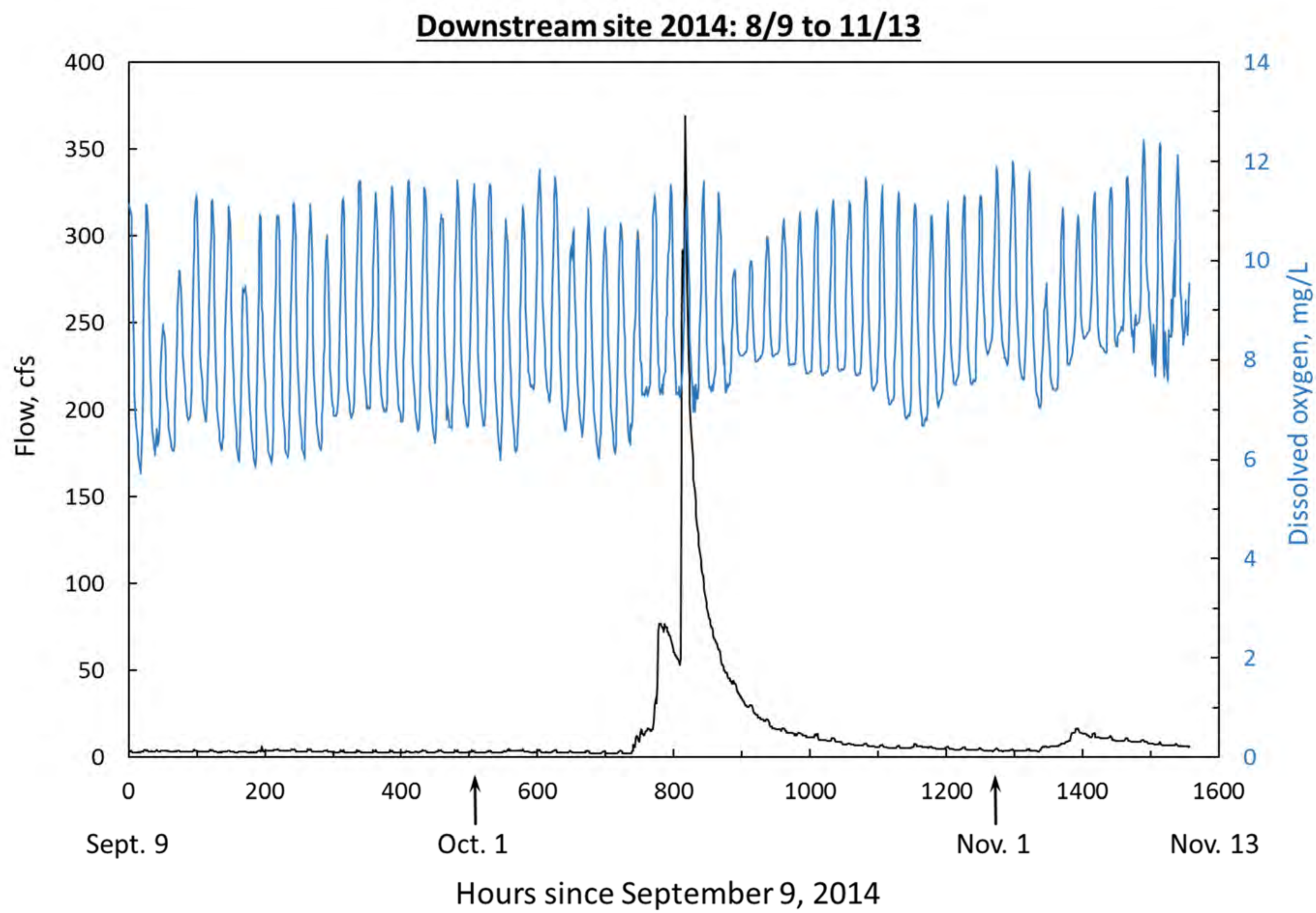

Figure 2. Flow and dissolved oxygen concentration downstream of the C&H Farm between September 9 and November 13, 2014.

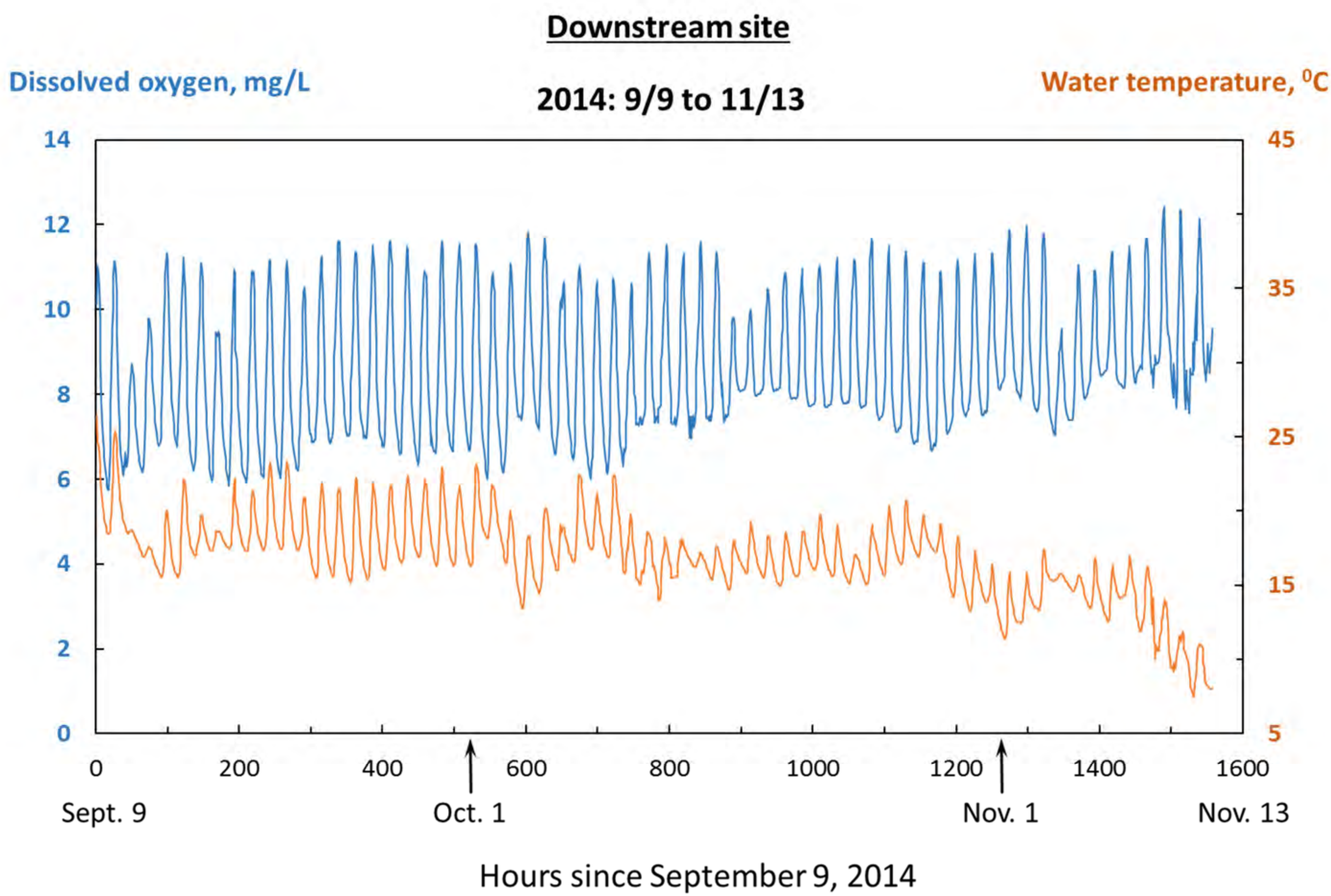

Figure 3. Water temperature and dissolved oxygen concentration downstream of the C&H Farm between September 9 and November 13, 2014.

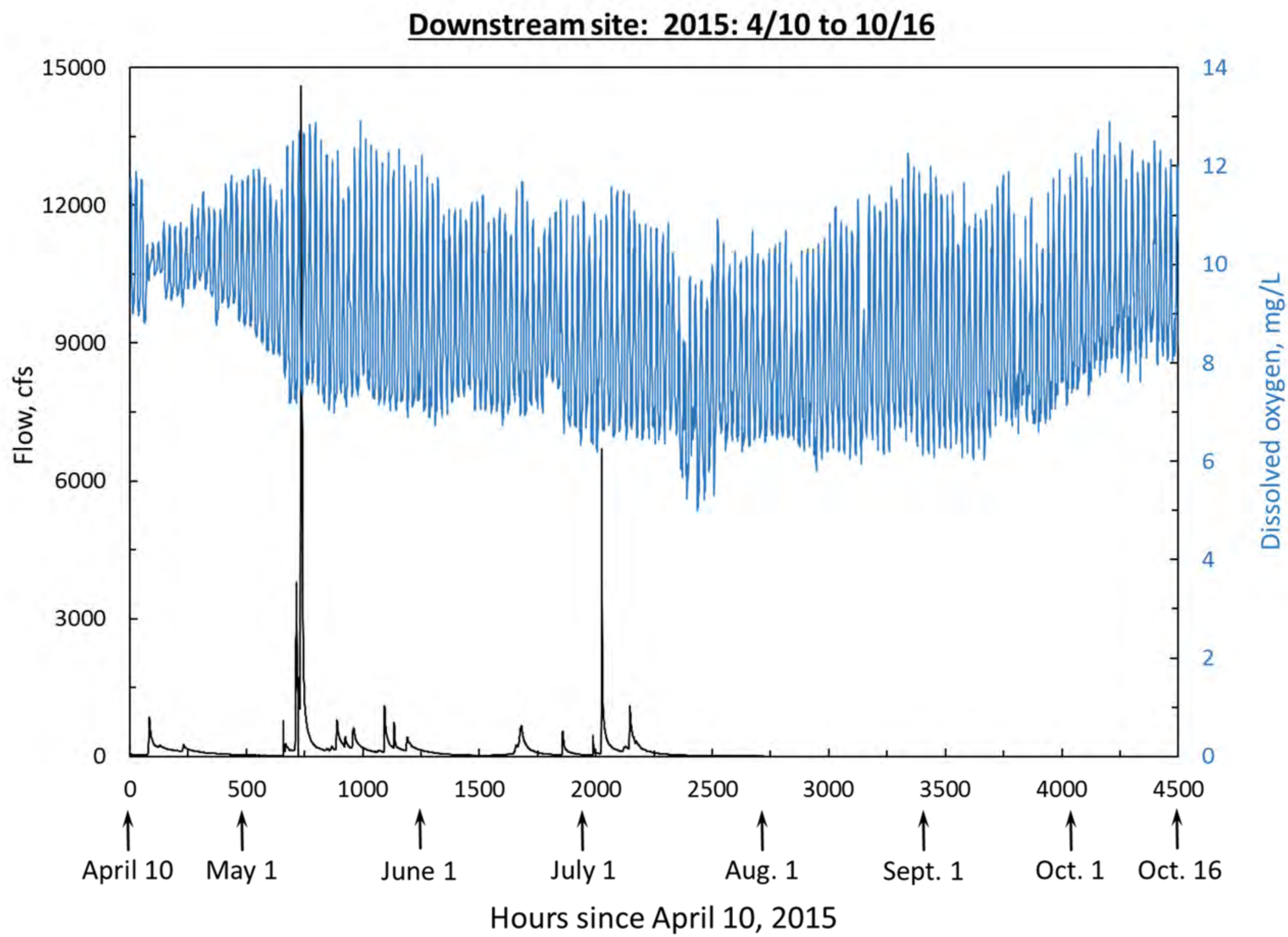

Figure 4. Flow and dissolved oxygen concentration downstream of the C&H Farm between S April 10 and October 16, 2015.

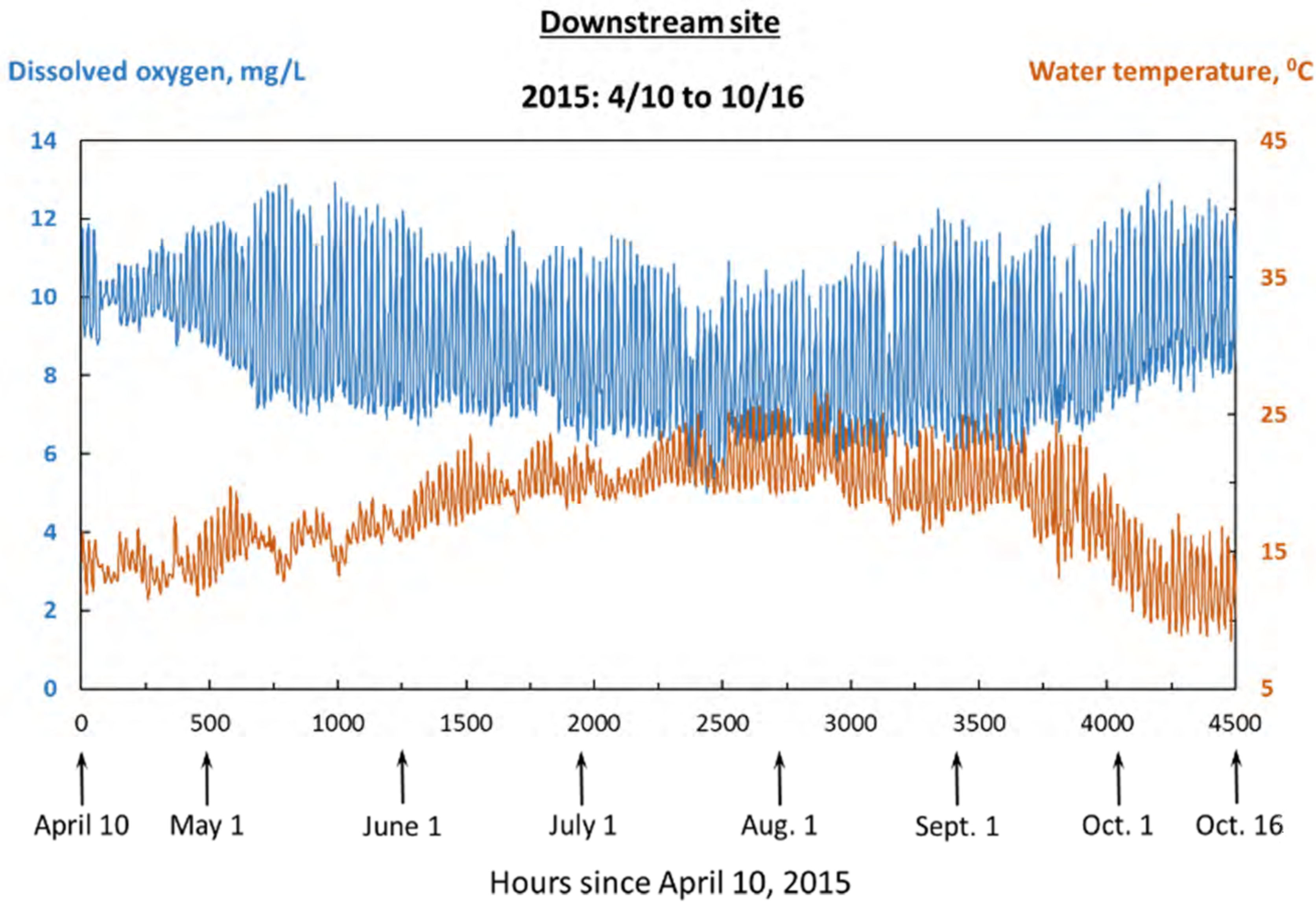

Figure 5. Water temperature and dissolved oxygen concentration downstream of the C&H Farm between April 10 and October 16, 2015.

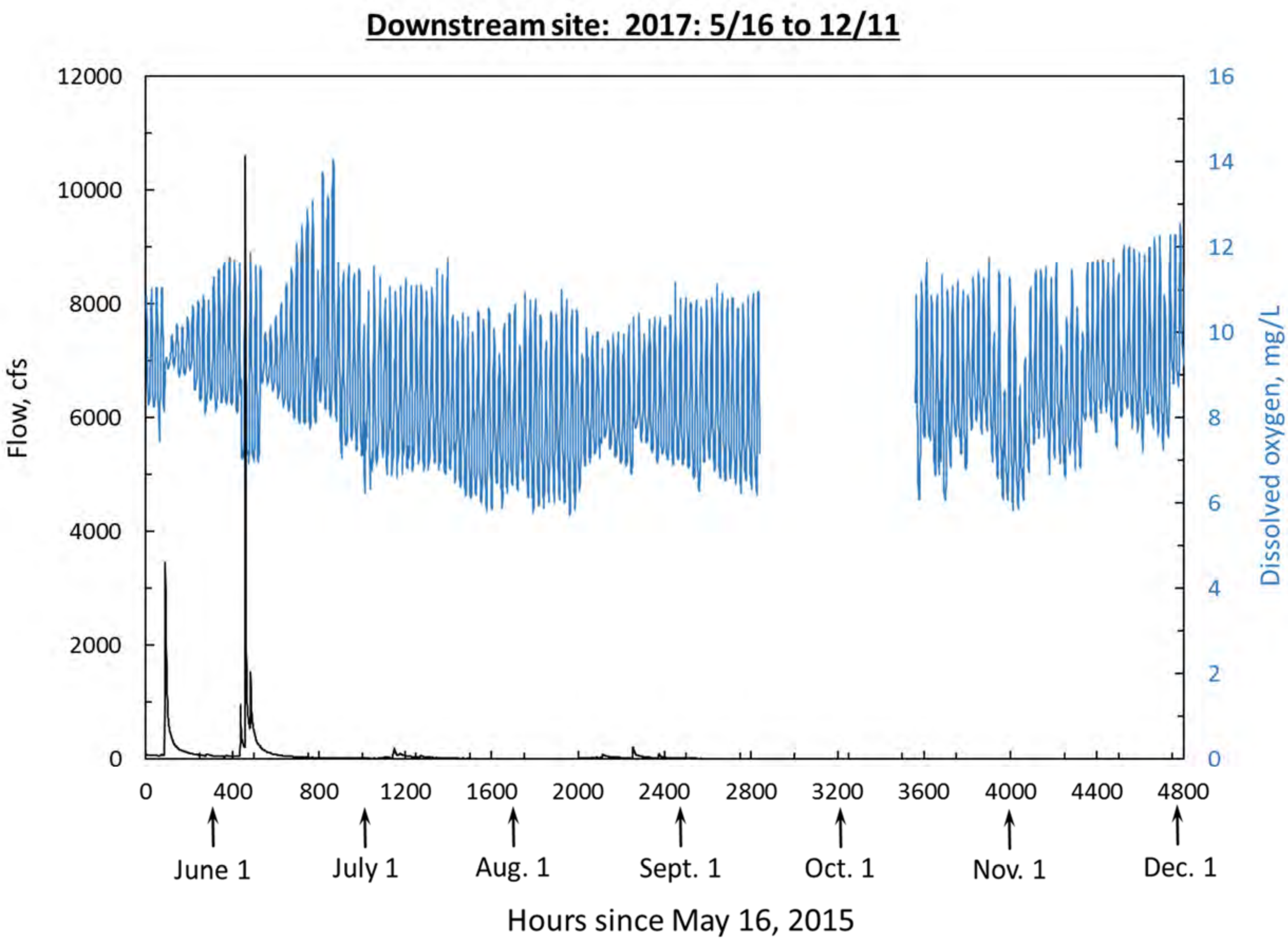

Figure 6. Flow and dissolved oxygen concentration downstream of the C&H Farm between May 16 and December 11, 2017.

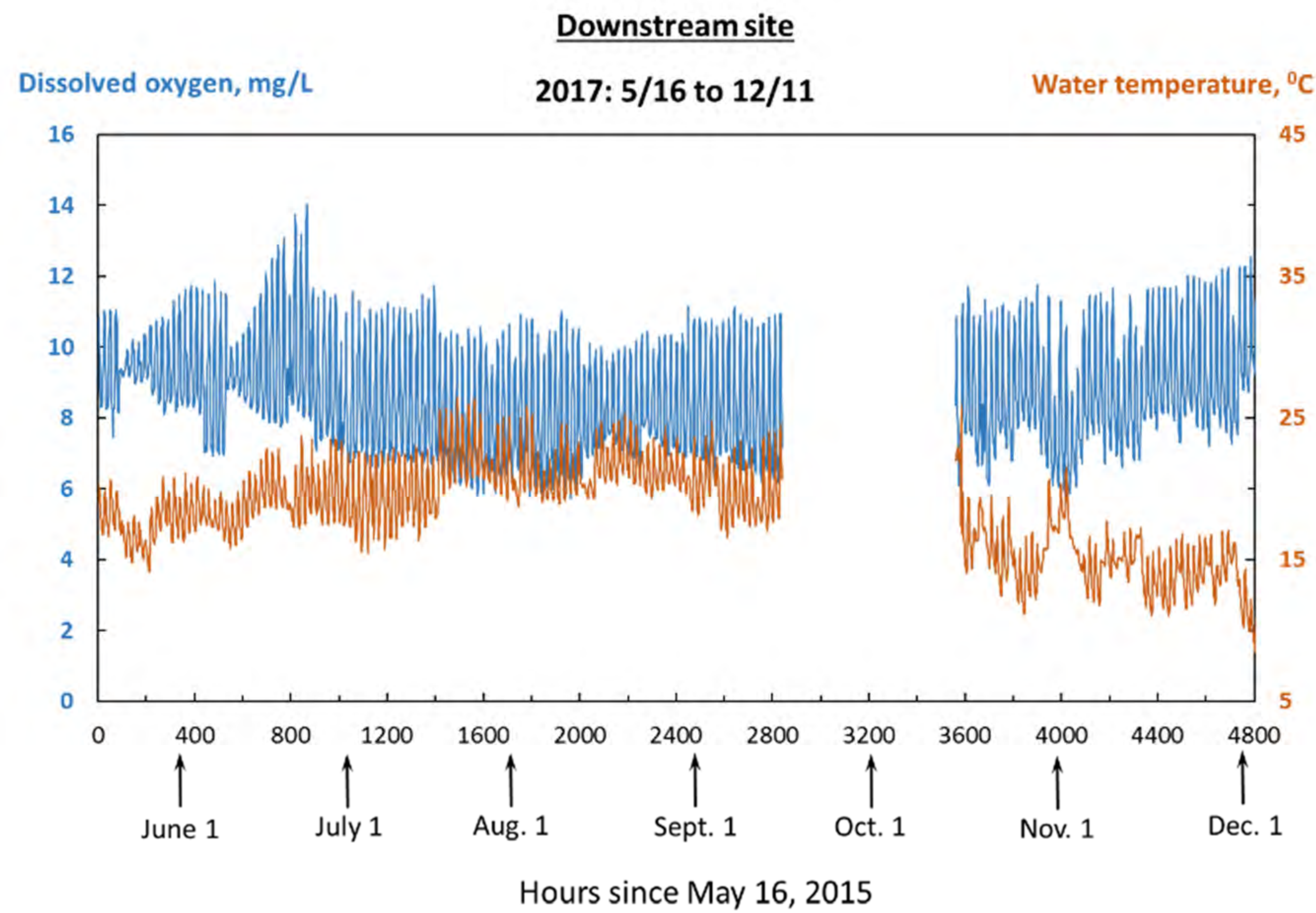

Figure 7. Water temperature and dissolved oxygen concentration downstream of the C&H Farm between May 16 and December 11, 2017.

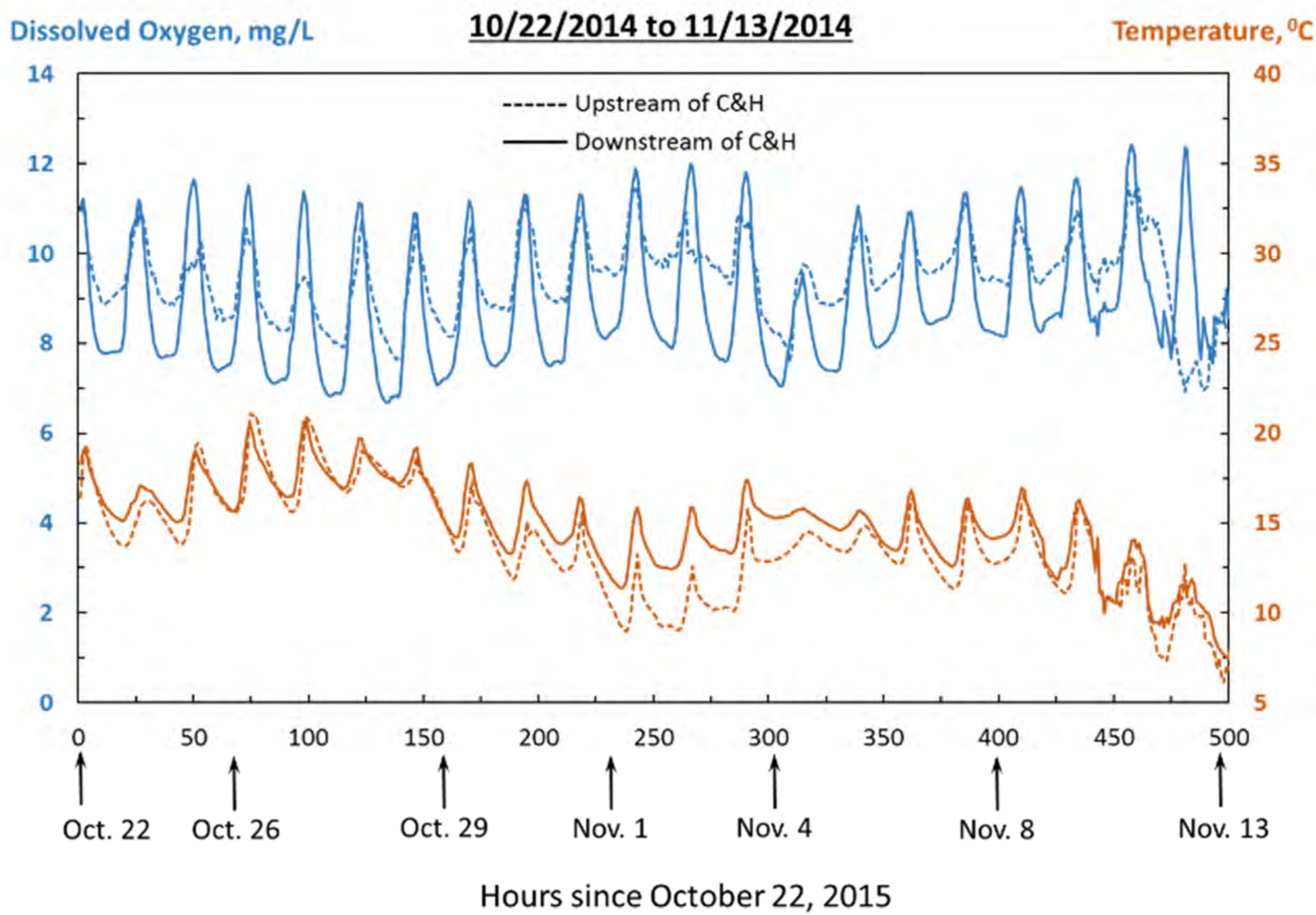

Figure 8. Water temperature and dissolved oxygen concentration upstream and downstream of the C&H Farm between October 22 and November 13, 2014.

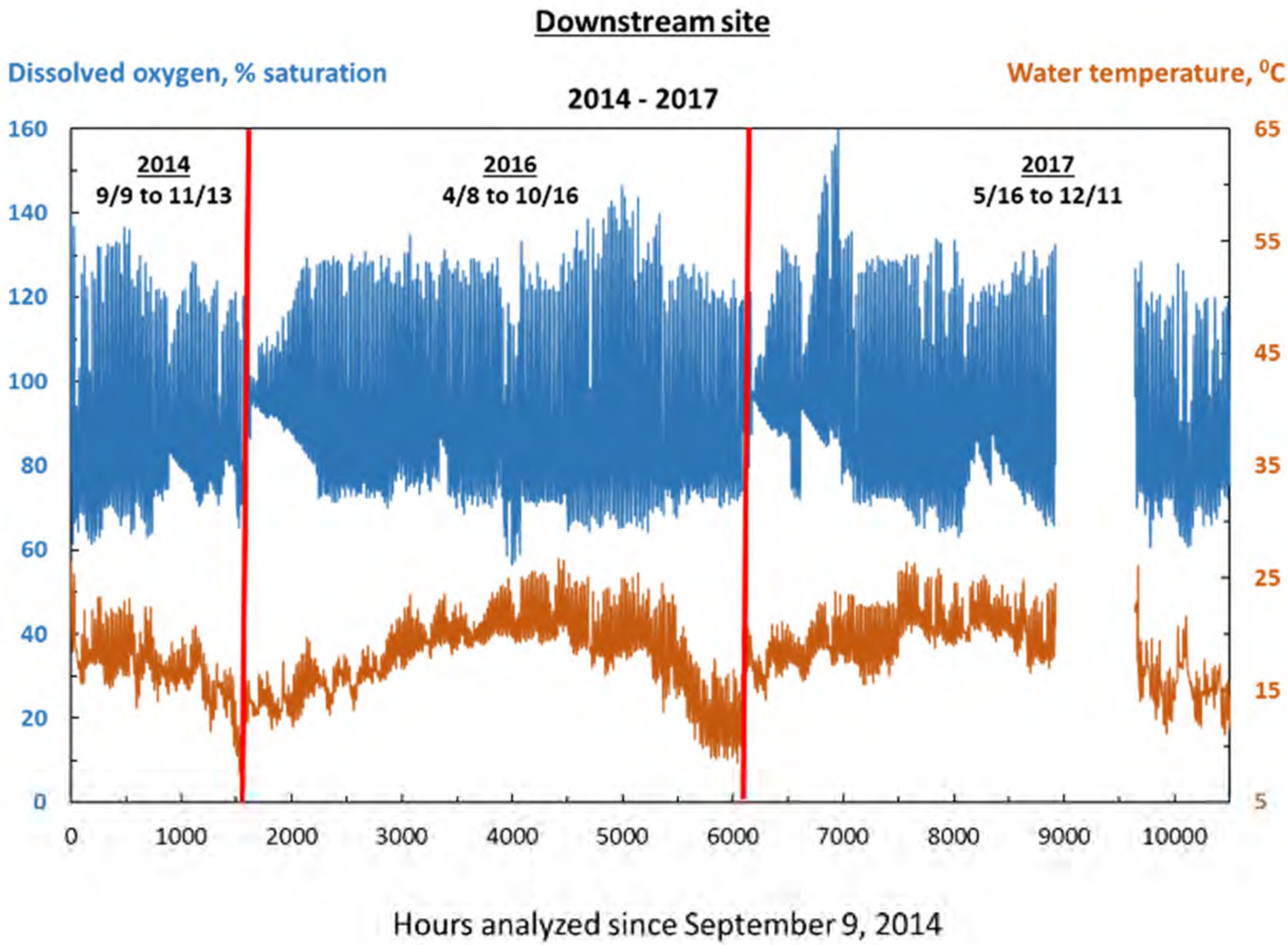

Figure 9. Water temperature and dissolved oxygen saturation downstream of the C&H Farm between September 9 and December 11, 2017.

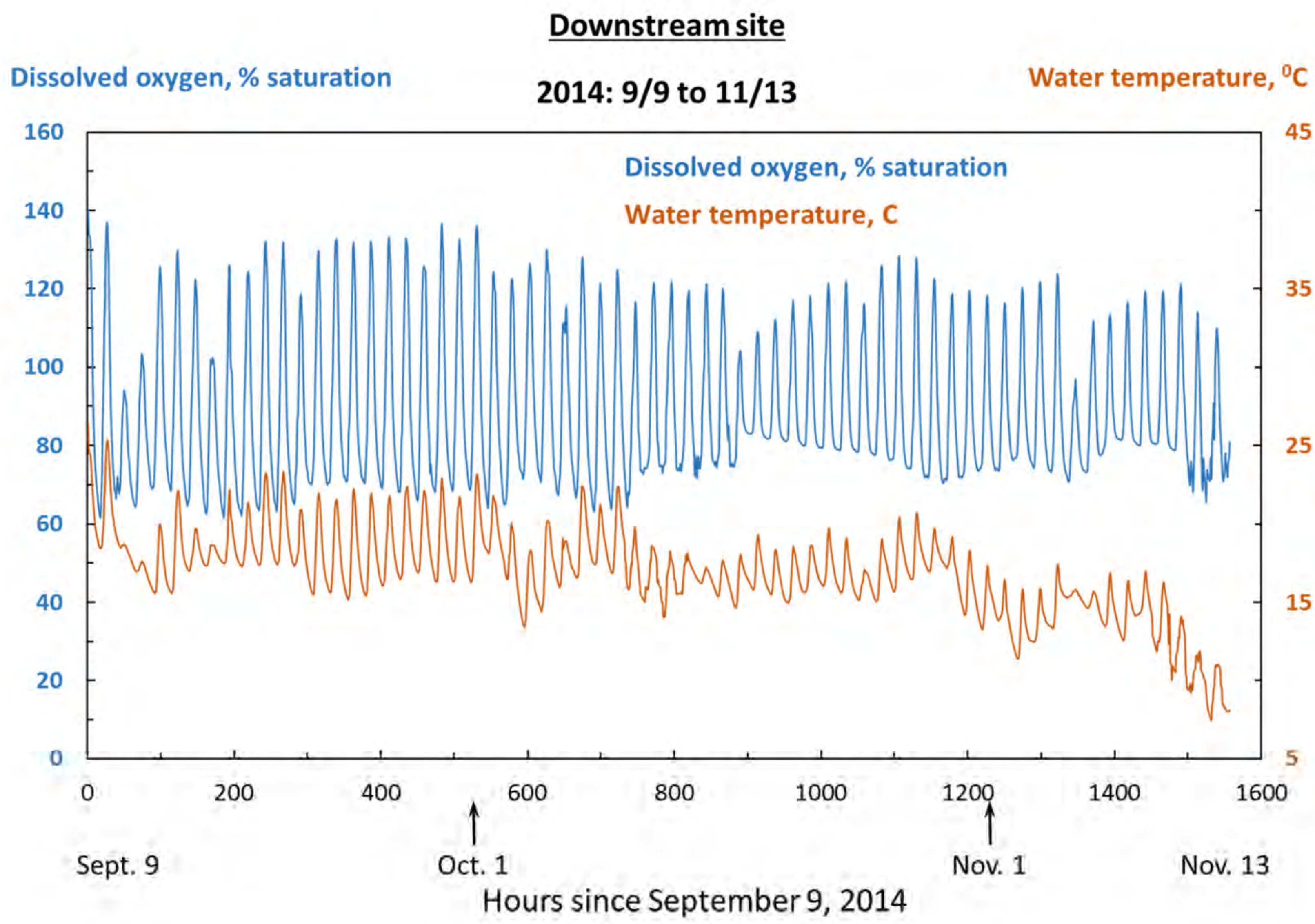

Figure 10. Water temperature and dissolved oxygen saturation downstream of the C&H Farm between September 9 and November 13, 2014.

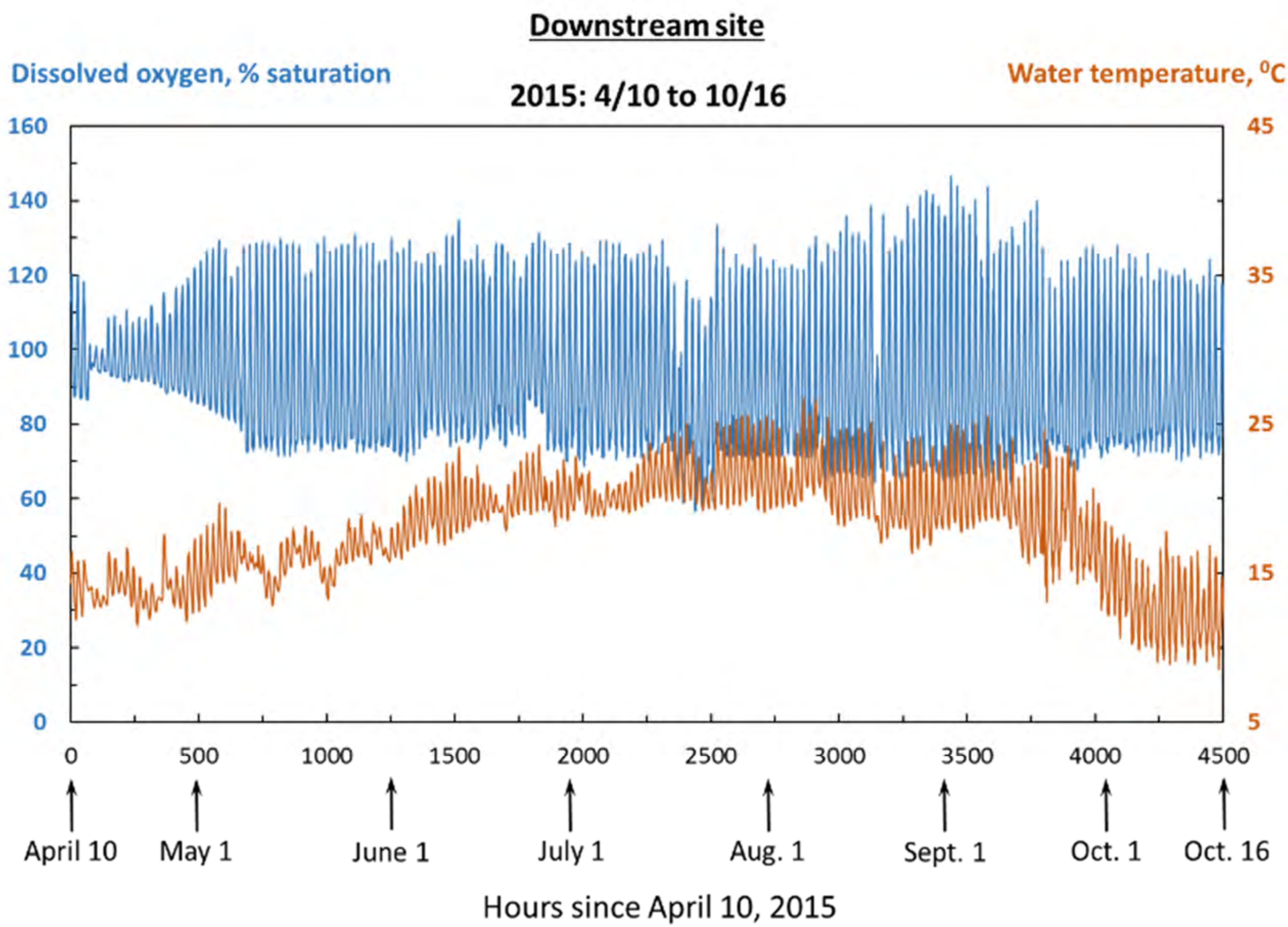

Figure 11. Water temperature and dissolved oxygen saturation downstream of the C&H Farm between April 10 and October 16, 2015.

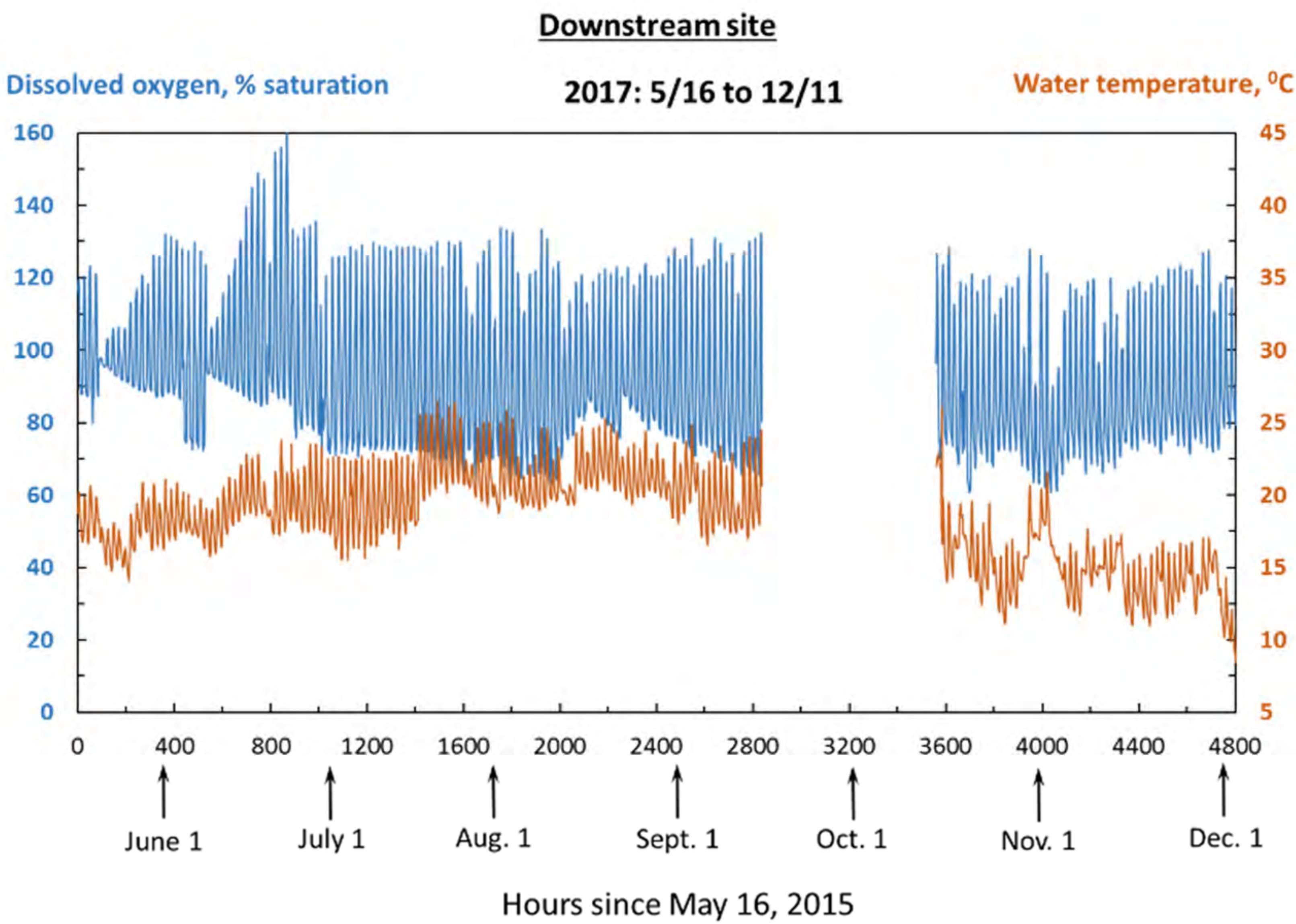

Figure 12. Water temperature and dissolved oxygen saturation downstream of the C&H Farm between May 15 and December 11, 2017.

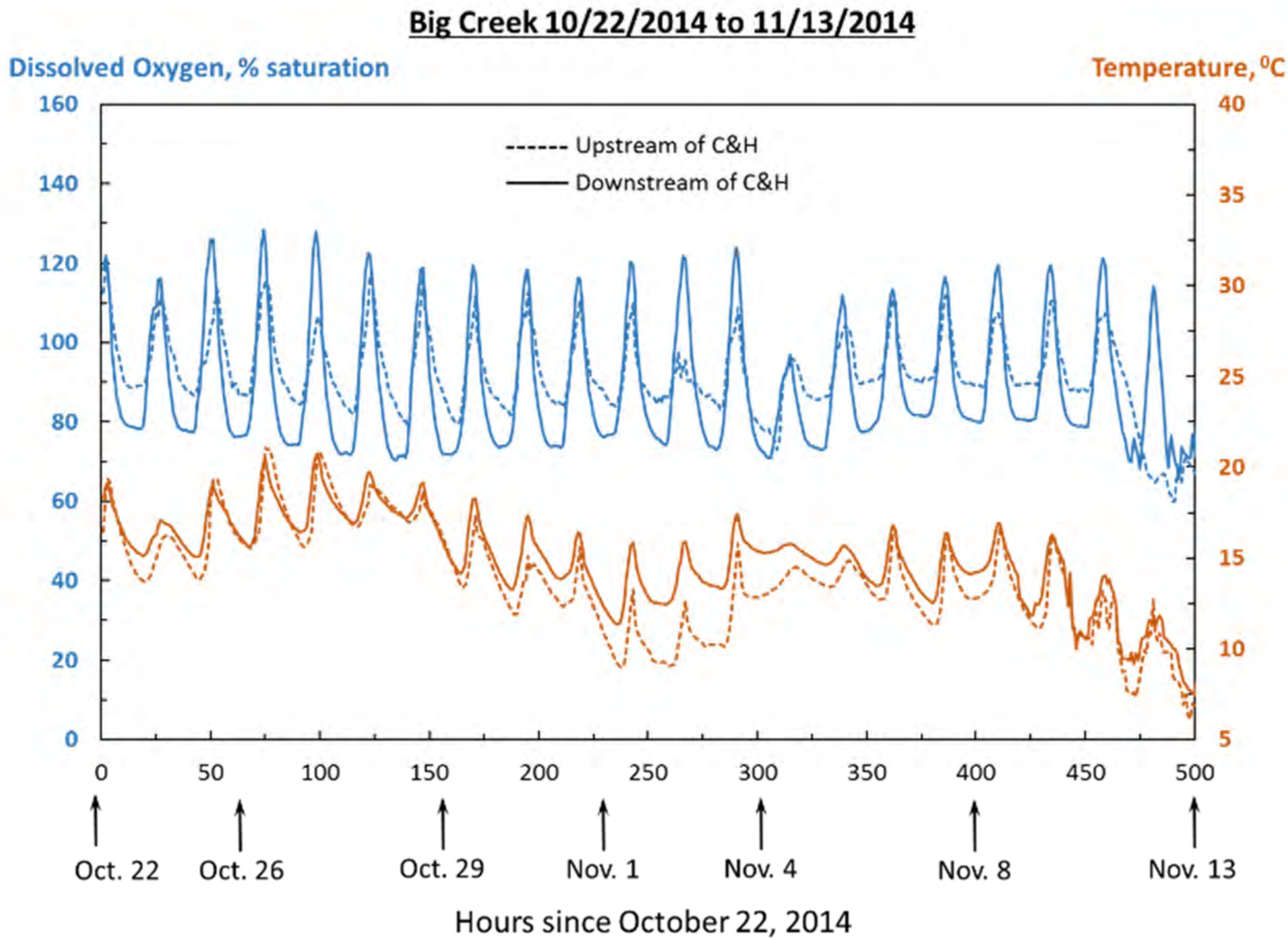

Figure 13. Water temperature and dissolved oxygen saturation upstream and downstream of the C&H Farm between October 22 and November 13, 2014.

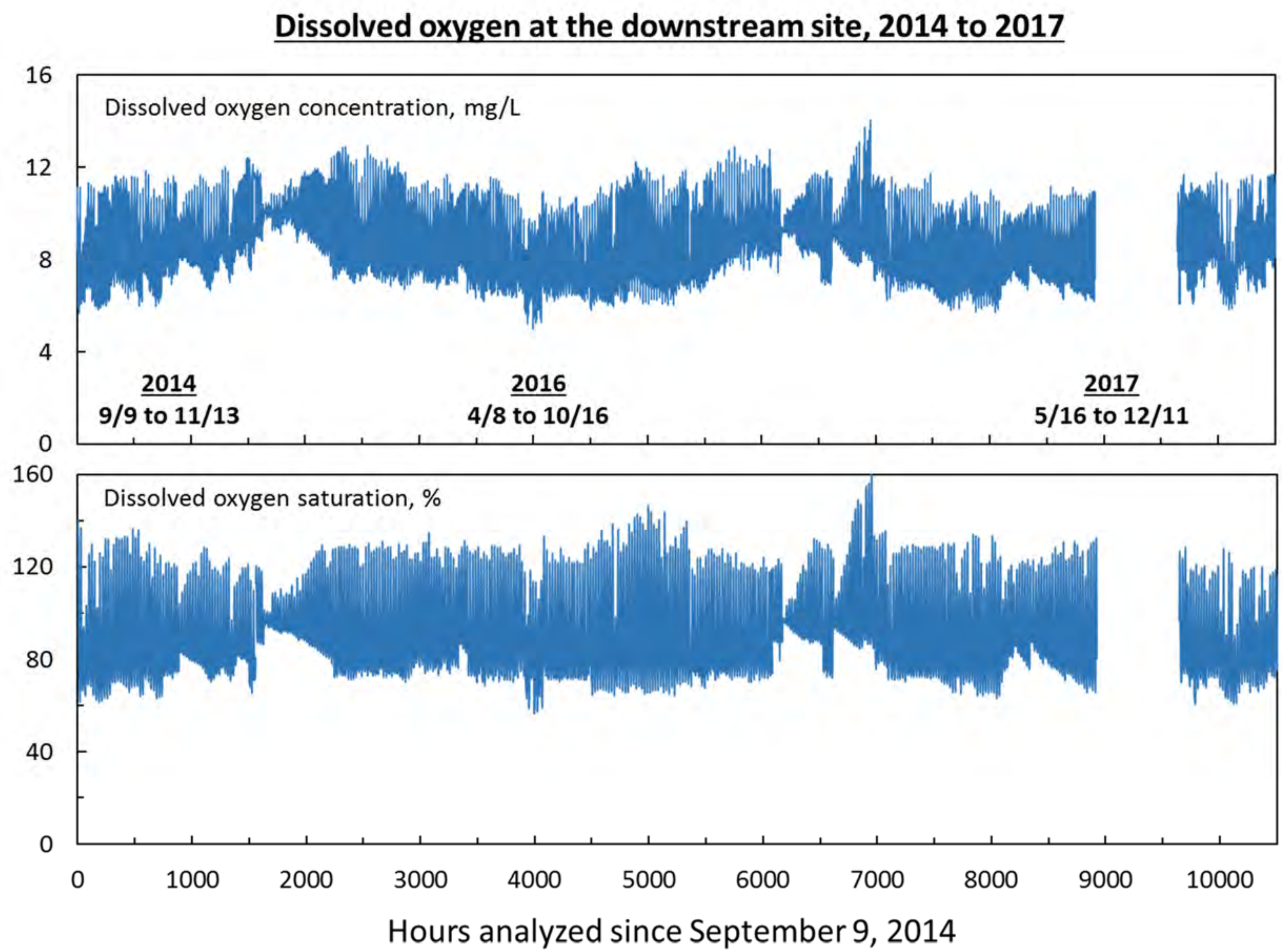

Figure 14. Dissolved oxygen concentration and % saturation downstream of the C&H Farm between 2014 and 2017.

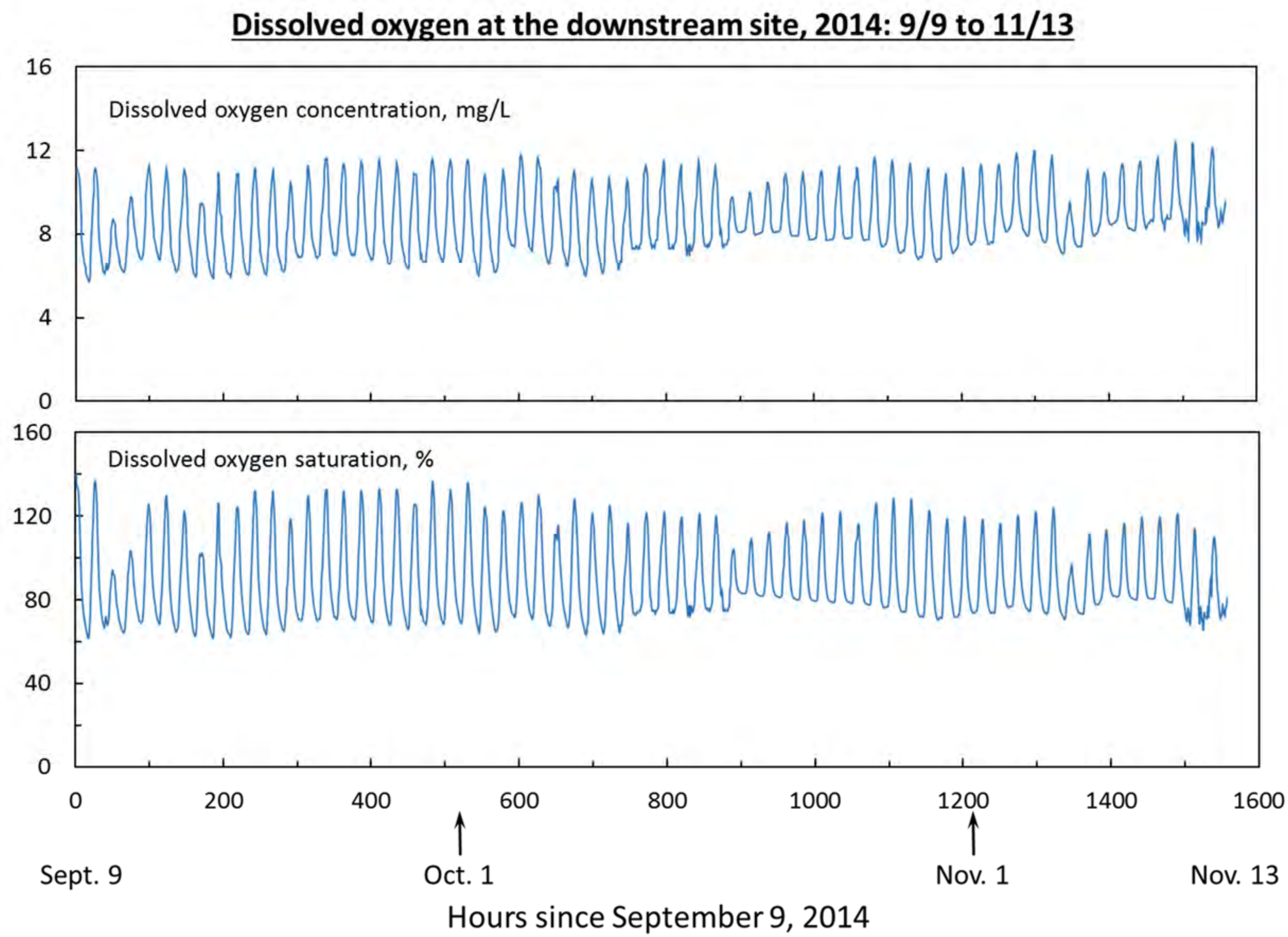

Figure 15. Dissolved oxygen concentration and percent saturation downstream of the C&H Farm between September 9 and November 13, 2014.

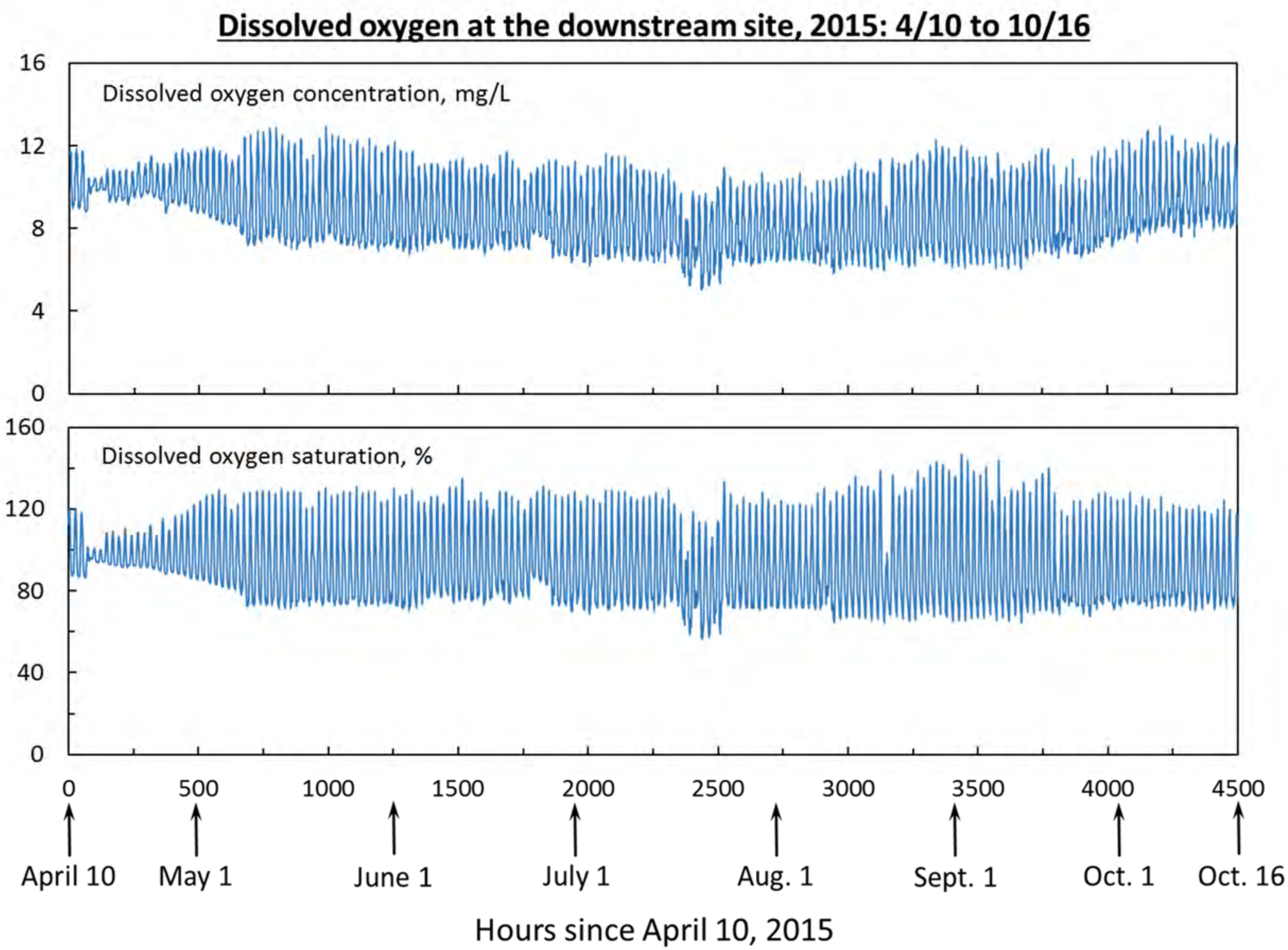

Figure 16. Dissolved oxygen concentration and percent saturation downstream of the C&H Farm between April 10 and October 16, 2015

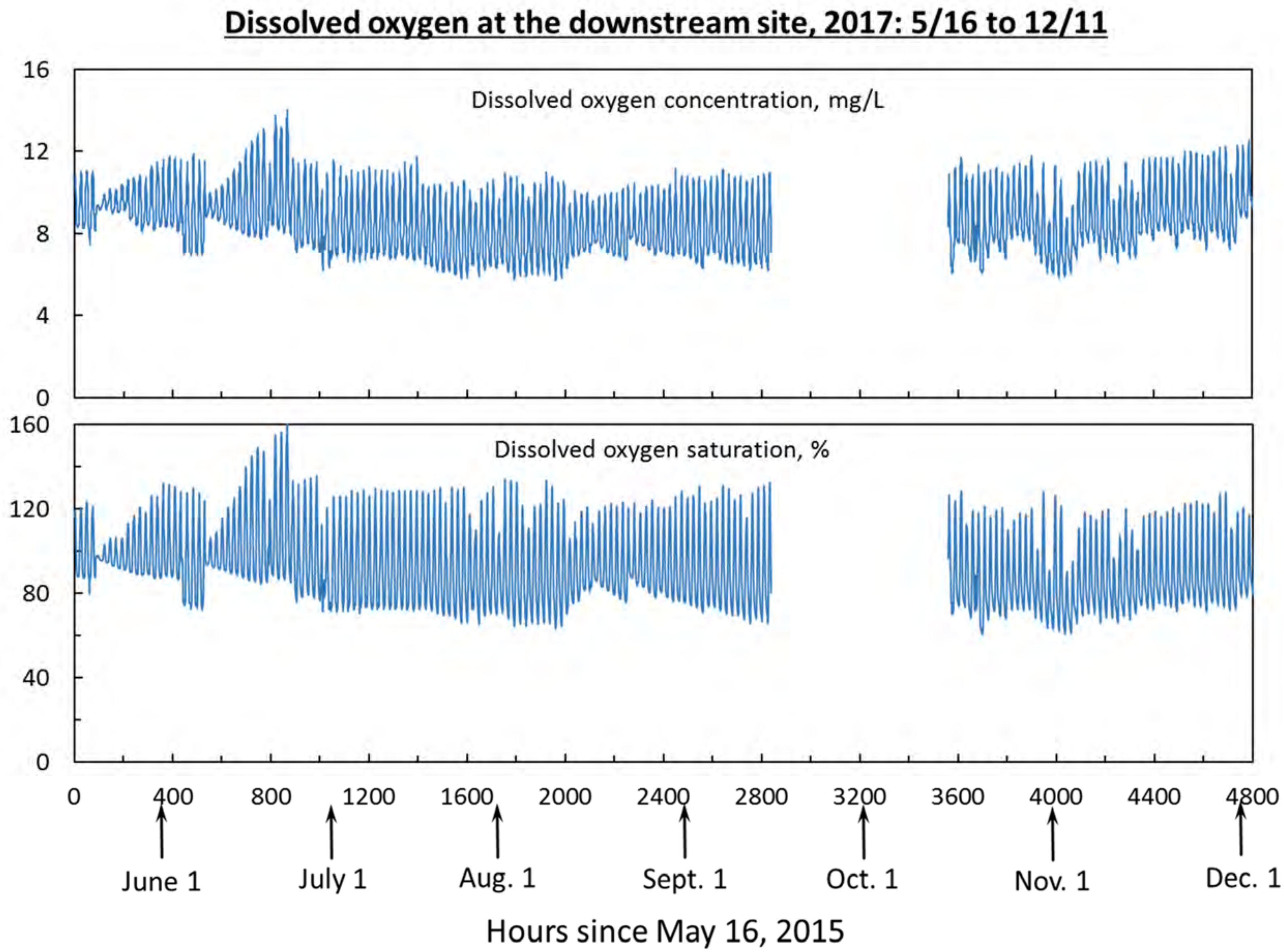

Figure 17. Dissolved oxygen concentration and percent saturation downstream of the C&H Farm between May 16 and December 11, 2017.

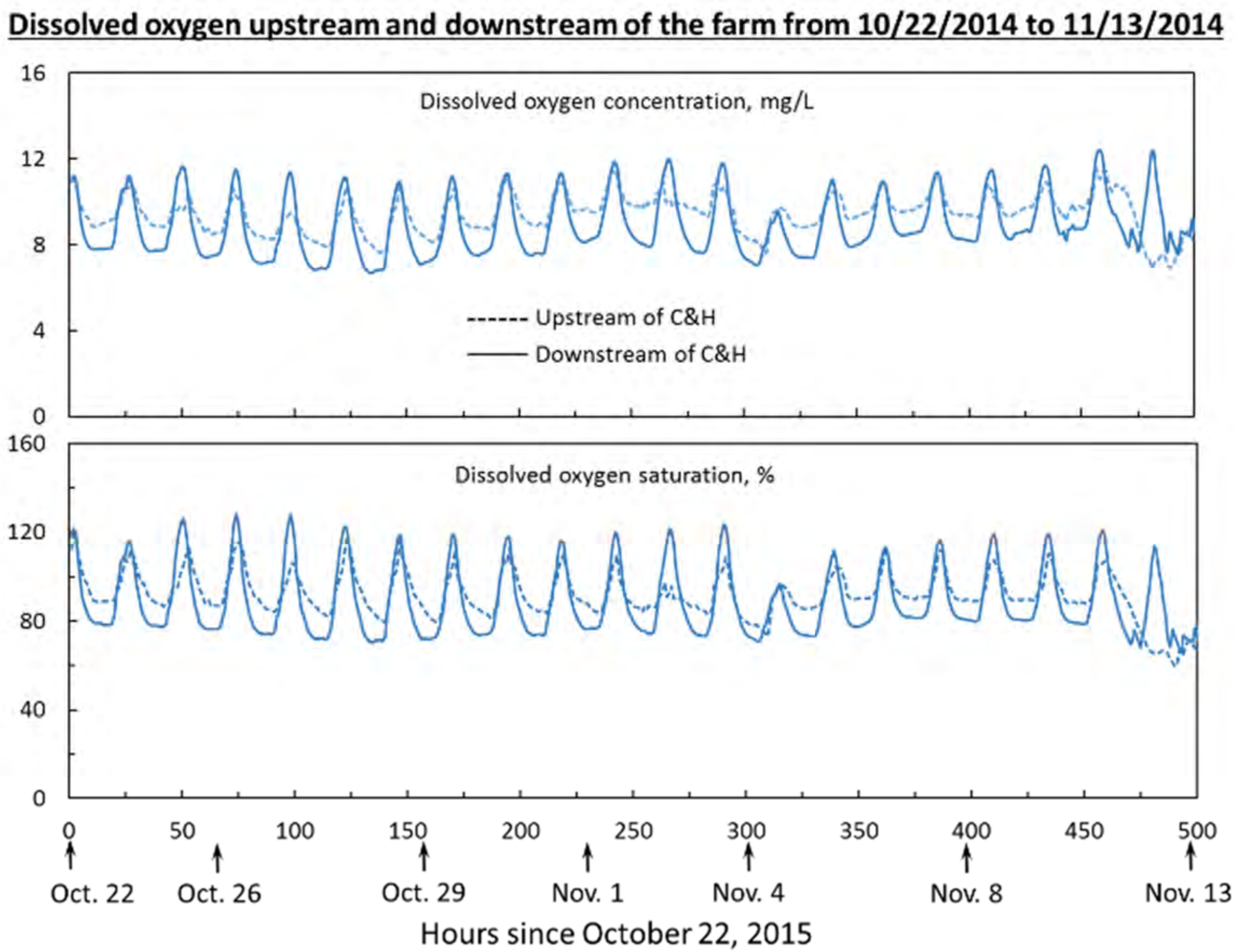

Figure 18. Dissolved oxygen concentration and percent saturation upstream and downstream of the C&H Farm between October 22, 2014 and November 13, 2014.

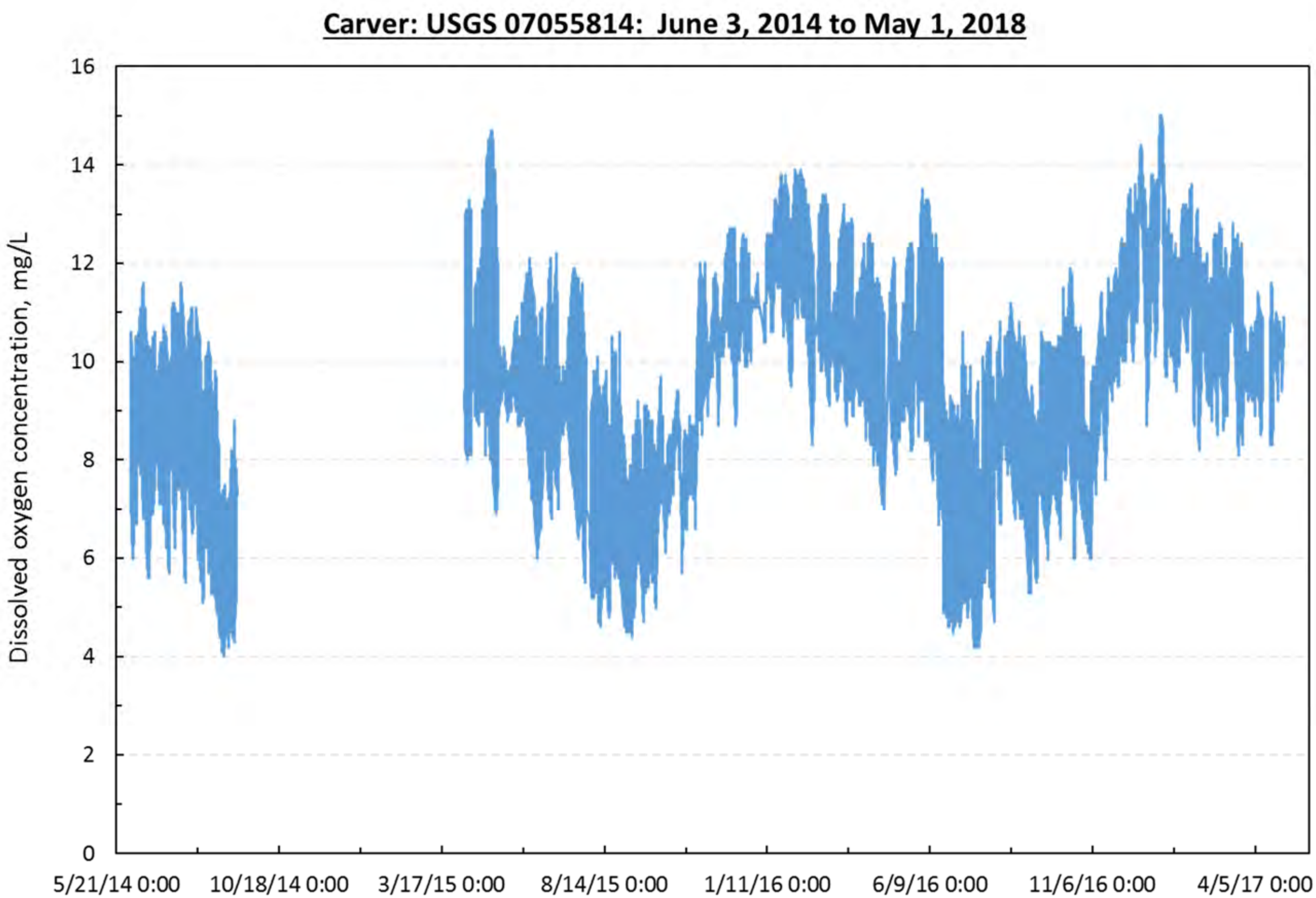

Figure 19. Dissolved oxygen concentration at the USGS Carver site (USGA: 07055814) for June 3 to May 1, 2018.

APPENDIX J: MANURE TREATMENT

Calcium Enhanced Precipitation of Swine Manure: Supporting Concepts and Lab Scale Trial Findings

Contents

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Summary

1. A mixture of locally sourced lime and hydrated lime amendments, decreased water-soluble P concentrations of the liquid and precipitate or solids fraction of holding pond slurry. Use of an off-the-shelf granular agricultural grade lime product, had no consistent effect on water-soluble P concentration.
2. Hydrated lime amendments tended to enhance the effectiveness of separation of solids from liquid in manure slurry, as related to increasing the percent solids and P concentration of the separated solids. In principle, this would be beneficial for transport of P off the generating farm.
3. Hydrated lime amendments appeared to increase manure slurry pH sufficiently to increase N loss via ammonia volatilization. If manure slurry was viewed as a N fertilizer, the increased loss of N would not be desirable. If air quality was a concern, the increased loss of N would not be desirable.
4. Use of granular agricultural grade lime at the rates used, had no consistent effect on the solids separation process for manure slurry from the C&H Farm.
5. Despite certain potential benefits of lime amendment providing options available to the Farm to manage the slurry in compliance with nutrient management planning requirements, all amendments presented economic, logistical, and labor constraints severely limit their viability for adoption.

Background

An important consideration of liquid manure solids separation is the fate and economic value of the resulting liquid and solids fractions. The desired properties of the separated fractions, operator preferences, regulatory considerations, and economics should determine the type and degree of treatment.

Research has shown that amendment with aluminum, iron, and calcium compounds can increase the concentration of phosphorus (P) and manure solids into a lower moisture manure product. Such chemical amendment, preferentially separates the manure into a P-rich portion for transport to more distant locations for utilization, and a P-poor portion for use closer to the farm. In contrast to aluminum and iron, calcium in the form of $CaCO_3$ (Ag lime) or $Ca(OH)_2$ (Hydrated Lime) are often uses as soil amendments for beneficial soil pH modification. In addition, manure amendment with calcium compounds should result in calcium phosphate compounds, which are a common source of P fertilizers. In addition, due to the fact that P is a finite resource, it is desirable to retain P availability in manure solids for beneficial use, where P is needed for optimal crop production. In the area of alternative manure solids usage via thermal energy conversion (gasification), there is interest on the effects of calcium on energy conversion and bio-char production.

For this reason, we investigated the effectiveness of calcium (Ca) binding with manure P to enhanced natural settling of manure solids. Depending on the chemical and physical properties of the settled solids, the necessary mechanical and structural components of a manure separation system could be designed to meet the nutrient and transportation needs, and hopefully economic constraints of the farm enterprise.

A guiding concept any manure treatment technology is to generate a by-product that has value as a fertilizer, can be transported large distances (in this case, out of the Buffalo River Watershed), or provides a farmer with options to match manure applications to pasture needs and nutrient offtake. A direct benefit of such treatment technology would be to minimize nutrient accumulations in soil beyond optimal levels for pasture / crop production and thereby reducing the potential for nutrient runoff. In addition, because P is a finite resource, it is desirable to retain P in manure for beneficial use, where needed for optimal pasture / crop production.

For this reason, we investigated the effectiveness of calcium (Ca) binding with manure P enhanced by natural settling of manure solids. In principal, after addition of Ca to manure various Ca phosphate compounds are formed, which settle out with manure solids. Depending on the chemical and physical properties of the settled solids, the necessary mechanical and structural components of a manure separation system could be designed to meet the transportation needs and hopefully economic constraints of the farm enterprise.

Methods

Overview

This research treated liquid swine manure with hydrated lime, $Ca(OH)_2$, and agricultural lime, $CaCO_3$. The hydrated lime was added to manure slurry in either a liquid slurry form (30% by weight) or as a dry powder. The agricultural lime was added in the dry fine granular form. The three calcium sources were added to the manure at 3 amendment levels with 3 replicates. A non-amendment control for each chemical source and additional final non-amendment control were also processed. The resulting 31 mixtures were sampled prior to separation via gravity settling in containers lined with 150 micron filter bags. After allowing time for settling, the filter bags were lifted from the containers and allowed to drain prior to collecting leachate from the containers and precipitate from the filter bags. The remaining material was left in the containers and filter bags for storage under ambient conditions but protected from precipitation for 10 days before being sampled again.

Setting Amendment Rates

Due to the variability of swine manure, it was appropriate to set the amendment chemical addition rates on the day of the trail using the manure to be treated in the trail. The 30% (gm/gm) hydrated lime slurry was added at the rate of 0, 10, 20, 30, 40, 60, 80, and 100 ml/l to manure in clear bottles. After mixing and allowing the solids to settle, it was determined via visual inspection to set the base line full Ca amendment rate at 50 mL/L of 30% hydrated lime slurry per liter of manure (Figure 1). The corresponding 1/2X rate and 2X rates would be 25 mL/L and 100 mL/L. Stoichiometric calculations determined the equivalent elemental Ca amendment rates for the dry hydrated and agricultural lime as 1/2X, 1X, and 2X rates (Table 1).

Figure 1. Clear test bottles after 30 % (wt/wt) $Ca(OH)_2$ slurry was added to 500 ml of manure at the rates of 0, 10, 20, 30, 40, 60, 80, and 100 mL/L and allowed to settle. Based on both the clarity of the top liquid and settled solids a target rate of 50 mg/L (5%) was select for the chemical amendment trial.

Table 1. Chemical amendment rates based a 5% (mL/mL) target mixture rate of Ca hydroxide to manure slurry and 17 liters of manure slurry.

Chemical and form	Amendment rate			
	O x Target rate	½ x Target rate	1 x Target rate	2 x Target rate

Ca Hydroxide, 30% (gm/gm) slurry	0 mL	425 mL	850 mL	1700 mL
Ca Hydroxide, dry powder	O gm	154 gm	307 gm	614 gm
Ca Carbonate, dry fine granular	O gm	207 gm	415 gm	830 gm

Collection of Manure Slurry

An on-farm system to chemically and physically treat manure slurry would likely take place the manure slurry as it is discharged from the barns and before it enters holding Pond 1. Thus, a manure slurry collection and mixing system was designed for this chemical trial (Supplemental Figure S1). On the day of the trial (September 4, 2014), a pump was used to capture a portion of the manure discharged from the barns into holding Pond 1 as one of the manure pits was being drained. The captured manure was pumped into a 360-gallon tank (i.e., 1,363 L) via two mixing nozzles to ensure uniform mixing of the manure slurry in the tank (see Figure S2 for nozzle configuration).

Once this tank was filled, a discharge valve was opened to drain a portion of the collected manure into holding Pond 1. By adjusting the discharge valve and pump throttle, the manure flow rate into and out of the tank were balanced resulting in the tank manure volume remaining fixed (Figure S1). This balanced-flow process continued until the manure pit in the barn had been drained and a composite sample of all the manure slurry from the drained pit was collected. After manure was collected was completed, valves were closed so that the pump continually mixed manure slurry in the tank for the remainder of the trial (Figure S1).

Amendment of Manure Slurry

Using one of the tank's valves, manure was drained from the tank into 5-gallon buckets in 17-liter volumes as needed for the chemical amendment. For each chemical amendment, rate, and replication combination 17 L of manure slurry was drained from the tank into a bucket (Table 2). The desired amount of chemical was added and mixed into the manure using a battery-powered drill with attached stirring paddle. Before any settling could occur, the mixture was poured into a second bucket lined with a 150 micron filter bag (see Figure S3). A subsample was collected as it was poured into the lined bucket. At this time, the lined bucket was set aside and the suspended solids allowed time to settle.

After settling each filter bag was lifted from its bucket and allowed to drain into the bucket for 3 minutes. Samples of the concentrated manure slurry (precipitate) in the filter bag and the leachate from the bucket were sampled for analysis. This process was repeated until three replicates of each chemical/rate combination in Supplemental Table S1 had been prepared.

Table 2. Chemical additions associated with the various amendment rates.

Chemical addition per liter of liquid manure

Amendment	Rate	Water mass [1]	Wet mass [1]	Dry mass [2]	Ca mass [3]
		mL/L	gm/L	gm/L	gm/L
Manure only[4]	0.0	-	1000	-	-
$Ca(OH)_2$ slurry (LS)	1/2X	25	30.10	9.03	4.89
	1X	50	60.21	18.06	9.77
	2X	100	120.42	36.13	19.55
$Ca(OH)_2$ (HL)	1/2X	-	9.03	9.03	4.89
	1X	-	18.06	18.06	9.77
	2X	-	36.13	36.13	19.55
$CaCO_3$ (AL)	1/2X	-	12.20	12.20	4.89
	1X	-	24.40	24.40	9.77
	2X	-	48.80	48.80	19.55

[1] Includes mass of water in Lime Slurry. Assumes Hydrated Lime and Ag. Lime Moisture content to be 0% when it might have been in <3% range.

[2] Mass of Ca(OH)2 and CaCO3 only added assuming chemicals 100% pure when there where likely slight levels of impurities.

[3] Mass of Ca added assuming chemicals 100% pure when there where likely various forms of Ca compounds and impurities within the Ag lime used.

[4] In calculations Liquid manure density assumed equal to water as this is standard assumption and assumed %TS would be <5%. The measured %TS was just under 2%.

Once the manure from the filter bags were sampled, tripods were used to suspend them above their respective bucket (Figure S4). The combination of buckets and tripods were placed under a fenced in awning, which allowed for full air movement while protecting them from rainfall and damage from animals.

After 5 days, the filter bags were dry enough that they were placed on tables to reduce the potential for wind damage and rewetting of the bags. On September 15, 2014, a total of 10 days after treatment, the manure slurry mixture in the filter bags and leachate in the 5-gallon buckets was mixed and sampled for analysis. The remaining precipitate from the filter bags was delivered for energy content analysis.

A total of 93 samples were collected the day the manure was treated, with an additional 62 samples collected after storage for 10 days. Each sample was analyzed for total solids (TS), pH, total N (N), ammonium-N (NH_4-N), nitrate-N (NO_3-N), total P (P), total potassium (K), total Ca (Ca), and water extractable P (WEP)

Preliminary Findings

Preliminary assessment of the three lime products to act as a flocculation agent to enhance precipitation of slurry solids and to sequester P in a less available form are detailed in Supplementary Figures S5 through S16. With the exception of nitrate-N, the coefficient of variation associated with the control samples prior to filtering was 6% or less. These low values, coupled with the fact that the control samples were collected over the course of the sampling day, indicate that a homogenous manure mixture was maintained.

Amendment of manure slurry with each of the three lime products increased flocculation of solids (Figure 2). Hydrated lime was most effective, followed by Ag lime and locally sourced lime.

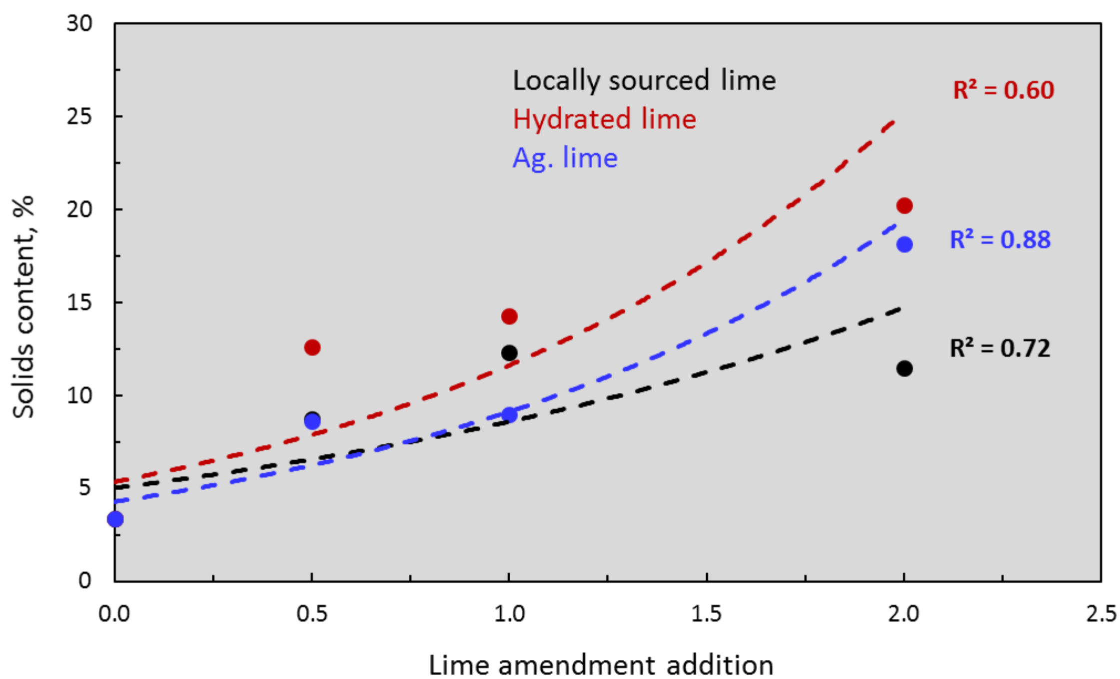


Figure 2. Relationship between solids content of the precipitate three hours after addition of three lime amendments, where the target amendment (i.e., 1.0) is equivalent to 5% volume basis (i.e., 50 mL lime to 1000 mL slurry). Values are average of four replicates.

Addition hydrated lime amendment increased pH of the manure mixture. Higher amendment levels resulted in higher pH levels (Table S2). Addition of the pre-mixed lime slurry was more effective than the same Ca addition of dry lime powder. At the rates added, the Ag lime did not influence the pH of amendment mixture. This may be due in part to the Ag lime rate calculation procedures likely overestimated the Ca concentration in the lime. With increasing amendment rates, total N concentration decreased. In addition to the mass addition-dilution effect mentioned above, the elevated pH levels suggest that ammonia volatilization may be occurring.

Amended Slurry Leachate

Locally sourced lime and hydrated lime were appreciably more efficient at decreasing the water-soluble P concentration of amended slurry leachate, where samples were collected three hours after slurry amendment (Figure 3). In fact, the water-soluble concentration of slurry leachate amended with target levels of locally sourced and hydrated lime (i.e., 5% by volume) were just a respective 7 and 33% of control concentrations. The agricultural grade lime amendment only decreased water-soluble P concentration 41% compared to the control (Figure 3 and Table S2).

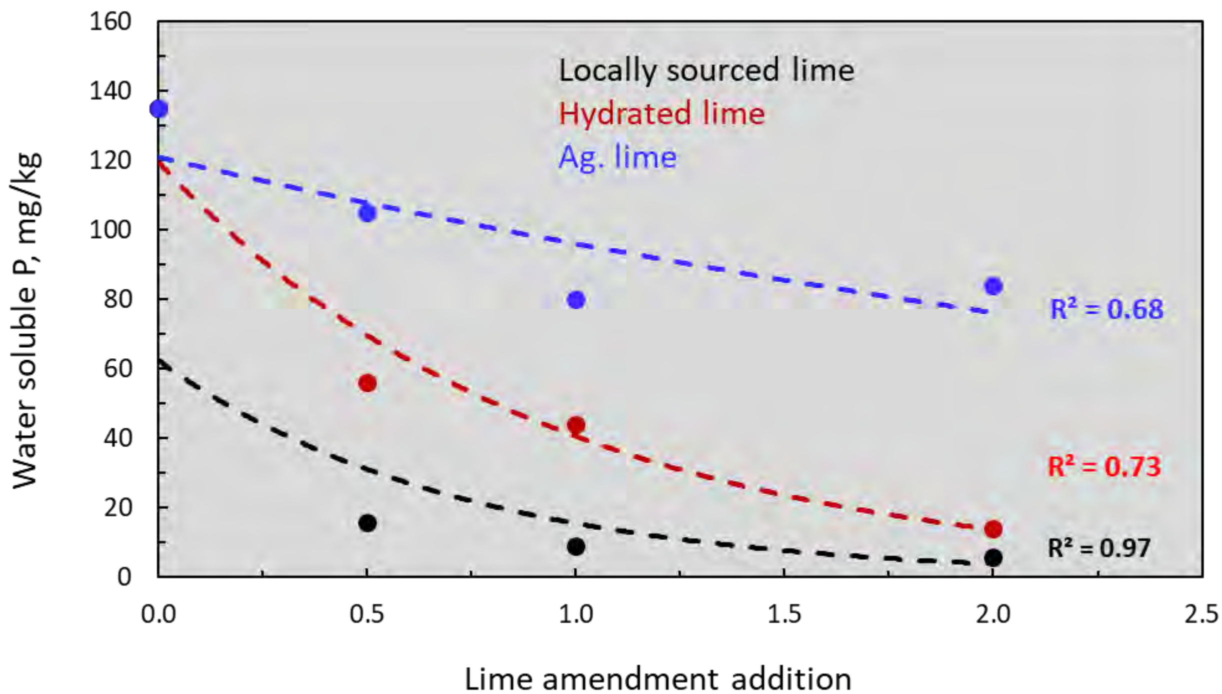


Figure 3. Relationship between water extractable P concentrations of leachate three hours after addition of three lime amendments, where the target amendment (i.e., 1.0) is equivalent to 5% volume basis (i.e., 50 mL lime to 1000 mL slurry). Values are average of four replicates.

Amended Slurry Precipitate

The precipitated material remaining after liquid removal by filtration, were also affected differentially by lime amendments. Figure 4 shows locally sourced and hydrated lime decreased water soluble P concentration of the precipitate material (target amendment was 6 and 4% of the control, respectively), while agricultural grade lime actually increased water soluble P concentration nearly three-fold. Why agricultural lime increased water soluble P concentration is unknown at the present time and further research is needed.

The separation process resulted in higher total P concentrations in separated slurry solids than original pre-treatment mixture and separated leachate. There was a statistically significant decrease in total P concentration as hydrated lime amendment rates increased (Table S2). Because of the total P increase, leachate had the highest water-soluble to total P ratio, with the separated solids the lowest. This effect is likely partially the result of increasing mass additions associated with increasing amendment rates.

Separation increase the total N to total P ratio in the leachate, while decreasing the ratio in the solids, with the hydrated lime amendments enhancing this trend (Table S2). However, the total N to total P ratios also decreased during storage, being more pronounced with the hydrated lime amendment. This is likely the result in ammonium-N loss during storage.

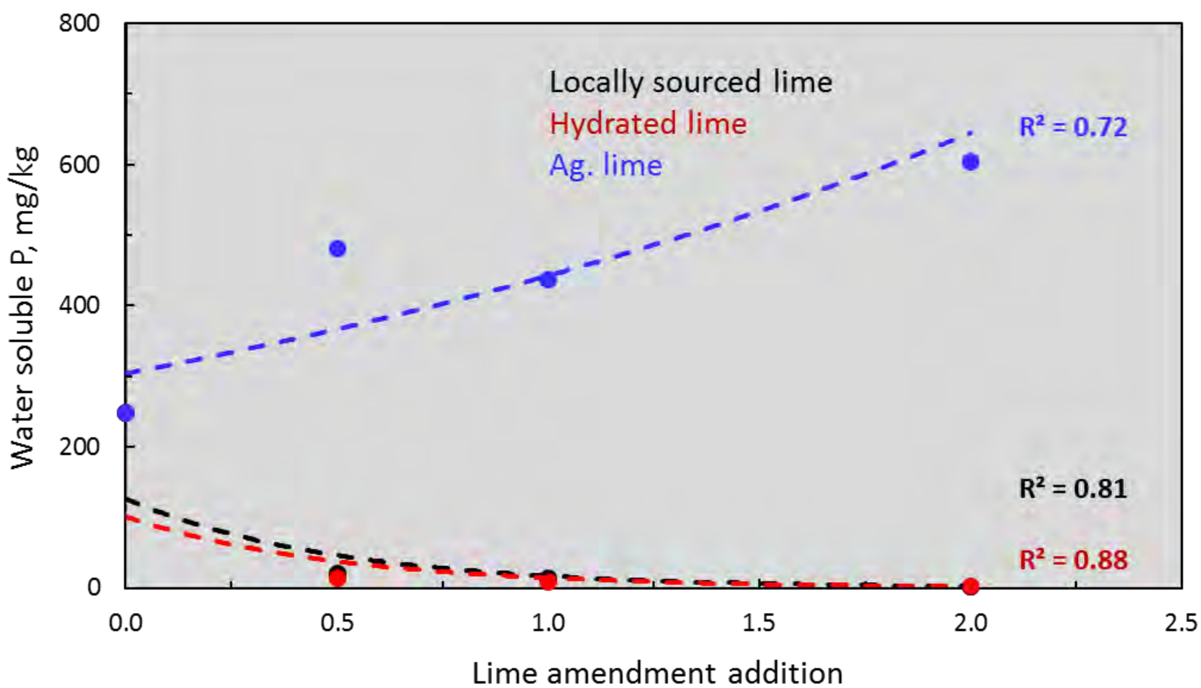


Figure 4. Relationship between water extractable P concentrations of the precipitate three hours after addition of three lime amendments, where the target amendment (i.e., 1.0) is equivalent to 5% volume basis (i.e., 50 mL lime to 1000 mL slurry). Values are average of four replicates.

Conclusions

The general findings were:

1. Hydrated lime amendments tended to enhance the manure solids separation effectiveness as related to increasing the % Solids and P concentration of the separated solids. In principle, this would be beneficial for transport of P off the generating farm.
2. Hydrated lime amendments also increased the manure pH enough that N losses via ammonia volatilization seemed to be increased. If the manure were viewed as a desirable N fertilizer, the increased losses would not be desirable. If air quality were, it atmospheric ammonia emissions would not be desirable.
3. Use of granular agricultural grade lime at the rates used, had no consistent effect on the solids separation process.

In addition to these findings, there are several considerations in the design, financing, and operation of a chemically enhanced gravity separation system. The first is the legal implications. It is generally understood that in Arkansas liquid manures must be applied to land permitted by ADEQ for that purpose. Currently ADEQ's Regulation No 5 provides the only method to remove this requirement is the manure to be composted. Manure solids separation may enable composting but it will not meet the requirements by itself. As a result, unless the regulations are revised or reinterpreted, solids separation may facilitate off farm transportation, the manure destination would still be a permitted site. This would likely restrict the potential for off farm sale of the separated manure solids that could conceptually offset increase manure management costs.

The second consideration relates to the procurement and management of the chemical amendments. In addition to the purchase of the chemicals delivery to, storage on, and metering to the manure must be accomplished. While a formal cost analysis of infrastructure, procurement, and labor cost was not made, it is anticipated that the costs would be greater than the current approach of land application on land within reasonable transport distance to the farm.

The increased N losses due to ammonia valorization would also reduce the fertilizer value of the remaining liquids that would be land applied on the generating farm. It would also increase concerns regarding atmospheric ammonia emissions. Addressing these concerns would require additional expenditures related to infrastructure and management costs.

Given these considerations, it is more practical and sustainable from an individual farm perspective to not invest in enhanced gravity separation via hydrated lime amendments. Rather the practice of local land application of some combination of manure top water, higher solids content bottom water, or an agitated mixture is more sustainable. However, with this approach sufficient land needs to be available to allow manure to be applied at rates that maintain soil test P levels near agronomic levels.

Despite the potential benefits of lime treatment providing options to manage slurry in compliance with nutrient management planning requirements, all presented economic, logistical, labor, and legal constraints severely limit their viability for adoption.

Supplemental Figures and Tables

Figure S 1. Work area being set up after the 1,363 L tank was filled with manure and set up in agitation mode to keep manure solids in suspension. Green hose drains the tank. Blue hose discharges into tank via internal mixing nozzles. Bottom front center of tank is location of valve used to extract 17 L manure samples for treatment.

Figure S 2. Inlet nozzles inside the manure slurry collection tank, configured to mix manure slurry as it is pumped from holding pond 1.

Figure S 3. Collection bucket lined with filter bag prior to addition of manure slurry and chemical amendment.

Figure S 4. Buckets containing manure leachate and suspended filter bags prior to being placed under awning for weather protection and 10-day storage.

Table S 1. Descriptive code format for chemically treated manure samples.

Treatment		
	Ca source/Rate/Material sampled/ Day sample collected/Replicate	
Example	LS 1 M 1 A	
Interpretation	Lime Slurry, 1 x target rate, mixed, day of treatment, first replicate	
Ca Source		
LS	Lime Surry on 30% wt. basis	
HL	Hydrated lime dry powder	
AL	Ag Lime Dry granules	
CS	Control sample	
Rate		
0	Control no additive	
0.5	1/2 x Target Rate	
1	1 x Target Rate	
2	2 x Target Rate	
Material Sampled		
M	Mixed after Ca addition prior to filtering	
L	Leachate after filtration	
P	Precipitate after filtration	
Day Sample Collected		
1	Sampled day of treatment	
2	Sampled after days of storage	
Replication		**Control Sample Details**
A	1st Replicate	Control Sample collected prior to LS samples
B	2nd Replicate	Control Sample collected prior to HS samples
C	3rd Replicate	Control Sample collected prior to AL samples
D	4th Replicate	Control Sample collected after AL samples

Table S 2. Analysis results summary from chemically treated manure samples. For each set of amendment replicates the minimum, maximum, mean, standard deviation sample, and coefficient of variation (%), and concentration reduction are provided. The concentration reduction (%) was calculated as the concentration of the ((1CSOM Mean – Analysis Mean of interest)/ 1CSOM Mean)*100).

Sample code	% Solids	pH	Total Kjeldahl N	Ammonium -N	Nitrate-N	Total P	Total K	Total Ca	Water extractable P
	%		- - - - - - - - - - -	- - - - - - - - - - -	- - - - - - - - - - -	mg/kg	- - - - - - - - - - -	- - - - - - - - - - -	- - - - - - - - - - -
1CS0MA	1.94	7.5	1735	849	0.18*	858	1387	664	168
1CS0MB	1.92	7.6	1863	811	0.76	880	1364	774	165
1CS0MC	1.96	7.6	1782	835	0.18*	873	1322	739	173
1CS0MD	1.98	7.6	1918	835	0.18*	881	1373	737	180
1CS0M Min	1.98	7.5	1735	811	0.18*	858	1322	664	165
1CS0M Max	1.98	7.6	1918	849	0.76	881	1387	774	180
1CS0M Mean	1.95	7.6	1824	832	0.32	873	1361	728	172
1CS0M Std	0.03	0	82	16	0.29	10	28	46	6
1CS0M CV%	1.39	0.4	4	2	91.35	1	2	6	4
1CS0LA	0.96	7.6	1476	803	0.18*	325	1335	176	152
1CS0LB	0.89	7.6	1289	730	0.18*	318	1358	207	141
1CS0LC	1.08	7.6	1467	737	0.18*	428	1323	299	144
1CS0LD	0.94	7.6	1486	743	0.18*	315	1272	246	102
1CS0L Min	0.89	7.6	1289	730	0.18*	315	1272	176	102

Sample code	% Solids	pH	Total Kjeldahl N	Ammonium -N	Nitrate-N	Total P	Total K	Total Ca	Water extractable P
1CS0L Max	1.08	7.6	1486	803	0.18*	428	1358	299	152
1CS0L Mean	0.97	7.6	1429	753	0.18*	346	1322	232	135
1CS0L Std	0.08	0	94	33	0	54	37	53	22
1CS0L CV%	8.27	0.4	7	4	0	16	3	23	16
1CS0PA	2.5	7.5	2037	851	0.18*	1090	1431	926	226
1CS0PB	2.67	7.5	1940	803	0.18*	1166	1393	1086	213
1CS0PC	4.53	7.3	2709	782	0.18*	2068	1368	1974	300
1CS0PD	3.86	7.3	2689	810	0.18*	1763	1327	1717	258
1CS0P Min	2.5	7.3	1940	782	0.18*	1090	1327	926	213
1CS0P Max	4.53	7.5	2709	851	0.18*	2068	1431	1974	300
1CS0P Mean	3.39	7.4	2344	812	0.18*	1522	1380	1426	249
1CS0P Std	0.97	0.1	413	29	0	472	44	500	39
1CS0P CV%	28.75	1.2	18	4	0	31	3	35	15
1LS½MA	3.09	12	1684	516	0.35	837	1337	5118	33
1LS½MB	3.22	12	1768	557	0.18*	953	1348	5241	31
1LS½MC	3.13	12	1658	593	0.48	906	1355	5235	31
1LS½M Min	3.09	12	1658	516	0.18*	837	1337	5118	31

Sample code	% Solids	pH	Total Kjeldahl N	Ammonium -N	Nitrate-N	Total P	Total K	Total Ca	Water extractable P
1LS½M Max	3.22	12	1768	593	0.48	953	1355	5241	33
1LS½M Mean	3.15	12	1703	555	0.33	898	1347	5198	32
1LS½M Std	0.07	0.1	57	38	0.15	58	9	69	1
1LS½M CV%	2.15	0.7	3	7	45.59	6	1	1	2
1LS½LA	0.91	10	1252	570	0.18*	101	1320	299	19
1LS½LB	1.06	13	833	497	0.18*	45	1258	872	9
1LS½LC	0.92	10	1145	583	0.18*	115	1305	356	20
1LS½L Min	0.91	10	833	497	0.18*	45	1258	299	9
1LS½L Max	1.06	13	1252	583	0.18*	115	1320	872	20
1LS½L Mean	0.96	11	1077	550	0.18*	87	1294	509	16
1LS½L Std	0.09	1.5	218	47	0	37	32	316	6
1LS½L CV%	9.03	13	20	8	0	42	3	62	38
1LS½PA	8	12	2358	610	0.35	2355	1430	15573	21
1LS½PB	10.1	12	2611	653	0.18*	2787	1345	17487	22
1LS½PC	8.05	13	2447	612	0.18*	2371	1416	14752	21
1LS½P Min	8	12	2358	610	0.18*	2355	1345	14752	21
1LS½P Max	10.1	13	2611	653	0.35	2787	1430	17487	22

Sample code	% Solids	pH	Total Kjeldahl N	Ammonium -N	Nitrate-N	Total P	Total K	Total Ca	Water extractable P
1LS½P Mean	8.71	12	2472	625	0.23	2505	1397	15937	21
1LS½P Std	1.2	0	129	25	0.1	245	46	1403	0
1LS½P CV%	13.8	0.1	5	4	42.46	10	3	9	1
1LS1MA	4.5	13	1597	658	0.41	802	1291	9317	8
1LS1MB	4.81	13	1434	629	0.46	861	1288	10133	6
1LS1MC	4.78	13	1887	648	0.18*	909	1320	10124	9
1LS1M Min	4.5	13	1434	629	0.18*	802	1288	9317	6
1LS1M Max	4.81	13	1887	658	0.46	909	1320	10133	9
1LS1M Mean	4.7	13	1639	645	0.35	858	1300	9858	8
1LS1M Std	0.18	0	230	15	0.15	54	18	469	1
1LS1M CV%	3.74	0.1	14	2	43.43	6	1	5	16
1LS1LA	0.96	13	891	398	0.18*	22	1222	592	9
1LS1LB	1	13	980	507	0.18*	34	1201	709	9
1LS1LC	0.89	13	1011	474	0.18*	35	1270	690	11
1LS1L Min	0.89	13	891	398	0.18*	22	1201	592	9
1LS1L Max	1	13	1011	507	0.18*	35	1270	709	11
1LS1L Mean	0.95	13	961	460	0.18*	30	1231	664	9

Sample code	% Solids	pH	Total Kjeldahl N	Ammonium -N	Nitrate-N	Total P	Total K	Total Ca	Water extractable P
1LS1L Std	0.05	0	62	56	0	7	35	63	1
1LS1L CV%	5.52	0.1	6	12	0	24	3	9	11
1LS1PA	11.54	13	2739	705	0.18*	2138	1299	23213	11
1LS1PB	11.62	13	2719	683	0.35	2167	1280	23904	14
1LS1PC	13.76	13	3208	762	0.5	2754	1339	29446	17
1LS1P Min	11.54	13	2719	683	0.18*	2138	1280	23213	11
1LS1P Max	13.76	13	3208	762	0.5	2754	1339	29446	17
1LS1P Mean	12.31	13	2889	716	0.34	2353	1306	25521	14
1LS1P Std	1.26	0	277	41	0.16	347	30	3416	3
1LS1P CV%	10.22	0.1	10	6	47.74	15	2	13	24
1LS2MA	7.45	13	1584	676	0.18*	779	1222	16820	1
1LS2MB	7.23	13	1615	633	0.35	746	1228	16842	1
1LS2MC	7.14	13	1602	590	0.18*	832	1248	17245	1
1LS2M Min	7.14	13	1584	590	0.18*	746	1222	16820	1
1LS2M Max	7.45	13	1615	676	0.35	832	1248	17245	1
1LS2M Mean	7.27	13	1600	633	0.23	785	1233	16969	1
1LS2M Std	0.16	0	16	43	0.1	43	14	239	0

Sample code	% Solids	pH	Total Kjeldahl N	Ammonium -N	Nitrate-N	Total P	Total K	Total Ca	Water extractable P
1LS2M CV%	2.15	0.1	1	7	42.46	6	1	1	32
1LS2LA	1.07	13	938	457	0.18*	27	1200	942	6
1LS2LB	1.2	13	916	440	0.18*	27	1217	999	5
1LS2LC	1.06	13	858	491	0.18*	25	1207	938	6
1LS2L Min	1.06	13	858	440	0.18*	25	1200	938	5
1LS2L Max	1.2	13	938	491	0.18*	27	1217	999	6
1LS2L Mean	1.11	13	904	463	0.18*	26	1208	959	6
1LS2L Std	0.08	0	41	26	0	1	9	34	0
1LS2L CV%	6.92	0.1	5	6	0	5	1	4	4
1LS2PA	12.66	13	2184	653	0.18*	1731	1262	34284	4
1LS2PB	11.25	13	1975	580	0.18*	1487	1245	30856	2
1LS2PC	10.42	13	1972	617	0.18*	1411	1251	28106	2
1LS2P Min	10.42	13	1972	580	0.18*	1411	1245	28106	2
1LS2P Max	12.66	13	2184	653	0.18*	1731	1262	34284	4
1LS2P Mean	11.45	13	2044	617	0.18*	1543	1253	31082	3
1LS2P Std	1.13	0	121	36	0	167	8	3095	1
1LS2P CV%	9.91	0.1	6	6	0	11	1	10	34

Sample code	% Solids	pH	Total Kjeldahl N	Ammonium -N	Nitrate-N	Total P	Total K	Total Ca	Water extractable P
1HL½MA	2.84	10	1783	646	0.18*	955	1398	4951	43
1HL½MB	3.02	10	1838	606	0.18*	937	1378	5042	34
1HL½MC	2.7	9.8	1791	691	0.18*	922	1410	3873	57
1HL½M Min	2.7	9.8	1783	606	0.18*	922	1378	3873	34
1HL½M Max	3.02	10	1838	691	0.18*	955	1410	5042	57
1HL½M Mean	2.85	10	1804	648	0.18*	938	1395	4622	45
1HL½M Std	0.16	0.2	30	43	0	17	16	650	12
1HL½M CV%	5.61	2.2	2	7	0	2	1	14	26
1HL½LA	0.93	9.1	1213	711	0.18*	187	1327	422	51
1HL½LB	0.94	8.9	1246	707	0.18*	220	1351	405	57
1HL½LC	0.98	8.9	1294	721	0.18*	259	1344	432	58
1HL½L Min	0.93	8.9	1213	707	0.18*	187	1327	405	51
1HL½L Max	0.98	9.1	1294	721	0.18*	259	1351	432	58
1HL½L Mean	0.95	9	1251	713	0.18*	222	1341	419	56
1HL½L Std	0.03	0.1	41	7	0	36	12	14	4
1HL½L CV%	2.79	1.3	3	1	0	16	1	3	7

Sample code	% Solids	pH	Total Kjeldahl N	Ammonium -N	Nitrate-N	Total P	Total K	Total Ca	Water extractable P
1HL½PA	14.43	13	3020	838	0.18*	3098	1350	29408	16
1HL½PB	13.37	13	3011	777	0.18*	2574	1222	24630	14
1HL½PC	10.05	13	2606	798	0.18*	2282	1329	19686	14
1HL½P Min	10.05	13	2606	777	0.18*	2282	1222	19686	14
1HL½P Max	14.43	13	3020	838	0.18*	3098	1350	29408	16
1HL½P Mean	12.62	13	2879	804	0.18*	2651	1300	24575	15
1HL½P Std	2.29	0	237	31	0	414	68	4861	2
1HL½P CV%	18.13	0.1	8	4	0	16	5	20	10
1HL1MA	3.56	12	1812	592	0.18*	924	1356	6953	14
1HL1MB	3.68	13	1779	596	0.18*	942	1365	8687	15
1HL1MC	3.78	13	1697	614	0.52	839	1339	6863	13
1HL1M Min	3.56	12	1697	592	0.18*	839	1339	6863	13
1HL1M Max	3.78	13	1812	614	0.52	942	1365	8687	15
1HL1M Mean	3.68	13	1763	601	0.29	902	1354	7501	14
1HL1M Std	0.11	0.1	60	12	0.2	55	13	1028	1
1HL1M CV%	3.05	1.1	3	2	68.86	6	1	14	6
1HL1LA	0.93	9.2	1290	683	0.18*	185	1329	406	56

Sample code	% Solids	pH	Total Kjeldahl N	Ammonium -N	Nitrate-N	Total P	Total K	Total Ca	Water extractable P
1HL1LB	0.91	9.4	1249	683	0.18*	141	1320	392	41
1HL1LC	0.91	9.6	1245	689	0.18*	135	1281	464	36
1HL1L Min	0.91	9.2	1245	683	0.18*	135	1281	392	36
1HL1L Max	0.93	9.6	1290	689	0.18*	185	1329	464	56
1HL1L Mean	0.92	9.4	1261	685	0.18*	154	1310	421	44
1HL1L Std	0.01	0.2	25	3	0	27	25	38	11
1HL1L CV%	1.21	2	2	0	0	18	2	9	24
1HL1PA	11.19	13	2668	741	0.18*	2611	1323	23139	15
1HL1PB	15.05	13	2704	860	0.18*	2638	1276	33244	7
1HL1PC	16.61	13	2726	783	0.67	2731	1245	39822	5
1HL1P Min	11.19	13	2668	741	0.18*	2611	1245	23139	5
1HL1P Max	16.61	13	2726	860	0.67	2731	1323	39822	15
1HL1P Mean	14.28	13	2699	795	0.34	2660	1281	32068	9
1HL1P Std	2.79	0	29	60	0.29	63	39	8404	5
1HL1P CV%	19.53	0.1	1	8	84.27	2	3	26	60
1HL2MA	6.21	13	1717	580	0.18*	871	1336	13766	4
1HL2MB	6.05	13	1734	598	0.5	800	1269	13828	5

Sample code	% Solids	pH	Total Kjeldahl N	Ammonium -N	Nitrate-N	Total P	Total K	Total Ca	Water extractable P
1HL2MC	6.12	13	1693	550	0.18*	840	1337	14929	5
1HL2M Min	6.05	13	1693	550	0.18*	800	1269	13766	4
1HL2M Max	6.21	13	1734	598	0.5	871	1337	14929	5
1HL2M Mean	6.12	13	1715	576	0.28	837	1314	14174	4
1HL2M Std	0.08	0	20	24	0.19	35	39	654	0
1HL2M CV%	1.3	0.1	1	4	66.16	4	3	5	9
1HL2LA	0.89	12	1133	511	0.18*	58	1294	409	17
1HL2LB	0.99	13	1149	529	0.18*	53	1323	559	12
1HL2LC	0.99	13	1155	522	0.18*	56	1282	503	13
1HL2L Min	0.89	12	1133	511	0.18*	53	1282	409	12
1HL2L Max	0.99	13	1155	529	0.18*	58	1323	559	17
1HL2L Mean	0.96	12	1145	521	0.18*	56	1300	490	14
1HL2L Std	0.06	0.2	11	9	0	3	21	76	3
1HL2L CV%	6.15	1.6	1	2	0	5	2	16	18
1HL2PA	20.51	13	2301	648	0.18*	2086	1173	52339	3
1HL2PB	21.31	13	2343	654	0.18*	1999	1158	54756	3
1HL2PC	18.94	13	2336	736	0.18*	1884	1192	47195	3

Sample code	% Solids	pH	Total Kjeldahl N	Ammonium -N	Nitrate-N	Total P	Total K	Total Ca	Water extractable P
1HL2P Min	18.94	13	2301	648	0.18*	1884	1158	47195	3
1HL2P Max	21.31	13	2343	736	0.18*	2086	1192	54756	3
1HL2P Mean	20.25	13	2327	679	0.18*	1990	1174	51430	3
1HL2P Std	1.21	0	23	49	0	101	17	3862	0
1HL2P CV%	5.96	0.1	1	7	0	5	1	8	1
1AL½MA	2.24	7.5	1765	819	0.18*	873	1340	1766	193
1AL½MB	2.22	7.5	1851	842	0.18*	861	1361	1860	190
1AL½MC	2.33	7.5	1872	862	0.18*	907	1357	1746	185
1AL½M Min	2.22	7.5	1765	819	0.18*	861	1340	1746	185
1AL½M Max	2.33	7.5	1872	862	0.18*	907	1361	1860	193
1AL½M Mean	2.26	7.5	1829	841	0.18*	880	1353	1791	189
1AL½M Std	0.06	0	57	22	0	24	12	61	4
1AL½M CV%	2.67	0.1	3	3	0	3	1	3	2
1AL½LA	0.91	7.6	1323	693	0.18*	270	1264	210	153
1AL½LB	0.9	7.6	1335	719	0.18*	291	1310	250	92
1AL½LC	0.93	7.6	1351	766	0.18*	308	1346	270	71
1AL½L Min	0.9	7.6	1323	693	0.18*	270	1264	210	71

Sample code	% Solids	pH	Total Kjeldahl N	Ammonium -N	Nitrate-N	Total P	Total K	Total Ca	Water extractable P
1AL½L Max	0.93	7.6	1351	766	0.18*	308	1346	270	153
1AL½L Mean	0.91	7.6	1336	726	0.18*	290	1307	243	105
1AL½L Std	0.02	0	14	37	0	19	41	31	42
1AL½L CV%	1.99	0.4	1	5	0	7	3	13	40
1AL½PA	9.39	7.2	3207	855	0.18*	2950	1308	15912	531
1AL½PB	7.33	7.3	2991	874	0.18*	2273	1258	11874	402
1AL½PC	9.17	7.3	2972	874	0.18*	2681	1266	13791	509
1AL½P Min	7.33	7.2	2972	855	0.18*	2273	1258	11874	402
1AL½P Max	9.39	7.3	3207	874	0.18*	2950	1308	15912	531
1AL½P Mean	8.63	7.3	3056	868	0.18*	2635	1277	13859	481
1AL½P Std	1.13	0.1	131	11	0	341	27	2020	69
1AL½P CV%	13.09	1.1	4	1	0	13	2	15	14
1AL1MA	2.57	7.5	1828	868	0.18*	851	1353	3083	214
1AL1MB	2.83	7.5	1853	819	0.18*	929	1364	3586	220
1AL1MC	2.75	7.5	1817	829	0.18*	895	1344	3851	214
1AL1M Min	2.57	7.5	1817	819	0.18*	851	1344	3083	214
1AL1M Max	2.83	7.5	1853	868	0.18*	929	1364	3851	220

Sample code	% Solids	pH	Total Kjeldahl N	Ammonium -N	Nitrate-N	Total P	Total K	Total Ca	Water extractable P
1AL1M Mean	2.72	7.5	1833	839	0.18*	892	1354	3506	216
1AL1M Std	0.13	0	19	26	0	39	10	390	4
1AL1M CV%	4.91	0.1	1	3	0	4	1	11	2
1AL1LA	1.07	7.6	1361	736	0.18*	352	1316	615	84
1AL1LB	0.9	7.6	1319	776	0.18*	271	1291	270	75
1AL1LC	0.97	7.6	1350	764	0.18*	292	1336	351	82
1AL1L Min	0.9	7.6	1319	736	0.18*	271	1291	270	75
1AL1L Max	1.07	7.6	1361	776	0.18*	352	1336	615	84
1AL1L Mean	0.98	7.6	1343	759	0.18*	305	1315	412	80
1AL1L Std	0.09	0	22	21	0	42	23	180	5
1AL1L CV%	8.81	0.2	2	3	0	14	2	44	6
1AL1PA	7.25	7.3	2674	824	0.18*	1922	1274	13517	370
1AL1PB	11.62	7.2	3085	874	0.18*	2588	1194	26354	530
1AL1PC	8	7.2	2718	847	0.18*	2233	1343	15489	413
1AL1P Min	7.25	7.2	2674	824	0.18*	1922	1194	13517	370
1AL1P Max	11.62	7.3	3085	874	0.18*	2588	1343	26354	530
1AL1P Mean	8.95	7.2	2826	848	0.18*	2248	1270	18454	438

Sample code	% Solids	pH	Total Kjeldahl N	Ammonium -N	Nitrate-N	Total P	Total K	Total Ca	Water extractable P
1AL1P Std	2.34	0.1	226	25	0	333	75	6913	83
1AL1P CV%	26.12	1.3	8	3	0	15	6	37	19
1AL2MA	3.33	7.5	1891	929	0.18*	867	1318	6264	234
1AL2MB	3.25	7.5	1877	852	0.18*	874	1368	6361	230
1AL2MC	3.33	7.5	1852	846	0.18*	872	1372	6757	228
1AL2M Min	3.25	7.5	1852	846	0.18*	867	1318	6264	228
1AL2M Max	3.33	7.5	1891	929	0.18*	874	1372	6757	234
1AL2M Mean	3.3	7.5	1873	876	0.18*	871	1353	6461	231
1AL2M Std	0.05	0	20	46	0	4	30	261	3
1AL2M CV%	1.45	0	1	5	0	0	2	4	1
1AL2LA	0.98	7.6	1319	759	0.18*	290	1313	494	78
1AL2LB	1.19	7.6	1372	758	0.18*	350	1312	920	89
1AL2LC	1.08	7.6	1334	732	0.18*	312	1300	682	84
1AL2L Min	0.98	7.6	1319	732	0.18*	290	1300	494	78
1AL2L Max	1.19	7.6	1372	759	0.18*	350	1313	920	89
1AL2L Mean	1.08	7.6	1342	750	0.18*	317	1308	699	84
1AL2L Std	0.11	0	27	15	0	30	7	213	6

Sample code	% Solids	pH	Total Kjeldahl N	Ammonium -N	Nitrate-N	Total P	Total K	Total Ca	Water extractable P
1AL2L CV%	9.73	0.1	2	2	0	10	1	31	7
1AL2PA	19.63	7.2	2600	787	0.18*	2330	1233	36401	626
1AL2PB	14.88	7.2	3014	823	0.18*	2444	1252	38626	533
1AL2PC	19.84	7.3	3284	817	0.18*	2551	1160	47155	657
1AL2P Min	14.88	7.2	2600	787	0.18*	2330	1160	36401	533
1AL2P Max	19.84	7.3	3284	823	0.18*	2551	1252	47155	657
1AL2P Mean	18.12	7.2	2966	809	0.18*	2442	1215	40727	605
1AL2P Std	2.8	0	344	19	0	111	48	5676	65
1AL2P CV%	15.48	0.6	12	2	0	5	4	14	11
2CS0LA	1.11	8	991	483	0.18*	499	1536	246	127
2CS0LB	1.21	8	874	420	0.18*	516	1515	845	147
2CS0LC	1.09	8.1	881	406	0.18*	476	1555	220	147
2CS0LD	1.09	8.1	969	462	0.18*	509	1538	263	125
2CS0L Min	1.09	8	874	406	0.18*	476	1515	220	125
2CS0L Max	1.21	8.1	991	483	0.18*	516	1555	845	147
2CS0L Mean	1.12	8	929	443	0.18*	500	1536	393	137
2CS0L Std	0.06	0.1	60	36	0	18	16	302	12

Sample code	% Solids	pH	Total Kjeldahl N	Ammonium -N	Nitrate-N	Total P	Total K	Total Ca	Water extractable P
2CS0L CV%	5.41	0.8	6	8	0	4	1	77	9
2CS0PA	27.7	8.8	9652	1153	1.05	12692	3053	14069	1059
2CS0PB	26.73	8.9	12258	1151	1.05	14631	3542	16162	977
2CS0PC	25	8.1	8605	760	1.05	12413	3975	13003	1222
2CS0PD	30.69	9	12838	1266	1.05	15026	3694	15962	1246
2CS0P Min	25	8.1	8605	760	1.05	12413	3053	13003	977
2CS0P Max	30.69	9	12838	1266	1.05	15026	3975	16162	1246
2CS0P Mean	27.53	8.7	10838	1083	1.05	13690	3566	14799	1126
2CS0P Std	2.39	0.4	2034	221	0	1329	386	1524	129
2CS0P CV%	8.67	4.6	19	20	0	10	11	10	11
2LS½LA	1	8.5	335	65	0.18*	178	1527	755	27
2LS½LB	1.03	8.8	341	66	0.18*	184	1416	739	25
2LS½LC	1.16	8.3	440	94	0.18*	288	1450	1182	38
2LS½L Min	1	8.3	335	65	0.18*	178	1416	739	25
2LS½L Max	1.16	8.8	440	94	0.18*	288	1527	1182	38
2LS½L Mean	1.06	8.5	372	75	0.18*	217	1465	892	30
2LS½L Std	0.09	0.2	59	17	0	62	56	252	7

Sample code	% Solids	pH	Total Kjeldahl N	Ammonium -N	Nitrate-N	Total P	Total K	Total Ca	Water extractable P
2LS½L CV%	8.27	2.5	16	22	0	29	4	28	24
2LS½PA	28.61	9.2	4051	254	1.05	9551	2491	65309	196
2LS½PB	23.83	8.3	3988	82	3.05	9929	2628	67821	227
2LS½PC	31.64	8.9	4140	172	1.05	9770	2769	65084	184
2LS½P Min	23.83	8.3	3988	82	1.05	9551	2491	65084	184
2LS½P Max	31.64	9.2	4140	254	3.05	9929	2769	67821	227
2LS½P Mean	28.03	8.8	4060	169	1.72	9750	2629	66071	203
2LS½P Std	3.94	0.5	76	86	1.16	190	139	1519	22
2LS½P CV%	14.05	5.3	2	51	67.35	2	5	2	11
2LS1LA	1.07	13	190	17	0.18*	92	1541	1172	10
2LS1LB	0.95	13	207	43	0.45	62	1435	848	10
2LS1LC	0.93	12	193	35	0.18*	58	1408	755	10
2LS1L Min	0.93	12	190	17	0.18*	58	1408	755	10
2LS1L Max	1.07	13	207	43	0.45	92	1541	1172	10
2LS1L Mean	0.98	13	197	32	0.27	71	1461	925	10
2LS1L Std	0.08	0.1	9	13	0.16	19	70	219	0
2LS1L CV%	7.64	0.4	5	42	58.82	26	5	24	3

Sample code	% Solids	pH	Total Kjeldahl N	Ammonium -N	Nitrate-N	Total P	Total K	Total Ca	Water extractable P
2LS1PA	34.58	13	4072	178	1.05	9053	2767	104067	35
2LS1PB	32.26	13	4137	157	5.39	7509	2104	88832	26
2LS1PC	30.78	13	3934	155	2.19	7633	2116	85937	32
2LS1P Min	30.78	13	3934	155	1.05	7509	2104	85937	26
2LS1P Max	34.58	13	4137	178	5.39	9053	2767	104067	35
2LS1P Mean	32.54	13	4047	164	2.88	8065	2329	92945	31
2LS1P Std	1.91	0	103	13	2.25	858	379	9740	5
2LS1P CV%	5.88	0.2	3	8	78.26	11	16	10	15
2LS2LA	2.02	13	196	44	0.18*	120	1429	3193	4
2LS2LB	1.71	13	161	36	0.18*	67	1453	2158	4
2LS2LC	2	13	212	47	0.18*	111	1367	3190	5
2LS2L Min	1.71	13	161	36	0.18*	67	1367	2158	4
2LS2L Max	2.02	13	212	47	0.18*	120	1453	3193	5
2LS2L Mean	1.91	13	190	42	0.18*	99	1416	2847	5
2LS2L Std	0.17	0	26	6	0	28	44	597	1
2LS2L CV%	9	0.1	14	14	0	28	3	21	15

Sample code	% Solids	pH	Total Kjeldahl N	Ammonium -N	Nitrate-N	Total P	Total K	Total Ca	Water extractable P
2LS2PA	34.18	13	1316	138	1.05	5520	1872	128405	20
2LS2PB	33.78	13	3234	146	1.05	5521	1920	125661	21
2LS2PC	33.53	13	2500	174	1.05	5511	1740	117627	21
2LS2P Min	33.53	13	1316	138	1.05	5511	1740	117627	20
2LS2P Max	34.18	13	3234	174	1.05	5521	1920	128405	21
2LS2P Mean	33.83	13	2350	153	1.05	5517	1844	123898	21
2LS2P Std	0.33	0	968	19	0	6	93	5602	1
2LS2P CV%	0.97	0.2	41	13	0	0	5	5	5
2HL½LA	0.54	8.2	420	198	0.18*	128	879	277	37
2HL½LB	0.6	8.2	453	217	0.55	148	920	268	38
2HL½LC	0.65	8	519	215	0.18*	233	1118	440	42
2HL½L Min	0.54	8	420	198	0.18*	128	879	268	37
2HL½L Max	0.65	8.2	519	217	0.55	233	1118	440	42
2HL½L Mean	0.6	8.2	464	210	0.3	170	972	328	39
2HL½L Std	0.05	0.1	50	11	0.22	56	128	97	3
2HL½L CV%	8.82	1.3	11	5	72.17	33	13	29	7
2HL½PA	31.84	12	4857	317	2.19	10120	2856	80281	57

Sample code	% Solids	pH	Total Kjeldahl N	Ammonium -N	Nitrate-N	Total P	Total K	Total Ca	Water extractable P
2HL½PB	31.75	13	4519	419	2.31	10691	2898	69858	51
2HL½PC	34.16	13	4148	420	4.53	11973	4206	80854	23
2HL½P Min	31.75	12	4148	317	2.19	10120	2856	69858	23
2HL½P Max	34.16	13	4857	420	4.53	11973	4206	80854	57
2HL½P Mean	32.58	13	4508	385	3.01	10928	3320	76998	43
2HL½P Std	1.37	0.1	355	59	1.32	949	767	6190	18
2HL½P CV%	4.19	0.7	8	15	43.78	9	23	8	42
2HL1LA	1.18	8.3	601	207	0.18*	316	1524	897	45
2HL1LB	1.16	8.4	562	208	0.18*	299	1546	1147	40
2HL1LC	1.26	8.3	553	196	0.18*	300	1581	1198	46
2HL1L Min	1.16	8.3	553	196	0.18*	299	1524	897	40
2HL1L Max	1.26	8.4	601	208	0.18*	316	1581	1198	46
2HL1L Mean	1.2	8.3	572	204	0.18*	305	1551	1081	44
2HL1L Std	0.05	0	26	6	0	9	29	161	3
2HL1L CV%	4.26	0.5	4	3	0	3	2	15	8
2HL1PA	41.55	13	3803	142	1.05	7187	1737	133242	12
2HL1PB	36.82	13	3255	136	1.05	7229	2240	119635	17

Sample code	% Solids	pH	Total Kjeldahl N	Ammonium -N	Nitrate-N	Total P	Total K	Total Ca	Water extractable P
2HL1PC	38.34	13	3177	131	1.05	6208	2059	138827	21
2HL1P Min	36.82	13	3177	131	1.05	6208	1737	119635	12
2HL1P Max	41.55	13	3803	142	1.05	7229	2240	138827	21
2HL1P Mean	38.91	13	3412	137	1.05	6875	2012	130568	17
2HL1P Std	2.41	0	341	5	0	578	255	9871	5
2HL1P CV%	6.21	0.1	10	4	0	8	13	8	29
2HL2LA	1.07	9.6	216	42	0.45	183	1292	1500	18
2HL2LB	1.3	12	242	21	0.18*	132	1539	1063	13
2HL2LC	1.41	12	329	62	0.18*	204	1511	1721	11
2HL2L Min	1.07	9.6	216	21	0.18*	132	1292	1063	11
2HL2L Max	1.41	12	329	62	0.45	204	1539	1721	18
2HL2L Mean	1.26	11	262	42	0.27	173	1447	1428	14
2HL2L Std	0.17	1.6	59	21	0.16	37	135	334	4
2HL2L CV%	13.68	14	23	50	58.82	21	9	23	26
2HL2PA	36.12	13	2657	118	1.05	7463	1987	128798	11
2HL2PB	39.26	13	2942	111	1.05	5563	1915	144154	9
2HL2PC	39.3	13	2498	100	1.05	5666	2154	148989	13

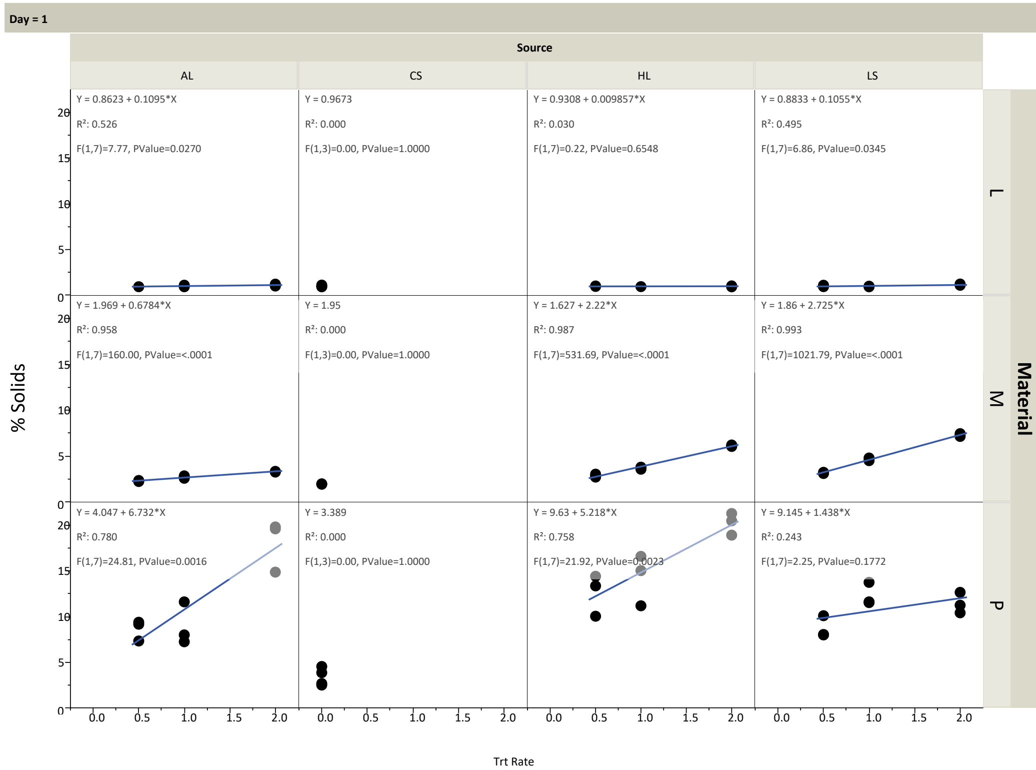
Sample code	% Solids	pH	Total Kjeldahl N	Ammonium -N	Nitrate-N	Total P	Total K	Total Ca	Water extractable P
2HL2P Min	36.12	13	2498	100	1.05	5563	1915	128798	9
2HL2P Max	39.3	13	2942	118	1.05	7463	2154	148989	13
2HL2P Mean	38.23	13	2699	110	1.05	6231	2019	140647	11
2HL2P Std	1.82	0	225	9	0	1069	123	10542	2
2HL2P CV%	4.77	0.2	8	8	0	17	6	7	15
2AL½LA	1.18	8	1002	495	0.18*	491	1485	822	162
2AL½LB	1.21	8	933	420	0.18*	500	1494	815	158
2AL½LC	0.67	7.9	644	377	0.18*	280	1054	88	115
2AL½L Min	0.67	7.9	644	377	0.18*	280	1054	88	115
2AL½L Max	1.21	8	1002	495	0.18*	500	1494	822	162
2AL½L Mean	1.02	7.9	860	431	0.18*	423	1345	575	145
2AL½L Std	0.3	0.1	190	60	0	125	251	422	26
2AL½L CV%	29.91	1	22	14	0	29	19	73	18
2AL½PA	47.66	8.6	9825	1071	1.05	10570	2718	113632	1436
2AL½PB	60.96	8.6	7554	807	1.05	10985	2850	147508	1909
2AL½PC	52.86	8.6	8470	1071	1.05	11909	2785	120942	1739
2AL½P Min	47.66	8.6	7554	807	1.05	10570	2718	113632	1436

Sample code	% Solids	pH	Total Kjeldahl N	Ammonium -N	Nitrate-N	Total P	Total K	Total Ca	Water extractable P
2AL½P Max	60.96	8.6	9825	1071	1.05	11909	2850	147508	1909
2AL½P Mean	53.83	8.6	8617	983	1.05	11155	2785	127360	1695
2AL½P Std	6.7	0	1143	152	0	686	66	17827	240
2AL½P CV%	12.45	0.4	13	15	0	6	2	14	14
2AL1LA	1.34	8.1	948	475	0.18*	490	1595	1268	151
2AL1LB	1.34	8	954	447	0.36	492	1542	1332	151
2AL1LC	1.33	8	956	436	0.18*	514	1565	1382	140
2AL1L Min	1.33	8	948	436	0.18*	490	1542	1268	140
2AL1L Max	1.34	8.1	956	475	0.36	514	1595	1382	151
2AL1L Mean	1.34	8	952	453	0.24	499	1567	1327	147
2AL1L Std	0.01	0.1	4	20	0.11	13	26	57	7
2AL1L CV%	0.48	0.7	0	4	45.22	3	2	4	4
2AL1PA	72.86	8.7	3962	813	1.05	11283	3212	139127	1929
2AL1PB	54.15	8.2	9354	818	1.05	8525	2180	170099	1658
2AL1PC	59.2	8.9	5333	705	1.05	13064	3249	127705	1644
2AL1P Min	54.15	8.2	3962	705	1.05	8525	2180	127705	1644
2AL1P Max	72.86	8.9	9354	818	1.05	13064	3249	170099	1929

Sample code	% Solids	pH	Total Kjeldahl N	Ammonium -N	Nitrate-N	Total P	Total K	Total Ca	Water extractable P
2AL1P Mean	62.07	8.6	6216	779	1.05	10957	2880	145644	1744
2AL1P Std	9.68	0.3	2802	64	0	2287	607	21936	161
2AL1P CV%	15.59	3.9	45	8	0	21	21	15	9
2AL2LA	1.44	8.1	931	454	0.18*	431	1528	1826	147
2AL2LB	1.34	8.1	951	452	0.18*	436	1510	1835	145
2AL2LC	1.3	8.1	874	444	0.18*	416	1536	1688	141
2AL2L Min	1.3	8.1	874	444	0.18*	416	1510	1688	141
2AL2L Max	1.44	8.1	951	454	0.18*	436	1536	1835	147
2AL2L Mean	1.36	8.1	918	450	0.18*	428	1525	1783	144
2AL2L Std	0.07	0	40	5	0	10	13	82	3
2AL2L CV%	5.27	0.3	4	1	0	2	1	5	2
2AL2PA	69.06	8.7	4961	802	1.05	9912	2544	155240	1765
2AL2PB	71.56	8.8	3226	497	1.05	3432	947	213582	1514
2AL2PC	69.92	8.7	5631	674	1.05	6936	1762	185573	1656
2AL2P Min	69.06	8.7	3226	497	1.05	3432	947	155240	1514
2AL2P Max	71.56	8.8	5631	802	1.05	9912	2544	213582	1765
2AL2P Mean	70.18	8.8	4606	658	1.05	6760	1751	184798	1645

Sample code	% Solids	pH	Total Kjeldahl N	Ammonium -N	Nitrate-N	Total P	Total K	Total Ca	Water extractable P
2AL2P Std	1.27	0.1	1241	153	0	3243	799	29179	126
2AL2P CV%	1.81	0.9	27	23	0	48	46	16	8

* Sample was below the laboratory Detection Limit of nitrate-N. For summary calculations was set to ½ of the Detection Limit since the value may have been greater than zero, nor was it at or above the detection limit of 0.35 mg/l.



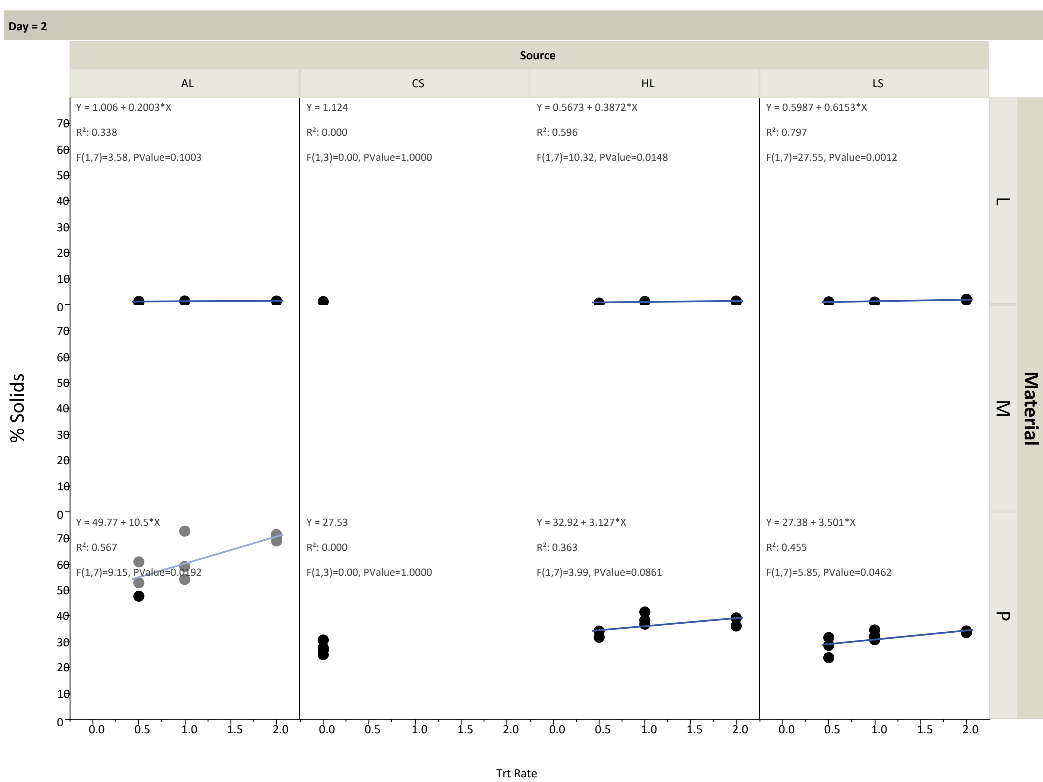
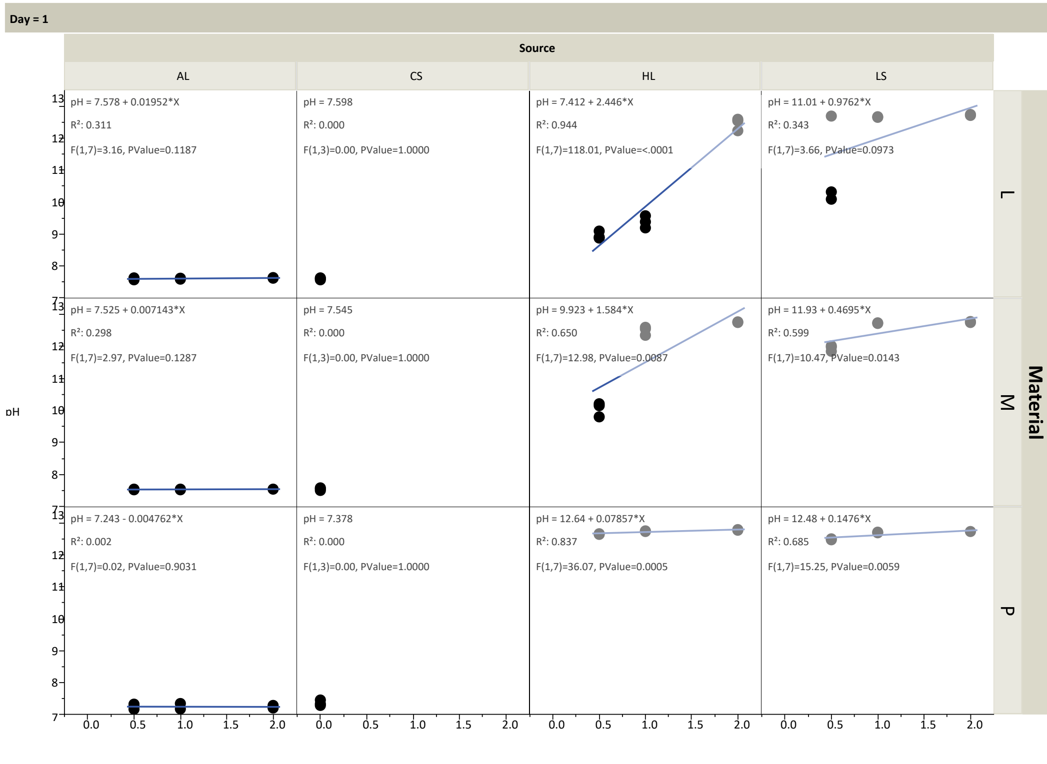


Figure S 5. Relationship between matrix manure % Solids (mg/L as is) and treatment rate. Refer to descriptive code table for interpretive information.



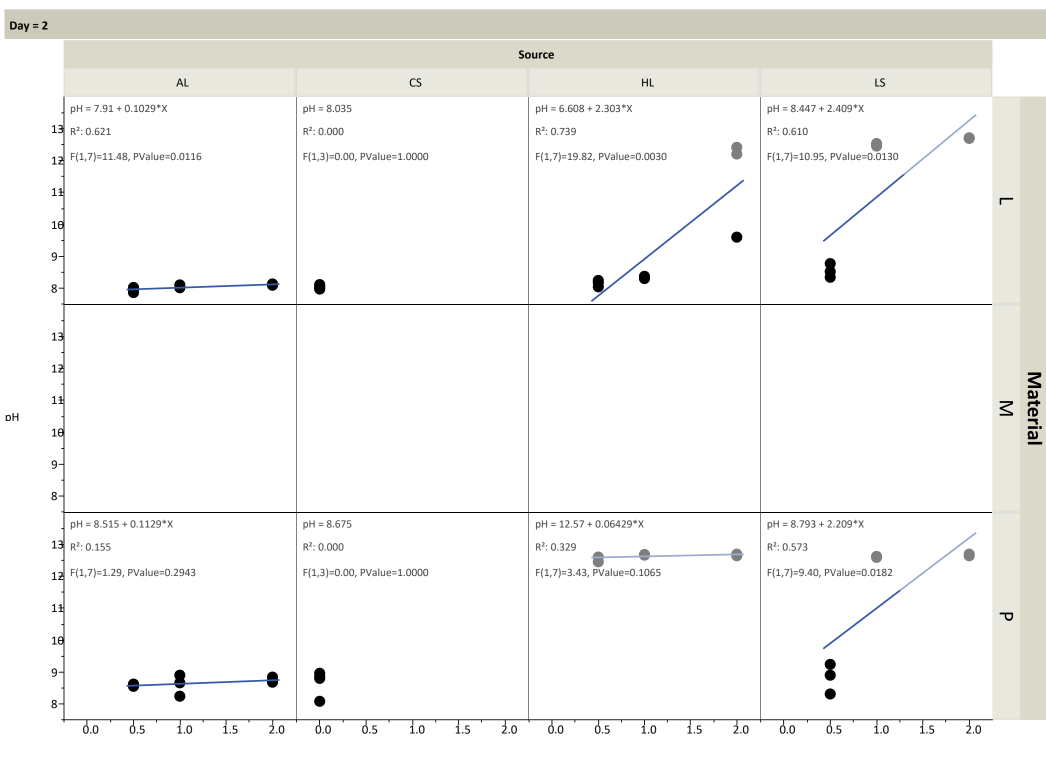
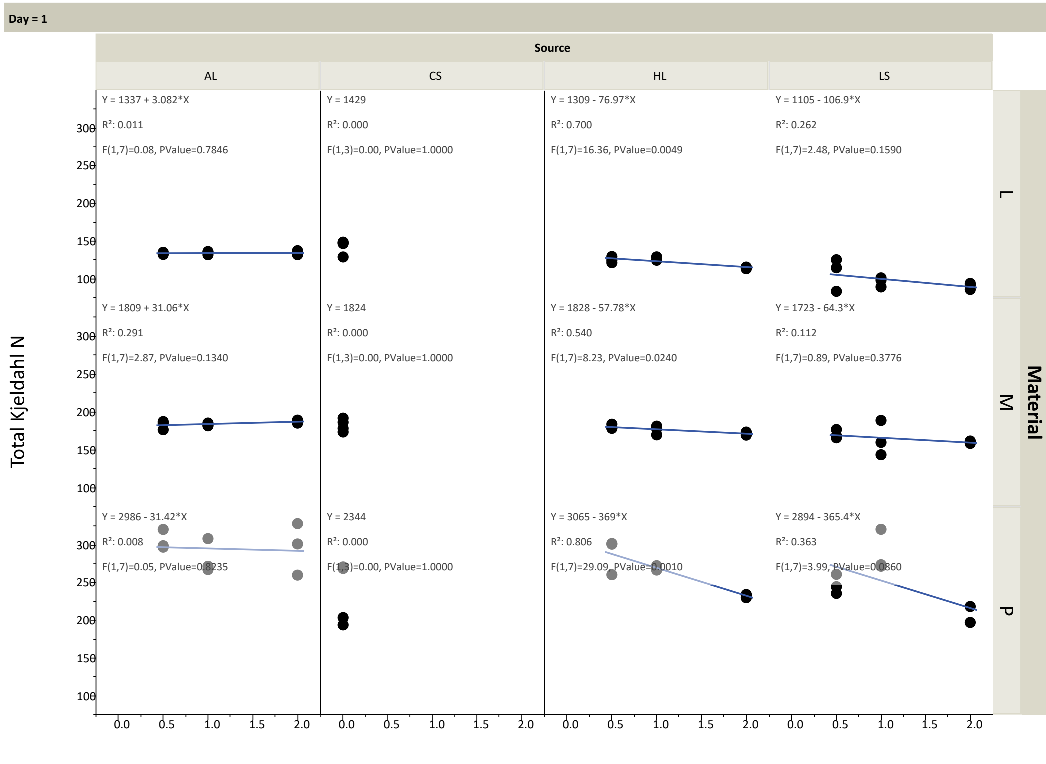


Figure S 6. Relationship between matrix manure pH and treatment rate. Refer to descriptive code table for interpretive information.



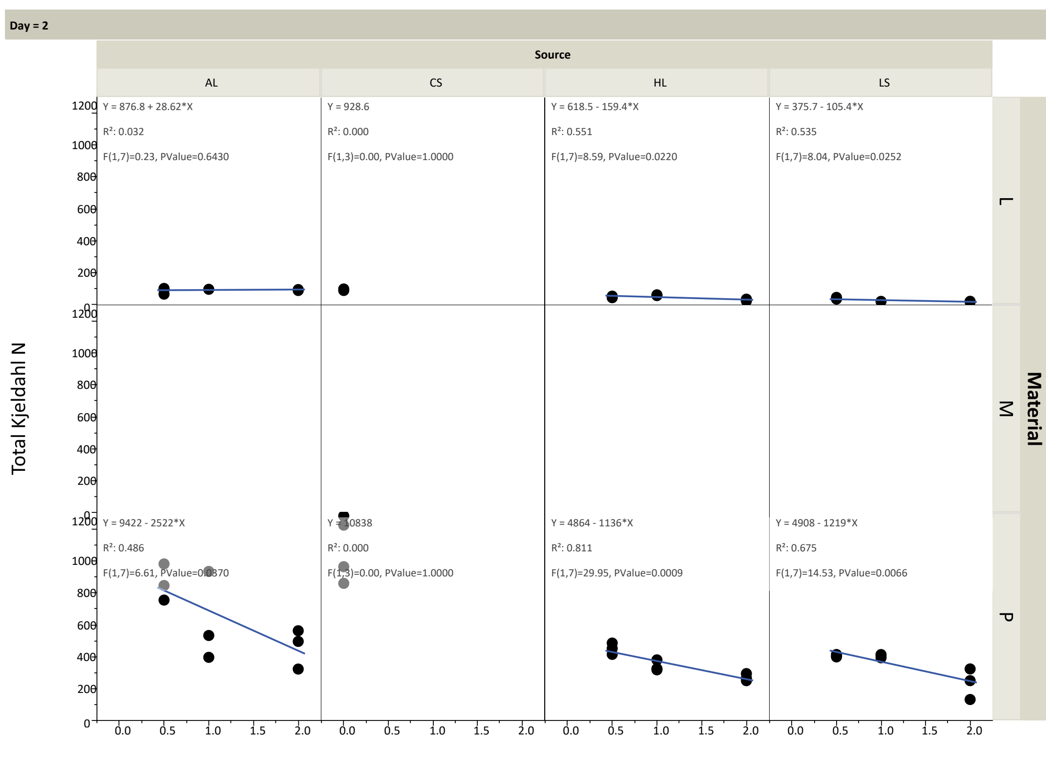
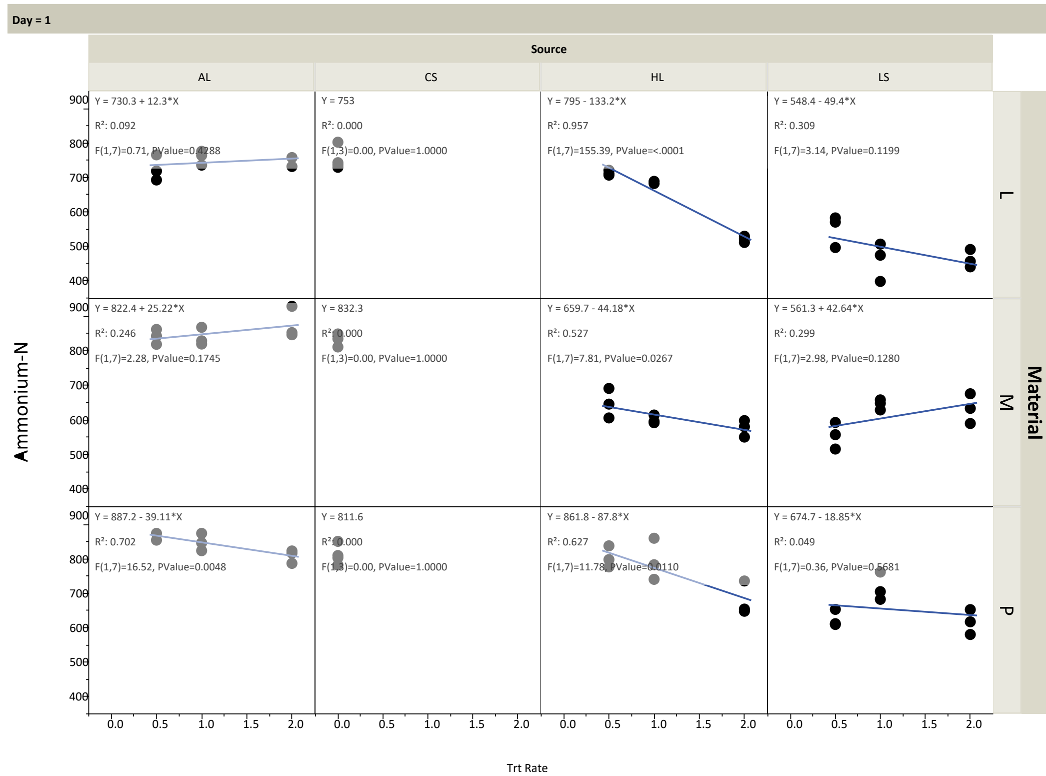


Figure S 7. Relationship between matrix manure Total Kjeldahl N (mg/L as is) and treatment rate. Refer to descriptive code table for interpretive information.



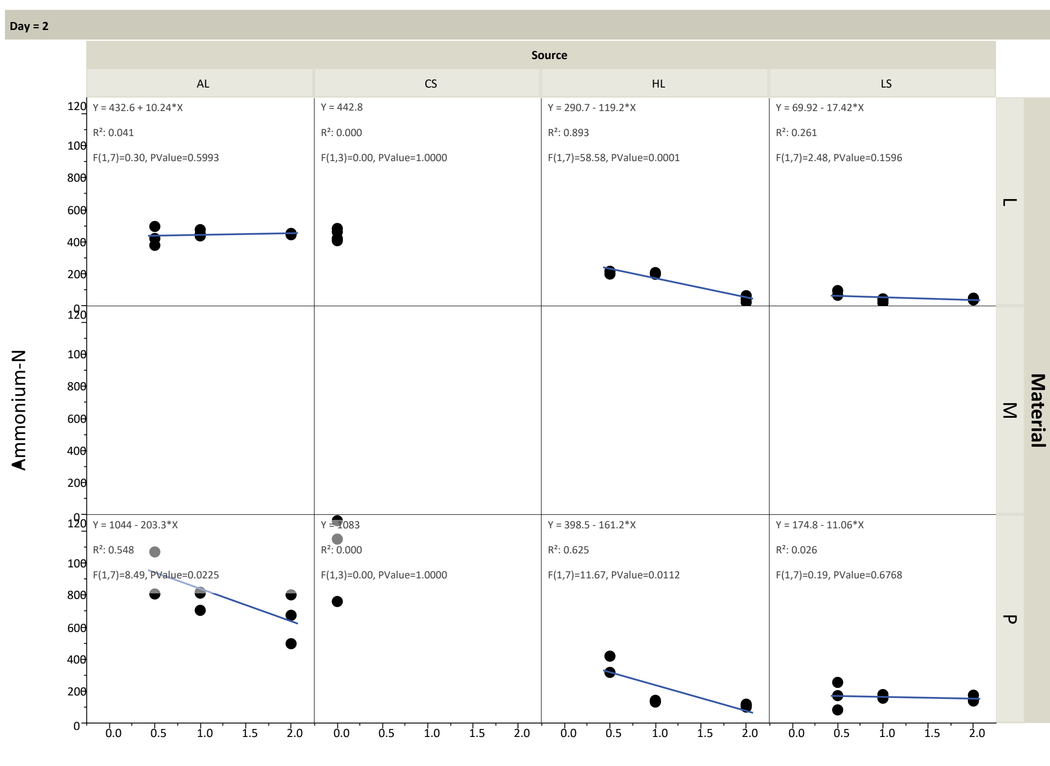
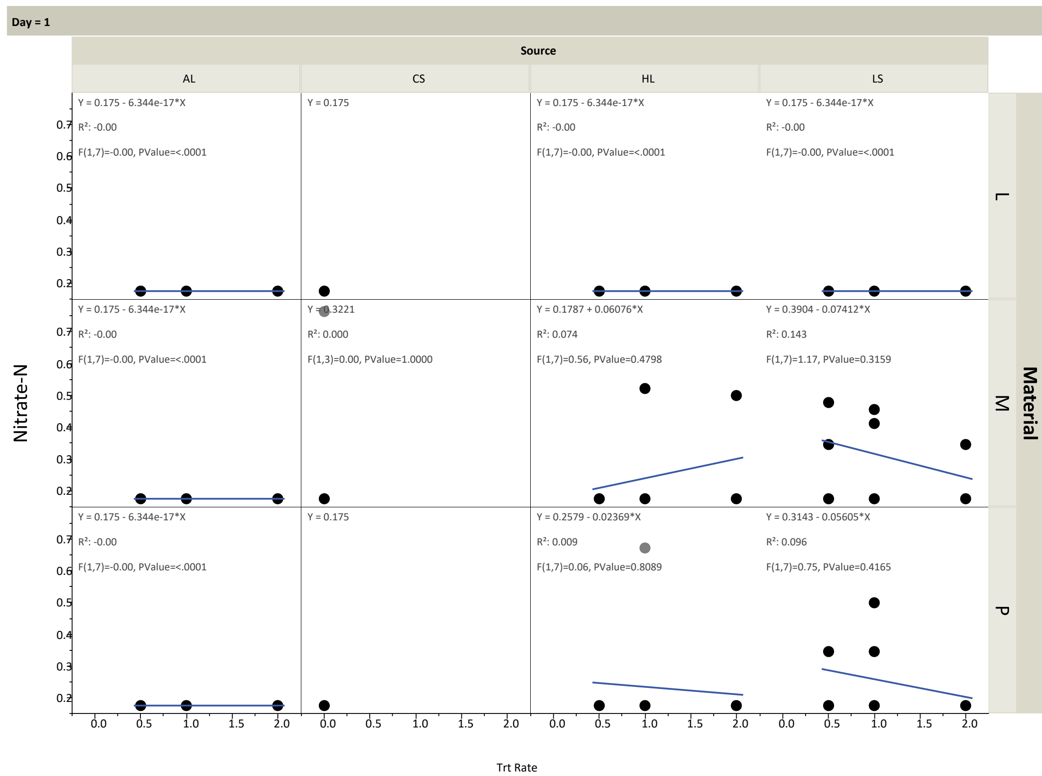


Figure S 8. Relationship between matrix manure ammonium-N (mg/L as is) and treatment rate. Refer to descriptive code table for interpretive information.



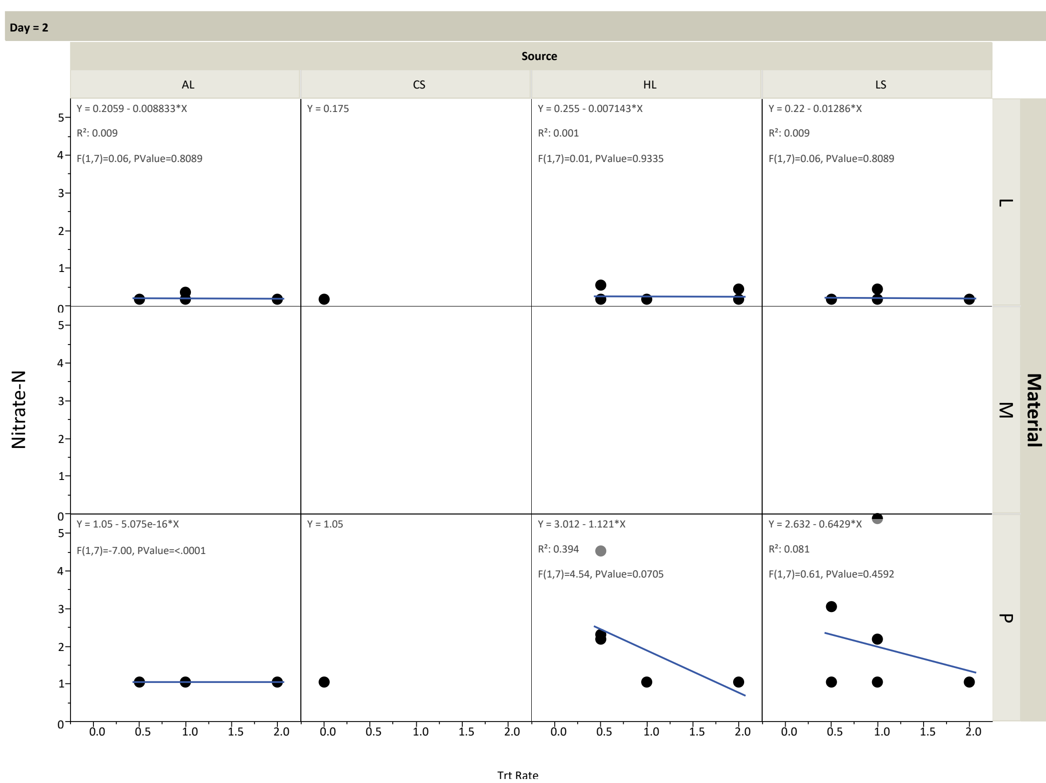
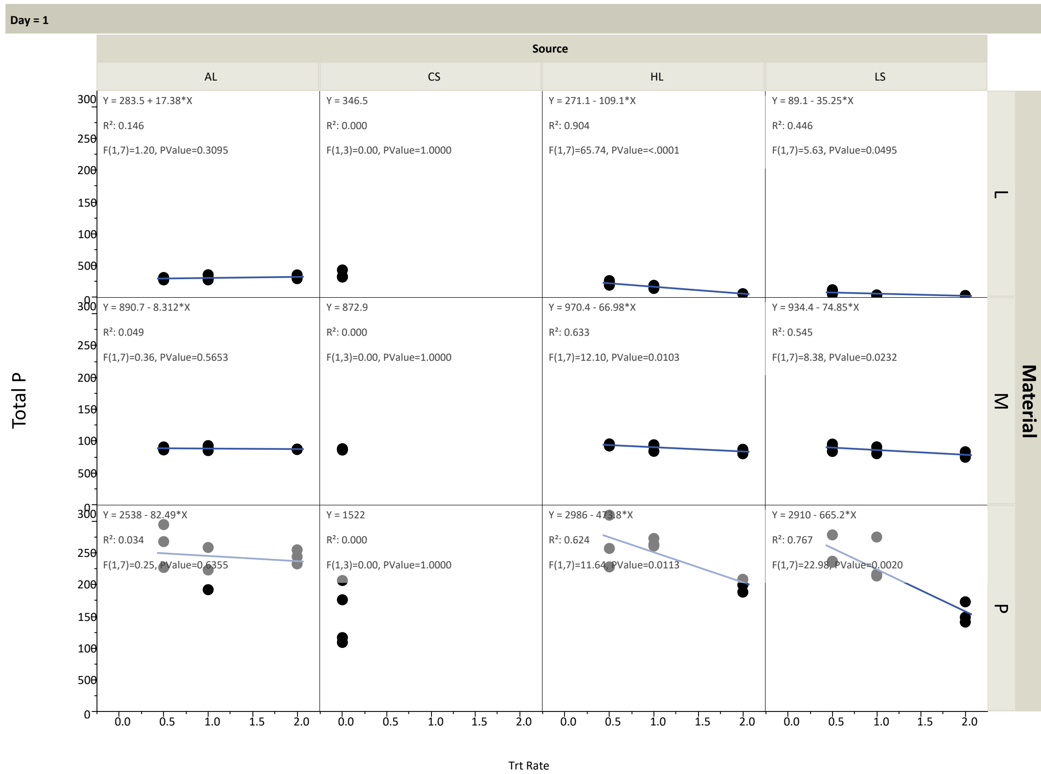


Figure S 9. Relationship between matrix manure nitrate-N (mg/L as is) and treatment rate. Refer to descriptive code table for interpretive information.



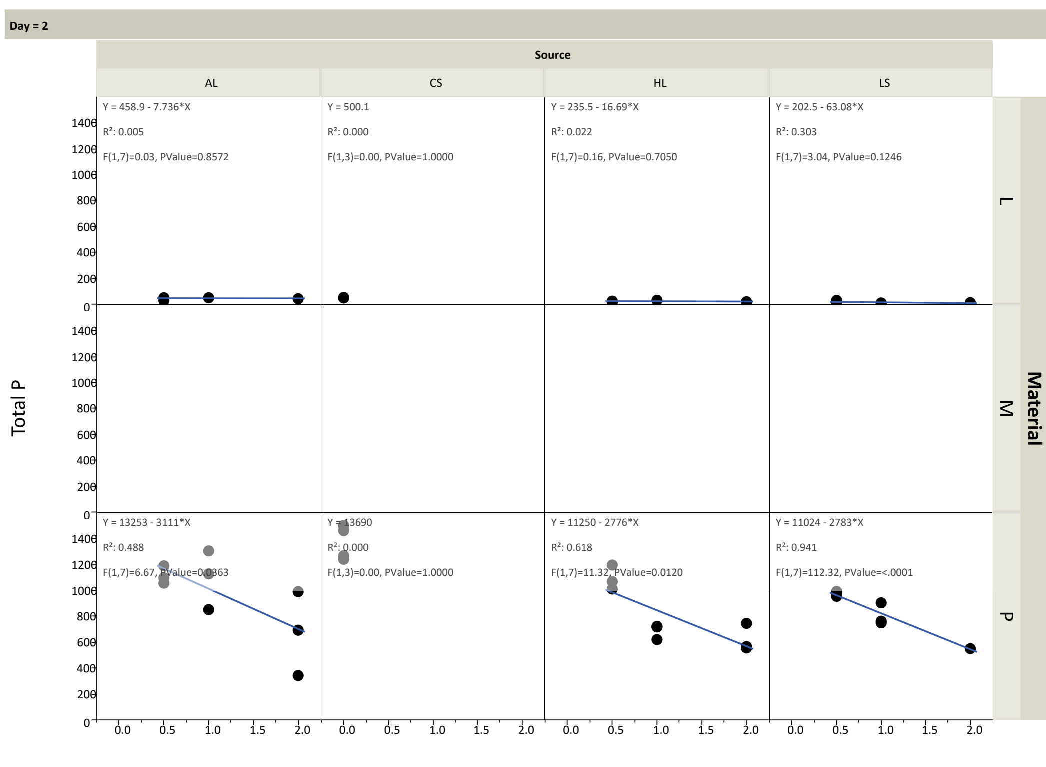
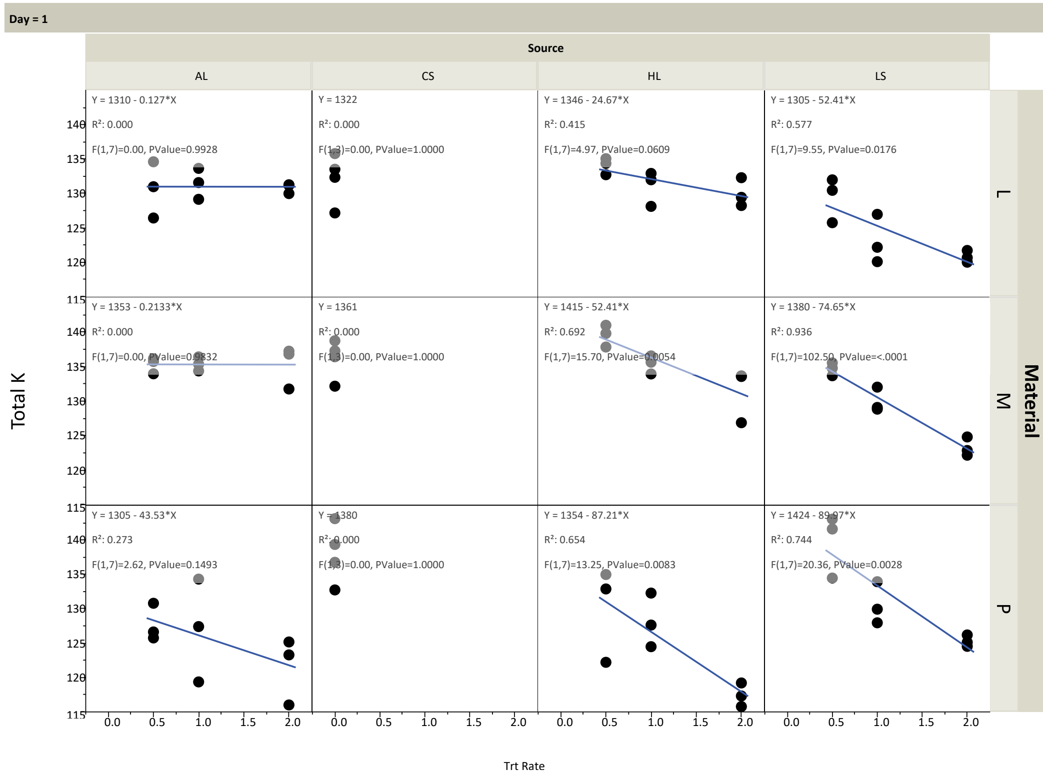


Figure S 10. Relationship between matrix manure total P (mg/L as is) and treatment rate. Refer to descriptive code table for interpretive information.



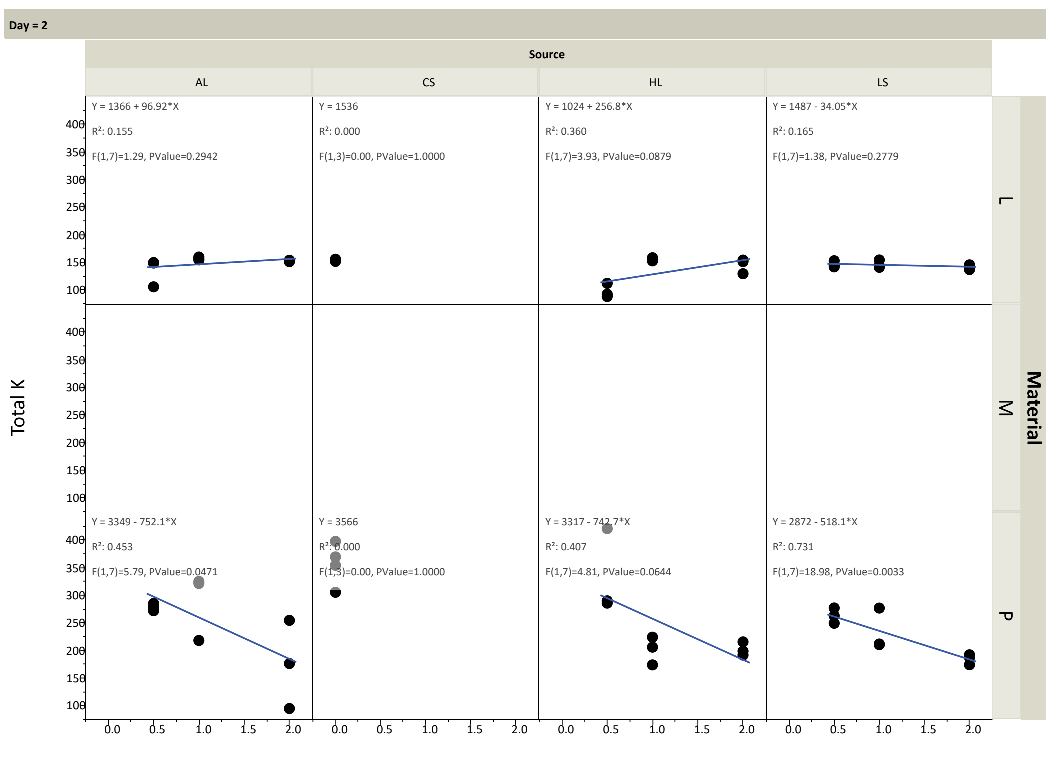
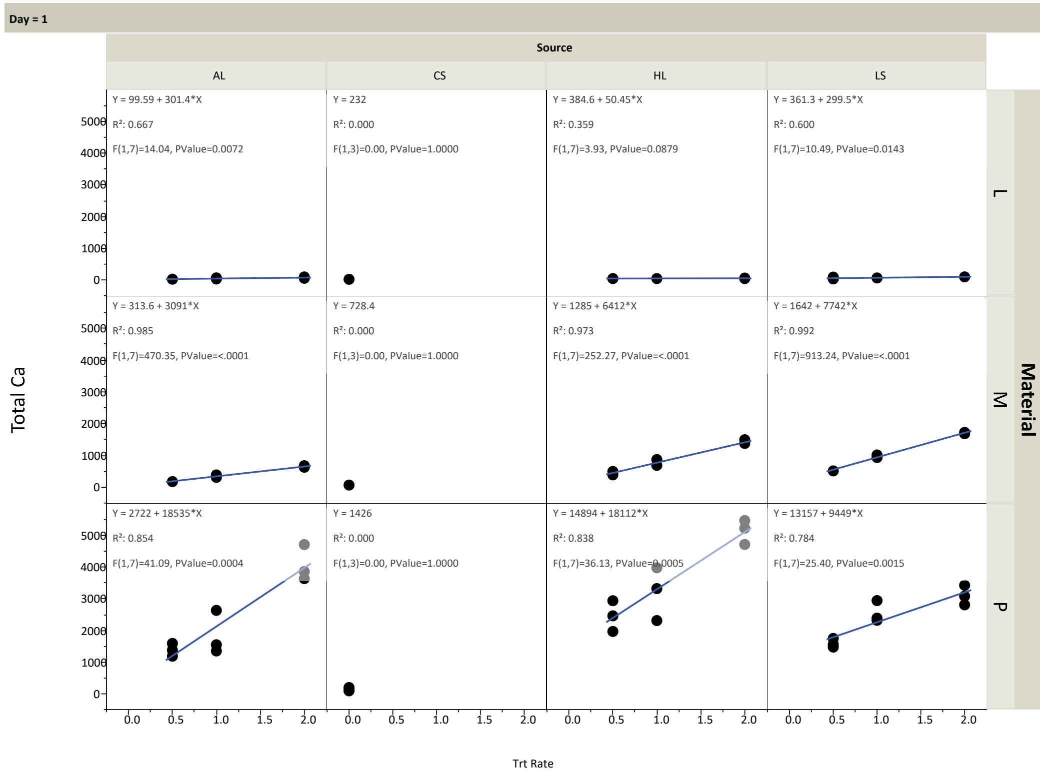


Figure S 11. Relationship between matrix manure total K (mg/L as is) and treatment rate. Refer to descriptive code table for interpretive information.



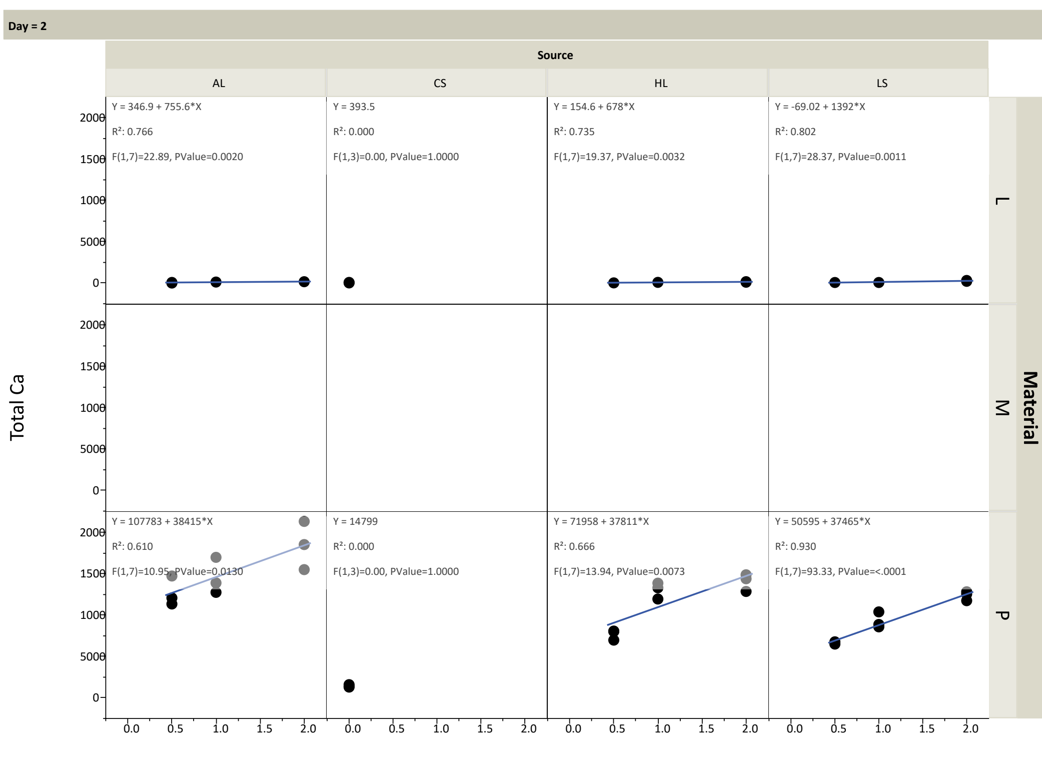
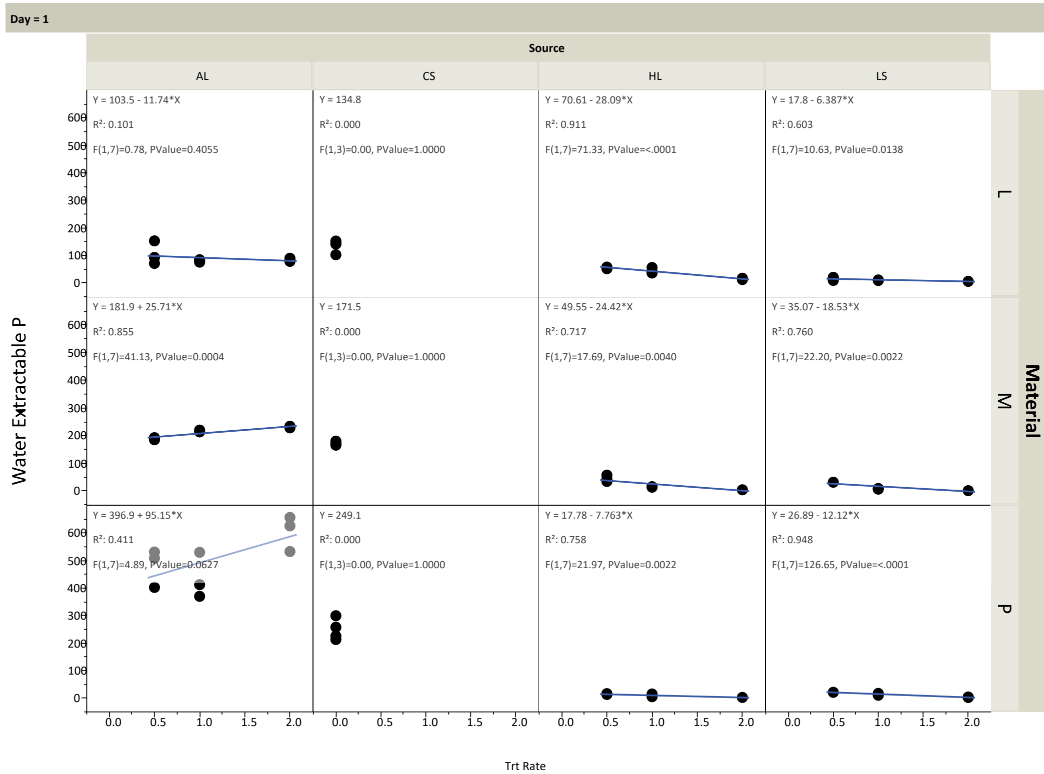


Figure S 12. Relationship between matrix manure total Ca (mg/L as is) and treatment rate. Refer to descriptive code table for interpretive information.



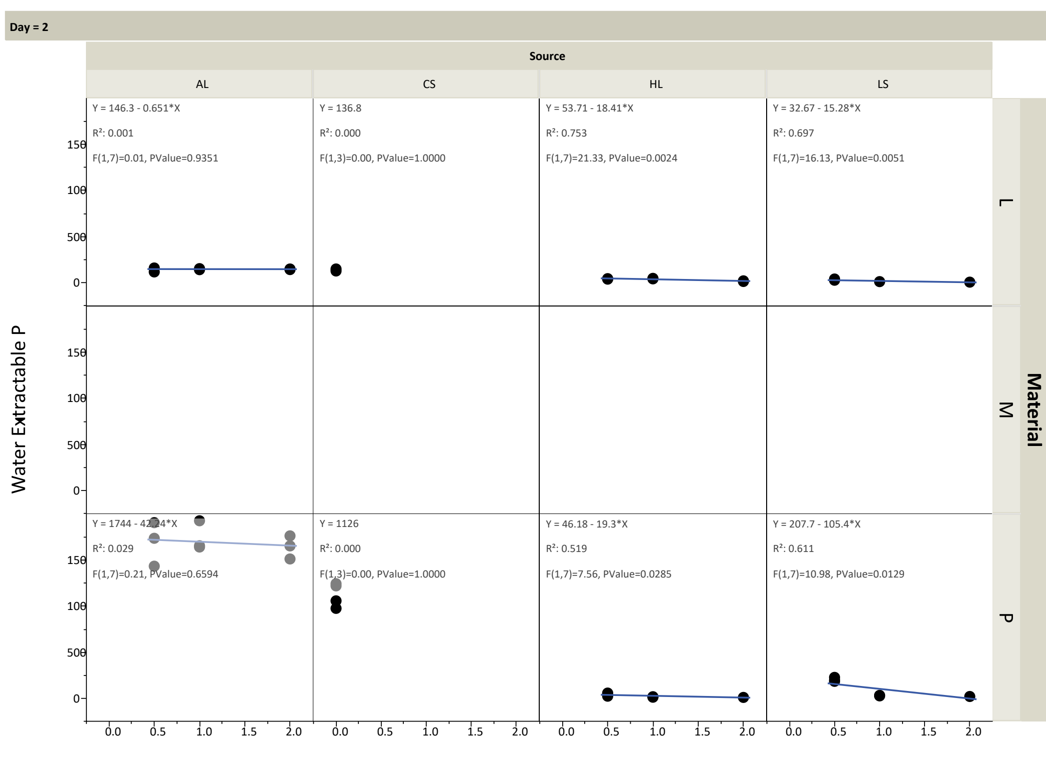


Figure S 13. Relationship between matrix manure water extractable P (mg/L as is) and treatment rate. Refer to descriptive code table for interpretive information.

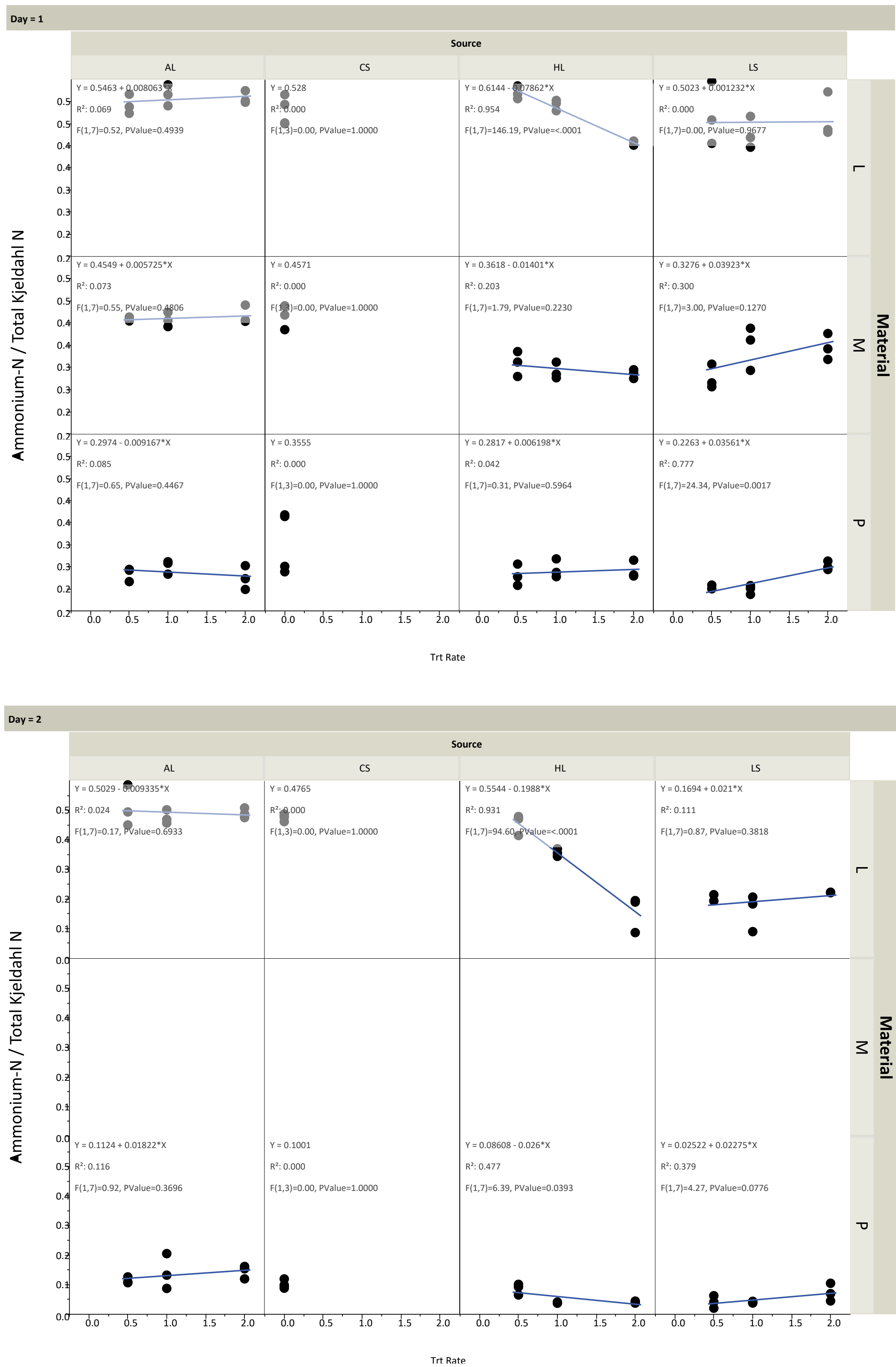
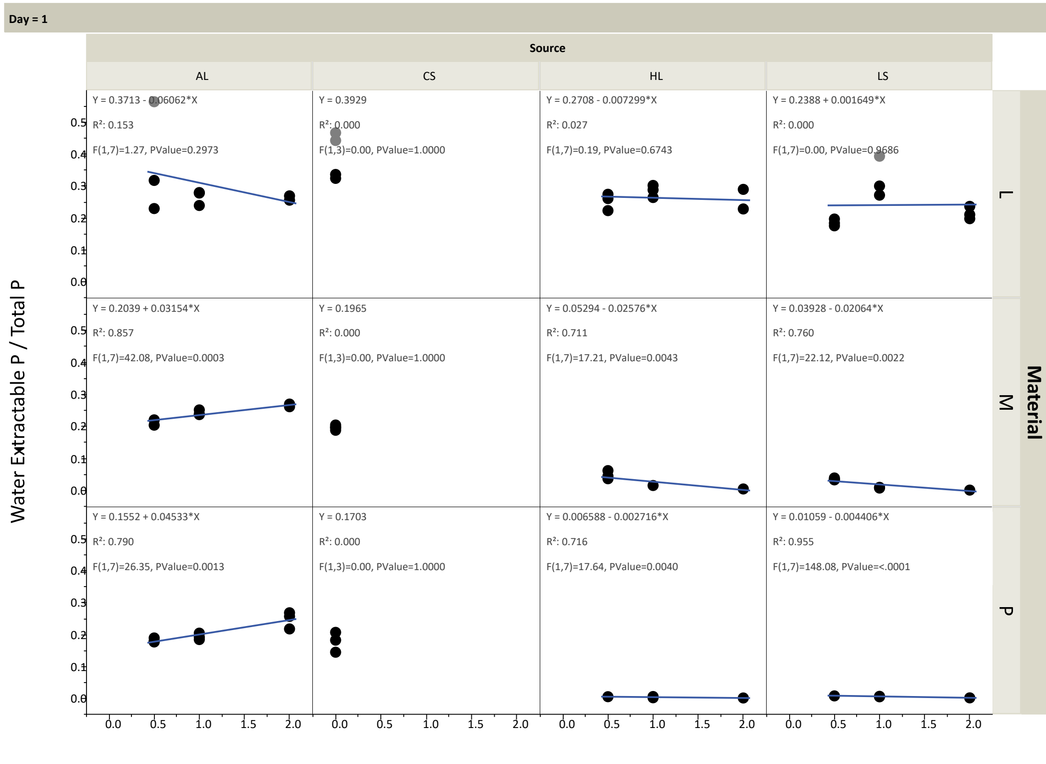


Figure S 14. Relationship between matrix manure ammonium-N / total Kjeldahl N (mg/L as is) and treatment rate. Refer to descriptive code table for interpretive information.



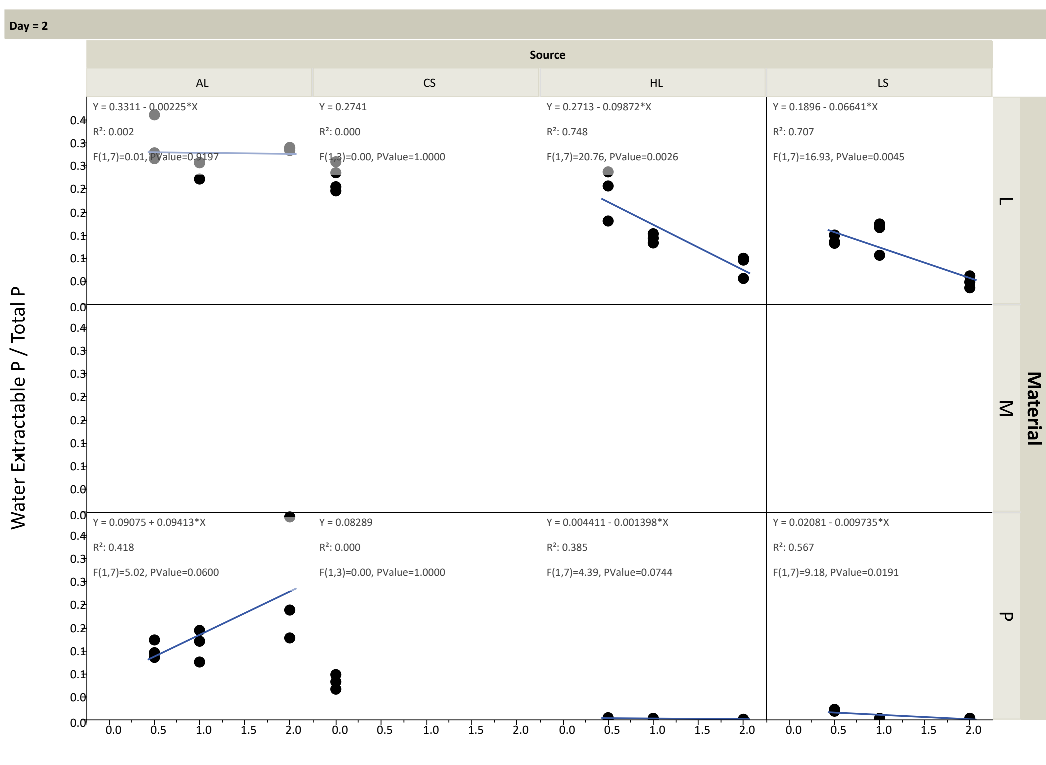


Figure S 15. Relationship between matrix manure water extractable P / Total P (mg/L as is) and treatment rate. Refer to descriptive code table for interpretive information.

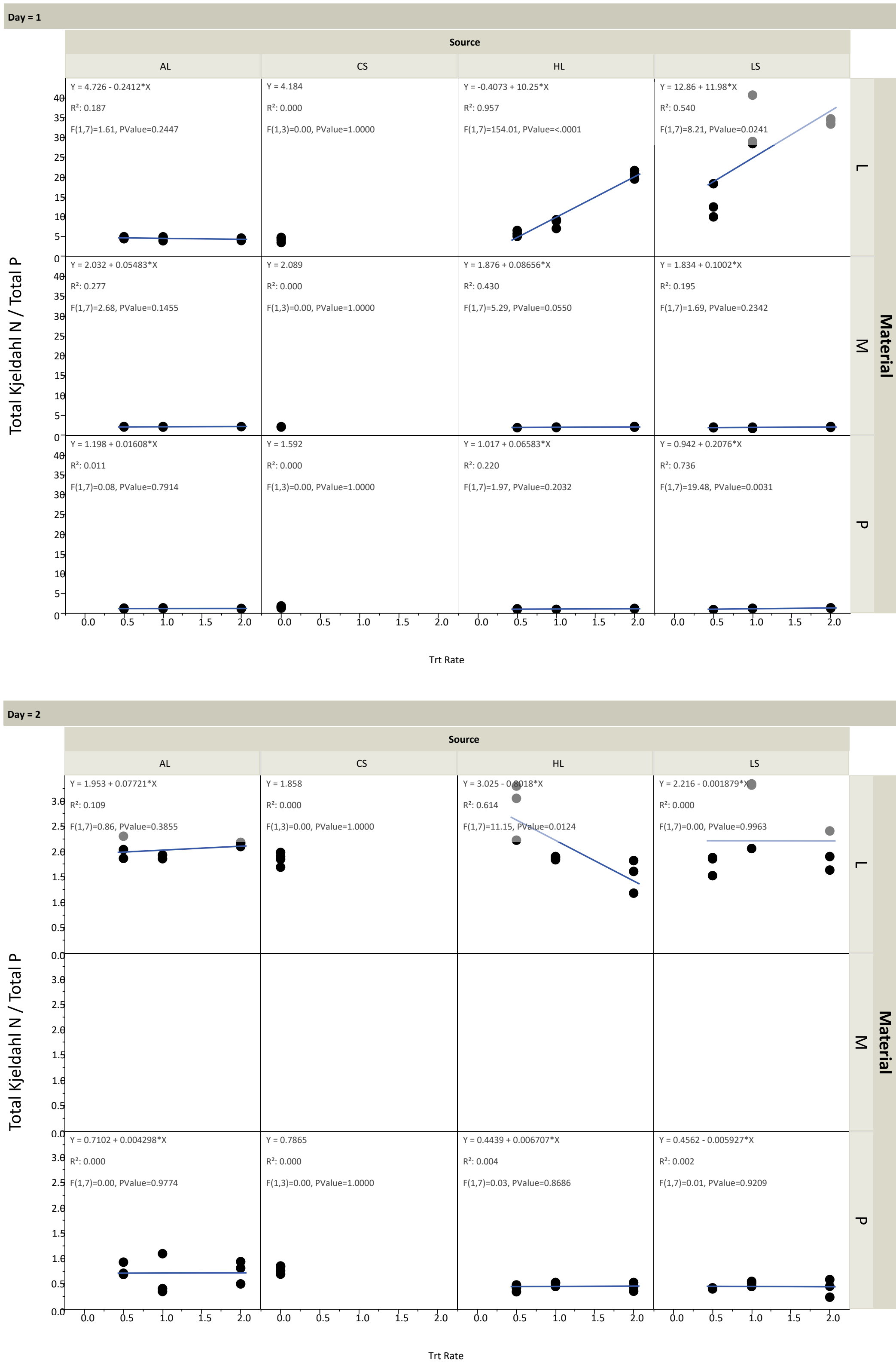


Figure S 16. Relationship **between matrix manure to**tal Kjeldahl N / **t**otal P (mg/L as is) **and treatment rate**. Refer to descriptive code table for interpretive information.

ELECTRICAL RESISTIVITY SURVEYS OF APPLIED HOG MANURE SITES, MOUNT JUDEA, AR

Final Report

Jon Fields and Todd Halihan

OKLAHOMA STATE UNIVERSITY
Boone Pickens School of Geology
105 Noble Research Center Stillwater, OK 74078-3031
405.744.6358, FAX 405.744.7841

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1.0 Executive Summary

Electrical Resistivity Imaging (ERI) surveys were conducted in December 2014 and March 2015 to evaluate the application of hog manure in riparian and adjacent areas in the Mount Judea, Arkansas area by defining potential groundwater flowpaths, soil structure, epikarst characteristics, and bedrock properties. ERI surveys generate a two dimensional cross section of geology based on the electrical properties of the subsurface. These properties are controlled by the type of soil or rock at a location and the electrical conductivity of the fluids in the soil. Rock with a low porosity and is competent, will be more resistive than fractured or weathered rock. Soil composed of fine grained material, like clay, is more electrically conductive than sandy soils. Features with more water content or higher salinity are more electrically conductive, while those with less water or salinity are more resistive.

The Phase I survey conducted a preliminary evaluation of applied hog manure in this setting to determine if electrical signatures were generated and could be investigated further. The application of hog manure has the possibility of providing a more electrically conductive signature in soil, which will appear in ERI surveys. These are not distinctly different from other electrically conductive substances in the subsurface; other analysis and sampling must be done to determine if the electrically conductive features are the signatures of hog manure.

The Phase II survey conducted evaluation of the previous fields and introduced another field with a recent application of hog manure. Three sites were compared: a background site with no applied hog manure (Field 5a), a site with application months before data collection (Field 12), and a site with a recent application only weeks before data collection (Field 1). The comparison determined the potential for electrical signatures to delineate the two application fields from each other, and from the background site. Soil sampling was conducted on all three fields as part of the phase II evaluation. The sampling provided a characterization and monitoring method to evaluate possible electrical signatures of applied hog manure.

Fields 5a and 12 were measured in December 2014 and March 2015; Field 1 was measured in March 2015. Field 5a was the background field with no application, Field 12 had a hog manure application in April 2014 and Field 1 received a hog manure application sometime in January or February 2015. Several datasets were collected and the following observations were made from the ERI data:

- ERI provided delineation of boundaries between soil, epikarst, and competent bedrock.
- The potential for rapid transport pathways in the underlying bedrock as joints or potential karst features were observed as conductive electrical features in a resistive background.
- Soil depth was measured to range from 0.5 to 3.5 meters (1.5 to 11.5 feet). On Fields 5a and 12, the thickness of soil increases moving toward the stream and thins towards higher elevations. This is consistent with the thickening of the alluvium as it is deposited closest to the stream.
- The average epikarst thickness is highly variable, ranging from 2.0 to 23.0 meters thick (6.0 to 75.0 feet).

- Soils of the background site (Field 5a) were lower in Zn in the soil solids, and lower in Mg and electrical conductivity in the soil fluids when compared to the results of the applied sites (Fields 12 and 1).
- Soils of the recently applied site (Field 1) were higher in K, Mn, and pH in the soil solids, and higher in K and pH in the soil fluids when compared to the results of the other two sites (Fields 5a and 12).
- There is a correlation between the spatial application of hog manure and increased electrical conductivity in the ERI and soil sampling results.
- There is an inverse relationship between the 0.5-meter resolution ERI bulk resistivity and soil fluid electrical conductivity at the background site. The applied sites have a direct relationship.

2.0 Glossary

This section includes the definitions for heavily used technical terms throughout this report. Accompanying many definitions are abbreviations for the references (WS – Water Science Glossary; GG – Geologic Glossary; UT – Glossary of Hydrological Terms; ES – A Dictionary of Earth Science; CK – A Lexicon of Cave and Karst Terminology; NOAA – National Oceanic and Atmospheric Administration; TH – ERI of the Arbuckle Simpson Aquifer)

Alluvium: deposits of clay, silt, sand, gravel, or other particulate material deposited by a stream or other body of running water in a streambed, on a flood plain, on a delta, or at the base of a mountain. (WS)

Apparent Resistivity: the resistance per length of a surface area, in essence the resistance of a cube to the one-way passage of electricity – this is used in many geophysical and hydrogeological applications. (UT)

Carbonates: frequently used with reference to sedimentary rocks composed of 95% or more of either calcite or dolomite – examples include limestone and dolomite. (ES)

Conductive Fluid: fluid that readily conducts electricity – the degree to which the fluid is conductive depends on the concentration of dissolved ions within the fluid – examples include sodium and chloride ions from dissolving table salt in water. (TH)

Disconformity: buried erosional surface representing a break in the geologic record of significant time but one which the beds above and below the surface are parallel; some disconformity surfaces are highly irregular, whereas others have no obvious relief. (ES)

Dissolution Feature: dissolution is the process in which a solid becomes dissolved in (ground) water– dissolution features include caves, sinkholes, enlarged fractures, and doline features. (UT)

Doline Feature: a closed topographic depression caused by dissolution or collapse of underlying rock or soil; synonymous with sinkhole. (UT)

Epikarst: a relatively thick portion of bedrock extending from the base of the soil zone and is characterized by extreme weathering and enhanced solution. Thickness may vary considerably; may be up to 30 meters thick. Significant water storage and transport are known to occur in this zone. (CK)

ERI: Electrical Resistivity Imaging – a geophysical method where an electrical current is injected into the ground through two electrodes; the resulting electrical potential is measured between two separate electrodes and the apparent resistivity is calculated. Thousands of these measurements allow for imaging of the subsurface. (TH)

Fault: a fracture in the Earth along which one side has moved relative to the other. (GG)

Flowpath: the subsurface course a water molecule or solute would follow in a given ground-water velocity field. (CK)

Fracture: a break or secondary discontinuity in the rock mass, whether or not there has been relative movement across it. Faults, thrusts, and joints are all fractures. Bedding planes are primary features and are not considered fractures. (CK)

GPS: Global Positioning System – a space based satellite navigation system that gives time and location anywhere on the Earth where there is an unobstructed line of sight with four or more satellites.

Groundwater: water that flows or seeps downward and saturates soil or rock, supplying springs and wells. Water stored underground in rock crevices and in the pores of geologic materials that make up the Earth's crust. The upper surface of the saturated zone is called the water table. (WS)

Joint: a break of geological origin in the continuity of a rock body occurring either singly, or more frequently in a set or system. The break is not attended by a visible movement parallel to the surface of the discontinuity. (CK)

Karst: the result of natural processes in and on the Earth's crust caused by dissolution and leaching of limestones, dolomites, gypsum, halite, and other soluble rocks. (CK)

Limestone: a sedimentary rock made mostly of the mineral calcite; it is usually formed from shells of once-living organisms or other organic processes, but may also form by inorganic precipitation. (GG)

OPUS: Online Positioning User Service – a service run by the National Geodetic Survey (NGS) as part of the National Oceanic and Atmospheric Administration (NOAA). The service solves the GPS position of the user by tying the survey-grade data to the National Spatial Reference System (NSRS). (NOAA)

Perched Groundwater: unconfined groundwater separated from an underlying body of groundwater by an unsaturated zone. The perching bed permeability is so low water percolating downward through it is not able to bring water in the underlying unsaturated zone above atmospheric pressure. (CK)

Perched Water Table: the water table for the perched groundwater. The upper surface of the perched groundwater. (CK)

Resistive Feature: fluids and rock bodies that do not readily conduct electricity – the degree to which a feature is resistive depends on porosity, salt content in the fluid, and rock or soil type. (TH)

Root Mean Square Error: is the average of the squares of the "errors", the difference between the estimator and what is estimated.

Sandstone: a clastic sedimentary rock composed of sand sized grains. (GG)

Soil Zone: the zone between the ground surface and the epikarst. Water is able to pass through this zone to reach the water table. (ES)

Quaternary: the most recent Period in the Cenozoic Era and encompasses the time interval of 1.6 million years ago through today. (GG)

Water Table: the upper surface of a zone of saturation except where that surface is formed by a confining unit; where the water pressure in porous medium equals atmospheric pressure. (CK)

3.0 Introduction

The purpose of this report is to document the results of a three-dimensional geophysical site characterization of three fields adjacent to Big Creek, which received hog manure applications or have the potential to receive it. This report defines the subsurface geoelectrical properties of three fields near Mount Judea, Arkansas in December 2014 and March 2015. One field (Field 5a) was selected to measure background data on the soil and subsurface environment, but has not yet received any hog manure. A second site (Field 12) was selected, where hog manure was applied in April 2014. A third site (Field 1) was selected, where hog manure was applied between January and February 2015.

3.1 Electrical Resistivity Imaging

Electrical resistivity imaging (ERI) provided a good method to understand the distribution of fluids and rock properties in the subsurface environment, especially in the presence of fractures (Bolyard, 2007; Gary et al., 2009; Halihan et al., 2009). The method allows an electrical image to be created of the subsurface, which typically provides a meter-scale dataset utilized to evaluate heterogeneity and fluid distribution. Improvements in sensitivity generated by the Halihan/Fenstemaker method (OSU Office of Intellectual Property, 2004), allow greater differentiation of these signatures (Miller et al., 2014). In a field setting, this results in a two-dimensional mapping of subsurface electrical properties in vertical cross sections. Data interpolation was utilized to construct horizon map data at various depths below the surface.

Figure 1 - Electrical resistivity equipment during data collection (12.17.14)

3.2 Soil Sampling

Soil sampling transects in each field provided confirmation data to support the geophysical datasets. Soil sampling has been used to characterize the physical and chemical properties of soils (Anderson, 1960; Schoenau, 2006). The University of Arkansas Soils Testing and Research Laboratory and Oklahoma State University's (OSU) Soil, Water and Forage Analytical Laboratory were used for testing the soils collected in the field. Samples were analyzed for fluid and solid chemical composition using the 1:1 soil-water extraction method and Mehlich-3 extraction method, respectively, to determine if signatures of applied hog manure were evident in the soil. OSU's School of Geology geochemistry laboratory was utilized for isotope ratio mass spectrometry analysis, to determine if the $\delta^{15}N/^{14}N$ ratios of the samples matched those of hog manure. Soil sampling data were compared against the electrical resistivity data to evaluate how the soil physical and chemical properties affected the geophysical signatures observed for the sites.

3.3 Project Statement

This report documents a geophysical investigation of three sites along Big Creek near Mount Judea, Arkansas using electrical resistivity and soil sampling datasets. It describes the field sites and literature available for methods utilized and properties of applied hog manure. The results of the study will be presented with the geologic and hydrogeologic structure evaluated from the electrical data. The soil data results will be presented and correlations among datasets will be evaluated and discussed. Conclusions about the electrical resistivity and soil sampling datasets will be made at the end of this report.

4.0 Site Description and Selection

The three test sites (Fields 1, 5a, and 12) are given in Figure 2. These three sites were chosen to coincide with additional surface water quality monitoring on these fields by the University of Arkansas Big Creek Research and Extension Team. Access to the sites was granted by the landowners. The positions of the selected sites are representative of fields adjacent to Big Creek which are permitted to receive hog manure. Field 5a (background site) currently receives mineral fertilizers and poultry litter, while Field 12 (application site) received one application of hog manure in late April of 2014, and Field 1 (recent application site) has received two applications of hog manure with the most recent being between January and February of 2015. This section will describe the geologic and hydrologic settings of three test sites.

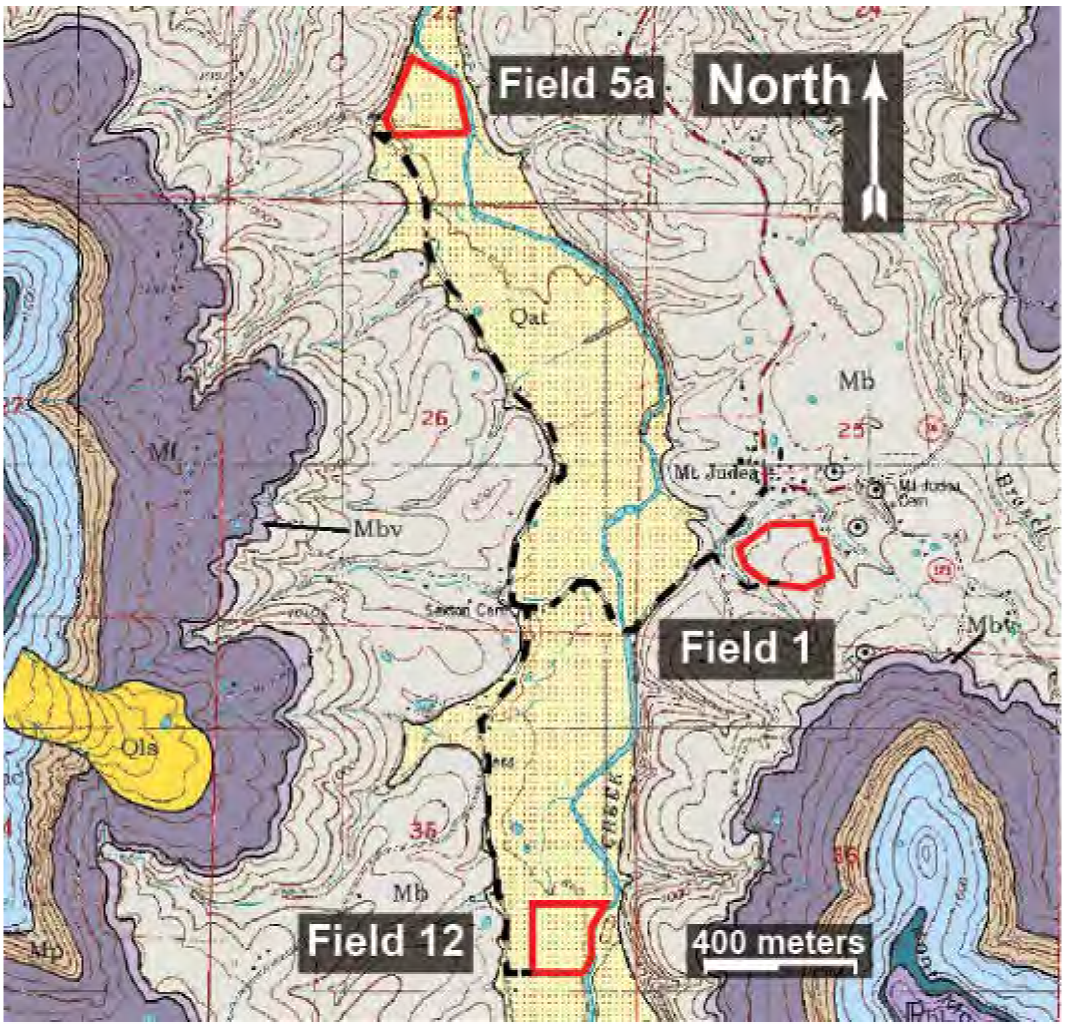

Figure 2 – Site map indicating the three fields (Field 1, 5a, and 12) in red and roads leading to these sites in dashed black lines. The Geologic map of the Mt. Judea Quadrangle, Newton County, Arkansas is from Chandler and Ausbrooks, revised 2015.

4.1 Geologic Setting

The geologic setting for the sites is mantled epikarst (soil over epikarst over competent carbonate bedrock). Fields 5a and 12 sit on Quaternary alluvium deposits, while Field 1 sits on a fine- to coarse-grained fossiliferous limestone with interbedded chert. The Boone Formation is the underlying bedrock for each site. The geologic setting for Fields 1, 5a, and 12 are detailed below.

Fields 5a and 12 (Figures 3 and 4, respectively) share similar geologic settings adjacent to Big Creek (Figure 2). The alluvium at the surface of both sites consists of clay, silt, sand, and gravel deposited by Big Creek. Alluvium can be organic rich and flat lying; good for use as cropland. Underlying the alluvium is an epikarst system and underlying unweathered limestone bedrock (Williams, 2008). Epikarst is a zone extending from the base of the soil zone to the unweathered portion of the limestone bedrock and is characterized by fracturing and weathered bedrock (Klimchouk et. al., 2004). This zone is generally a domain with faster fluid flow and greater water storage than the unweathered bedrock, with distinct saturation at the soil and epikarst boundary and again at the epikarst and karst boundary (Perrin et. at., 2003). General epikarst porosity ranges from 1% (Smart et. al., 1986) to 10% (Williams, 1985) and averages about 10 – 15 meters (33 – 49 feet) in depth (Klimchouk et. al., 2004).

Field 1 (Figure 5) is located on a hillside about 400 m from Big Creek and underlain by the Boone Formation. It is an Early Mississippian Period limestone found in the Ozark regions of Eastern Oklahoma, Southern Missouri, and Northern Arkansas where karst dissolution features including sinkholes, caves, and enlarged fissures are common (Ferguson, 1920). This formation averages 90 – 120 meters (300 – 400 feet) thick (Ferguson, 1920).

The Boone Formation is a gray, fine to coarse-grained fossiliferous limestone with interbedded dark and light chert. The basal unit of the Boone Formation in the area is the St. Joe Limestone (Ferguson, 1920). The St. Joe is a fine-grained, crinoidal limestone containing some smoothly bedded chert and displaying coarse bioclastic texture. The color is generally gray but can be red, pink, purple, brown, or amber. Thin calcareous shales can be found in sequences throughout the St. Joe. The base of the St. Joe contains phosphate nodules within a green shale or conglomerate and is disconformable in most places. At a few locations, basal sandstone is found at the base of the St. Joe Limestone. The basal sandstone is a fine to medium-grained, moderately sorted, sub-rounded to rounded sandstone. It is white to light gray and tan on fresh surfaces, thin to thick bedded, and contains phosphate nodules and white to light gray chert. It is generally up to 3.5 meters (12 feet) thick (Ferguson, 1920). The Boone Formation is the bedrock at all three sites, but Field 1 is missing the alluvium Fields 5a and 12 have above the bedrock.

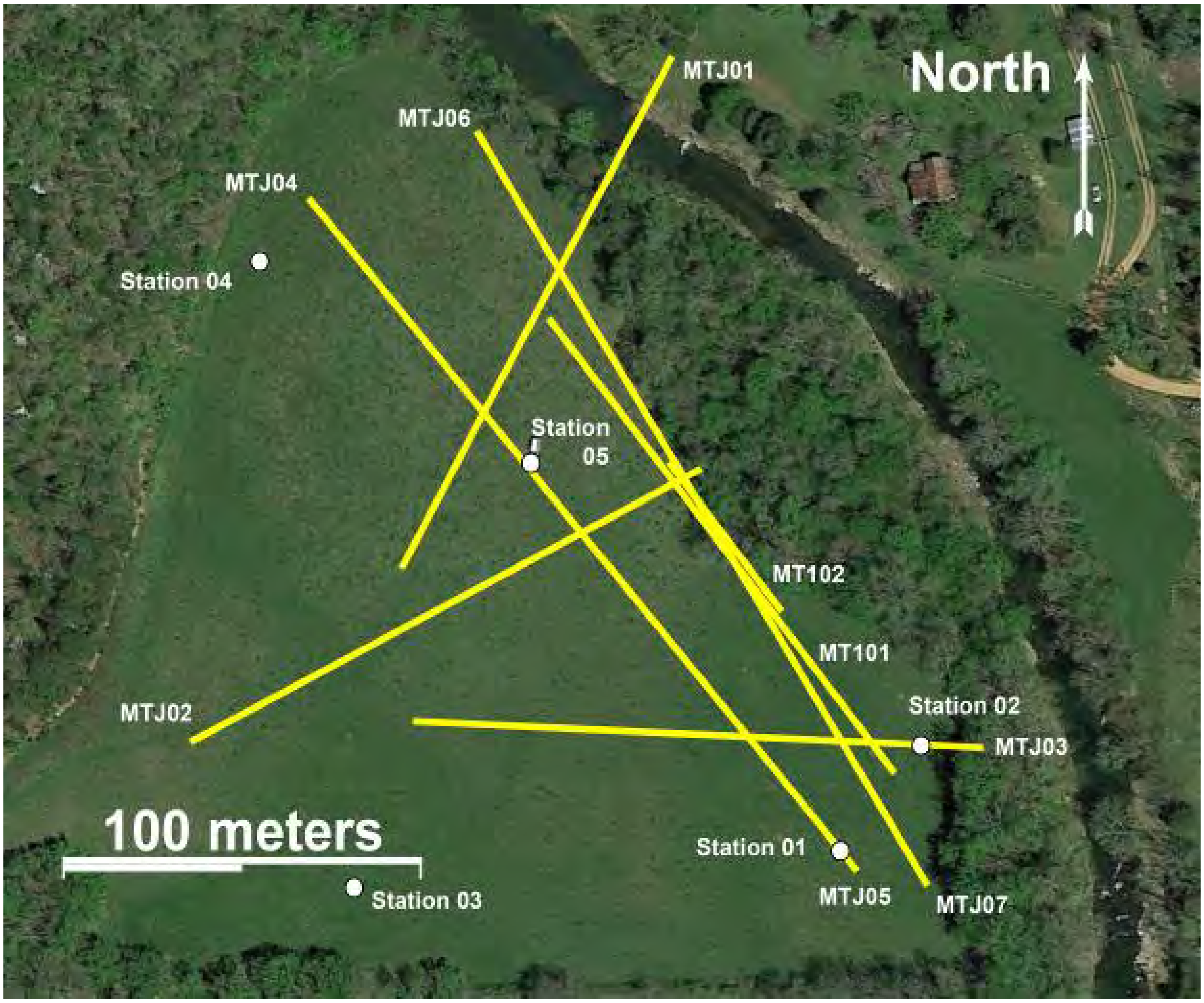

Figure 3 – Field 5a (background site) ERI transects collected during December 2014 and March 2015 are in yellow, shallow well locations (stations) also noted. Aerial photo obtained from Google Earth.

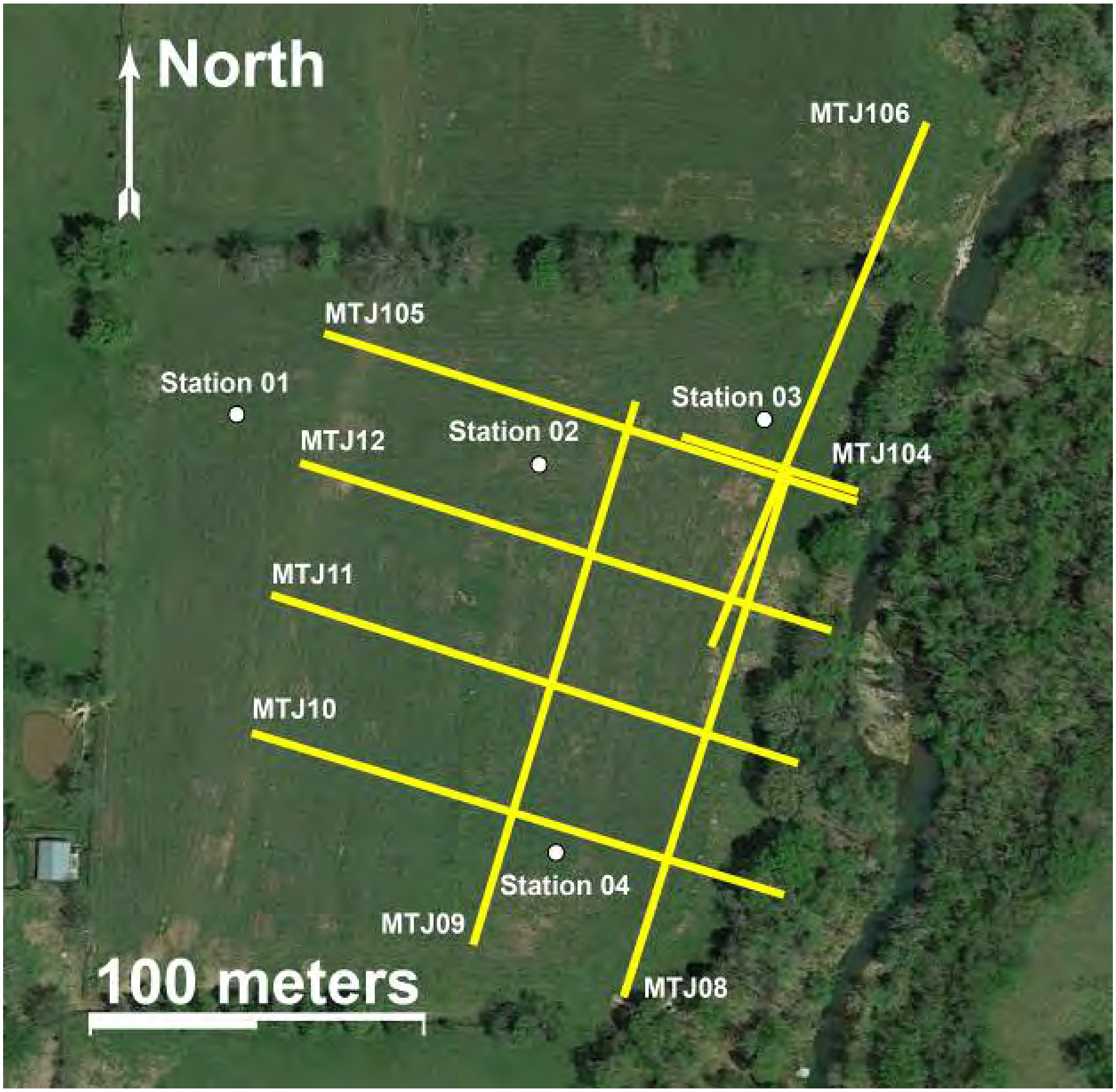

Figure 4 – Field 12 (application site) ERI transects collected during December 2014 and March 2015 are in yellow, shallow well locations (stations) also noted. Aerial photo obtained from Google Earth.

Figure 5 – Field 1 (recent application site) ERI transects collected during March 2015 are in yellow. Aerial photo obtained from Google Earth.

4.2 Hydrologic Setting

The hydrologic setting for the sites is a mantled epikarst (soil over epikarst over competent carbonate bedrock). Precipitation enters the subsurface through the soil zone and enters the epikarst area. Fluids move through the epikarst area and enter the unweathered competent bedrock through fractures and other openings. Understanding the storage and transmission properties of these three zones is essential to understanding the migration of nutrients from applied hog manure in the area. This section will discuss the hydrologic settings of the soil zone, epikarst zone, bedrock, the local water table and the application of hog manure at the time of data collection.

The soil zones in an alluvial setting are often reworked stream deposits that have been mobilized several times since they were originally deposited. They are often highly variable in grain size and organic content. Silt-sized grains in Fields 5a and 12 should result in the ability of the soil to hold fluids for some period of time. The soil zones in an epikarst environment are thin and often contain rock within the zone near the surface. The soil zone consistency is sporadic as the hydrological processes erode areas at differing rates. The soil and epikarst interface in Field 1 is shallower than Fields 5a and 12, resulting in the potential for less soil filtering that the other sites prior to fluids entering into the epikarst zone.

In geologic settings like northern Arkansas, the epikarst zone is a significant source of water storage and transmission and many springs have been tapped to support local communities (Galloway, 2004). These types of groundwater systems can include perched water tables, which exist above regional water tables. These are called perched because they are places where low permeability soil or bedrock layers hold water above an unsaturated zone and often produce springs on the side of a bluff or sometimes in an open field if the relief is high enough to expose this feature. The boundary of the soil zone with the epikarst zone is visible in some locations in the fields used for this study. Perched features are not apparent at either site. This zone is expected to have wide variability in flow rates and a high amount of storage (Williams, 2008). There can be slow seepage through weathered pores and pieces of less weathered bedrock, to relatively rapid flow through fractures and karst features. The electrical features measured at these sites generally indicate high porosity zones and the extent of weathering in these locations (Williams, 2008; Halihan et al, 2009).

Flow through the bedrock will depend on the location of fractures or karst features. Flowpaths will most commonly be electrically conductive relative to the unweathered bedrock beneath the water table. In settings with little dissolution and strong faulting or fracturing, the flowpaths will appear as linear features in ERI datasets (Halihan et al, 2009), but in the event of karst features, they can appear wider (Bolyard, 2007; Gary et al., 2009). Fractures or karst flowpaths present in the bedrock can be localized or but often follow larger regional trends.

The regional water table was not evaluated for this report but at the two sites on the alluvium, the local water table was shallow during the investigation. For Field 5a, the depth to the local water table was approximately 1.5 meters (5 feet) below the land surface. For Field 12, the local water table was approximately 2 meters (6.5 feet) below the surface. The local water table was not detected in Field 1. Precipitation previous to and during the investigation resulted in both sites having moist to saturated soil conditions. The site soil of Field 1 was saturated.

Farm manure application records show that slurry was applied to Fields 12 and 1 but not 5a. Field 12 received one application in April 2014 of 48,000 gallons (182 meters^3) spread over 9.9 acres (40,064 meters^2) for an application flux of 0.18 inches (0.5 centimeters) of applied manure. This application was eleven months prior to sampling for both ERI and soil composition. Field 1 received four applications of applied manure. Total application was 82,000 gallons (310 meters^3) over an average of 6.9 acres (27,923 meters^2), which provides a total flux of 0.44 inches (1.1 centimeters) prior to sampling. The latest application before ERI and soil sampling was in January or February 2015 when 21,000 gallons (79 meters^3) were applied to 7.3 acres (29,542 meters^2) resulting in an event flux of 0.11 inches (0.3 centimeters) approximately a month prior to sampling. The applied material was electrically conductive fluid with reported conductivities ranging from 8,410 to 12,890 micromhos/cm.

5.0 Methods

As part of this assessment, Oklahoma State University (OSU) designed and conducted ERI experiments to integrate the ERI data with site data and soil data to provide an understanding of the subsurface distribution of flowpaths on Fields 5a, 12, and 1. Field methods included ERI surveys, topographic site surveying using differential GPS (global positioning system) techniques, and soil sampling along ERI surveys. The experimental design was based on observing changes between applied and unapplied fields to determine if changes correlated to changes in electrical properties. The sampling was not intended to test or evaluate if levels of measured constituents were at levels above or below any recommended concentrations as other studies concerned with that issue were sampling these same sites.

5.1 General Field and Laboratory Methods

The general methods used to collect the ERI, GPS, and soil sampling data are given below followed by site-specific descriptions of the methods used.

5.1.1 ERI Data

ERI data collection requires special instruments and transect planning. The ERI data collection instrumentation used was an Advanced Geosciences, Inc. (AGI) SuperSting R8/IP resistivity instrument. The instrument is a multi-channel earth resistivity meter with memory storage. The multi-channel design allows for measuring times to be decreased. The project design for Phase I from OSU was to use 56 electrodes at 3-meter spacing (9.8 feet). This spacing allowed for detailed data collection at 1.5-meter (4.9 feet) resolution for a lateral distance of 165-meters (541 feet) and a depth of investigation of 33 meters (108 feet) for each image. The design for Phase II was to use 56 electrodes at both 3-meter spacing (9.8 feet) and 1-meter spacing (3.3 feet). This spacing allowed for the same 1.5-meter resolution data along three lines as in Phase I, but also allowed for data collection at 0.5-meter (1.6 feet) resolution for the lateral distance of 55 meters (180 feet) and a depth of investigation of 11 meters (36 feet) for three separate lines. The spacing is dependent upon balancing the depth of investigation with how much resolution is needed.

Each ERI line was placed using field measuring tapes to 165 meters (541 feet) or 55 meters (180 feet). For each line, 56 stainless steel stakes were inserted into the soil approximately 1-foot deep oriented in a straight line. The resistivity cable was laid out and each electrode on the cable was connected to each stake. The cables were connected to the instrumentation once the line was laid out. A generator and an AGI 12-volt power supply were used to power the instrument. Electrical testing was ready to begin after transects were set up.

Tests were run on the instrument and cable to ensure each electrode was properly connected to each stake and the instrument was running properly. Contact resistance tests were conducted to ensure the circuits were complete. Electrodes with contact resistance greater than 2,000 ohms fail the test and those stakes were either pushed deeper in the soil to help create a better contact with the soil, or an electrically conductive fluid like salt water was poured around the stake to improve contact between the stake and underlying soil. Lower contact resistance indicates better contact with subsurface material, increasing signal strength and improving better data quality and accuracy. With the high soil moisture at the site during the surveys, no extra fluids were required to obtain good electrode contact. ERI data collection could begin after tests are concluded.

The collected data were evaluated for data quality prior to departing the field. In the laboratory, field electrical data were paired with topographic data and processes to determine 2D resistivity surveys beneath the electrode lines. Data from individual depth horizons were extracted from individual datasets and interpolated to generate depth slices of the site data to provide map views of the site electrical structure. Both 2D vertical and horizontal data were visualized using RockWorks software.

5.1.2 Site Topographic Surveying

Topographic surveys were required for generating the two-dimensional cross-sections produced from the ERI data as well as created a site topographic map. The GPS used for site surveying was a Topcon Positioning Systems, Inc. HyperLite GNSS Base and Rover with Bluetooth connected handheld unit. Personal GPS units come to within approximately 3 meters (10 feet) of a person's true location, but this commercial grade instrument provides locations to within approximately a centimeter (1/2 inch) of its true location. This instrument was set up by positioning a base receiver and utilizing a second mobile receiver to obtain data. Tree cover can be problematic for the Rover to obtain satellite data. At times, points cannot be collected because the Rover was under too much tree canopy. This was the case on both sites near the stream (i.e., Big Creek) and along the site boundaries if tree canopy was dense. The majority of the data were collected in open field conditions, allowing good coverage of the ERI locations.

5.1.3 Soil Sampling

Soil sampling was conducted using a field kit, a list of criteria to be met, and evenly proportioned among the three sites. The soil sampling equipment used was an AMS Basic Soil Sampling Kit which included of a 3 ¼" hand auger tool. The samples were collected to a depth of 0.1 meters (4 inches). Samples were placed in zip-lock bags and stored in a cooler until analysis. The locations for sampling were based on a few criteria: samples were collected at 0.25 meters (9.8 inches) away from an ERI electrode to improve the fit between both the soil sampling and modeled ERI sets of bulk resistivity data. The remaining criteria were chosen on a field-by-field basis. Field 5a consisted of 10 samples correlating to distances along transect MTJ101 (Figure 6) and an attempt to sample across a known soil contact. Field 12 consisted of 11 samples, three of which are in the unapplied area of the field, correlating to distances along transect MTJ105 (Figure 7). Field 1 consisted of 10 samples, one of which is in the unapplied area of the field, that correlate to distances along transect MTJ111 (Figure 8). After collection, the soil samples were submitted for analysis.

Soil samples were analyzed for the chemistry of the soil solids and grain size of the samples by the University of Arkansas Soil Testing and Research Laboratory using the Mehlich-3 extraction method and sieve analysis (Mehlich, 1984). The Mehlich-3 extraction method provided results for the following constituents for the soil solids: pH, phosphorous (P), potassium (K), calcium (Ca), magnesium (Mg), sodium (Na), sulfate (SO_4), iron (Fe), manganese (Mn), copper (Cu), zinc (Zn), and boron (B).

Soil samples were analyzed for soil fluid chemistry by Oklahoma State University's Soil, Water and Forage Analytical Laboratory using a 1:1 soil-water extraction method as part of a soil salinity management test (Klute, 1986; U.S. Salinity Laboratory Staff, 1954). The 1:1 soil-water extraction method provided the following constituents for the soil fluids: pH, potassium

(K), calcium (Ca), sodium (Na), magnesium (Mg), electrical conductivity (EC), total soluble salts (TSS), potassium adsorption ratio (PAR), sodium adsorption ratio (SAR), exchangeable potassium percent (EPP), and exchangeable sodium percent (ESP).

The OSU School of Geology conducted isotopic ratio mass spectrometry (IRMS) analysis for nitrogen isotope ratios of the soil samples. The IRMS analysis provided isotopic composition of the soil which was cross-referenced with that of known isotopic values for hog manure. Samples were placed into tin capsules, weighed, and formed into spheres before being combusted by an Elemental Analyzer (EA). The EA converted the samples to N_2 gas and passed them through the IRMS where the ion ratios were measured. Reference samples, blank tins, and doubles of each sample were run to ensure accuracy of the machine. The resulting data then underwent correction procedures using values of the reference samples (De Groot, 2004).

5.2 Site Methods

These were the field methods applied at each site utilized in the study. Three sites are described for both ERI and soil data collection.

5.2.1 Field 5a

In December 2014, seven ERI transects (MTJ01 - MTJ07) were collected at Field 5a (Figure 3). Three transects ran approximately east-west, while the other four transects ran approximately north-south. Transects were 165 meters long and with 3-meter spacing to share a similar depth of investigation. Transect MTJ01 was the sole transect to cross Big Creek (Figure 14). Transects MTJ02 and MTJ03 were oriented at an angle to MTJ01 but both shared the east-west trend. MTJ04 and MTJ05 were two of the four that ran north-south and were paired to create a longer total transect. These transects ran roughly parallel to the stream and the fence line, and crossed the three east-west trending transects. MTJ06 and MTJ07 were very similar to MTJ04 and MTJ05. They also ran parallel to the stream and fence line, and crossed the three east-west trending transects, but the pair of transects sat approximately 75 meters to the east of MTJ04 and MTJ05. Together, these datasets allowed coverage of Field 5a to evaluate the geologic context of the area.

In March 2015, two ERI transects (MTJ101 & MTJ102) were collected at Field 5a (Figure 3). The two transects were in the same orientation as some surveys in from December, approximately north-south and parallel to the stream. The transects were collinear, sharing similar stake locations and both sat atop the MTJ106 and MTJ107 transects which were run during December at this site. MTJ101 was 165 meters long with 3-meter spacing to share the same depth of investigation as the previous surveys taken on Field 5a. MTJ102 was 55 meters long with 1-meter spacing for a higher resolution of the same area as MTJ101. Soil sample locations for the background site (Field 5a) were chosen based on the Phase I ERI results of MTJ106/MTJ107.

The Phase I data indicated a possible change in soil characteristics from a thin and rocky soil in the northern part of the field to a thicker soil in the southern part of the field. When conducting the statistical analysis on the data, this change in soil characteristics was used to separate the data into two groups. The sample locations for this site were selected in order to capture the possible soil profile change. The samples correlate to distances along MTJ101 (Figure 6). The separation of the soil samples into the thin, rocky northern half and the thicker southern half was split in the middle at the 82.5-meter mark. Five samples fall in the northern half (0 – 82.5 m) and five samples fall in the southern half (82.5 – 165 m).

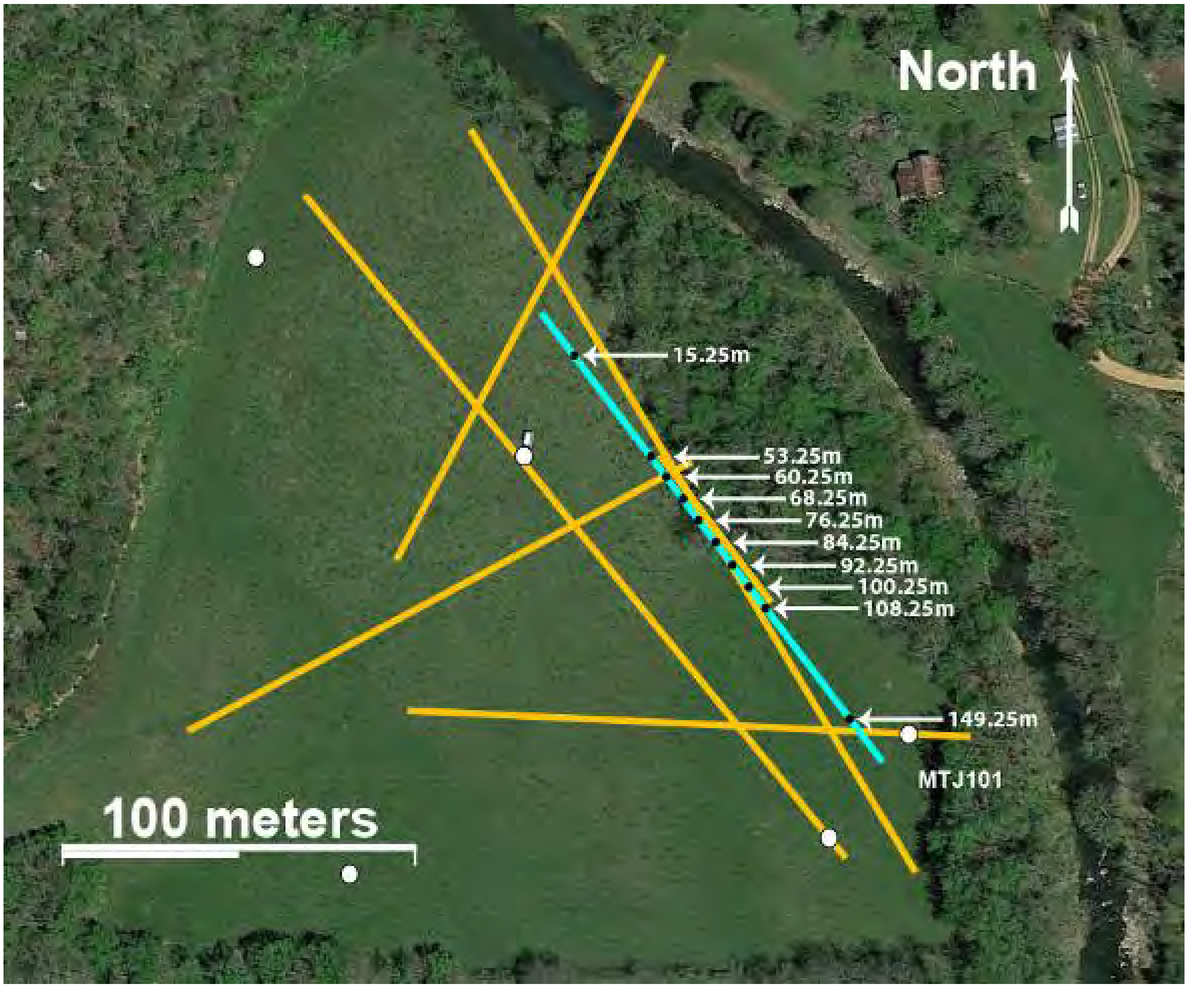

Figure 6 – Black dots represent soil sample locations along transect MTJ101 (blue line) in Field 5a (background site). Yellow lines represent other ERI lines collected at site.

5.2.2 Field 12

In December 2014, five ERI transects were collected from Field 12 (MTJ08-MTJ12) (Figure 4). Three of transects ran approximately east-west, while the other two transects ran north-south. Transects were 165 meters long with 3-meter spacing to share a similar depth of investigation. Transects MTJ08 and MTJ09 ran parallel to each other and nearly parallel to Big Creek, covering almost the entire length of the field. Transects MTJ10, MTJ11, and MTJ12 ran perpendicular to MTJ08 and MTJ09. All three were parallel to each other and the fence line. These three ran north-south and were separated from each other by approximately 40 meters. This set of transects covered a sufficient area of the field to evaluate the geologic objectives and covered the boundary between the unapplied edge of the field and application zone in the center of the field.

In March 2015, three ERI transects (MTJ104 - MTJ106) were collected at Field 12 (Figure 4). Two transects were in the same orientation as the surveys in December, approximately east-west and perpendicular to the stream. The transects were collinear, sharing similar stake locations. MTJ105 was 165 meters long with 3-meter spacing to share the same depth of investigation as the previous surveys taken on Field 12. MTJ104 was 55 meters long with 1-meter spacing for a higher resolution of the same area as MTJ105. These two were approximately 40 meters to the north of MTJ12 and both started at the edge of the field nearest the stream. The third transect shared the north-south orientation of transects MTJ08 & MTJ09 and was collected as part of a northern extension to MTJ08. MTJ106 was 165 meters long with 3-meter spacing to share the same depth of investigation as the other surveys on Field 12. These surveys examined the northern edge of the field (the lowest corner of the field), and increased the area of investigation. Locations of the soil samples for the applied sites (Field 12 and 1), samples were collected in both the application zone and the unapplied edge of the field (100 feet from edge of field). The sample locations of Field 12 were denser nearest to the edge of the application zone to try and determine if the boundary between application zone and the unapplied edge of the field can be visualized and paired with the ERI data consistently. The samples correlate to distances along MTJ105 (Figure 7).

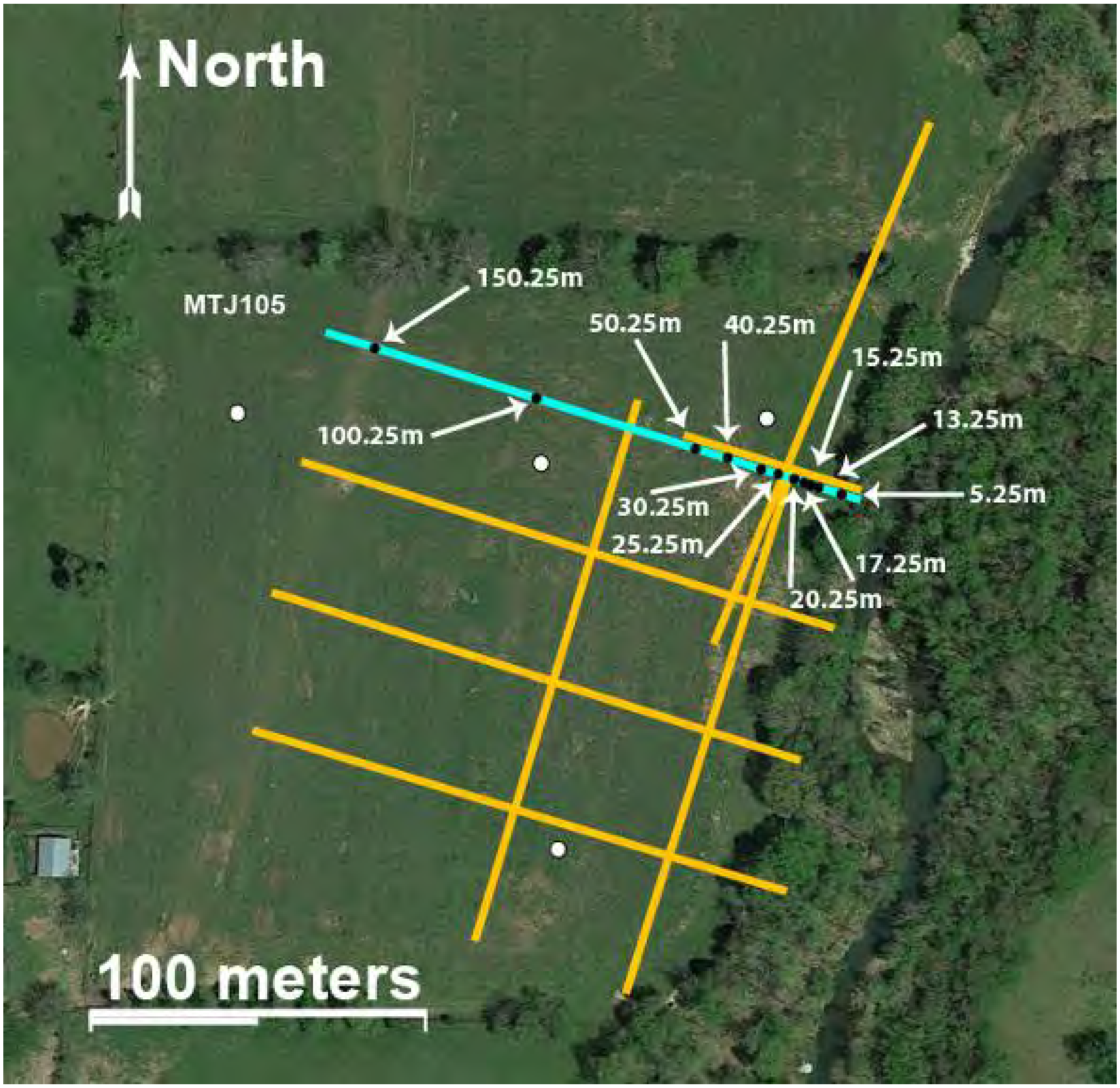

Figure 7 – Black dots represent soil sample locations along transect MTJ105 (blue line) on Field 12 (application site). Yellow lines represent other ERI lines collected at site.

5.2.3 Field 1

In March 2015, two ERI transects (MTJ111 & MTJ112) were collected at Field 1 (Figure 5). The two transects are collinear and are oriented north-south. MTJ111 was 165 meters long with 3-meter spacing so as to share the same depth of investigation as the previous surveys taken on the other fields. MTJ112 was 55 meters long with 1-meter spacing for a higher resolution of the same area as MTJ111. For the applied sites (Field 12 and 1), samples were collected in both the application zone and the unapplied edge of the field (100 feet from edge of field). The sample locations of Field 12 were denser nearest to the edge of the application area to try and determine if the boundary can be visualized and paired with the ERI data consistently. The sample locations of Field 1 were denser in the small gully in the center of the line but also attempted to determine if there is a difference in the application zone and the unapplied edge of the field. The samples correlate to distances along MTJ111 (Figure 8).

Figure 8 – Black dots represent soil sample locations along transect MTJ111 (blue line) on Field 1 (recent application site). Yellow line represent other ERI line collected at site.

5.3 Data Analysis

During previous work to install monitoring wells by the University of Arkansas, soils were hand-augured until hitting a surface hard enough to prevent further penetration (also known as depth of refusal). These depths were evaluated along with the ERI surveys to produce a distributed understanding of the soil depth and thickness across the sites. The epikarst thickness was found using the ERI surveys based on the use of a strong vertical resistivity gradient to delineate weathered epikarst from competent bedrock. Electrically conductive features can be displayed as pathways within the soil and epikarst. Resistive electrical layers are interpreted as the limestone bedrock at depth on each site. Linear electrically conductive pathways through the bedrock are interpreted as potential joints or faults. Electrically conductive zones are interpreted as potential dissolution or weathered portions of the bedrock.

Statistical analysis was run on the ERI data to determine if statistically significant differences existed between the soil ERI data among the three fields. Data were selected from the upper line of each dataset where soil samples were collected. The data were averaged to smooth out variability using a five point moving average. A two-tailed t-test was used to determine significance and alpha was assumed to be 0.05, or the 95% confidence interval. The data were also tested for the three sites to evaluate if the 0.5-meter resolution data were statistically different from the 1.5-meter resolution datasets.

Statistical analysis was run on the soil sample test results to determine if significant variations existed in the parameters between the three fields (see Appendix 6 for data). A two-tailed t-test was used to determine significance and alpha was assumed to be 0.05, or the 95% confidence interval. A margin of error was calculated as $0.98/\sqrt{n}$ (Johnson and Bhattacharyya, 2006), where *n* is the number of samples. Analyses were performed to compare the background data against the applied sites and to compare the recently applied site to the other two sites.

Correlation between the datasets was analyzed by comparing the two soil types sampled in the background field against the soil analysis data. Correlation for the applied sites was performed by comparing the areas inside the application zone against the corresponding ERI data. Goodness of fit estimates for the relationships were calculated using Excel. The goodness of fit analyses were separated into one of four categories: none or very weak relationship ($r^2 < 0.1$), weak relationship ($0.1 < r^2 < 0.3$), moderate relationship ($0.3 < r^2 < 0.5$), and strong relationship ($0.5 < r^2$).

6.0 Results

Field work in Mt Judea consisted of two trips for a total of eight field days. Lab work for processing and interpreting data constituted months of the project. Results include the processed and corrected GPS data; processed ERI data detailing soil, epikarst, and bedrock features; and soil analysis comparing the soil chemistry and nitrogen isotopes. Resulting raw data can be found in the electronic report appendices.

6.1 GPS Data Analysis

Location data was collected using the GPS system and processed to evaluate the position of the ERI datasets and site topography. The base data were submitted to the Online Positioning User Service (OPUS), operated by the National Oceanic and Atmospheric Administration (NOAA), and the products were corrected for easting, northing, and elevation of the base positions in UTM coordinates. These were applied to the datasets to obtain centimeter-scale accuracy for the topography in the ERI datasets.

6.2 ERI Data Structure

The average root mean square error (RMSE) between the resistivity model and the field apparent resistivity data was 3.16% for Field 5a and 3.34% for Field 12. For Phase II, the processed ERI datasets averaged a RMSE of 3.95% for Field 5a, 3.35% for Field 12, and 6.18% for Field 1. The lower the RMSE percentage, the better the relationship between the collected apparent resistivity data and the calculated subsurface resistivity model. Values above 15% are considered poor. The range of RMSE for the site was 3.0% to 7.8% overall, with an average RMSE of 4.0%. The data quality for the site is good. There were no utilities or other anthropogenic features and the soil was moist at the time of data collection, providing good contact with the ground.

The resistivity values for the sites range from *very electrically conductive* to *highly resistive* (Figure 9). The terms used to indicate a specific range are indicated in *italics* for clarity. Electrically conductive areas generally include the shallow portions of the images, with strong resistors at depth. The resistivities for Field 5a range from 1 to 6×10^5 Ohm-meters with a median value of 1500 Ohm-meters. The resistivities for Field 12 range from 20 to 6×10^5 Ohm-meters with a median value of 1600 Ohm-meters. The resistivities for Field 1 range from 4 to 1×10^6 Ohm-meters with a median value of 1300 Ohm-meters.

The interpretation scale for the resistivity values of the images is electrical features:

- **Above 1000 Ohm-meters** generally represent unweathered bedrock with fresh groundwater and referred to as *highly resistive*.
- **Between 500 to 1000 Ohm-meters** represent weathered bedrock with fresh groundwater and referred to as *very resistive*.
- **Between 150 and 500 Ohm-meters** typically represent significantly weathered bedrock material with fresh groundwater and referred to as *resistive*.
- **Less than 150 Ohm-meters** (but greater than 50 Ohm-meters) are interpreted as soil and/or possible electrically conductive fluids and referred to as *electrically conductive*.

- **Below 50 Ohm-meters** represent fine soils, microbial mass, and/or electrically conductive fluids and referred to as *very electrically conductive*.

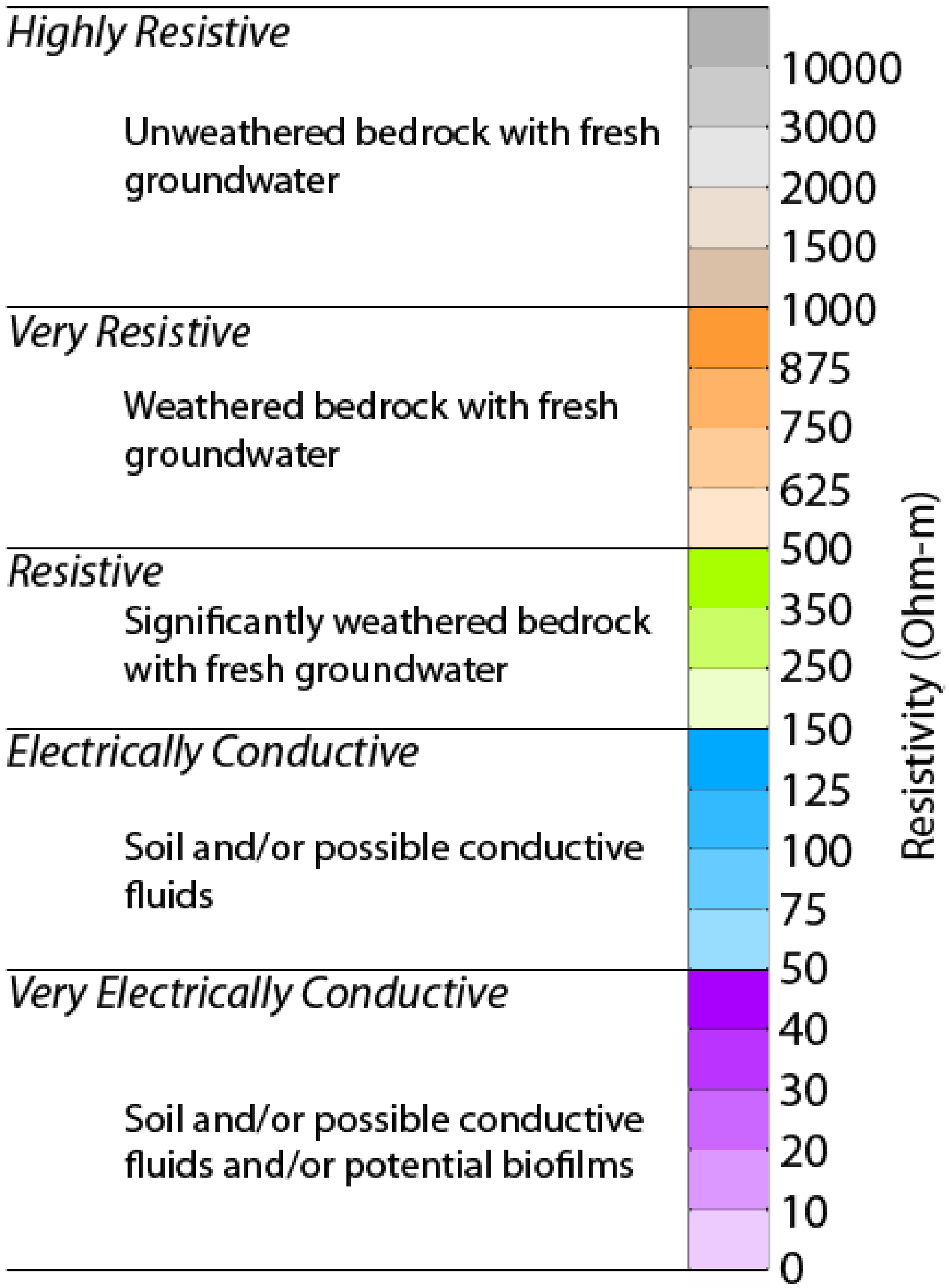

Figure 9 – Resistivity scale for Mount Judea ERI datasets. Cool colors are used to indicate more electrically conductive subsurface locations and warm colors are used to indicate more resistive locations.

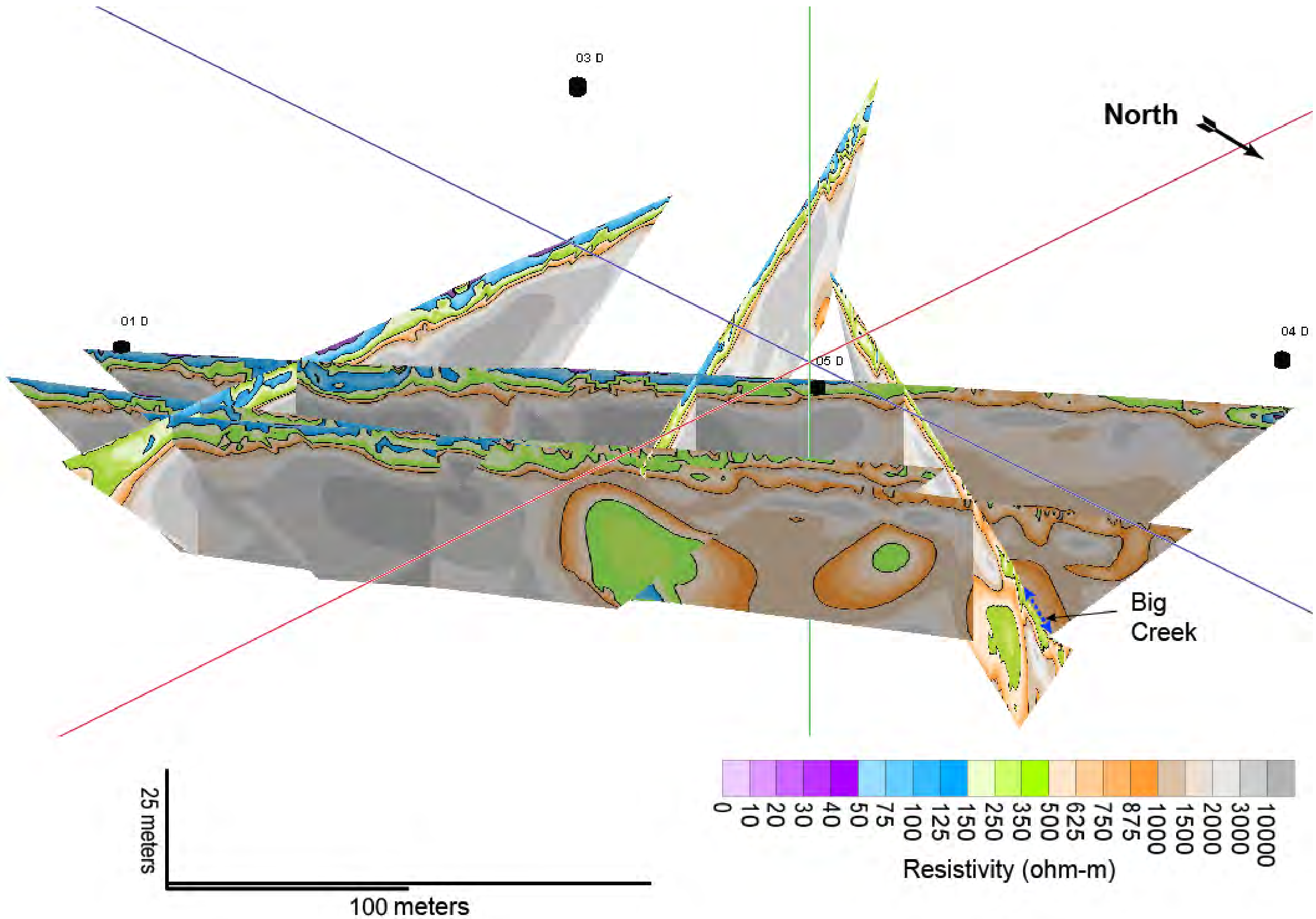

Figure 10 – Field 5a (background site) view from northeast corner of field (from Big Creek toward the field).

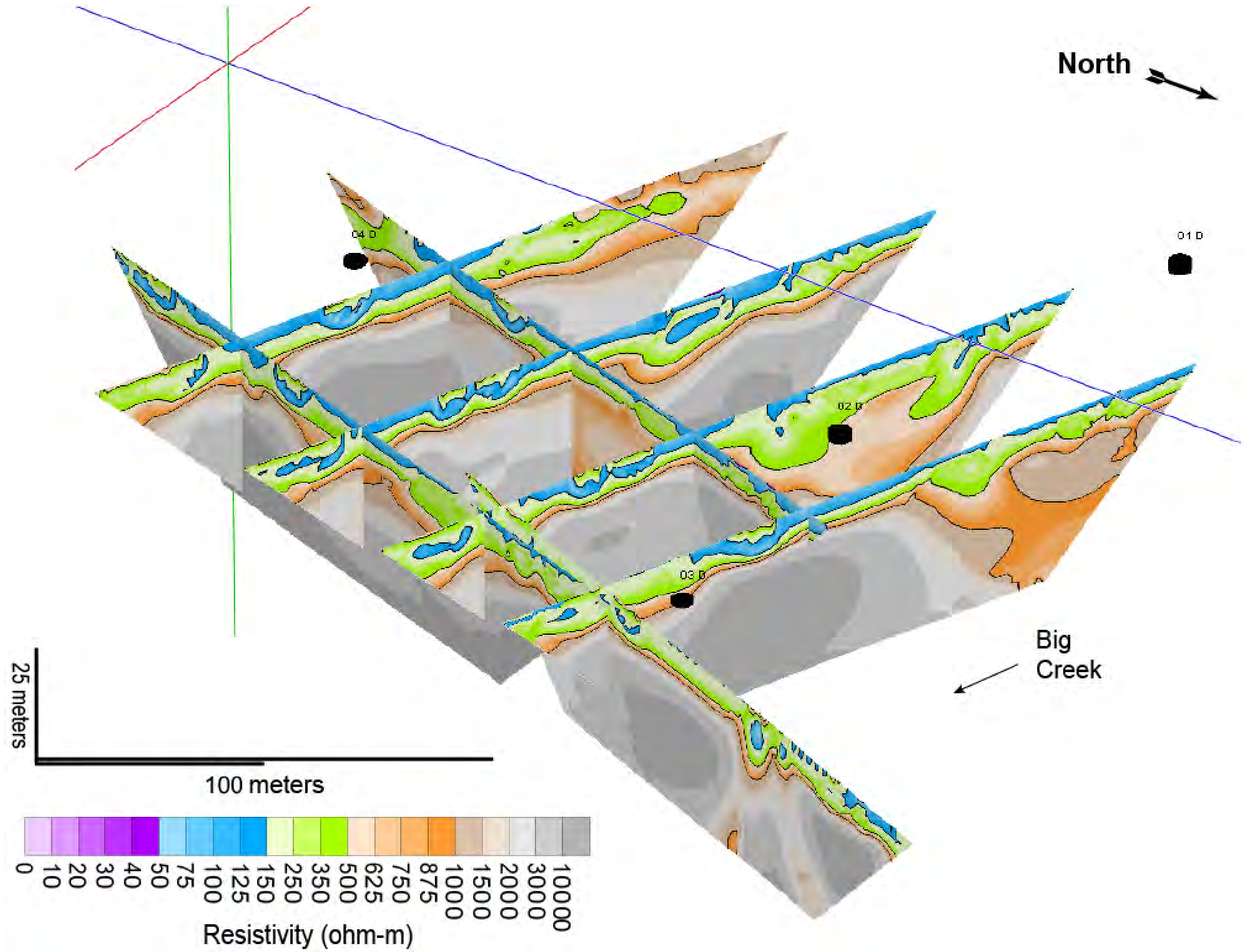

Figure 11 – Field 12 (application site) view from northeast corner of field (from Big Creek toward the field).

6.2.1 Soil Structure

The soil structure analysis consists of soil thickness and soil properties. Soil thicknesses for each site were picked and confirmed through hand dug borings on site conducted during previous University of Arkansas work on these fields. The borings were dug to refusal, or where the soil turns to epikarst (significantly weathered bedrock). Soil properties were detailed based on field notes, ERI results, and grain size analysis.

Field 5a is a low-lying grazing area with low relief and an uneven topsoil surface. Field 5a exhibits average soil thicknesses of 0.5 to 4.5 meters (1.5 to 14.75 feet). Soil thickness on Field 5a varies throughout. There is a significant resistivity difference between the *highly* to *very resistive* north and more *electrically conductive* southern portion (Figure 10). A broad topographic mound is situated northwest of the center of Field 5a; the soil thickness is thinner to the far north and far west of the field (see Appendix 3). This trend is consistent with the direction to which the alluvium would be deposited nearest to the stream. Soils on transects MTJ06 and MTJ07 (Figure 12A) are *electrically conductive* features, which thin to near zero soil thickness toward the far north. Grain size analysis (see Appendix 6) indicates Field 5a is a sandy loam to clay loam. Field 5a and Field 12 share some of the soil characteristics.

Field 12 is a low-lying grazing area with low relief and an uneven topsoil surface. Field 12 exhibits similar average soil thicknesses at 0.7 to 4 meters (2.25 to 13 feet). Soil thickness on Field 12 is not as variable as Field 5a, but there is a *very resistive* region of the site in the shallow soil area of the southwest portion of the investigation area (Figure 11). Field 12 is flatter and the soil thins to the west (see Appendix 3). MTJ12 (Figure 13A) shows thinning where the *electrically conductive* features become thicker as the image gets closer to the stream. This trend is consistent with the direction to which the alluvium would be deposited nearest to the stream. Areas where the soil profile is thinner on the images are consistent with the rocky soils encountered when electrodes were placed for data collection. Grain size analysis (see Appendix 6) indicates Field 12 is a sandy loam to clay loam.

Field 1 is a grazing area situated on a hillside east of the stream. It has low to moderate relative relief and an uneven topsoil surface. Field 1 shows an average soil thickness of 0.5 meters (1.5 feet) determined from the ERI surveys of MTJ111 and MTJ112 (Figure 17) and soil sampling. Hand dug confirmation borings were not conducted on this field. This site was not studied extensively enough to determine differences in resistivity correlations across the entire field. Field 1 has thinner and rockier soils than either Fields 5a or 12. Gravels were found in Field 1 samples with sizes up to 0.05 meters (2 inches) across and subsequently removed during soil sampling. Field 1 has a different soil thickness and properties than Fields 5a or 12.

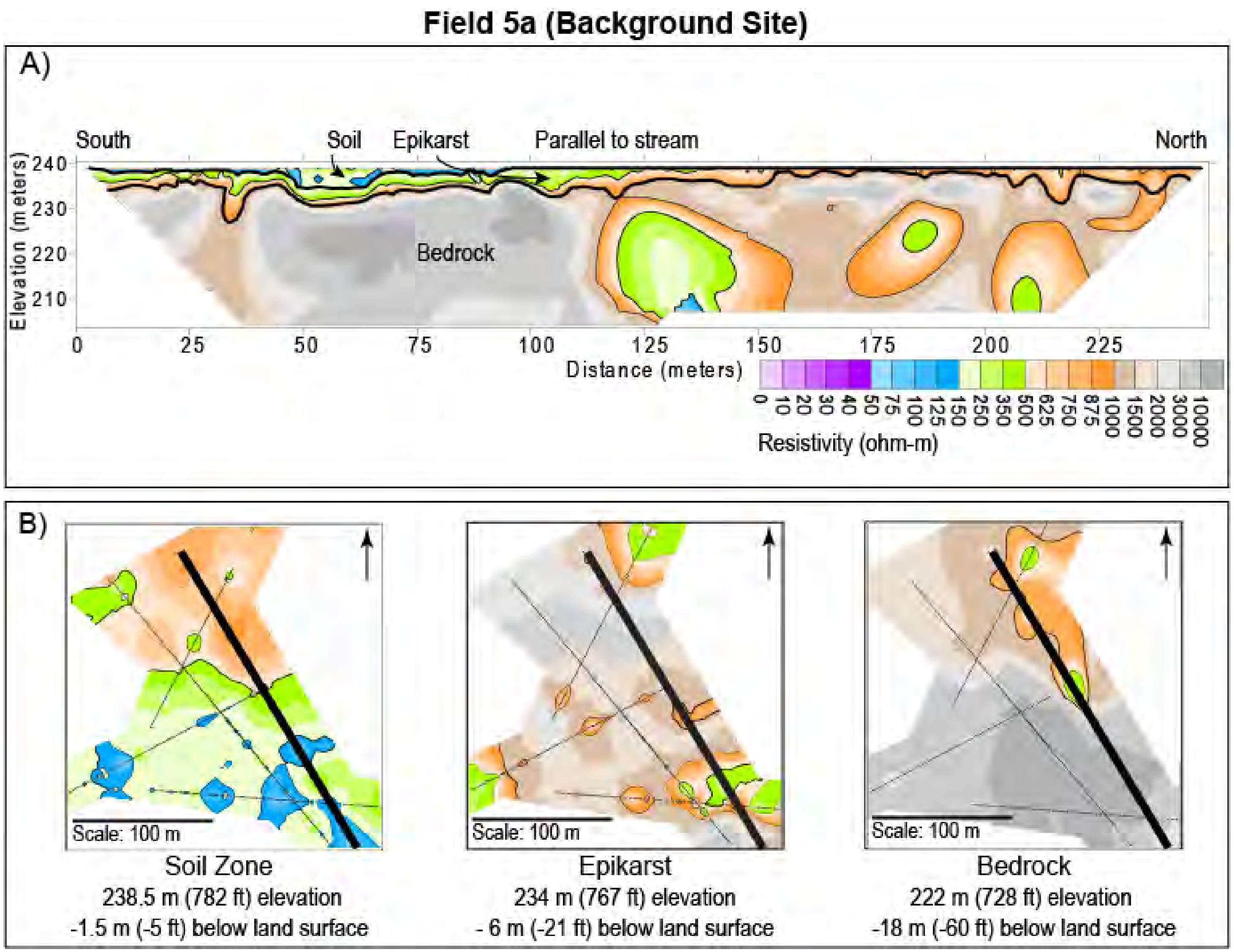

Figure 12 – A) Interpreted Soil-Epikarst boundary and Epikarst-Bedrock boundary for the Field 5a for combined ERI datasets MTJ06 and MTJ07 (background site) cross sections. B) Interpolated 2D depth slices of resistivity at differing elevations illustrating a map view of the subsurface. Heavy black line indicates location of cross section in A).

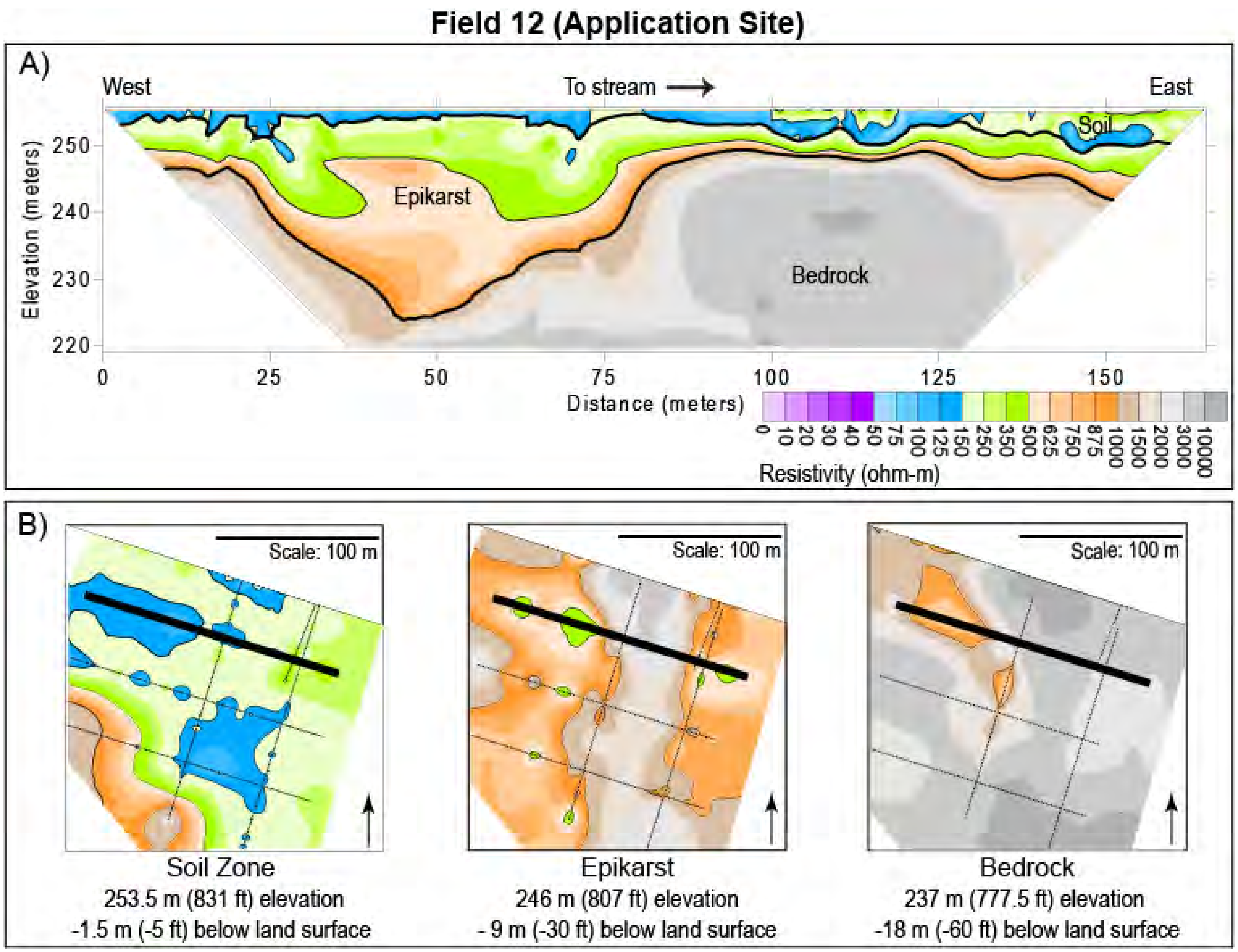

Figure 13 – A) Interpreted Soil-Epikarst boundary and Epikarst-Bedrock boundary for Field 12 for ERI dataset MTJ12 (application site) cross sections. B) Interpolated 2D depth slices of resistivity at differing elevations illustrating a map view of the subsurface. Heavy black line indicates the location of the cross section from A).

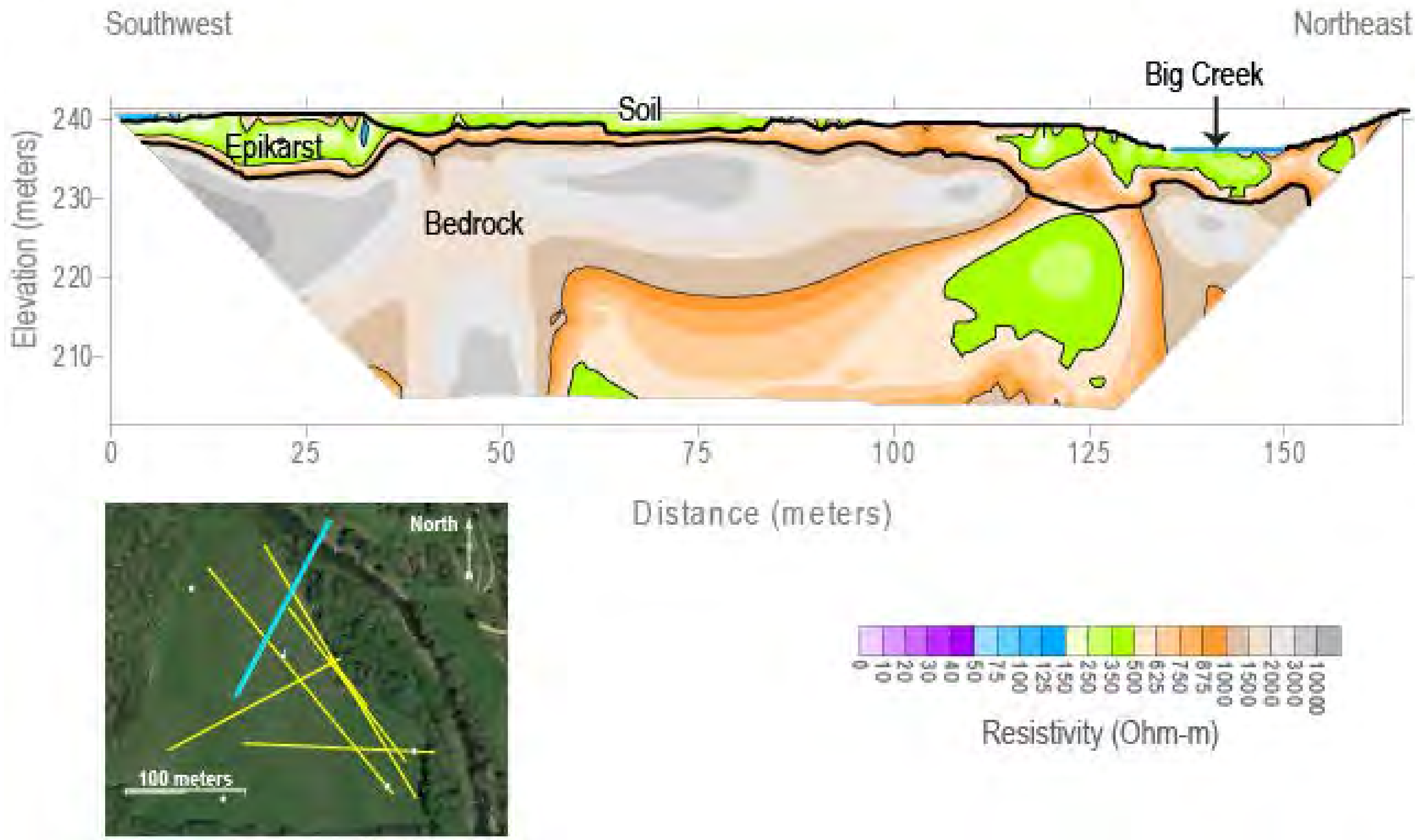

Figure 14 – Field 5a (background site) – Transect MTJ01 with 3-meter spacing.

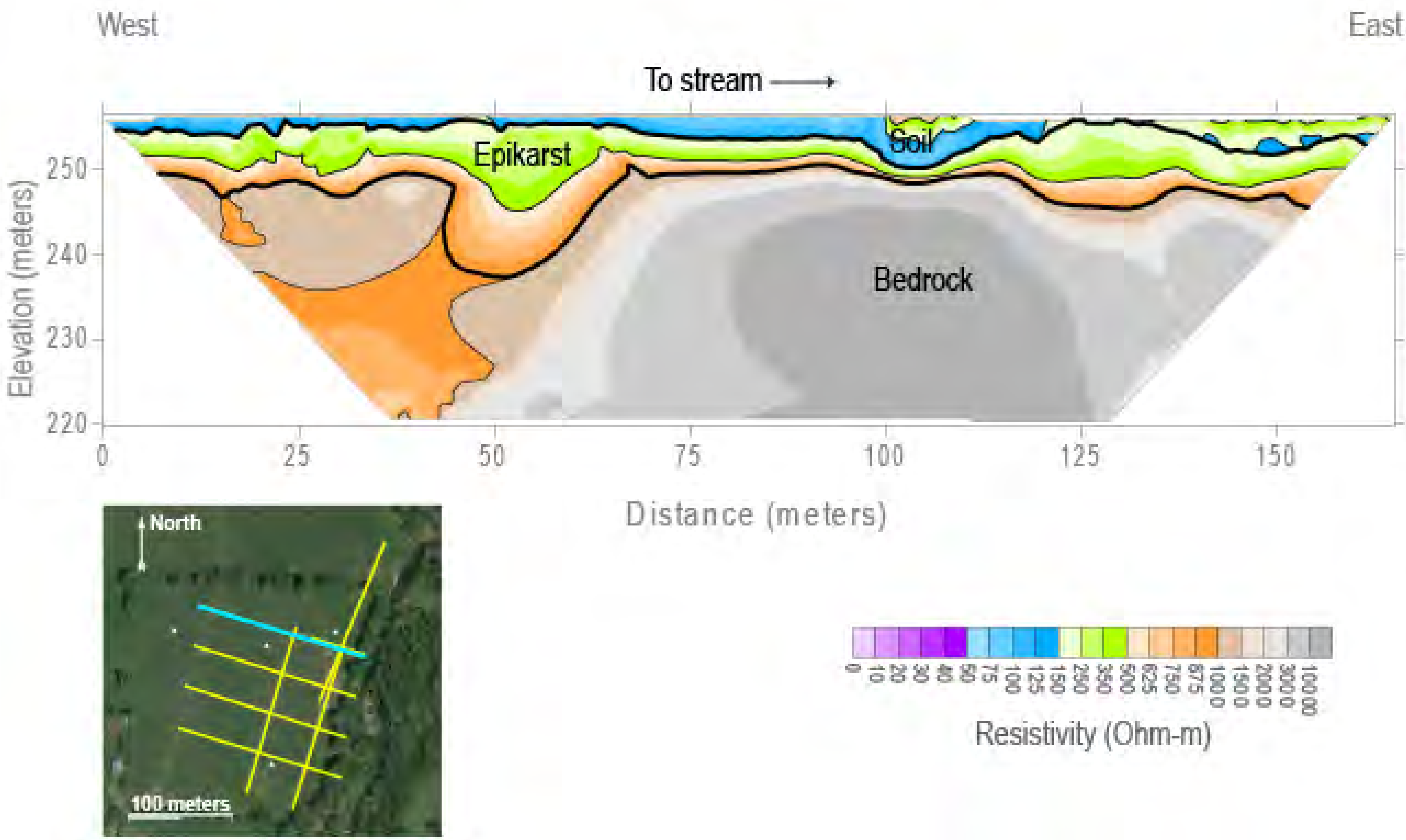

Figure 15 – Field 12 (application site) – Transect MTJ105 with 3-meter spacing.

Figure 16 – Field 12 (application site) – Transect MTJ106 with 3-meter spacing.

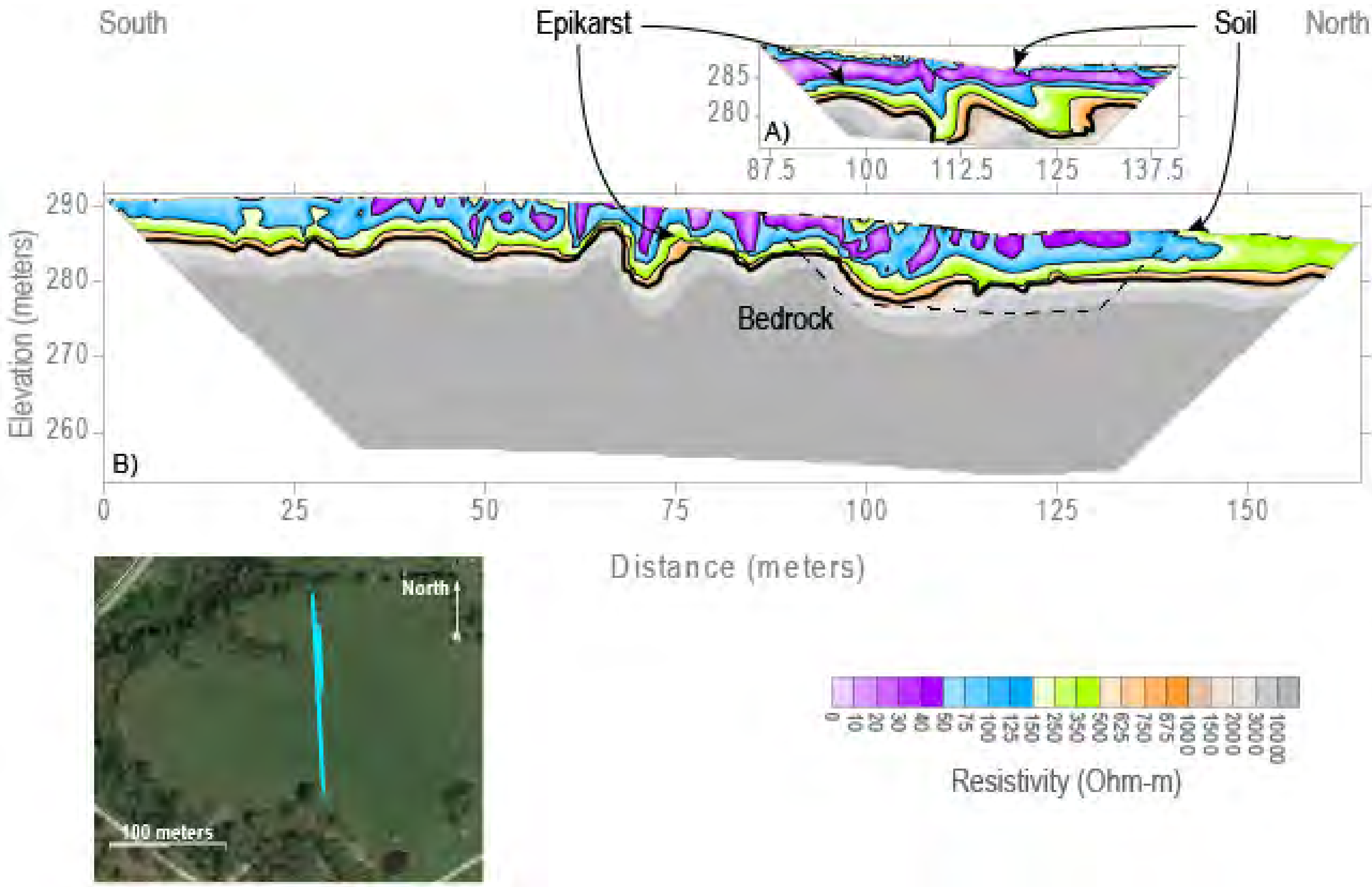

Figure 17 – Field 1 (recent application site) – Transect MTJ111 with 3-meter spacing and Transect MTJ112 with 1-meter spacing.

6.2.2 Epikarst Structure

The epikarst zone consists of the weathering profile of the underlying competent bedrock. Epikarst is visible on Field 5a (Figure 12), Field 12 (Figure 13), and Field 1 (Figure 17) as a more *resistive* to *electrically conductive* region below the base of the soil and above the *highly resistive* competent bedrock zones. No confirmation borings are available to evaluate rock properties in these zones on any of the sites. The thickness of the epikarst zone is highly variable (thicknesses range from 2 to 23 meters or 6.5 to 75.0 feet) throughout each field but averages 4 to 7 meters (13 to 23 feet) thick. Because the interpreted base of the epikarst varies from site to site, the threshold for competent rock was quantified at values larger than 1000 Ohm-meters. This is consistent with a strong horizontal resistivity gradient across the images (Figures 10, 11, and 17).

Average epikarst thickness for Field 5a is 4 meters (13 feet). It is relatively thin and similar to the soil zone, thicker in the southern half of the field. At locations where electrically conductive features exist in the bedrock, the epikarst generally appears connected in space with these features (Figures 12 and 14). ERI dataset MTJ01 shows the most variation in epikarst thickness on Field 5a (Figure 14).

Average epikarst thickness for Field 12 is 6 meters (20 feet) and the epikarst surface on Field 12 is very irregular in many transects (see Appendix 3). There appears to be a large doline feature (a closed topographic depression caused by dissolution or weathering of underlying rock or soil) within the bedrock on transect MTJ12, approximately 61 meters (200 feet) across at the top of the feature, starting 8 meters (26 feet) below the land surface and extending 23 meters (75 feet) vertically downward (Figure 13A).

The determined average epikarst thickness for Field 1 is 5 meters (16.4 feet). Delineating the top of the epikarst from the soil on Field 1 is different from the other sites as there are no hand dug confirmation borings near the transects and the resulting images show *very electrically conductive* features protruding into the subsurface in irregular vertical structures (Figure 17).Most of the samples along the line of soil sampling encountered the top of epikarst with limestone gravel in the top 6 inches of the site. This implies the soil zone is thin relative to the epikarst.

6.2.3 Bedrock

The Boone Formation is the underlying rock unit across these fields and is considered the bedrock. In many of the cross-sections, the limestone is interpreted as large, *highly resistive* blocks. The values for the more competent limestone are interpreted as those greater than 1000 Ohm-meters. It is evident on all three fields (Fields 5a, 12, and 1) that a *highly resistive* zone interpreted as bedrock is located at depth (Figures 12, 13, and 17, respectively). No confirmation borings are available in the bedrock zones to confirm rock properties, but limestone is present in the streams adjacent to Fields 5a and 12, and a quarry is present near Field 1.

Field 5a is, on average, electrically resistive and has a thin layer of alluvium at the foot of a steep hill to the west of the field (Figure 12). The majority of the surveys taken in this field display a very large and blocky *highly resistive* bedrock, especially in the southwest corner. Lines MTJ01 and MTJ06 (Figures 14 and 12, respectively) both show the northern corner of the field is electrically different bedrock than the southern portion of the field (Figure 12B). This zone also has a number of *electrically conductive* features that could be interpreted as karstic zones. The largest of these zones is at 120 meters along ERI line MTJ06/07 (Figure 12A).

Field 12 does not have as many *electrically conductive* features at depth as Field 5a. The field does have some possible doline features within the bedrock (Figure 13A). There are also some possible fractures indicated by vertically oriented conductors to the northern section of the field in MTJ105 and MTJ106 (Figures 15 and 16, respectively). The bedrock here appears more competent and blocky than Field 5a, but still appears to be potentially fractured.

Field 1 does not have the same alluvium layer above limestone bedrock as Field 5a and 12, therefore the bedrock boundary is shallower on this site alone. Field 1 does not share the same fractured characteristics as the other two sites (Figure 17). This site has a very high electrical gradient going from the epikarst zone to the *highly resistant* bedrock.

6.2.4 Site Comparison of ERI Data

A difference can be seen in bulk electrical resistivity values of the three sites. Fields 5a and 12 compare favorably with very similar electrical resistivity values. The resistivities for Field 5a range from 1 to $6x10^5$ Ohm-meters with a median value of 1500 Ohm-meters. The resistivities for Field 12 range from 20 to $6x10^5$ Ohm-meters with a median value of 1600 Ohm-meters. Field 1 is slightly more electrically conductive overall when comparing the three sites. The resistivities for Field 1 range from 4 to $1x10^6$ Ohm-meters with a median value of 1300 Ohm-meters. The values of bulk electrical conductivity (the inverse of electrical resistivity) from the top of the three 165-meter long, 1.5-meter resolution ERI transects, one from each site, run during Phase II, show a difference between the electrical conductivity of Field 1 and the electrical conductivities of Fields 5a and 12 (Figure 18). The increases in Field 1 and Field 12 occur at around 30 meters laterally on the image, which would be the boundary of application of manure. , The strong variations between the fields are not as clear in the higher resolution datasets (55-meter long, 0.5-meter resolution). Field 1 still has the most conductive feature, but it is similar to a feature on Field 5.

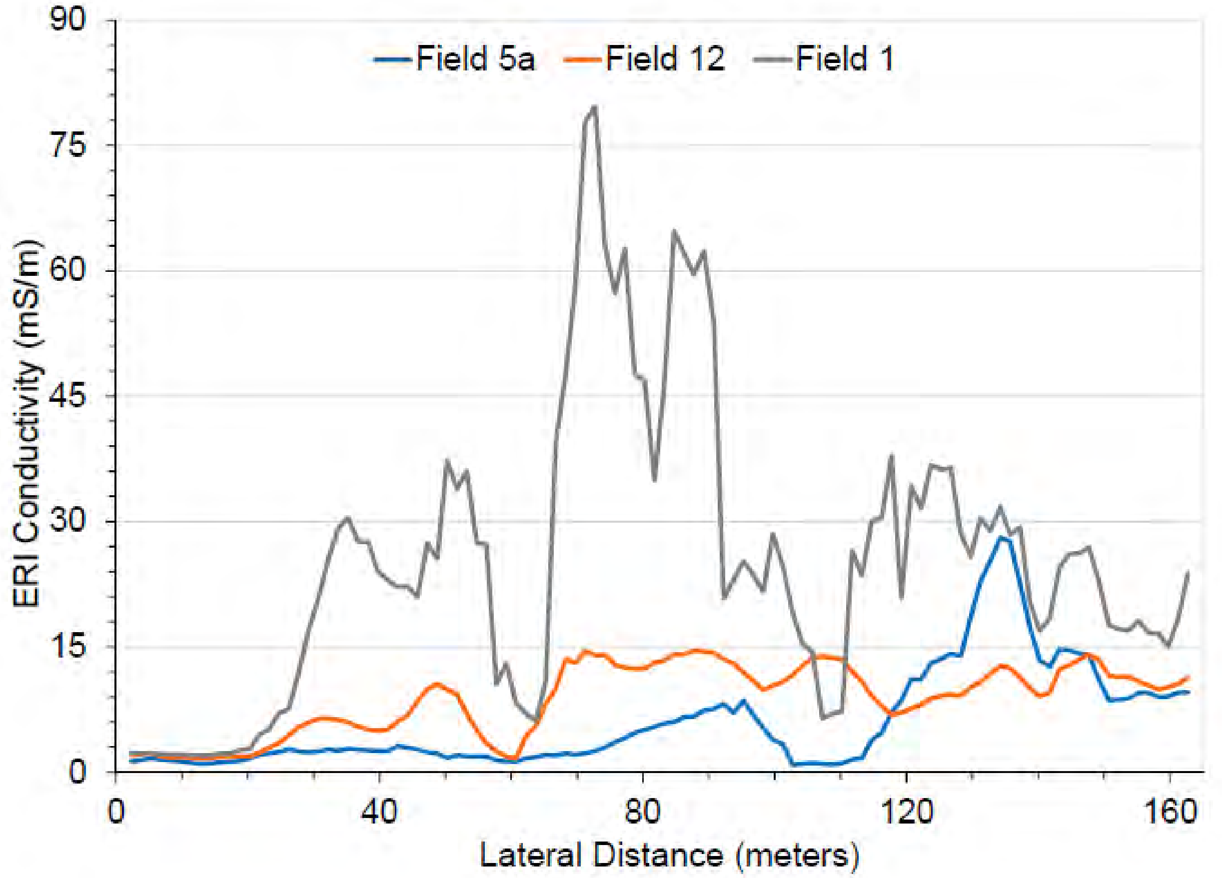

Figure 18 – Electrical conductivity of the top row of data from each site during Phase II at 1.5-meter resolution. Data has been smoothed with a 5 point moving average to make the plot clearer.

6.3 Soil Analysis

Soil samples were collected along the ERI transects during March 2015 to correlate between geophysical (resistivity data) and physical and chemical properties of the soil. In sum, 31 soil samples were collected, across the three fields (see Appendix 6). Statistics were run on the results to determine if there are any correlations between the fields, soil types, or applied versus unapplied areas.

6.3.1 Soil Testing

Soil tests were conducted to examine all three sites. The tests were then compared to determine if there were trends in the data. Soil pH and elements extracted by Mehlich-3 are averaged across all samples collected in each field and given in Table 1 (full dataset given in Appendix 6). Similarly, values for the soil salinity test for each field are averaged and presented in Table 2 (full dataset given in Appendix 6). Fields 1 and 12 (application sites) are consistently higher than Field 5a (i.e., background) in many constituents (Tables 1 and 2). Field 1 is highest in all categories except in calcium and sodium values. Field 1 has similar values to Field 12 in both fluid electrical conductivity (EC) and total soluble salts (TSS). Statistical analysis was conducted to determine of there were significant differences among sites.

Table 1 – Soil sampling averages for various constituents on each field after Mehlich-3 extraction method (dry method for solids analysis).

Constituents	Field 1	Field 5a	Field 12
pH	6.5	5.4	5.7
P (ppm)	83.2	49.3	72.1
K (ppm)	232.1	66.5	100.9
Ca (ppm)	1314.8	1283.0	1696.9
Na (ppm)	15.4	15.1	107.6
Mg (ppm)	129.2	76.7	13.9
SO_4 (ppm)	28.6	24.5	28.7
Fe (ppm)	194.6	170.4	179.0
Mn (ppm)	636.4	188.7	201.1
Cu (ppm)	1.6	1.4	1.9
Zn (ppm)	5.0	2.6	4.3
B (ppm)	0.1	0.1	0.1

6.3.2 Nitrogen Isotopes

Isotope analysis was conducted and compared for trends in the data to examine all three sites. Nitrogen isotope analysis was utilized to determine if there was a detectable signature of the applied hog manure within any of the soil samples. The del 15N/14N ratio ($\delta^{15}N$ / $\delta^{14}N$) is compared to isotope signatures from other agricultural areas. The data from all 31 samples and their duplicates ranged from 3.803‰ – 6.628‰ across all three sites. The average is lowest for Field 1 (recent application site), with an average at 4.762‰ (0.485 SD) and a range of values from 3.944‰ – 5.811‰. Field 5a (background site) has the next larger average $\delta^{15}N$ / $\delta^{14}N$ ratio with a value of 5.101‰ (0.606 SD) and a range of 3.803‰ – 6.314‰. Field 12 (application site) has the largest average ratio at 5.629‰ (0.703 SD) with a range from 4.174‰ – 6.628‰.

Table 2 – Soil sampling averages for various constituents on each field after 1:1 soil-water extraction method (fluid method).

Constituents	Field 1	Field 5a	Field 12
pH	6.7	5.8	6.0
K (ppm)	75.0	6.0	20.7
Ca (ppm)	50.9	38.2	73.5
Na (ppm)	15.2	11.2	12.5
Mg (ppm)	7.4	3.3	6.7
EC (micromhos/cm)	857.9	488.1	891.9
TSS (ppm)	566.2	322.2	588.6
PAR (ratio)	1.6	0.2	0.4
SAR (ratio)	0.6	0.5	0.4
EPP (%)	16.5	5.0	6.9
ESP (%)	0.0	0.0	0.0

6.3.3 Statistical Analysis of Soil Data

In Field 5a (background site), a simple random sample at a 95% confidence interval and a margin of error of 31% was calculated, where *n* is the 10 total samples. This dataset provides an understanding of the relationship among the variables, but it is not statistically strong because the number of samples is small. The constituents (from both Mehlich-3 and 1:1 soil-water methods) of statistical significance were: pH, Ca, Mg, SO_4, Fe, Cu, Zn, B, and EC. The statistical tests were applied to the two halves of the field, divided by soil type. The statistical analysis indicates a significant difference between the northern and southern parts of the field. This is also apparent in the percentage of sand making up soil texture, with the northern portion of the field having a sandier soil.

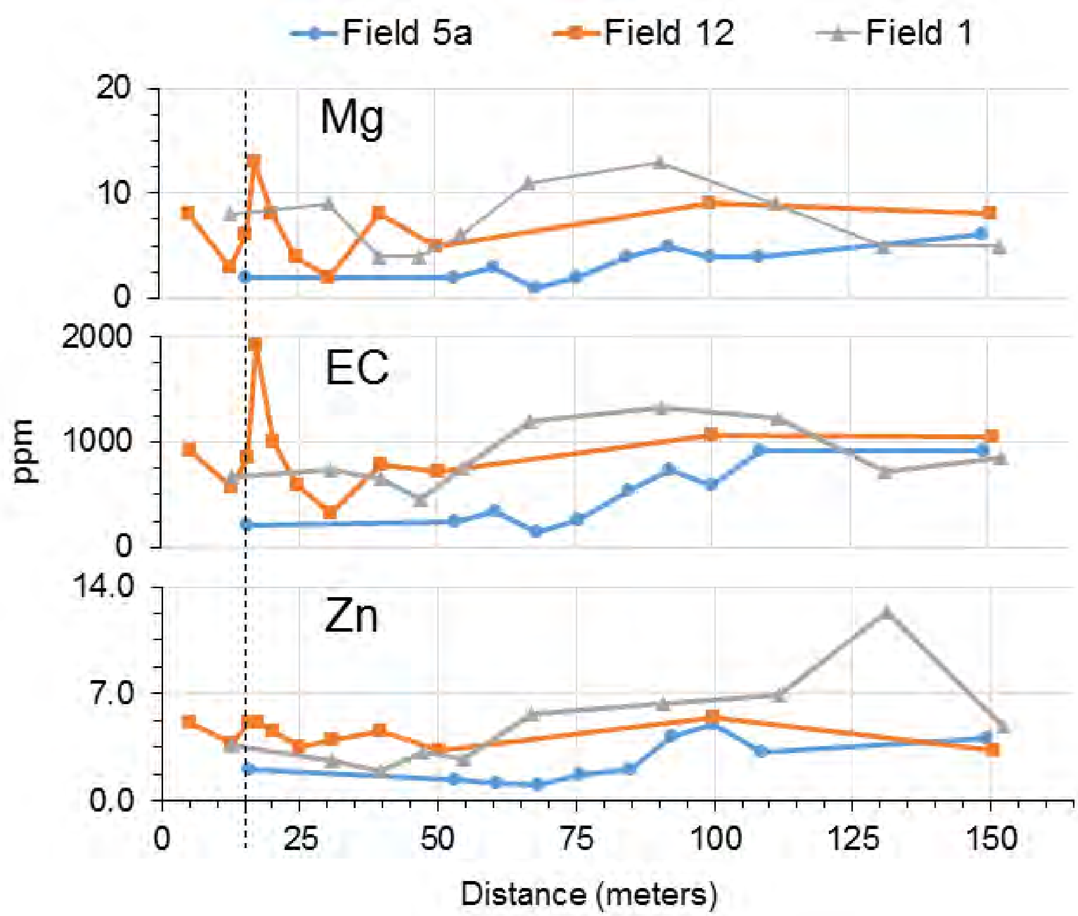

Figure 19 – Soil sampling results plotted showing the constituents of Field 5a were found to be statistically different from the other fields.

In Field 12 (application site) 11 total samples were analyzed. This dataset provides an understanding of the relationship between the variables, but it is not statistically strong because of the small number of samples. The constituents (from both Mehlich-3 and 1:1 soil-water methods) of interest were: pH, P, K, Ca, Mg, SO_4, Cu, Zn, B, EC, and δ15N / δ14N. The statistical tests were applied to the two groups of soil samples from the field, the unapplied edge of the field and application zone. The statistical analysis indicates there is not a significant difference between the unapplied edge of the field and application zone. Weak and strong relationships between the constituents and the corresponding resistivity values existed.

In Field 1 (recent application site), 10 total samples were available. The statistical tests could not be applied to the two groups from Field 1 because there is only one sample in the unapplied edge of the field and is insufficient for analysis.

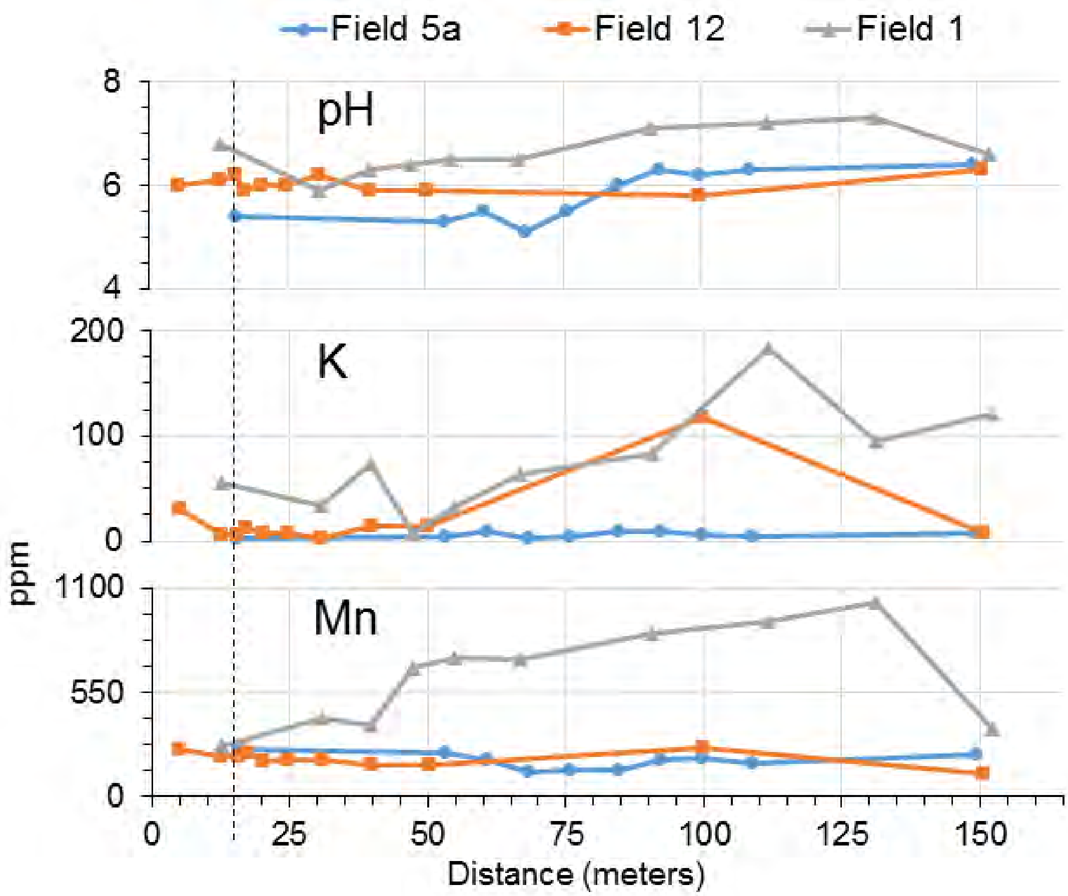

Figure 20 – Soil sampling results plotted showing the constituents of Field 1 were found to be statistically different from the other fields.

The same t-test was run to statistically compare the fields against each other, and compared the constituent of each field. Field 5a is statistically lower than both Fields 12 and 1 in Mg, Zn, and EC. Field 1 is statistically higher than both Fields 5a and 12 in pH, K, and Mn. Although Field 12 was statistically different in some constituents for one field, it was not statistically different for the other field.

Isotopic signatures were used to find the isotopic signature of hog manure. Finding, or not finding, a particular isotopic value indicates whether or not the soil samples contained any trace amounts of hog manure. The δ15N / δ14N values ranged from 3.803 ‰ to 6.628 ‰ across all three fields. Field 5a had higher average values than Field 1. When comparing this to a compilation of other data, we see this range falls on the peaks of “natural” and “fertilized” soils, and in fact are at the low end for “animal waste” values (Aly et. al, 1981; Aravena et. al, 1993; Black and Waring, 1977; Bremner and Tabatabai, 1973; Fogg et. al, 1998; Freyer, 1978, 1991; Garten, 1992, 1996; Gormly and Spalding, 1979; Heaton, 1986, 1987; Heaton et. al, 1997; Hoering, 1957; Kohl et. al, 1971; Kreitler, 1975, 1979; Moore, 1977; Paerl and Fogel, 1994; Shearer et. al, 1974, 1978; Wolterink et. al, 1979). Hog waste δ15N / δ14N averages have been found to be within 10 ‰ to 20 ‰ range (Fogg et. al, 1998; Krietler, 1975, 1979; Wolterink et. al, 1979). The fields do not provide a significant N isotopic signature in this dataset to allow for the separation of signatures for applied manure and other sources of N (i.e., native, fertilizer, poultry litter).

6.3.4 Site Comparison

Field 5a shows a distinct trend in bulk electrical resistivity data which compares well with soil thickness and soil test results. The electrical resistivity data in Figure 18 shows a much more resistive half of the field in the north (0 – 80 meters) and a more electrically conductive half of the field in the south (80 – 165 meters). To the north, the site thins to a rocky soil; to the south it thickens and the soil is composed of finer particles. Figure 19 shows the soil test results for this site and indicate the north half of the field has lower values for the three *distinctly different* constituents: Mg, Zn, and electrical conductance.

Field 12 appears to have somewhat more electrically conductive soil over a broader area than Field 5a and shows an overall increase in bulk electrical conductivity from 30 meters (100 feet). This electrically conductive area is not located near the stream, where application of manure would not occur (unapplied edge of the field) under the recommended protocols of the comprehensive nutrient management plan. The electrical resistivity data shows consistency across the entire field. The soil thickness is also thicker across the entire field when compared to Field 5a. Soil test results showed no indication Field 12 was statistically different from the other two fields.

Field 1 does not share the same electrical features seen in the alluvium of Fields 5a and 12, but does appear to have more electrically conductive features present within the epikarst zone. The features present show a relatively more resistive soil zone but a *very electrically conductive* epikarst zone that extends nearly the length of the field and dissipates at the unapplied edge of the field, approximately 30 meters (100 feet) from the northern edge of the field. This distance from the northern edge of the field is consistent with the recommended protocols of the comprehensive nutrient management plan for where the application of manure would not occur. The soil on this site was thin and rocky and grain size analysis showed this site was different than the other two sites. Figure 20 shows the soil test results for this site and indicate three *distinctly different* constituents are higher than the other two sites.

The anticipated ERI relationship with fluid electrical conductivity of soil water samples would be as electrical conductivity of the fluid increased, the bulk resistivity of the soil would decrease. There was no strong relationship between these parameters for the lower resolution (1.5-meter) datasets. While these datasets showed the applied fields had a higher bulk conductivity (lower resistivity) than the background sites, the datasets averaged too deeply into the subsurface, leading to some significant contrasts at the surface between the two ERI dataset resolutions.

The expected the relationship held for the background site (Field 5a) for the higher resolution dataset (Figure 21). The fluid EC has an inverse relationship with bulk resistivity with an R^2 value of 0.56. The applied fields have an inverse relationship with higher EC fluids resulting in higher resistivity zones with an R^2 value of 0.50 for Field 12 and 0.98 for Field 1. This type of relationship indicates the bulk electrical properties are not only responding to the addition of a fluid with a higher electrical conductivity, but another soil electrical property must be changing as well. This may be due to the growth of biofilms, as microbial activity increases after the application of manure.

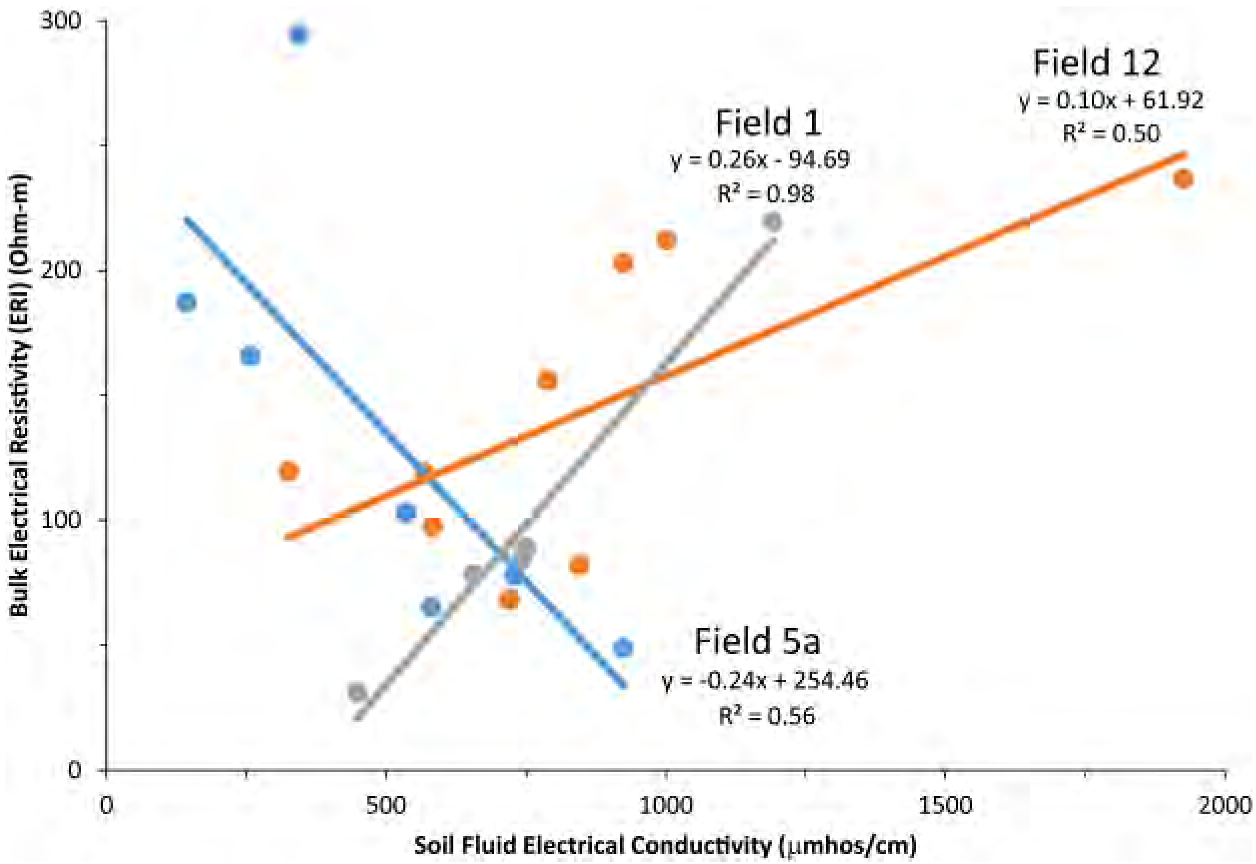

Figure 21 – Soil Fluid Electrical Conductivity measured from soil samples collected along three ERI transects compared with ERI bulk resistivity data with 0.5-meter resolution for three fields near Mount Judea, Arkansas. Field 5a is the background site and Fields 1 and 12 had applied hog manure.

7.0 Discussion

Fields 5a and 12 share many electrical and soil-depth characteristics but there are a few distinctions that separate them from each other. Field 1 is different from the other two sites in many aspects. Soil analysis is a complex issue that requires an in depth investigation to determine possible correlations between constituent levels. Much of the literature points to the overarching idea that individual site testing is required for understanding the individual site's properties. A significant portion of the literature is dedicated to analysis of constituents related to crop growth, but for this work, only constituents that had statistical variations between sites were analyzed.

The electrical structure of the soil, epikarst, and bedrock were consistent with the literature of weathered mantled carbonate bedrock areas (Carriere et al., 2013; Gambetta et al., 2009; Halihan et al., 2005, 2009; Miller et al., 2014; Stepisnik and Mihevc, 2008). The soil thickness increasing towards the streams would be expected in an alluvial valley. The epikarst zone having significant variability in lateral and vertical properties was consistent with evaluations from other carbonate locations (Gambetta et al., 2009; Halihan et al., 2005, 2009). The data are consistent with previous investigations and indicate more permeable flowpaths would exist in the bedrock of the site, but no drilling or hydraulic testing data are available from the sites included in this investigation.

The results of the soil tests are representative of the conditions on each field, but are a small dataset for the fields overall. The sampling was used to evaluate parameters which may change with electrical properties and provide future indicator parameters for geophysical soil monitoring. The concentrations of constituents for Fields 12 and 1 were not sufficiently high to definitively indicate the presence of hog manure when compared to literature values for applied sites (Choudhary et. al, 1996; DeRouchey et. al, 1999; Hannan, 2011; Klimek, 2012; Plaza et. al, 2004; Smith et. al, 2007; Suhadolc et. al, 2004; Turner et. al, 2010). This is expected as the largest amount of application was less than a half centimeter. It is known that constituent levels tend to increase over time as fertilizers are applied depending on the rate of application and rate of crop offtake (Choudhary et. al, 1996; Hannan, 2011; Reddy, 1980; Schoenau, 2006) and it "may take several years of application before significant differences can be detected" (Schoenau, 2006). Currently, the data do show Fields 12 and 1 have consistently higher values for many of the constituents than Field 5a. Vegetation requirements govern application amounts for hog manure to prevent any excess buildup of particular constituents (Racz and Fitzgerald, 2000).

Field 5a was statistically lower in Zn in the soil solids (Table 1), and lower in Mg and electrical conductance in the soil fluid (Table 2) than the other two fields. Studies show Mg levels in soils can be higher due to natural causes from the weathering of limestone (Hannan, 2011; Plaza et. al, 2004) or anthropogenic impacts, such as hog manure (Schoenau, 2006). Field 5a sits primarily on alluvium and does not receive hog manure, which is in the same geologic setting. Lower levels of zinc on the background site is consistent with the literature, as hog manure can carry increased levels of Zn (Klimek, 2012; Racz and Fitzgerald, 2000; Suhadolc et. al, 2004). Lower fluid EC on the background site is consistent with the hog manure soil amendments having higher fluid electrical conductivity (which is physically different than bulk electrical conductivity measured with ERI) (Turner et. al, 2010).

Field 1 was statistically higher in pH, K, and Mn in the soil solids (Table 1) than the other two fields. Field 1 was also statistically higher in pH and K in the soil fluids (Table 2). Fields receiving manure from hogs receiving some types of feed can alter levels of K (Hannan, 2011), but this can also result from materials weathering from carbonates (Schoenau, 2006). Some fields where the soil is developed from a limestone layer beneath it can have higher pH levels compared to the background site with alluvium soil (Plaza et. al, 2004). A study on the relation of Mn with applied hog manure was not found.

The relationships for the three fields between bulk electrical resistivity and fluid electrical conductivity indicated the relationship to the application of manure did not simply cause the media to become more conductive. Research in biogeophysics indicates microbial activity may be generating the decrease in bulk conductivity (increase in bulk resistivity) as the fluid electrical conductivity increases. If microbial populations are developing to consume the available applied material, this type of relationship between the bulk and fluid properties may occur. Additional research on the microbial populations in the field and transient monitoring of electrical properties would be required for this to be conclusive.

8.0 Conclusions

The field data collected in Mount Judea, Arkansas, in December 2014 and March 2015 characterizes the subsurface of Fields 5a (background site), 12 (application site), and 1 (recent application site) with 1.5-meter resolution on scales of 165 meters laterally and 33 meters vertically. Three additional surveys with 0.5-meter resolution were also conducted to evaluate soil properties with higher resolution. These results were useful in defining the characteristics of the soil zone, epikarst zone, and the bedrock.

8.1 Soil Structure

This series of ERI surveys contributed to understanding the structure and distribution of material underlying Fields 5a, 12, and 1. The surveys confirmed the soil thickness, presence, extent, and depth of epikarst features and bedrock material. The average soil thickness across the sites is very similar (1 to 4.5 meters or 3 to 14.75 feet) except for the area in which Field 5a exhibits thinning of the soil (to 0.5 meters or 1.5 feet). Field 1 had a soil thickness of 0.5 meters (1.5 feet).

8.2 Epikarst Structure

The 33-meter (108 feet) depth of investigation for this experiment was sufficient in finding the vertical electrical changes to high resistivity that are interpreted as the bottom of the epikarst zone. The epikarst thickness is similar on both Fields 5a and 12 with a range of 2 to 23 meters thick (6.5 to 75 feet), with an average of approximately 7 meters (23 feet), but the distribution of possible fracturing in bedrock or karst features was variable, as expected. There is no confirmation drilling at the sites to evaluate rock properties of the epikarst zone, but results are consistent with other investigations of epikarst zones (Williams, 2008). The surveys were consistent among orthogonal lines across the sites in depicting the extent of bedrock weathering and amount of weathering at each site.

8.3 Bedrock

The ERI surveys show the bedrock as consistent, *highly resistive* features. Lateral variations in resistivity values of the bedrock potentially indicate depositional setting of beds or channels and deformation such as faulting. The ERI surveys determined depth to bedrock and highlights possible dissolution features and fracturing typical of this geologic formation.

8.4 Soil Analysis

Soil sampling showed that there are differences among sites. Field 5a's results draw good comparisons between the soil structure and soil tests and has consistently lower values in many of the soil parameters but is only statistically lower in Mg, Zn, and fluid electrical conductance. Field 12 is not statistically different from either site but is still higher than Field 5a in many test results. Field 1 has consistently higher values in many of the soil parameters but is only statistically higher in pH, K, and Mn. These results show statistical differences can be observed in recently applied areas. With lower amounts of application or over time, these signatures may not be detectable.

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10.0 Electronic Appendices

Appendix 1: Geodetic Data (Microsoft Excel format)

Appendix 2: ERI raw modeled data (Microsoft Excel format)

Appendix 3: ERI images (PDF format)

Appendix 4: 3D Site Models (RockWare RockWorks format)

Appendix 5: Site Photos (PDF format)

Appendix 6: Soil Analysis (Microsoft Excel format)

APPENDIX L: RELATED PEER-REIVIEWED PUBLICATIONS AND FACT SHEETS

Burke, J., Sharpley, A.N., L. Berry, K. Brye, M.B. Daniels, E. Gbur, K.W. VanDevender, S. King, P. Hays, and B.E. Haggard. 2018. Nutrient concentrations in Big Creek correlate to regional watershed land use. Cooperative Extension Service, Division of Agriculture, University of Arkansas. Fact Sheet FSA9537. 5 pages. Available at https://www.uaex.edu/publications/pdf/FSA-9537.pdf.

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Sharpley, A.N., B.E. Haggard, L. Berry, K. Brye, J. Burke, M.B. Daniels, E. Gbur, T. Glover, P. Hays, T. Kresse, and K.W. VanDevender. 2017. Nutrient concentrations in Big Creek correlate to regional watershed land use. Agricultural & Environmental Letters 2017 2:170027. Available at https://dl.sciencesocieties.org/publications/ael/articles/2/1/170027.

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FSA9537

Nutrient Concentrations in Big Creek Correlate to Regional Watershed Land Use

James Burke
Program Associate

Andrew Sharpley
Professor

Larry Berry
Program Associate

Kris Brye
Professor

Mike Daniels
Professor

Ed Gbur
Professor

Karl VanDevender
Professor

Stephen King
Principal Scientist, Science and Technology Facilities Council, Rutherford Appleton Laboratory

Phil Hays
Professor

Brian Haggard
Professor

In the Ozark Mountain karst region, nutrient concentrations in streams of the Buffalo, Upper Illinois and Upper White River watersheds increase as the percent of land in pasture and urban use increases. Averaged over the last three years, nutrient concentrations in Big Creek above and below the C&H Farm are similar to concentrations found in other watersheds where there is a similar amount of pasture and urban land use.

Background

Land use within watersheds influences the quantity and quality of water draining from a watershed. As land disturbance increases and use intensifies, there is a general increase in stormwater runoff and nutrient inputs that leads to a greater potential for nutrient discharge to receiving waters. For instance, with urban growth, more impervious surfaces increase the flashiness of runoff, stream flows and wastewater treatment discharge. Also, as areas of agricultural production grow, more fertilizer is applied to achieve optimum production. Thus, as the percent of a watershed drainage area in pasture, row crop or urban use increases, there is a general increase in nutrient concentrations in storm and base flows.

In this fact sheet, we show the effect of land use on nitrogen (N) and phosphorus (P) concentrations in streams of the Ozark Highlands and Boston Mountains, northwest Arkansas, by combining previously published data for the Upper Illinois River Watershed (Haggard et al., 2010), Upper White River Watershed (Giovannetti et al., 2013) and ongoing monitoring in the Buffalo River Watershed. The location of these watersheds is shown in Figure 1. The relationships between stream nutrient concentrations and land use for the region are used to determine if a permitted concentrated animal feeding operation (CAFO) in Big Creek Watershed, a sub-watershed of the Buffalo River Watershed, has affected stream water quality. Land use in these watersheds is given in Table 1.

Nitrate-N, total N, dissolved P and total P concentrations have been measured over varying periods during base flow at the outlet of sub-watersheds in the Big Creek (two sites, 2014 to 2017), Buffalo (20 sites, 1985 to 2017), Upper Illinois (29 sites, 2009) and Upper White River Watersheds (20 sites, 2005 to 2006) (Figure 1).

Data from Big Creek were paired with discharge available from a gaging station just downstream from the swine CAFO, where the USGS developed the rating curve; discharge information was only available from May 2014 through December 2017. The data were then used to look at changes in flow-adjusted nutrient concentrations[A] in Big Creek (White et al., 2004).

[A]Concentration is defined as the mass of a substance (M), such as a nutrient, over the volume of water (V) in which it is contained, or C = M/V. "**Flow-adjusted nutrient concentrations**" – when looking at how concentrations change over time in streams, we have to consider how concentrations might also change with stream flow (volume of water) and not just change in mass; nutrient concentrations often have some type of relation to flow, maybe increasing or even decreasing as stream flow increases. We have to flow-adjust concentrations so we can remove the variability in concentrations that flow might cause to see how things are changing over time.

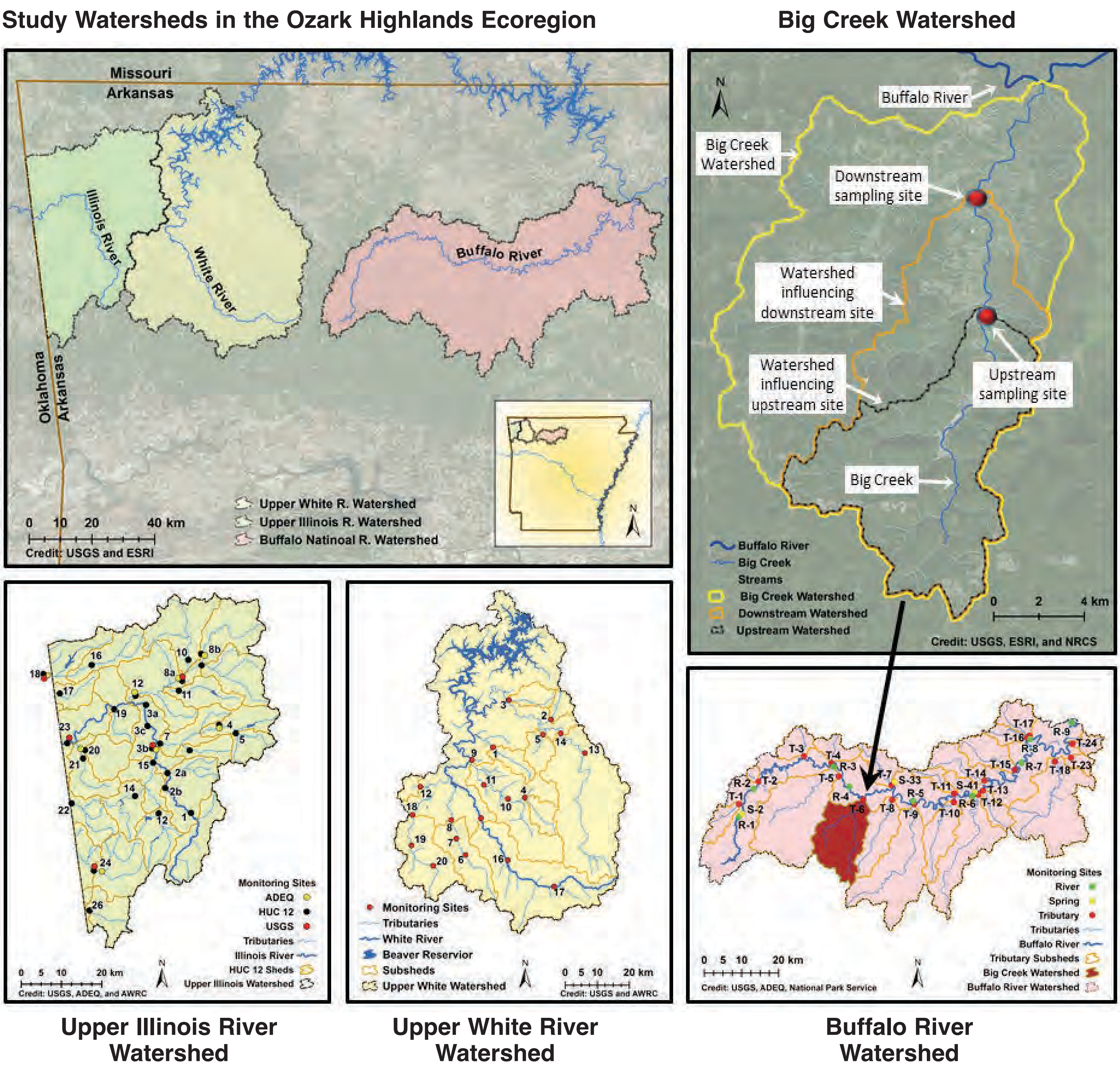

Figure 1. Location of the Big Creek, Buffalo River, Upper Illinois River and Upper White River watersheds in the Boston Mountains and Ozark Highlands ecoregion. *Information from U.S. Geological Survey (USGS), Environmental Systems Research Institute (ESRI) and National Aeronautics and Space Administration (NASA).*

Table 1. Percent of forest, pasture and urban land use in the Big Creek, Buffalo River, Upper Illinois and Upper White River watersheds.

Watershed	Forest	Pasture	Urban
	- - - - - - - - - -	%	- - - - - - - - - -
Big Creek*			
Upstream	89.5	8.0	2.6
Downstream	79.5	17.0	3.5
Buffalo River	52 - 99	0 - 25	0 - 1
Upper White River	34 - 90	7 - 55	0 - 44
Upper Illinois River	2 - 70	27 - 69	3 - 61

*Up and downstream of CAFO operation and fields permitted to receive manure.

Putting Stream Nutrient Concentrations Into Context at Big Creek

Geometric mean concentrations[B] of stream P and N are related to the percent of watershed drainage area in pasture and urban land use for the Buffalo, Upper Illinois and Upper White River watersheds (R^2 of 0.56 to 0.81 where the number of observations is 71; Figure 2)[C]. The dashed lines on Figure 2 represent the upper and lower thresholds concentrations, where there is a 95 percent confidence that a stream draining a watershed with a specific percent pasture and urban land use will have a P and N concentration within those thresholds.

The relationship between land use and stream nutrient concentrations is not a model that can be used to predict concentration. Given the large variability observed in these relationships, they simply show trends between two variables, land use and stream nutrient concentrations. Continued monitoring of stream concentrations in Big Creek will continue to more reliably define trends.

As the percent pasture and urban land (i.e., land use intensity) increases, so does stream P and N concentrations (see Figure 2). The general increase in nutrient concentrations is consistent with the fact that fertilizer (as mineral and manure sources) is routinely applied to pastures to maintain forage production, as well as deposition of nutrients by grazing cattle.

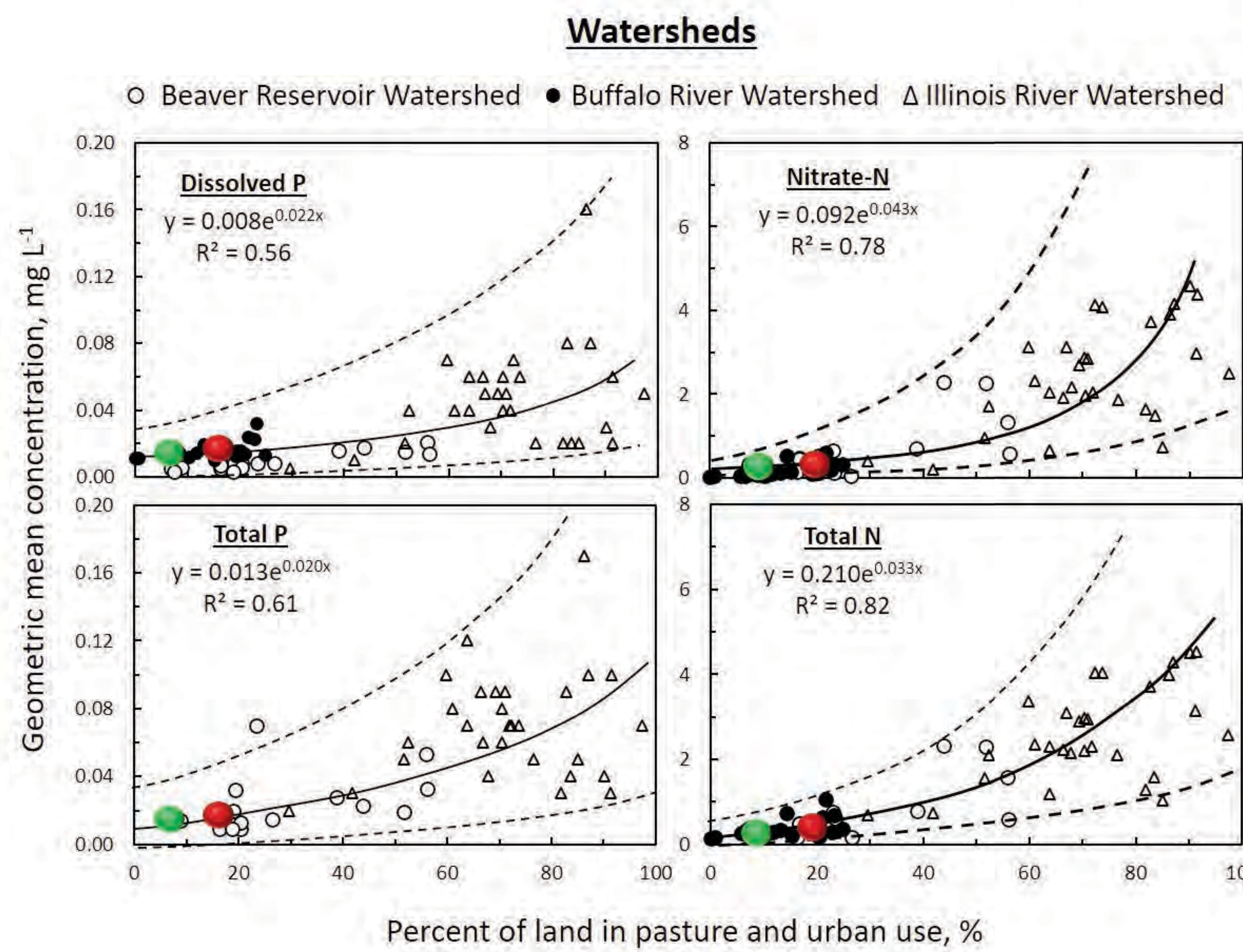

Figure 2. Relationship between land use and the geometric mean N and P concentrations (mg L^{-1}) in the Buffalo, Upper Illinois and Upper White River watersheds. Dashed lines represent the 95 percent confidence intervals for the estimated mean (solid line). Green points are geometric mean concentrations measured upstream of the CAFO on Big Creek and red points are geometric mean concentrations measured downstream of the CAFO on Big Creek.

[B]"**Geometric means**" – There are many ways to calculate the central or typical value of a data set, like the average or median. With water quality data, the geometric mean is often used because it minimizes the influence of really low or high values on the average.

[C]"**R^2**" is the **coefficient of determination** – the proportion of variance in the dependent variable (i.e., vertical axis) that is predictable from the independent variable (i.e., horizontal axis). The closer to 1 the value is, means less variability and the better the relationship between the two variables is.

In the Big Creek watershed, the percent of land influenced by human activities (i.e., pasture plus urban) doubles from ~10 percent to ~20 percent in the drainage area upstream and downstream of the CAFO. In Big Creek itself, upstream of the swine production CAFO, the geometric mean concentrations of dissolved P, total P, nitrate-N and total N during base flow were 0.009, 0.030, 0.10 and 0.20 mg L^{-1}, respectively, between September 2013 and December 2017. Directly downstream of the CAFO, the geometric mean concentrations in Big Creek during base flow over the same period were 0.011, 0.030, 0.25 and 0.37 mg L^{-1}, respectively.

Geometric mean nutrient concentrations in Big Creek above and below the swine production CAFO and its current potential sphere of influence from slurry applications are similar to or lower than concentrations measured in rivers draining other subwatersheds in the Upper Illinois and Upper White River watersheds with similar proportions of agricultural land use. (See Figure 2.)

Have Nutrient Concentrations Changed in the Short Term at Big Creek?

Long-term (e.g., decadal scale) water quality data are needed to reliably assess how stream nutrient concentrations have changed in response to watershed management and climate variations (Hirsch et al., 2015). The literature shows that stream nutrient concentrations can change relatively quickly in response to effluent management (e.g., Haggard, 2010; Scott et al., 2011), but seeing a response (i.e., decrease or increase in concentrations) from landscape management can take decades or more (Green et al., 2015; Sharpley et al., 2013). A myriad of factors may influence observed nutrient concentrations in streams, including discharge, biological processes and climactic conditions (i.e., drought and floods), and dominant transport pathways. Thus, we need to use caution when interpreting trends in water quality over databases that only cover a limited timeframe. Flow-adjusted concentrations showed no

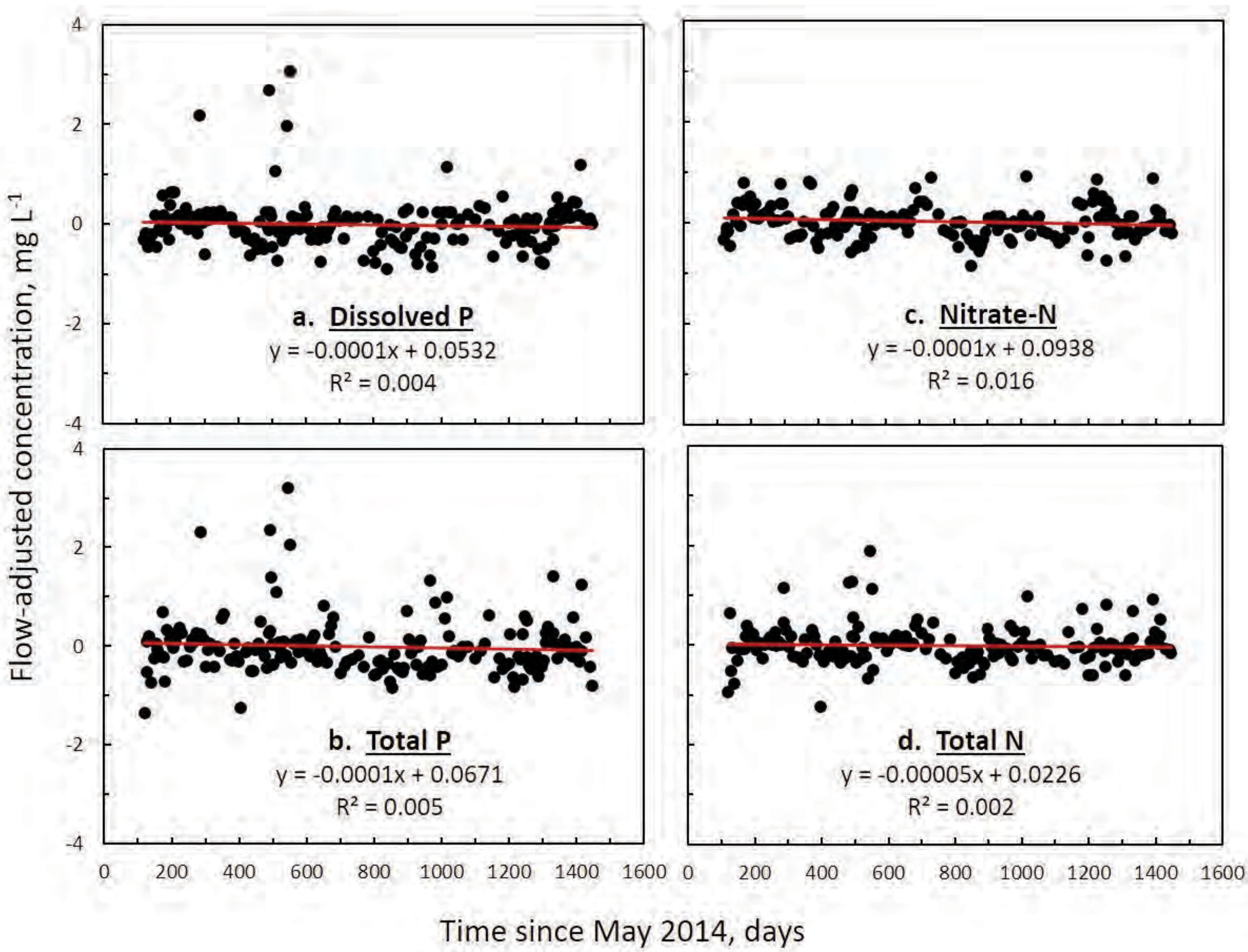

Figure 3. Change in flow-adjusted concentration of (a) dissolved P, (b) total P, (c) nitrate-N and (d) total N over time since May 2014, when monitoring in Big Creek started.

statistically significant increasing or decreasing trends in dissolved P, total P, nitrate-N and total N ($R2 < 0.016$); where number of observations is 182) over the current monitoring period (Figure 3).

Summary

Nutrient concentrations at Big Creek upstream and downstream of the swine CAFO, and indeed most tributaries of the Buffalo River, are low relative to other watersheds in this ecoregion (Figure 2). This provides a starting point to build a framework to evaluate changes in nutrient concentrations of streams as a function of land use and management.

The evaluation of flow-adjusted concentrations over time showed that nutrients in Big Creek were not increasing over the short duration of monitoring for which concentration and discharge data were available (May 2014 through April 2017). At this point in time, it is evident that nutrient concentrations in Big Creek have not increased at the monitored site. However, flow and nutrient concentration data over a longer period are needed to reliably quantify water quality trends and characterize sources, and monitoring needs to continue for at least a decade to evaluate how discharge, season and time influence nutrient fluxes.

Stream nutrient concentration-land use relationships are not a predictive tool. However, use of these relationships provides a method to determine if nutrient concentrations in a given watershed are similar to observed nutrient concentration-land use gradients in other watersheds of the Ozark Highlands and Boston Mountains. Over time, tracking these relationships provides a mechanism to note and evaluate changes in nutrient concentrations.

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JAMES BURKE and **LARRY BERRY** are program associates with the Crop, Soil and Environmental Sciences Department, University of Arkansas System Division of Agriculture in Fayetteville. **KRIS BRYE**, **ANDREW SHARPLEY**, **EDWARD GBUR**, and **MIKE DANIELS** are professors with the Crop, Soil and Environmental Sciences Department, University of Arkansas System Division of Agriculture. Brye, Gbur and Sharpley are located in Fayetteville, and Daniels is located in Little Rock. **STEPHEN KING** is a principal scientist with the Science and Technology Facilities Council at the Rutherford Appleton Laboratory in Oxfordshire, United Kingdom**. PHIL HAYS** is a professor with the Department of Geosciences at the University of Arkansas in Fayetteville. **KARL VANDEVENDER** is a professor with the Bio and Ag Engineering Department, University of Arkansas System Division of Agriculture in Little Rock. **BRIAN HAGGARD** is a professor and director of the Arkansas Water Resources Lab, Department of Biological and Agricultural Engineering, University of Arkansas in Fayetteville.

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Research Letter

Organic Phosphorus Can Make an Important Contribution to Phosphorus Loss from Riparian Buffers

Rosalind J. Dodd, Andrew N. Sharpley*, and Lawrence G. Berry

Core Ideas

- Forested and vegetative buffers can retain P runoff from adjacent fields.
- High concentrations of molybdate unreactive P were detected in soil water extracts.
- With time, these buffer soils can be a source of soluble inorganic and organic P.
- High microbial activity in buffer soils suggests biologically mediated P release.

Abstract: Vegetative buffer strips (VBS) and managed or unmanaged riparian zones between the edge of field and receiving watercourse are widely adopted conservation practices aimed at reducing nonpoint nutrient pollution. However, their effectiveness at decreasing phosphorus (P) loss has been mixed. This study investigated the effectiveness of a VBS and a forested riparian zone (FRZ) in decreasing P loss from pasture soils receiving swine manure and aimed to determine the potential factors controlling P release, using water extractable P (WEP) as a proxy for P loss. The inorganic WEP concentrations were significantly greater in the fertilized pasture zone soils than the VBS or FRZ soils. However, there was no significant difference between the field and riparian soils for total WEP due to increased contribution from organic WEP in these soils. Degree of P saturation, which is a function of soil test P, was a good predictor of inorganic WEP, but not organic WEP, where the variation in concentrations was better explained by variables involved in biotic P release.

Forested riparian zones (FRZs) or vegetated buffer strips (VBS) are composed of a zone of managed or unmanaged vegetation between the edge of the field and the receiving watercourse. They are widely used to decrease nutrient and sediment runoff leaving agricultural fields and entering adjacent flowing waters. The main functions of these areas are to slow the flow of surface runoff, promoting sedimentation and infiltration, and to act as a filter to trap sediment and reduce dissolved nutrient concentrations through soil sorption and plant uptake (Hoffmann et al., 2009). Numerous studies have demonstrated the effectiveness of VBS at decreasing particulate P loss; however, their effect on dissolved P is less clear (Dodd and Sharpley, 2016). Detailed reviews of the literature have highlighted studies where such VBS have become sources rather than sinks of P where soil P concentrations are elevated (e.g., Hoffmann et al., 2009; Roberts et al., 2012; Sheppard et al., 2006).

Three possible mechanisms for the release of P from VBS have been suggested (Roberts et al., 2012): (i) decreased P sorption capacity due to saturation of P sorption sites, (ii) desorption of P from soil surfaces or dissolution of precipitated P, and (iii) biological cycling through the plant and microbial pools. Compared to much-studied geochemical processes, relatively little is known about processes involved in the microbial P cycle or the impact of differing land management strategies on these. Furthermore, the contribution of dissolved organic P forms to P loss from VBS is often overlooked (Dodd and Sharpley, 2015), and we suggest that organic forms could make up a substantial proportion of dissolved P in soils with active microbial P cycling. This study aims to address this research gap.

Abbreviations: DPS, degree of soil phosphorus saturation; FPZ, fertilized pasture zone; FRZ, forested riparian zone; M3-P, Mehlich extractable P; MBC, microbial biomass C; MBN, microbial biomass N; MBP, microbial biomass P; TC, total C; TN, total N; TP, total P; TWEP, total water extractable phosphorus; VBS, vegetated buffer strips; WEP, water extractable phosphorus; WEPi, inorganic water extractable phosphorus; WEPo, organic water extractable phosphorus.

R.J. Dodd, Faculty of Agriculture and Life Sciences, Lincoln Univ., Lincoln, Christchurch, New Zealand; A.N. Sharpley and L. G. Berry, Dep. of Crop, Soil and Environmental Sciences, Univ. of Arkansas, Fayetteville, AR, USA.

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*Corresponding author (sharpley@uark.edu).

The Buffalo River is an important recreation area in northwest Arkansas. In 2013, a concentrated animal feeding operation (CAFO) was permitted to operate in this watershed (Arkansas Department of Environmental Quality, 2017), raising concerns of potential impairment of area waters for recreational use. In this operation, swine manure is land applied to pasture land, either grazed by cattle or hayed. Fields adjacent to a stream have a 30-m buffer, to which no manure or fertilizer can be applied, providing an ideal opportunity to investigate the fate and cycling of soil P along a gradient of a fertilized pasture zone (FPZ), grass VBS, and a forested riparian zone (FRZ). Three fields with different management histories, soil properties, and slope were selected to investigate the potential for dissolved P release, as measured by water extractable P, across these three zones. We addressed two main objectives:

1. To determine the effect of landscape position on the potential for P release as both dissolved inorganic and organic P.

2. To investigate the soil chemical and biological properties that control the release of dissolved P from these soils.

While it is acknowledged that vegetation can be an additional source of P loss, especially from forested riparian areas, where there may be accumulation of litter material, quantification of its contribution was beyond the scope of this study, which focuses on the release of soil P to water.

Materials and Methods

The study site is located in Mount Judea, AR (Fig. 1). Three fields were sampled (Fields 1, 5a, and 12; Fig. 2). Dominant soil types, along with management, for these are listed in Table 1. All three fields received poultry litter once every 2 yr in March from 2004 to 2012 (4.5 Mg ha^{-1} yr^{-1}; approximately 50 kg P and 120 kg N ha^{-1} yr^{-1}). Fields 1 and 12 currently receive only swine manure. In 2014, Field 1 received a total of 47 kg P ha^{-1} and 94 kg N ha^{-1} and Field 12 received 65 kg P ha^{-1} and 128 kg N ha^{-1}. In 2015, Field 1 received a total of 7.3 kg P ha^{-1} and 32 kg N ha^{-1} and Field 12 received 35 kg P ha^{-1} and 146 kg N ha^{-1}. While no swine manure has been applied to Field 5a, diammonium phosphate fertilizer was applied annually since 2012 at 11 kg P and 25 kg N ha^{-1}.

On Fields 1 and 12, receiving swine manure, a required application buffer of 30 m from the field edge is in place. Field 1 has a steep topography and drains into an ephemeral stream located within the riparian zone and connected to Big Creek. Fields 5a and 12 have slopes of <2%. These fields border Big Creek and are prone to flooding during large storm events. Field 1 is continuously grazed by cattle, whereas grass is cut for silage in Fields 5a and 12.

At each field, three transects were laid across the site running through the FPZ, VBS, and into the FRZ. For each transect, soil samples were taken at the 0- to 10-cm depth from three locations within the FPZ, one location within the manure application VBS, and one location in the FRZ, which borders the stream. Soil sampling at all fields was performed over the course of 1 d on four occasions, October 2014, January 2015, April 2015, and July 2015, corresponding to autumn, winter, spring, and summer to account for seasonal variability.

Fig. 1. Buffalo River watershed location in Arkansas, USA.

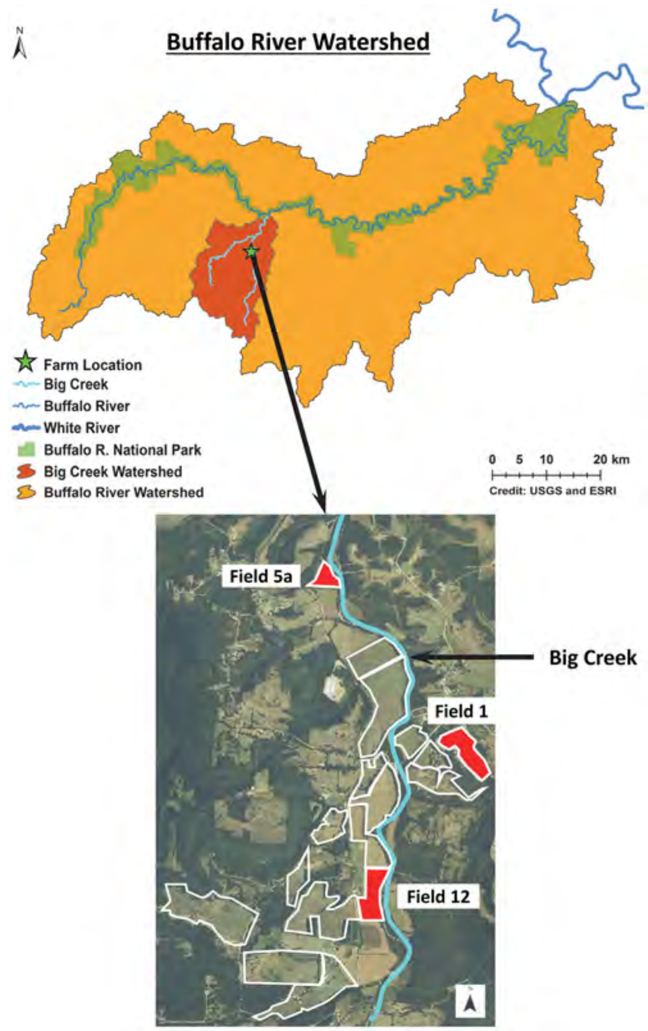

Fig. 2. Location of Big Creek watershed, farm, and fields studied.

Table 1. Field properties and management.

Site	Soil series	Area	Range in slope	Management
		ha	%	
Field 1	Noark very cherty silt loam	6.3	2.0–20.0	Grazed at 0.5 animal units ha^{-1}
Field 5a	Razort loam	10.8	0.2–1.0	Hayed and grazed at 0.3 animal units ha^{-1}
Field 12	Spadra loam	9.6	0.5–2.0	Hayed and grazed at 0.3 animal units ha^{-1}

As much of the vegetation mat as possible was removed in the field. Soil samples were separated into two subsamples for biotic and abiotic analysis. Samples for biotic analysis (microbial biomass and enzyme activity) were sieved <2 mm and stored at 4°C until analysis. Samples for abiotic analysis were air-dried, ground, and sieved <2 mm. Additional plant material, shoots, and roots were removed by hand before sieving.

Soil samples were analyzed for the following properties using the methods outlined in Table 2: total WEP (TWEP), inorganic WEP (WEPi), organic WEP (WEPo), Mehlich extractable P (M3-P), degree of soil P saturation (DPS), total P (TP), total C (TC), total N (TN), pH, microbial biomass P, C, and N (MBP, MBC, MBN), and phosphatase enzyme activities. Phosphorus concentration for all analyses except M3-P was determined using the molybdate blue method of Watanabe and Olsen (1965); M3-P concentrations were determined via inductively coupled plasma.

The P content determined colorimetrically directly following extraction with water is more accurately described as molybdate reactive P and consists mainly of orthophosphate ions and a small proportion of easily hydrolyzable inorganic and organic P. The difference between this value and that determined following digestion is more accurately described as molybdate unreactive P and consists mainly of organic P forms but also a smaller fraction of condensed inorganic P, such as polyphosphates (Haygarth and Sharpley 2000). Due to the dominance of inorganic P in molybdate reactive P and organic P in molybdate unreactive P, WEPi and WEPo have been used to distinguish between these two forms of P to avoid confusion and allow a clear message to be presented.

Before all statistical analysis, the data were examined for normality and the following parameters were log-transformed: TWEP, WEPi, and WEPo. To examine the differences in soil properties across the three landscape positions, the data from the three samples taken along each transect within the FPZ were averaged to provide one value for each zone (FPZ, VBS, and FRZ) for each transect. Data from each of the three fields and from each of the transects within the fields were treated as replicates, giving nine location replicates per zone. These data were subjected to a one-way ANOVA by zone blocked by season, providing four seasonal replicates for each location replicate and a total replication of 36 data points per zone. For all parameters, a Tukey test was used to determine significant differences between the zones at the $p < 0.05$ level of significance.

To determine which soil properties were contributing to the release of WEP and which soil parameters are important in regulating the release of P, a stepwise regression was undertaken using the following parameters: acid phosphomonoesterase, alkaline phosphomonoesterase, phosphodiesterase, total phosphatase, MBN, MBP, MBC, M3-P, DPS, pH,

Table 2. Summary of analytical methods used.

Parameter†	Analytical method	Reference
TWEP	1:20 soil-to-water extraction followed by centrifugation, filtration <0.45 μm, and acid persulfate digestion	Self-Davis et al. (2009) and Rowland and Haygarth (1997)
WEPi	1:20 soil-to-water extraction followed by centrifugation and filtration <0.45 μm	Self-Davis et al. (2009)
WEPo	Assumed to be the difference between TWEP and WEPi	—
M3-P	1:10 soil-to-Mehlich-3 extractant and centrifugation	Mehlich (1984)
DPS	Calculated from M3-P, Fe, and Al according to the equation DPS = M3-P/0.5 × (M3-Fe + M3-Al) × 100	Adapted from Schoumans (2009)
TP	Alkaline oxidation	Dick and Tabatabai (1977)
TC	Combustion on an Elementar VarioMax CN	Provin (2014)
TN	Combustion on an Elementar VarioMax CN	Provin (2014)
pH	1:2 soil-to-water extraction	—
MBP	Chloroform-fumigation extraction	Adapted from Brookes et al. (1985) and McLaughlin et al. (1986)
MBC	Chloroform-fumigation extraction	Vance et al. (1987)
MBN	Chloroform-fumigation extraction	Vance et al. (1987)
Acid P_{mono}	Enzyme assays using 5mM *para*-nitrophenyl phosphate as the substrate buffered at pH 6.5	Tabatabai (1994)
Alk P_{mono}	Enzyme assays using 5mM *para*-nitrophenyl phosphate as the substrate buffered at pH 11	Tabatabai (1994)
Pdi	Enzyme assays using 1 mM bis-*para*-nitrophenyl phosphate as the substrate buffered at pH 8	Tabatabai (1994)
Total phosphatase	Sum of acid P_{mono}, alk P_{mono}, and Pdi	—

† acid P_{mono}, acid phosphomonoesterase; alk P_{mono}, alkaline phosphomonoesterase; DPS, degree of soil phosphorus saturation; M3-P, Mehlich extractable P; MBC, microbial biomass C; MBN, microbial biomass N; MBP, microbial biomass P; Pdi, phosphodiesterase; TC, total C; TN, total N; TP, total P; TWEP, total water extractable phosphorus; WEPi, inorganic water extractable phosphorus; WEPo, organic water extractable phosphorus.

TP, TC, and TN. All analyses were performed using the SPSS statistical package version 22 (IBM, 2013).

Results and Discussion

Water extractable soil P concentration has been shown to be directly related to the potential for dissolved P release from soils to surface runoff (Pote et al., 1996; Sharpley, 1995). The total, inorganic, and organic WEP (TWEP, WEPi, WEPo) concentrations across the three fields was significantly lower in the VBS than the FPZ, reflecting the larger inputs of P to the FPZ (Fig. 3). However, there was no significant difference in TWEP between the pasture and FRZs despite a decrease in WEPi. This is a result of the significantly higher concentrations of WEPo present in the FRZ, where WEPo made up 57% of TWEP in these soils compared with just 24% in the pasture soils. This suggests that dissolved organic P can contribute to total P release in riparian soils.

The release of soil P to water can occur through abiotic and biotic processes. Desorption and dissolution reactions dominate the abiotic release mechanisms and are governed by soil chemical properties and number of available sorption sites (Arai and Sparks, 2007). Microbial soil biomass can contain a significant pool of P in temperate pastures (Oberson and Joner, 2005). This pool is in constant flux, immobilizing P from or replenishing P in the soil solution during microbial growth or cell death. Phosphorus release from this pool occurs through three main mechanisms: (i) mineralization (Oehl et al., 2001), (ii) cell lysis in response to environmental stress (e.g., dessication) (Turner and Haygarth, 2001), or (iii) predation by soil fauna (Bonkowski, 2004). Biotic processes can also control the form of dissolved P in solution through the exudation of phosphatase enzymes, which can catalyze the conversion of soluble organic P compounds to orthophosphate ions for plant uptake (Richardson et al., 2011).

Table 3 shows the abiotic and biotic soil properties of the soils across the three landscape zones. The FPZ soils had significantly higher concentrations of TP and M3-P, but lower concentrations of TC and TN, compared with the FRZ soils. Additionally, the DPS was significantly higher in the FPZ soils compared with the VBS and FRZ soils, indicating more of the P sorption sites had become saturated. Surprisingly, we saw no significant difference in microbial biomass P, C, or N concentrations among zones, despite expected increased leaf litter inputs in the FRZ. However, the total phosphatase activity was 17% higher in the FRZ soils than the field soils, suggesting increased microbial activity.

To determine which pools of P and which soil properties were key in controlling the release of P to water, we performed a stepwise regressions for TWEP, WEPi, and WEPo using data from all three sites and four sampling dates. The results from this analysis are shown in Table 4. Both TWEP and WEPi were well predicted by the model (adjusted r^2 =

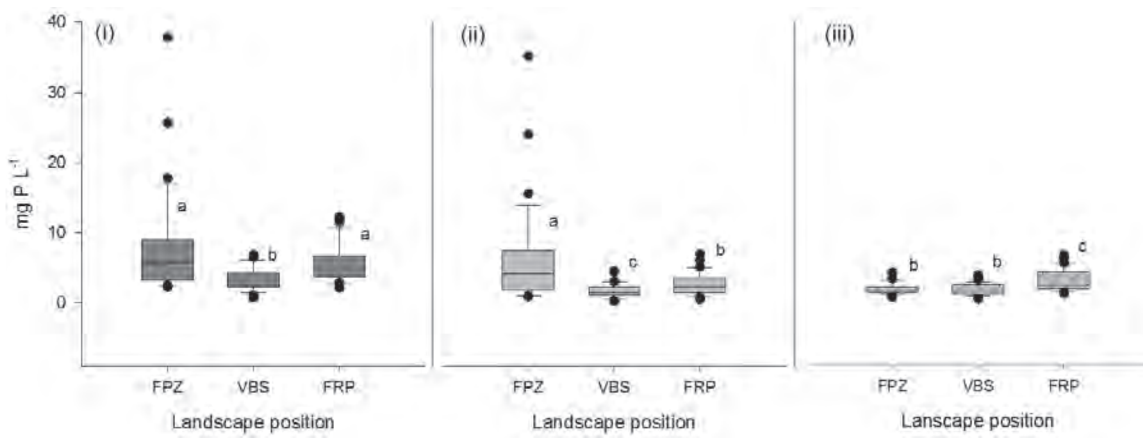

Fig. 3. Box plots showing the concentration of (i) total water extractable P, (ii) inorganic water extractable P, and (iii) organic water extractable P across the three zones (fertilized pasture zone [FPZ], vegetative buffer strip [VBS], and forested riparian zone [FRZ]). Letters denote significant differences between zones at $p < 0.05$ as determined by Tukey's test of multiple comparisons.

Table 3. Difference in mean soil properties across the different landscape zones, fertilized pasture zone (FPZ), vegetative buffer strip (VBS), forested riparian zone (FRZ): pH, total C (TC), total N (TN), total P (TP), Mehlich-3 P (M3-P), degree of P saturation (DPS), microbial biomass P (MBP), microbial biomass C (MBC), microbial biomass N (MBN), acid phosphomonoesterase (acid P_{mono}), alkaline phosphomonoesterase (alk P_{mono}), phosphodiesterase (Pdi), and total phosphatase activities.

Zone	Soil chemical properties						Soil biological properties						
	pH	TC	TN	TP	M3-P	DPS	MBP	MBC	MBN	Acid P_{mono}	Alk P_{mono}	Pdi	Total phosphatase
		—— % ——		— mg kg⁻¹ —		%	—— mg kg⁻¹ ——			—— μmol pNP† g⁻¹ h⁻¹ ——			
FPZ	5.87b‡	2.06b	0.23b	640a	67a	7.48a	26	371	85	3.00a	1.33b	1.20b	5.53b
VBS	5.71b	1.88b	0.21b	584ab	48b	4.89b	23	386	79	2.59ab	0.93b	0.96b	4.56b
FRZ	6.40a	3.21a	0.26a	521b	28c	4.57b	28	356	101	2.33b	2.05a	2.05a	6.66a
p value	<0.001	<0.001	<0.05	<0.01	<0.005	<0.001	NS	NS	NS	<0.005	<0.001	<0.001	<0.001

† pNP, *para*-nitrophenyl phosphate.

‡ Means followed by the same letter are not significantly different at the $p < 0.05$ level of significance according to Tukey's test for multiple comparisons.

Table 4. Model predictions of total water extractable P (TWEP), inorganic water extractable P (WEPi), and organic water extractable P (WEPo) from stepwise regression across all data. The *F* statistic for all three model predictions is <0.001.

TWEP			WEPi			WEPo		
$r^2_{adjusted}$	Predictor	Relative importance	$r^2_{adjusted}$	Predictor	Relative importance	$r^2_{adjusted}$	Predictor	Relative importance
0.66	Degree of soil P saturation	0.80	0.65	Degree of soil P saturation	0.93	0.37	Total phosphatase activity	0.78
	Total phosphatase activity	0.18		Total phosphatase activity	0.07		Microbial biomass N	0.17
	M3-P	0.02					pH	0.05

0.66 and 0.65, respectively), and variation in these concentrations was mostly explained by DPS, with a small contribution from total phosphatase activity, an indicator of biologically mediated P release.

In contrast to WEPi, variation in WEPo was less closely related to any of the measured parameters (adjusted $r^2 = 0.37$). Furthermore, DPS was not included in the selected model, and total phosphatase activity explained most of the variation in WEPo. While total phosphatase activity was greatest in FRZ soils, the activity of the different types of enzyme varied across the landscape positions (Table 3). Acid phosphomonoesterase activity was highest in the FPZ soils and of a similar magnitude to that found agricultural soils with a history of poultry manure application and high soil test P**???Spelled out STP; correct???** concentrations (Tomlinson et al., 2008). Acid phosphomonoesterase is thought to be mainly released by plant roots and some microbes, and there is evidence that high concentrations phosphatase enzymes can be present in manures (Nannipieri et al., 2011). Furthermore, these enzymes have been shown to sorb strongly onto soil particles (Burns, 1986; Nannipieri et al., 2011); hence, the large acid phosphomonoesterase activates found in the FPZ may be directly due to manure application. In contrast, alkaline phosphomonoesterase and phosphodiesterase activities were greatest in the FRZ, in keeping with the small increase in pH (Table 3). These enzymes are thought to be released by soil microorganisms rather than plant roots. The differences in phosphatase activities across the zones suggest that release of P from riparian soils is likely to be controlled in part by the biologically mediated release of organic P.

This study demonstrates that the significant decrease in soil test P concentrations in FRZ soils compared with regularly fertilized FPZ does not necessarily translate to a reduction in the total amount of P, which can be released to runoff due to the increase in WEPo. Furthermore, while DPS, of which soil test P is a component, was a good predictor of WEPi release, additional factors relating to biological cycling need to be considered when trying to account for the potential release of organic P.

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Phosphorus Retention and Remobilization along Hydrological Pathways in Karst Terrain

Helen P. Jarvie,*[,†] Andrew N. Sharpley,[‡] Van Brahana,[§] Tarra Simmons,[‡] April Price,[‡] Colin Neal,[†] Alan J. Lawlor,[∥] Darren Sleep,[∥] Sarah Thacker,[∥] and Brian E. Haggard[⊥]

[†]Centre for Ecology & Hydrology, Wallingford OX10 8BB, U.K.

[‡]Department of Crop, Soil & Environmental Sciences, Division of Agriculture, University of Arkansas, Fayetteville, Arkansas 72701, United States

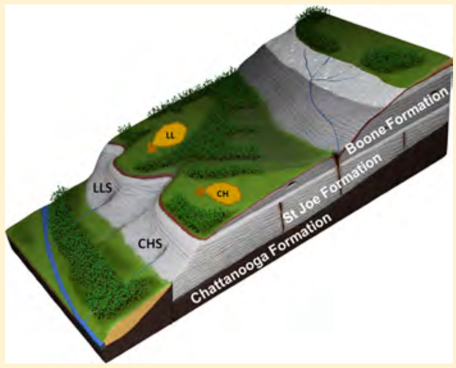
[§]Department of Geosciences, University of Arkansas, Fayetteville, Arkansas 72701, United States

[∥]Centre for Ecology & Hydrology, Lancaster LA1 4YQ, U.K.

[⊥]Arkansas Water Resources Center, University of Arkansas, Fayetteville, Arkansas 72701, United States

Supporting Information

ABSTRACT: Karst landscapes are often perceived as highly vulnerable to agricultural phosphorus (P) loss, via solution-enlarged conduits that bypass P retention processes. Although attenuation of P concentrations has been widely reported within karst drainage, the extent to which this results from hydrological dilution, rather than P retention, is poorly understood. This is of strategic importance for understanding the resilience of karst landscapes to P inputs, given increasing pressures for intensified agricultural production. Here hydrochemical tracers were used to account for dilution of P, and to quantify net P retention, along transport pathways between agricultural fields and emergent springs, for the karst of the Ozark Plateau, midcontinent USA. Up to ~70% of the annual total P flux and ~90% of the annual soluble reactive P flux was retained, with preferential retention of the most bioavailable (soluble reactive) P fractions. Our results suggest that, in some cases, karst drainage may provide a greater P sink than previously considered. However, the subsequent remobilization and release of the retained P may become a long-term source of slowly released "legacy" P to surface waters.



INTRODUCTION

More than 25% of the world's population either lives on or obtains its drinking water from karst aquifers. Karst underlies 30% of the land area of China, 30% of Europe, and 20% of the United States.[1,2] Karst aquifers exert an important control on the quality and ecology of surface waters in these areas.[3] The complexity of subsurface drainage[4,5] and the difficulties in deconvoluting flow pathways and groundwater contributing areas[6] have been a significant barrier to detailed studies of nutrient transport and fate in karst systems.[7,8] Nevertheless, it is widely assumed that karst drainage systems (formed by dissolution of carbonate rocks, mainly limestone) are highly vulnerable to phosphorus (P) impairment from agricultural sources.

This vulnerability is assumed to arise from the low nutrient buffering capacity of the thin cherty soils which overlie karst and the rapid transmission of surface runoff through conduits enlarged by dissolution,[9,10] which is thought to bypass the zones where key processes of P retention occur.[11−13] Nonetheless, highly intensive monitoring of Irish karst springs, in areas of livestock, demonstrated major P attenuation (reduction in P concentrations) relative to agricultural runoff,[14,15] with low P concentrations in spring discharge, even during storm events when agricultural P losses are expected to be highest. This attenuation was attributed to a combination of both hydrological dilution and P retention during infiltration and transmission of runoff along groundwater conduit pathways.

Crucially, we lack information on the extent to which P attenuation is controlled by P retention processes during transit along karst flow paths,[14] or by hydrological dilution of agricultural runoff by cleaner groundwater sources.[16] This is of strategic importance for understanding the P buffering capacity and wider resilience of karst landscapes to nutrient inputs.[10,17,18] Many karst lands have traditionally been used for low-intensity livestock farming, owing to poor soils and their unsuitability for arable production.[9] However, there is increasing pressure for intensive livestock production, as global demands for greater efficiency in food production intensify.[19,20] Given the move toward more intensive livestock production systems, which accumulate P,[21,22] and the perceived vulnerability of karst drainage systems to P loss, there is now a pressing and strategic

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Table 1. Summary of Concentrations of Soluble Reactive Phosphorus (SRP), Total Phosphorus (TP), Potassium (K), Rubidium (Rb), and Calcium (Ca) in Field Runoff and Spring-Water Samples

		field runoff (m^3 ha^{-1}) spring flow (L s^{-1})	SRP (mg L^{-1})	TP (mg L^{-1})	Rb (μg L^{-1})	K (mg L^{-1})	Ca (mg L^{-1})
Langle Field (LL)	mean	38.0	2.21	2.57	6.97	10.4	5.12
	median	35.5	1.87	2.12	5.96	10.2	4.94
	range	3.4−91.5	0.59−5.02	0.8−5.53	0.93−20.6	2.04−26.3	2.11−9.87
Copperhead Field (CH)	mean	23.1	0.68	1.09	2.94	6.11	3.45
	median	14.6	0.57	1.03	2.52	5.11	3.43
	range	1.8−79.9	0.47−1.22	0.63−1.91	0.58−8.76	1.4−14.7	1.95−7.34
Langle Spring (LLS)	mean	13.1	0.029	0.057	1.06	1.54	37.5
	median	9.38	0.012	0.034	0.878	1.14	36.7
	range	1.24−59	0−0.403	0.002−0.608	0.195−3.57	0.534−4.92	12.2−65.9
Copperhead Spring (CHS)	mean	22.5	0.019	0.041	1.08	1.37	40.5
	median	2.62	0.017	0.032	1.1	1.4	42.9
	range	0.19−253	0.001−0.12	0−0.58	0.328−1.9	0.84−2.17	14.5−61.5

need for better understanding of the fate and transport of P in karst landscapes. Here this shortfall is addressed for karst terrain in south-central USA. Hydrochemical tracers and endmember mixing analysis[23−26] were used to assess the vulnerability to P loss, by accounting for the hydrological dilution of agricultural runoff and directly quantifying net P retention, during infiltration through the soil, and along karst transport pathways, through to the emergent springs.

■ EXPERIMENTAL METHODS

Study Area. The study was undertaken at the University of Arkansas long-term Savoy Experimental Watershed (SEW), NW Arkansas, USA.[27] The SEW is located in the Illinois River Watershed, a mixed land-use watershed (~4330 km^2), which spans the states of Arkansas and Oklahoma.[28,29] The SEW covers 1250 ha and is typical of the karst terrain of the Ozark Plateau of midcontinental USA (Figure SI-1a, Supporting Information). The soils of the SEW are predominantly silt loams (see Supporting Information). Around 70% of the land is native forest, with the remaining 30% rolling pasture grazed by beef cattle (~2 cows ha^{-1}). The SEW also supports poultry production, with the resulting poultry litter used to fertilize pastures. There are no septic tanks or settlements in the SEW, and agricultural runoff from pastures grazed by cattle provides the overwhelmingly dominant P source in the watershed.[30]

The stratigraphy of the SEW[30−32] (see Figure SI-1c, Supporting Information) includes (a) the limestone aquifer of the St. Joe Formation, (b) the Boone Formation, an impure limestone which mantles the St. Joe Formation and forms "epikarst", and (c) a layer of regolith (vadose zone) which overlies the Boone Formation. Karst drainage has a major control on water quality in the Illinois River;[29,33] 67% of annual river flow comes from karst springs, rising to 80% of flow in the summer and fall.[34]

Sample Collection and Analysis. Surface runoff and spring-water chemistry and flow monitoring (Figure SI-1a and c, Supporting Information) were undertaken at the following: (1) two adjacent karst springs (Langle Spring, LLS, and Copperhead Spring, CHS), which flow continually from the St. Joe Formation (focused conduit flow) springs; (2) two surface runoff field plots (Langle, LL, 1.07 ha, and Copperhead, CH, 1.05 ha), which are located above and within the watershed (recharge zone) of the LLS and CHS springs. These runoff plots are located on Razort silt loams which make up most of the grazed pastures of the SEW. All pastures are treated similarly in terms of grazing intensity and maintenance fertilizer applications (30 kg P ha^{-1} every two years as either poultry litter or diammonium phosphate).

Flows at the karst springs (LLS and CHS) were monitored on 15-min intervals (see Supporting Information). Karst spring water was sampled weekly, with stage-triggered, subdaily automated sampling using an ISCO sampler during storm events. Figure SI-2 (Supporting Information) shows the distribution of samples collected on the rising and falling stage of the storm hydrographs. The volume of surface runoff from both fields was automatically measured, and samples were collected on a flow-weighted basis by an ISCO autosampler. All water samples were filtered within 24 h of the water being sampled and were analyzed following EPA standard protocols, as described below (and in the Supporting Information). Filtered (<0.45 μm) samples were analyzed for soluble reactive phosphorus (SRP), by colorimetric analysis,[35] and for a full suite of major cations (including potassium, K, and calcium, Ca) and trace elements (including lanthanum, La, and rubidium, Rb) (see Supporting Information). Unfiltered samples were analyzed for total phosphorus (TP), after acid-persulfate digestion, by colorimetric analysis.[35,36] These measurements are consistent with standard protocols for TP and SRP analysis.[37]

Use of Conservative Tracers and Endmember Mixing Analysis. Conservative chemical tracers and endmember mixing models were used to apportion water sources, and to differentiate the effects of hydrological dilution from the biogeochemical processes, which retain and cycle P during transit through the karst drainage system. Chemical tracers have been widely used in watershed hydrology for tracing water sources and flow pathways,[38] owing to their conservative behavior (chemical inertness). Here we made use of chemical tracers already in the watershed to apportion water sources. Using the hydrochemical monitoring data, tracers were chosen which had elevated concentrations in either base flow groundwater or in agricultural runoff. First, two-component endmember mixing models[23,39] were used to link the spring-water chemistry to sources within the watershed, by (a) quantifying the relative proportions of surface runoff and groundwater and (b) estimating the contribution of surface runoff from the agricultural grazed land. Second, comparing the mixing patterns of P in spring water with a conservative tracer of agricultural runoff allowed us to directly evaluate whether P was behaving nonconservatively (i.e., being taken up or released) along the hydrological pathways in the karst drainage system.

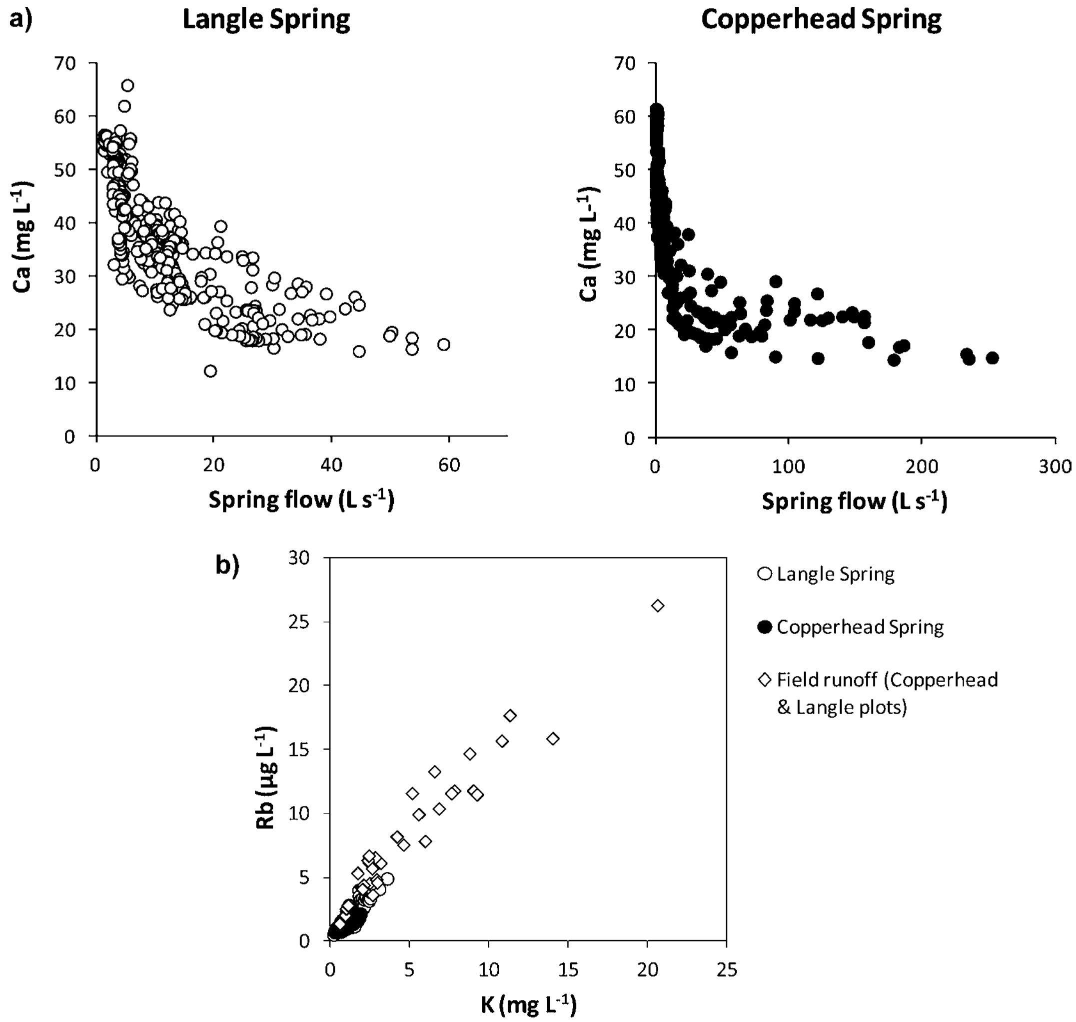

Figure 1. (a) Relationships between calcium (Ca) concentrations and flow at Langle and Copperhead springs. (b) Relationship between rubidium (Rb) and potassium (K) concentrations in field runoff and spring-water samples.

RESULTS AND DISCUSSION

Comparison of Agricultural Runoff and Spring-Water Chemistry. Concentrations of TP, SRP, K, and Rb were consistently highest in field runoff, relative to the springs (Table 1), and runoff from the grazed fields provides the greatest concentrations of P, K, and Rb within the SEW. In contrast, Ca concentrations were consistently highest in the springs, compared with runoff. This indicates a dominant base flow groundwater source of Ca, from dissolution of limestone, which is diluted by surface runoff (Figure 1a).

Concentrations of SRP, TP, K, and Rb were all higher in field runoff at LL compared with CH. This likely reflects higher cattle grazing density at LL (2.5 cows ha^{-1}) than at CH (1.0 cows ha^{-1}), as well as higher runoff per unit area that likely led to greater solute and particulate entrainment and transport capacity compared with CH. This may also reflect a larger hydrologically active area contributing runoff at LL, linked to greater soil compaction from more intensive cattle grazing.

For the springs, there was a greater variability in SRP, TP, K, and Rb concentrations at LLS than at CHS, despite a much lower variability in spring flow at LLS (Table 1). However, concentrations of TP, SRP, K, and Rb did not correlate with flow at either of the springs. For most storm events at LLS, concentrations of TP, SRP, K, and Rb increased dramatically above base flow concentrations, especially on the rising stage of the storm hydrograph (Figure SI-2, Supporting Information). These high concentrations on the rising stage are likely due to upstream point recharge of surface runoff from pasture land into the underlying St. Joe aquifer in locations where the confining chert layer is breached. At CHS, the response of TP, SRP, K, and Rb to storm events was more mixed. Small initial increases in concentration occurred with the onset of higher flows, followed by marked reductions in concentration, reflecting substantial dilution by a water source with relatively low SRP, TP, K, and Rb concentrations, most likely from the nonagricultural (ungrazed and forested) parts of the watershed. Indeed, karst inventories have verified that this part of the flow regime reflects runoff from areas which are not grazed by livestock.[30,31]

To evaluate the attenuation (i.e., the reductions in concentrations) of TP, SRP, K, and Rb during transit through the karst, the median concentrations in agricultural runoff were compared with the corresponding median concentrations in CHS and LLS springs (Table 1). The average attenuation of TP and SRP concentrations ranged from 96% to 99%. In contrast, the average attenuation of K and Rb concentrations was lower, at 56% to 89%. Correspondingly, under storm flow conditions, comparisons of average field runoff concentrations and the 90th percentile concentrations in spring water (which typically correspond with the rising stage of the storm hydrographs of

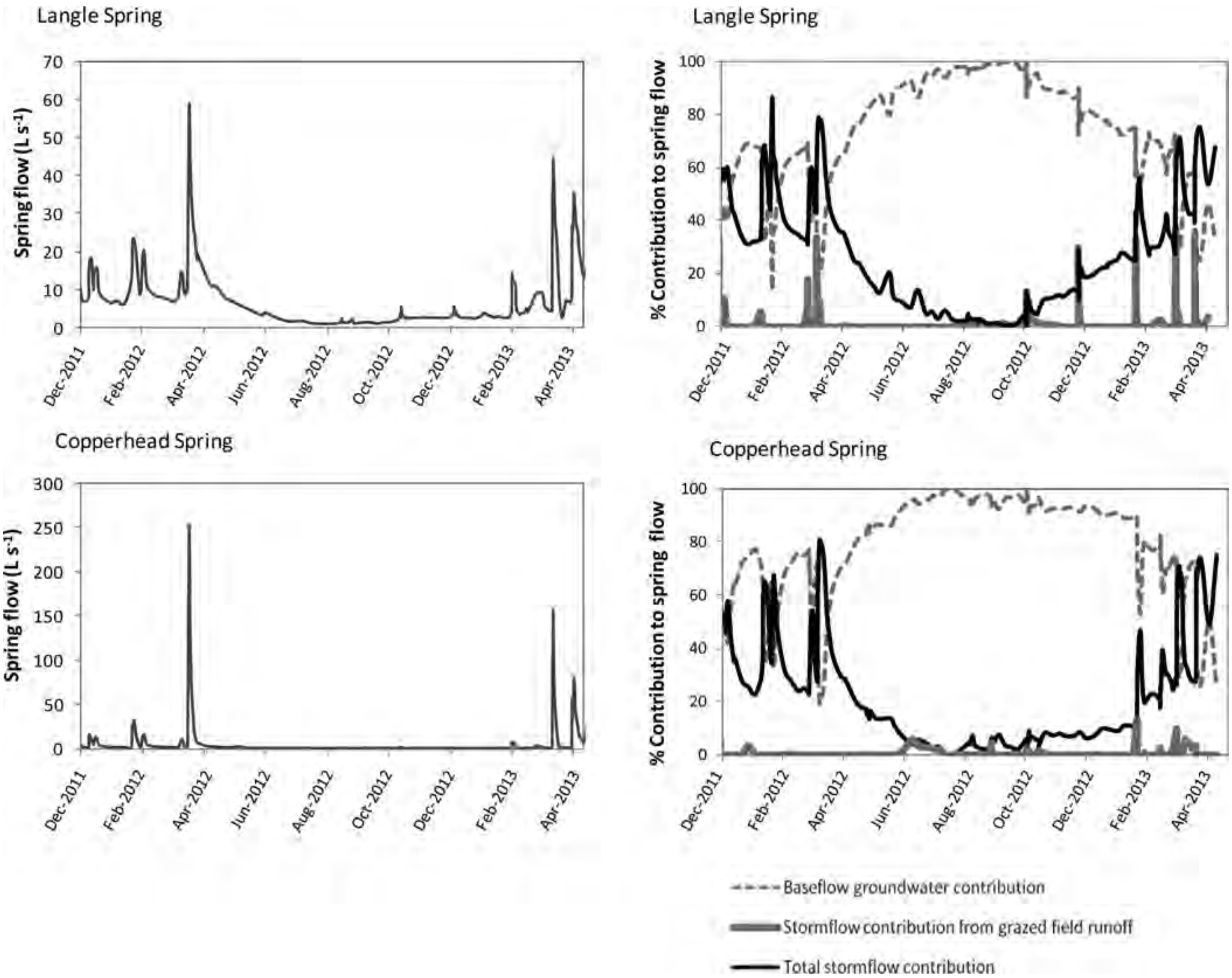

Figure 2. Hydrographs and water source apportionment for Langle and Copperhead springs.

the springs) revealed that storm flow attenuation of TP and SRP ranged from 93% to 96%, compared with 46% to 74% for K and Rb. Across all flow conditions, the higher rates of attenuation of P concentrations, relative to K and Rb, reflect the nonconservative behavior of P during transit through the karst.

K and Rb show high correlation (Figure 1b) due to their similar hydrogeochemistry (group 1a monovalent base cations of relatively small hydration size). Figure 1b shows a dominant two-component mixing series between a high concentration "endmember" (i.e., surface runoff from fertilizer and grazed pastures in runoff) and a low concentration spring-water "endmember" (i.e., runoff from nonagricultural and forested areas, which have no grazing or fertilizer inputs). Both K and Rb are highly soluble monovalent ions, and once transmitted into the karst drainage system, chemical interactions will be relatively small. Therefore, the attenuation of K and Rb during transport through the karst will be largely controlled by hydrological dilution, without retention mechanisms (with only possibly a small attenuation or release within the epikarst where there is a high proportion of clays[31,40]). In contrast, P behaves nonconservatively, reflected by the higher rates of attenuation of P relative to K and Rb.

Spring Hydrology and Water-Source Apportionment. Comparing the hydrology of the two springs (Figure 2), base flows at CHS were consistently lower than at LLS; the median flow at CHS was 2.62 L s^{-1}, compared with 13.1 L s^{-1} at LLS (Table 1). Further, CHS exhibited a more flashy flow regime than LLS, and storm flows were dramatically higher at CHS. For instance, the average of the highest 10% of flows was 139 L s^{-1} at CHS, compared with 40 L s^{-1} at LLS. This discrepancy reflects the following: (i) LLS being the "underflow" spring (3 cm lower than CHS), with a much larger groundwater drainage area under low-flow conditions than CHS, which accounts for the higher base flows at LLS; (ii) water capture (spring "piracy") by CHS during storm events, which has been shown to result in a dramatic expansion in the watershed drainage area for CHS relative to LLS.[32,33]

Contributions to spring water at LLS and CHS were apportioned by two-component endmember mixing analysis.[23,41] Here Ca was used as a tracer of groundwater and K as a tracer of agricultural runoff, based on the observed dominant groundwater source of Ca and the dominant agricultural runoff source of K. For the mixing model, endmembers were defined as the following:

(i) A base flow groundwater endmember with elevated Ca, and a storm flow endmember with low Ca concentrations.
(ii) Runoff endmember from agricultural land with high K concentration, and a spring base flow low K endmember.

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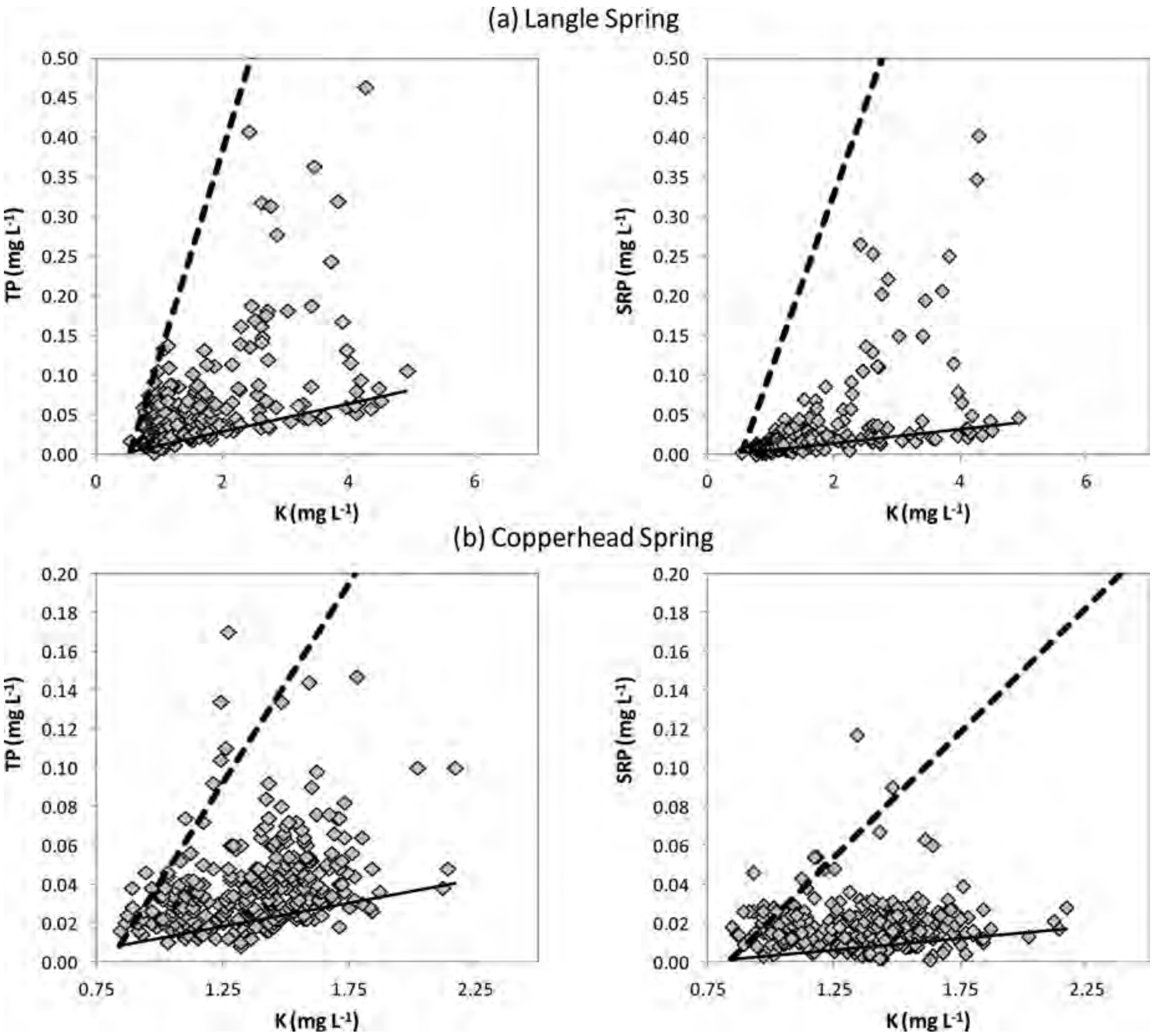

Figure 3. Relationships between total phosphorus (TP), soluble reactive phosphorus (SRP), and potassium (K) for (a) Langle Spring and (b) Copperhead Spring. The dashed line denotes the conservative mixing line, and the solid line denotes a line of maximum P retention (see text for explanation).

Applying a simple two-component mixing model[23,41] (eq 1) and the endmembers identified above, Ca concentrations were used to partition the contributions to spring flow at LLS and CHS from base flow groundwater (the high concentration endmember) and from stormwater runoff (the low concentration endmember). Then a second two-component mixing model was used for K, to quantify the contributions from grazed pasture runoff (eq 2).

$$\%\text{ total storm runoff} = 100 \times (Ca_{gw} - Ca_{m})/(Ca_{gw} - Ca_{ro}) \quad (1)$$

$$\%\text{ agricultural runoff} = 100 \times (K_{bf} - K_{m})/(K_{bf} - K_{ag}) \quad (2)$$

where Ca_{gw} was the groundwater Ca concentration (high concentration base flow endmember), defined here as the average Ca concentration for the lowest 10% of flows sampled, Ca_{m} was the measured spring-water Ca concentration, Ca_{ro} was the stormwater (agricultural runoff) endmember, defined here as the average field runoff Ca concentration, K_{bf} was the base flow endmember (average K concentration for the lowest 10% of spring flows sampled), K_{m} was the measured spring-water K concentration, and K_{ag} was the agricultural runoff endmember, defined here as the average field runoff K concentration. The values used to define the endmember concentrations at LLS and CHS are shown in Table SI-1, Supporting Information.

The water source apportionment for LLS and CHS (Figure 2) showed similar percentage contributions from base flow groundwater and total storm flow at LLS and CHS for most of the year and particularly during storm events. During winter and spring storm events, a much greater proportion of flow at LLS was derived from agricultural (grazed field) runoff (up to approximately a third of flow). This greater contribution of water from pastures than from nonagricultural land at LLS accounted for the higher storm-event concentrations of K and Rb at LLS. Agricultural runoff contributed a much lower proportion of winter and spring storm event flow at CHS (typically less than 10%). These results and the much higher storm flow discharges at CHS suggest that the water "piracy" at CHS, during storm events, captured water sources, which had a lower K and Rb concentration, from the nonagricultural (ungrazed and forested) areas.

Table 2. Measured and "Conservative" Annual Loads, and Mean Daily Base Flow and Storm Flow Loads, of Total Phosphorus (TP) and Soluble Reactive Phosphorus (SRP) in Langle and Copperhead Springs, with Net and Percentage TP and SRP Retention

		measured P load ($kg\ y^{-1}$ or $g\ d^{-1}$)	"conservative" P load ($kg\ y^{-1}$ or $g\ d^{-1}$)	net P retention ($kg\ y^{-1}$ or $g\ d^{-1}$)	% net P retention
Langle Spring (LLS)	annual TP load ($kg\ y^{-1}$)	7.01	22.3	15.3	69
	annual SRP load ($kg\ y^{-1}$)	1.85	19.0	17.2	90
Copperhead Spring (CHS)	annual TP load ($kg\ y^{-1}$)	2.65	5.7	3.1	54
	annual SRP load ($kg\ y^{-1}$)	0.98	3.3	2.3	70
Langle Spring (LLS)	avg base flow TP load ($g\ d^{-1}$)	10.3	23.3	13.0	56
	avg base flow SRP load ($g\ d^{-1}$)	2.21	19.8	17.6	89
Copperhead Spring (CHS)	avg base flow TP load ($g\ d^{-1}$)	1.27	3.55	2.28	64
	avg base flow SRP load ($g\ d^{-1}$)	0.45	2.14	1.69	79
Langle Spring (LLS)	avg storm flow TP load ($g\ d^{-1}$)	112	1448	1336	92
	avg storm flow SRP load ($g\ d^{-1}$)	51.4	1240	1189	96
Copperhead Spring (CHS)	avg storm flow TP load ($g\ d^{-1}$)	445	971	527	54
	avg storm flow SRP load ($g\ d^{-1}$)	175	567	392	69

Quantifying Net P Retention in Karst Drainage. Endmember mixing analysis[23−26] was applied using the "conservative" tracer, K, to explore the net P retention and release along karst hydrological pathways from infiltration through the soil, to spring discharge. First, concentrations of TP and SRP were plotted against K as the "conservative" tracer (Figure 3). Two dominant and distinct sources of spring water (both with different TP, SRP, and K concentrations) are hypothesized (Table SI-1, Supporting Information): (i) a high concentration agricultural endmember source (K_{ag}, TP_{ag}, SRP_{ag}), defined here as the average concentrations (of K, TP, and SRP) in agricultural field runoff at the LL and CH field plots, and (ii) a low concentration (nonagricultural) endmember (K_{na}, TP_{na}, SRP_{na}). As the source of this low concentration runoff could come from a wide range of nonagricultural sources (ungrazed and forest land) across the watershed, the most reliable means of capturing the integrated low-concentration endmember signal was to use the minimum measured spring-water K, TP, and SRP concentrations at LLS and CHS.

A theoretical linear two-component mixing series, i.e, a "conservative mixing line" between the high concentration and low concentration endmembers (Figure 3), would be observed if P behaved conservatively during mixing of the two endmember water sources during transport through the karst. In contrast, the observed relationships between TP and K, and SRP and K, in spring water were highly scattered at LLS and CHS (Figure 3). Most of the samples plot well below the conservative mixing line, showing predominantly net retention of TP and SRP relative to K. A few isolated samples plotted above the conservative mixing line, which are indicative of some sporadic net P release relative to the K tracer. The mixing patterns between TP, SRP, and K concentrations in Figure 3 had a well-defined lower boundary of samples with the lowest P concentrations relative to K (shown in Figure 3 as a "line of maximum P retention"). This line of maximum P retention probably represents a secondary endmember mixing line, between the same low concentration nonagricultural runoff endmember and a secondary agricultural field runoff endmember, with high K but lower P concentrations as a result of P retention processes filtering out P. We posit that the majority of this P was "filtered" out during diffuse recharge of water as through the soil and the epikarst, into the karst aquifer. The spring-water samples which lie between the line of maximum retention and the conservative mixing series therefore likely reflect the *net* effects of P retention and remobilization processes for runoff water entering the karst drainage system via a mixture of diffuse and point recharge.

By comparing the observed spring-water TP and SRP versus K relationships with the theoretical linear conservative mixing series, the *net* effects of P retention and release can be directly quantified (Figure 3). By applying the theoretical conservative mixing series (TP versus K and SRP versus K) to the measured spring-water K concentrations at LLS and CHS, "conservative" TP and SRP concentration time series were derived (Figure SI-3a,b, Supporting Information) and converted to loads, using the corresponding spring flow data. By taking the difference between measured and "conservative" TP and SRP loads, we calculated net TP and net SRP retention on an annual basis, as well as for base flows (lowest 10% of flows) and storm flows (highest 10% of flows) (Table 2).

Annual net TP retention ranged from 69% at LLS to 54% at CHS. Net percentage P retention was consistently higher for SRP compared with TP, not only on an annual basis but also under storm and base flow conditions. This indicated preferential retention of more labile SRP fractions by sorption/uptake and greater mobility of TP organic and particulate P fractions. Similar patterns of soluble and particulate P retention have also been observed in other karst soils and drainage systems.[7,11,13] Highest percentage net P retention occurred during storm events at LLS (92% TP retention and 96% SRP retention). However, the two springs showed very different patterns in P retention under storm and base flow conditions. At LLS, net P retention was greatest during storm flows than under base flow conditions, reflecting a high efficiency of P retention from agricultural runoff at LLS. In contrast, at CHS, a greater percentage of the P load was retained

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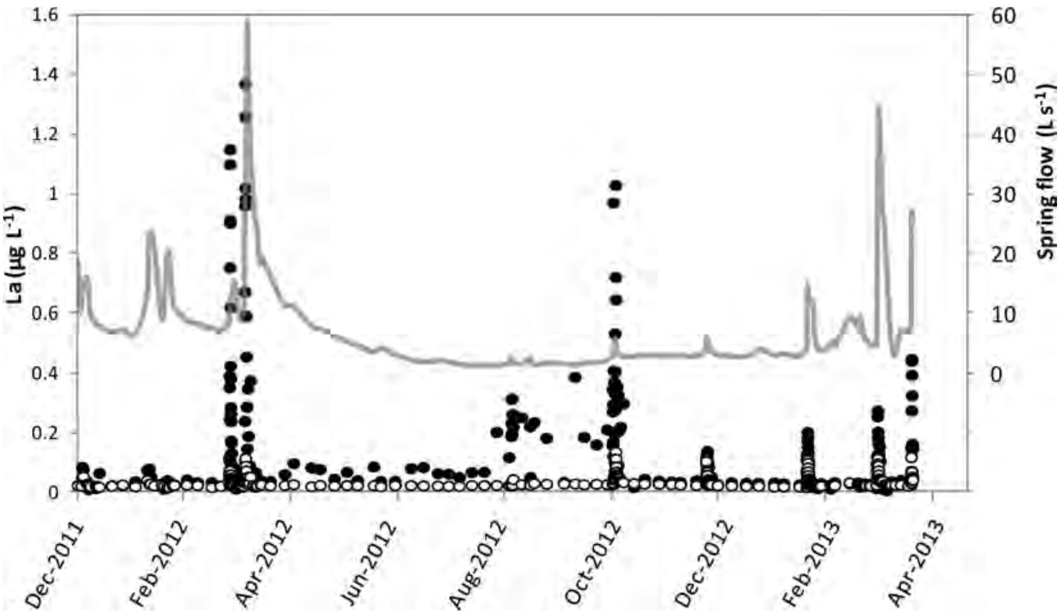

Figure 4. Time series of measured and "conservative" lanthanum (La) concentrations and flow at Langle spring. Measured La concentrations are denoted by solid circles; "conservative" La concentrations are denoted by open circles. See text for explanation of how "conservative" La concentrations were calculated.

under base flow than during storm flow. This reflects much lower base flows at CHS, which increase water residence time and promote particulate sedimentation and P retention, and higher storm flows linked to stream piracy, which provide greater flushing from nonagricultural areas, where flows have a low P concentration.

Contaminant Residence Times in Karst Drainage. While monitoring P relative to a conservative tracer provides us with valuable information on rates of annual and storm flow/base flow net retention, it provides no information about the residence times of P within the karst, or the time scales over which retention and remobilization may occur. This is of strategic concern in relation to the "legacy" of P within watersheds,[42,43] whereby time-lags in release of retained P may mask the effects of conservation measures on receiving water quality. By measuring a full suite of trace elements using ICP-MS, a "serendipitous" observation was made, which may help provide clues about the wider contaminant residence times within the karst drainage. Concentrations of "dissolved" (<0.45 μm) lanthanum (La) in storm flow spring discharge at LLS were more than an order of magnitude higher than could be accounted for by the runoff sources measured within the SEW. Figure 4 shows the concentrations of La in the spring discharge at LLS and a "conservative" (maximum) concentration from runoff, which accounts for the dilution of agricultural runoff during transit through the karst drainage, using K as a tracer. The high storm flow La concentrations observed at LLS are likely a "legacy" signal from a past tracer experiment. In 2001, lanthanum-labeled montmorillonite clays were injected into a losing stream at SEW as part of a study to examine clay and bacterial transport.[44]

While the La tracer was detected at LLS around 16 h after it was injected,[44] our monitoring suggests the La tracer was also retained within the karst drainage system and continues to be remobilized and released during storm events more than 10 years later. Unfortunately, it is impossible to perform a mass balance to quantify how much of the La applied in the tracer study remains within the karst drainage system and how long a La "legacy" might persist, as no La measurements were made in the intervening 10 years between the tracer injection in 2001 and our monitoring which started in November 2011. Within the scope of this study, it was also not possible to determine whether the La concentrations measured were truly dissolved or a <0.45 μm colloidal/clay fraction or whether La geochemistry is sufficiently similar to be used as an indicator of P transport. However, these results indicate that La, a tracer expected to be flushed rapidly through the karst, was retained and continues to be remobilized and released during storm events, more than 10 years later. This indicates the potential for contaminant retention in the subsurface karst drainage system, where contaminant storage and gradual rerelease may occur over time scales of at least a decade.

Wider Implications. Hydrochemical tracers of agricultural runoff allowed us to directly evaluate the nonconservative behavior of P, within karst drainage, and quantify net P retention. Our results challenge the widely held assumption that karst landscapes are always highly vulnerable to P loss and suggest that, in some cases, karst drainage may provide a greater sink for P than previously considered. P from agricultural runoff was attenuated by hydrological dilution from cleaner (nonagricultural) sources during transport through karst drainage. However, there was also a high capacity for net P retention, especially for Langle Spring, which was subject to the highest agricultural P loadings. Here ~70% of the annual TP flux and ~90% of the annual SRP flux was retained. Moreover, the buffering within the soils and karst drainage not only retained a high proportion of incoming fluxes of P from agricultural runoff but preferentially retained the most bioavailable P fractions. For instance, much research has documented the capacity of soil to retain applied P in various inorganic (Al, Fe, Ca complexes) and organic forms of varying stability.[45,46] The long-term accumulation of P in soil, however, can be released slowly to soil water.[28,47]

The mechanisms of P retention were not investigated here but likely include varying combinations of processes including adsorption onto clays, coprecipitation of P with $CaCO_3$, and binding with particulate humic substances[11−13] in the soil, in epikarst, and within the fractures and conduits. These adsorption products and precipitates will be physically retained as the water velocity slows and will be deposited as sediment along the base of the conduit flow paths. With the recurrence of high flow, these sediments are resuspended by turbulent flow and moved along the flow path, until redeposited, or eventually resurged at the base-level spring. Given the potential importance of $CaCO_3$−P coprecipitation for P retention in karst terrain, and the possibility of reductions in the efficiency of this coprecipitation mechanism under higher P and dissolved organic carbon (DOC) concentrations,[12,48,49] further work is needed to examine any unforeseen impacts of increasing agricultural intensification on this "self-cleansing" P retention mechanism. However, in this study, the site with the higher livestock intensity and with higher manure-enriched runoff actually demonstrated greater efficiency of P retention. This may indicate that critical P and DOC thresholds for inhibition of $CaCO_3$ precipitation were not reached or that other P retention process mechanisms were occurring.

The patterns in spring-water La concentrations suggest continued released of La from springs more than 10 years after a tracer injection and indicate the potential for long-term contaminant retention, storage, and subsequent release. Indeed, the complex nature of karst hydrological pathways can result in large distributions in water and contaminant residence times, and lag times for discharge to surface waters may be much longer than expected.[50−52] Our findings indicate that retention of P within karst drainage may reduce the risk of acute episodic storm-driven losses of agricultural P. However, the potential buffering of P in the epikarst, and within the fracture and conduit drainage system, can provide a slow, but long-term, source of P released via springs to surface waters. Further work is needed to determine the ecological impacts of such patterns of P release to receiving streams and the ability of those streams to assimilate those inputs, compared with higher pulse inputs during storm flows.

■ ASSOCIATED CONTENT

Supporting Information

Map of the SEW and the karst water flow system; time series of spring-water TP, SRP, K, and Rb concentrations; table of Ca, TP, and SRP endmember concentrations; soils and geology of the Savoy Experimental Watershed; experimental methods. This material is available free of charge via the Internet at http://pubs.acs.org.

■ AUTHOR INFORMATION

Corresponding Author

*Phone: ++44 (0)1491 838800. Fax: ++44 (0)1491692424. E-mail: hpj@ceh.ac.uk.

Notes

The authors declare no competing financial interest.

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Coupling High-Frequency Stream Metabolism and Nutrient Monitoring to Explore Biogeochemical Controls on Downstream Nitrate Delivery

Helen P. Jarvie,[*,†] Andrew N. Sharpley,[‡] Timothy Kresse,[§] Phillip D. Hays,[∥] Richard J. Williams,[†] Stephen M. King,[⊥] and Lawrence G. Berry[‡]

[†]NERC Centre for Ecology and Hydrology, Wallingford, OX10 8BB, United Kingdom

[‡]Department of Crop Soil and Environmental Sciences, University of Arkansas, Fayetteville, Arkansas 72701, United States

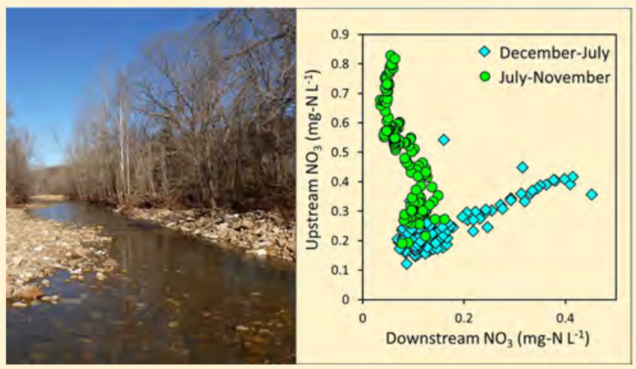
[§]U.S. Geological Survey, Lower Mississippi-Gulf Water Science Center, 401 Hardin Road, Little Rock, Arkansas 72211, United States

[∥]U.S. Geological Survey, Lower Mississippi-Gulf Water Science Center/University of Arkansas, Department of Geosciences, 216 Gearhart Hall, Fayetteville, Arkansas 72701, United States

[⊥]STFC Rutherford Appleton Laboratory, Harwell Campus, Didcot, Oxfordshire OX11 0QX, United Kingdom

S *Supporting Information*

ABSTRACT: Instream biogeochemical process measurements are often short-term and localized. Here we use in situ sensors to quantify the net effects of biogeochemical processes on seasonal patterns in baseflow nitrate retention at the river-reach scale. Dual-station high-frequency in situ nitrate measurements, were coupled with high-frequency measurements of stream metabolism and dissolved inorganic carbon, in a tributary of the Buffalo National River, Arkansas. Nitrate assimilation was calculated from net primary production, and combined with mass-balance measurements, to estimate net nitrification and denitrification. The combined net effects of these instream processes (assimilation, denitrification, and nitrification) removed >30−90% of the baseflow nitrate load along a 6.5 km reach. Assimilation of nitrate by photoautotrophs during spring and early summer was buffered by net nitrification. Net nitrification peaked during the spring. After midsummer, there was a pronounced switch from assimilatory nitrate uptake to denitrification. There was clear synchronicity between the switch from nitrate assimilation to denitrification, a reduction in river baseflows, and a shift in stream metabolism from autotrophy to heterotrophy. The results show how instream nitrate retention and downstream delivery is driven by seasonal shifts in metabolic pathways; and how continuous in situ stream sensor networks offer new opportunities for quantifying the role of stream biota in the dynamics, fate, and transport of nitrogen in fluvial systems.



1. INTRODUCTION

Nutrients, including nitrogen (N), phosphorus (P), and carbon (C) from agriculture and domestic wastewater, are a major source of water-quality impairment.[1] Excessive nutrient inputs to rivers, streams, and lakes can accelerate growth of nuisance and harmful algae. Resulting increases in microbial activity and depletion of dissolved oxygen (DO) have profound negative consequences for invertebrates and fish, potable water supply, and recreation.[2,3] However, biogeochemical processes in streams also play an important role in regulating downstream nutrient transport, with stream biota retaining and removing nutrients from the water column, reducing downstream ecological impacts.[4−6]

Streams can provide a major sink for nitrate (NO_3^-) through uptake (assimilation) by primary production and through denitrification.[7,8] The effectiveness of these processes varies throughout the year and between streams, but conventional methods for estimating NO_3^- uptake are based on relatively few, short-term experimental nutrient additions and isotope measurements,[9−11] making results difficult to extrapolate in space and time.[12] Continuous high-frequency in situ measurements offer new opportunities to explore NO_3^- source dynamics,[13−17] and instream processes have been inferred from single-station diurnal concentration cycles,[12,18,19] longitudinal profiling,[20−23] and nested sensor networks.[24]

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In this study, we used in situ sensors to quantify the net effects of biogeochemical processes on seasonal patterns in baseflow NO_3^- retention at the river-reach scale. The approach employed here is novel because it combines dual-station high-frequency NO_3^- measurements, with high-frequency measurements of stream metabolism (analysis of diurnal DO curves to calculate primary production and respiration), dissolved inorganic carbon (DIC), and excess partial pressure of carbon dioxide ($EpCO_2$), to explore the capacity of instream biogeochemical processes to retain and remove NO_3^-. High-frequency in situ monitoring of water chemistry and streamflow was undertaken along a 6.5 km experimental reach of Big Creek, a tributary of the Buffalo National Scenic River, Arkansas, U.S.A, and were used to calculate a NO_3^- mass balance along the reach. Net primary production was used to calculate NO_3^- assimilation by photoautotrophs. Daily NO_3^- removal rates and rates of NO_3^- assimilation by photoautotrophs were used to calculate net nitrification and denitrification. The biogeochemical controls on NO_3^- removal were then evaluated in relation to wider ecosystem drivers including streamflow, DO, and stream ecological function, to explore how seasonal shifts in metabolic pathways influence instream NO_3^- retention and downstream NO_3^- delivery.

2. MATERIALS AND METHODS

2.1. Site Description and Water-Quality Monitoring. Big Creek, a tributary of the Buffalo National Scenic River, Arkansas (Figure 1), is the subject of detailed water-quality monitoring because of a permitted swine concentrated animal feeding operation (CAFO) within the watershed, in operation since September 2013. The Big Creek watershed lies in the karst terrain of the Ozark Plateau of the midcontinental U.S.A. (Figure 1). The watershed area is 236 km^2, with 79% of the land area deciduous forest, 3% evergreen forest, 14% grassland/pasture, and 3% developed land (see Supporting Information, SI, S1.1). Swine-manure slurry from the CAFO has been land applied to permitted fields since January 1, 2014, in accordance with State regulations.

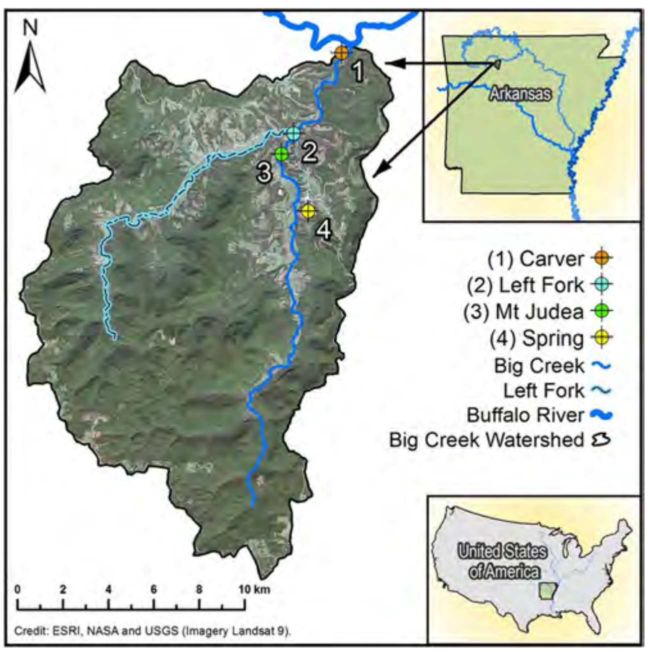

Figure 1. Map of the Big Creek watershed and its location.

The focus of this study is an experimental reach of Big Creek, downstream of the CAFO, from an upstream monitoring station at Mt Judea (USGS site 07055790; watershed area 106 km^2) to a downstream monitoring station at Carver (USGS site 07055814; watershed area 233 km^2), 7.21 and 0.69 km from the confluence between Big Creek and the Buffalo River, respectively (Figure 1). One tributary (Left Fork) enters Big Creek between Mt Judea and Carver. The watershed is a mantled karst terrain characterized by intimate connection between groundwater and surface water; transport of surface-derived nutrients can be rapid[25] (see S1.2).

USGS conducted high-frequency (15 min) NO_3^- monitoring using submersible ultraviolet nitrate probes at Carver (06/03/2014 to 04/29/2017) and Mt Judea (11/01/2014 to 11/01/2015); there was therefore one year of overlapping data (11/01/2014 to 11/01/2015), during which NO_3^- monitoring was undertaken at both Mt Judea and Carver. A water-quality sonde (YSI 6600) operating at Carver simultaneously collected 15 min interval DO, pH, specific conductance, and water temperature data. Further information about the high-frequency water-quality monitoring is provided in S1.3.

Water-quality samples, collected on a weekly basis since 09/12/2013, with additional opportunistic high-flow sampling, at Mt Judea, Left Fork and at a groundwater (spring) monitoring site (Figure 1), provided NO_3^- (by ion chromatography, Dionex ICS-1600); alkalinity (by fixed-end point acidimetric titration to pH 4.5[26]); and conductivity (VWR Symphony B10C) data. All nitrate concentrations are reported as NO_3−N (mg-N L^{-1}). Water-quality data are available at https://bigcreekresearch.org/.

2.2. Stream-Flow Measurements and Hydrograph Separation. Stream flow was measured using established USGS streamflow gauging methods[27] (see S1.4). A two-component mixing model was used to partition the contributions to streamflow from groundwater and surface runoff,[28] using alkalinity as a conservative groundwater tracer (see S1.5).

2.3. Analysis of Diurnal Dissolved Oxygen Curves to Calculate Primary Production and Respiration. The daily average gross primary production, daily average ecosystem respiration and reaeration coefficient were calculated from the series of diurnal DO curves at Carver (see S1.6), using a piecewise solution of the mass balance, DO model[29] simplified for the situation where the deficit does not vary spatially (eq 1): the Delta method.[30,31]

$$dD/dt + k_a D = ER_{av} - GPP_{av}(t) \quad (1)$$

where D is the DO deficit (mg-O_2 L^{-1}), t is the time (days), k_a is the reaeration coefficient, ER_{av} is the ecosystem respiration (mg-O_2 L^{-1} d^{-1}), and GPP_{av} is the gross primary production (mg-O_2 L^{-1} d^{-1}); these are standard measures of ecosystem respiration and gross primary production in river systems.[32]

Odum[33] suggested a classification system of flowing-water communities based on oxygen metabolism by using the ratio of GPP_{av} to ER_{av} (GPP/ER). Respiration is associated with both plant and microbial activity. Photosynthesis is only associated with plants. Autotroph-dominated communities are represented by GPP/ER values >1, whereas heterotroph-dominated communities are represented by GPP/ER values <1.

2.4. Use of the THINCARB Model for Calculating Dissolved Inorganic Carbon Concentrations and Excess

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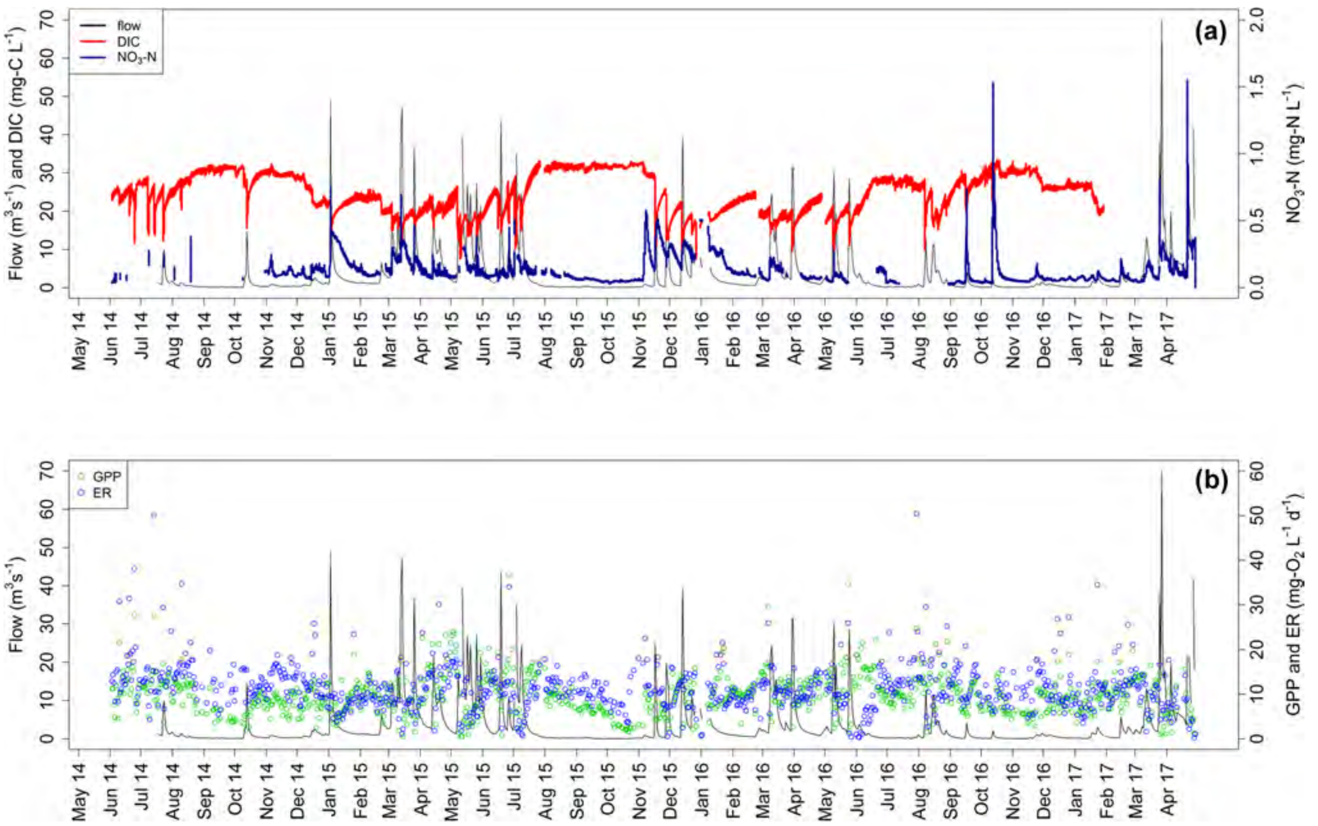

Figure 2. Time series at the downstream monitoring site (Carver), from May 2014 to May 2017, showing: (a) nitrate (NO_3–N), dissolved inorganic carbon (DIC) and streamflow; and (b) daily average gross primary production (GPP), ecosystem respiration (ER), and streamflow.

Partial Pressure of Carbon Dioxide. The THINCARB model (THermodynamic modeling of INorganic CARBon)[34] uses pH, Gran Alkalinity (Alk_{Gran}) and temperature measurements to calculate dissolved inorganic carbon (DIC) concentrations and DIC speciation from the excess partial pressures of carbon dioxide ($EpCO_2$) in freshwaters. THINCARB is open access and is described in detail in Jarvie et al. (2017);[34] an outline is provided in S1.7. Prior to use, alkalinity measurements in units of mg-$CaCO_3$ L^{-1} were first converted to Alk_{Gran} (in μeq L^{-1}), where 1 mg L^{-1} $CaCO_3$ = 19.98 μeq L^{-1}.[34]

THINCARB was applied to the high-frequency sonde data from Carver. Specific conductance was used as a surrogate for alkalinity: using the regression relationship between Alk_{Gran} and specific conductance (κ), measured across the Big Creek watershed, including the spring, and Mt Judea, Left Fork, and Carver stream sites: $Alk_{Gran} = 8.65\ (\pm 0.28) \times \kappa - 6.44\ (\pm 66)$, $R^2 = 0.95$, $n = 270$, $P < 0.001$ (numbers in parentheses represent twice the standard error). By applying this regression equation to the hourly κ series, an hourly alkalinity record was derived, which was then used alongside the hourly pH and water-temperature data, to calculate a high-frequency DIC and $EpCO_2$ series.

2.5. Mass-Balance Calculation of Baseflow Nitrate Fluxes, Instream Losses, and Net Nitrification and Denitrification. Daily mass-balance calculations were undertaken for eight quiescent, low-flow periods (each typically of 1−2 weeks). USGS stream-velocity readings from Carver ranged from 0.457 and 1.22 m s^{-1}, and with a stream distance along the experimental reach of 6.52 km, the travel times ranged from 3.96 to 1.48 h. Therefore, daily mass balances over a 24-h period were assumed sufficient to account for transit of NO_3^-, given: (a) the relatively short travel times; (b) the high degree of stationarity in flux transfers during quiescent baseflow conditions; and (c) that calculated daily mass balances were averaged over a 1−2 week period.

The 15 min NO_3^- measurements at Mt Judea and Carver were converted to daily means, and daily nitrate loads at each site were calculated using the corresponding gauged daily streamflow data. To account for flow accretion along the reach, the difference between the daily flow downstream at Carver, and the upstream site at Mt Judea was calculated. The increase in flows was assumed to be input from Left Fork (Figure 1).

Daily NO_3^- input loading to the reach (L_T) was calculated as the sum of the daily NO_3^- loads from Mt Judea (L_{MJ}) and Left Fork (L_{LF}):

$$L_T = L_{MJ} + L_{LF} \tag{2}$$

There was no high-resolution NO_3^- monitoring on Left Fork, so weekly NO_3^- measurements from grab samples taken at Left Fork were combined with the measured daily flow accretion to derive daily loads from Left Fork (S1.8.1). A sensitivity analysis evaluated the potential effects of under- or overestimating Left Fork NO_3^- concentrations by ±50% (Tables SI1 and SI2).

Within this karst watershed, some of the flow accretion will arise from direct groundwater input into Big Creek. Discharge data were not available from the Left Fork tributary, and direct apportionment of contributions from Left Fork and groundwater was not possible. We therefore evaluated a second, alternative "endmember" case scenario whereby all of flow

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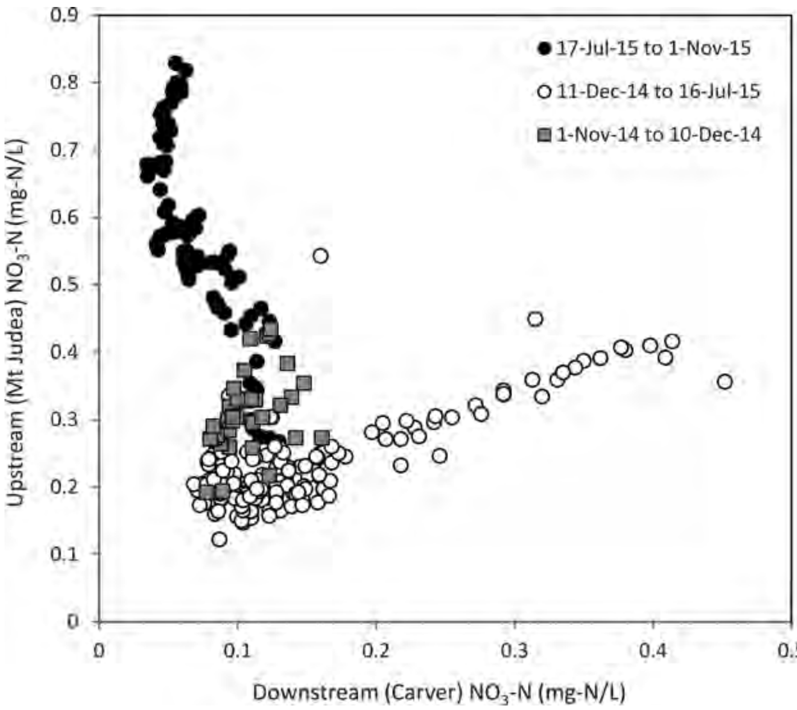

Figure 3. Scatter plot showing the relations between mean daily nitrate concentrations upstream at Mt Judea and downstream at Carver.

accretion was attributed to direct groundwater contribution (S1.8.2).

The daily instream NO_3^- load removal (L_R) along the reach was calculated as the difference between the daily input NO_3^- loading (L_T), and the daily NO_3^- load at Carver (L_C):

$$L_R = L_T - L_C \tag{3}$$

To allow direct comparison with rates of assimilatory NO_3^- uptake by photosynthesis, L_R (kg-N d^{-1}) was then converted to a daily NO_3^- removal rate, U_T (mg-N L^{-1} d^{-1}). U_T incorporates both assimilatory NO_3^- uptake by photo-autotrophs (U_A), heterotrophic NO_3^- removal through direct uptake and denitrification (U_D), and NO_3^- enrichment due to remineralization via nitrification (R):[20]

$$U_T = U_A + U_D - R \tag{4}$$

U_A was estimated from the GPP_{av} measurements.[12,35] GPP_{av} data were converted into net primary production (NPP), assuming that autotrophic respiration consumed 50% of the GPP_{av}.[36,37] NPP data were then converted from units of O_2 uptake (mg-O_2 L^{-1} d^{-1}) to C uptake (mg-C L^{-1} d^{-1}), with a photosynthetic quotient of 1.00, then converted to NO_3^- uptake (mg-N L^{-1} d^{-1}), using a molar ratio of C:N of 12.[38] Subtracting U_T from U_A provides a measure of either net nitrification (positive values) or net heterotrophic NO_3^- removal through direct uptake and denitrification, hereafter referred to as "net denitrification" (negative values). When the river was influent, loss of NO_3^- to groundwater was accounted for, as described in S1.8.3.

3. RESULTS AND DISCUSSION

3.1. Three-Year Time Series of Nitrate, Dissolved Inorganic Carbon and Stream Metabolism. The hourly NO_3^- and DIC concentrations variations at Carver were driven by streamflow, but in opposing directions (Figure 2a). The mean and median NO_3^- concentrations were 0.128 and 0.093 mg-N L^{-1}, respectively. Nitrate concentrations at Carver were lowest during baseflow (mean 0.043 mg-N L^{-1}; lowest 10% of flows) and highest during storm runoff (mean 0.278 mg-N L^{-1}; highest 10% of flows), arising from nonpoint-source mobilization and delivery of NO_3^- during rainfall events.

The mean and median DIC concentrations were 24.8 and 25.2 mg-C L^{-1}, respectively. DIC concentrations were highest during baseflow (mean 31.7 mg-C L^{-1}), with DIC concentrations diluted by storm runoff (mean 13.2 mg-C L^{-1}). Highest DIC and lowest NO_3^- concentrations occurred during the extended low-flows between August and November 2015.

The mean and median molar C:N ratios were 356 and 305, respectively. The mean C:N ratio during baseflow was 882, and 82 during stormflow. C:N ratios greater than ~6.6 are indicative of stoichiometric depletion of N relative to C.[39] Absolute NO_3^- concentrations below ~0.1 mg-N L^{-1} are deemed likely to be limiting to algae, with algal growth response to NO_3^- enrichment occurring between 0.38 to 1.79 mg-N L^{-1}.[40] Therefore, under average and baseflow conditions at Carver, a clear potential exists for algal growth to be limited by low NO_3^- availability.

No longer-term trends in either NO_3^- or DIC were observed over the three years. These high-frequency monitoring results are consistent with results from near-weekly water-quality monitoring of Big Creek at Mt Judea, which showed no statistically significant increasing or decreasing trends in dissolved or particulate forms of P and N concentrations since 2013.[41]

Earlier studies[6] have shown that Ozark streams can be very effective at retaining available nutrients, and buffering additional nutrient inputs. Therefore, the absence of any increasing trend in nutrients in the water column may result from the rapid and efficient uptake of nutrient inputs by stream biota. Consequently, high-resolution stream metabolism and nutrient measurements were used here to detect whether increased photosynthesis or respiration rates resulted from increased

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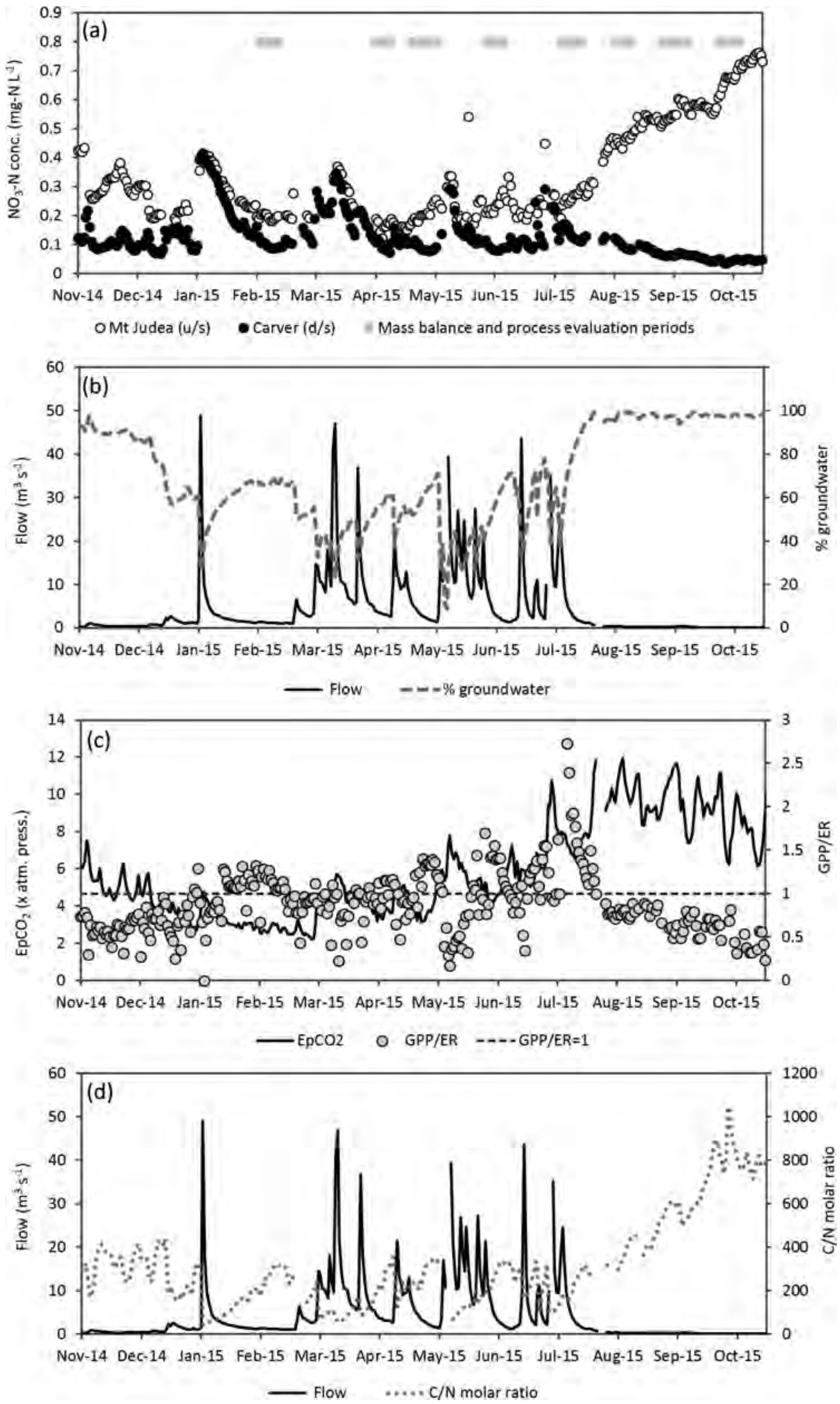

Figure 4. Time series from 1 November 2014 to 1 November 2015, showing: (a) Nitrate concentrations upstream at Mt Judea and downstream at Carver, and the lower-flow time periods used for mass balance calculation and evaluation of biogeochemical processes; (b) streamflow at Carver and the percentage groundwater contribution to streamflow; (c) daily ratio of gross primary production: ecosystem respiration (GPP/ER) downstream at Carver (horizontal dashed line shows GPP/ER of 1, i.e., balance between heterotrophy and autotrophy), and excess partial pressure of carbon dioxide ($EpCO_2$); and (d) streamflow and the molar C:N ratio (DIC, dissolved inorganic carbon/NO_3−N) downstream at Carver.

nutrient assimilation, even where no increases in water-column nutrient concentrations could be observed.

The time series in daily rates of GPP_{av} and ER_{av}, at Carver (Figure 2b), showed no definitive long-term trends between

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Table 1. Seasonal Patterns in Mean Daily NO_3^- Input Loadings (L_T) to Big Creek, Mean Daily Instream NO_3^- Load Removal (L_R) along the 6.5 km Experimental Reach, Under Low-Flow Conditions, and Mean Daily NO_3^- Load Removal As a Percentage of NO_3^- Inputs (U_E)[a]

season	date range	NO_3^- input loading to reach (L_T) (kg-N d^{-1})	instream NO_3^- removal along reach (L_R) (kg-N d^{-1})	instream NO_3^- removal (L_R) as % of NO_3^- input loading (L_T) (U_E)
winter	4–13 Feb 2015	17.3 (1.12)	7.68 (0.46)	44.7 (4.09)
spring 1	5–12 Apr 2015	44.1 (6.35)	19.0 (2.82)	43.9 (9.53)
spring 2	24 Apr–5 May 2015	37.9 (15.3)	16.9 (3.85)	47.6 (8.93)
early summer	2–10 Jun 2015	49.2 (23.6)	24.1 (8.54)	51.2 (5.34)
mid summer	11–21 Jul 2015	61.7 (44.2)	14.6 (2.82)	32.1(14.1)
late summer	7–16 Aug 2015	7.56 (1.22)	5.57 (0.59)	74.2 (4.66)
autumn 1	1–14 Sept 2015	5.81 (1.23)	4.49 (0.81)	77.8 (2.39)
autumn 2	1–11 Oct 2015	2.98 (0.29)	2.82 (0.25)	94.8 (1.20)

[a]Standard deviations are shown in parentheses.

2014 and 2017. GPP_{av} declined rapidly in response to major storm runoff events, but typically recovered within a couple of weeks. Highest GPP_{av} tended to occur during quiescent baseflow or recessional streamflow conditions during the summer (May through August). Both GPP_{av} and ER_{av} declined during the autumn (September through December), reflecting reductions in stream biological activity, and GPP_{av} tended to decline at a faster rate than ER. This was particularly apparent during the extended low-flows between August and December 2015, suggesting a decline in primary production relative to microbial activity and a transition from net autotrophic to net heterotrophic stream communities. During winter baseflows (November through January), ER_{av} tended to exceed GPP_{av}. During the 3-yr monitoring, no CAFO-related impacts on either stream nutrient concentrations or metabolism are discernible at Carver.

3.2. Temporal and Spatial Variability in NO_3^- Concentrations, Relative to Other Key Environmental Variables. Mean daily NO_3^- concentrations varied between baseflow and storm events at Mt Judea and Carver, during the one year of overlapping data (Figure 3). There was a clear differentiation between a higher-flow period characterized by regular storm events from mid-December 2014 to mid-July 2015, and lower-flow conditions from August to November/December 2015 (Figures 3 and 4).

During the higher-flow period, a positive correlation existed between upstream (Mt Judea) and downstream (Carver) NO_3^-, with a ratio approaching 1 (Figure 3). During this high-flow period, NO_3^- concentrations at both upstream and downstream sites ranged between ~0.1 and ~0.4 mg-N L^{-1}. Time series data show close convergence between upstream and downstream NO_3^- concentrations during storm-event peak concentrations (Figure 4a,b).

Under lower-flow conditions, NO_3^- concentrations were consistently higher upstream than downstream (Figure 3). The increase in NO_3^- concentrations at the upstream site during the summer and autumn 2015 corresponds with reductions in flow. This is typical of the longer-term hydrologically driven cycles in NO_3^- concentrations observed at the upstream site, reflecting a strong flow dependency, with highest concentrations under the lowest flows, and dilution with increasing flow (Figure SI1a,b,c). The strong increase in NO_3^- concentrations during July to November 2015 therefore reflects hydrological controls, and is consistent with falling flows. The high NO_3^- concentrations in autumn 2015 subsequently declined with the onset of higher flows (Figure SI1a,b).

The gap in NO_3^- concentrations between upstream and downstream sites widened with decreasing flow, particularly during the protracted low-flows between mid-July and November 2015. During this time, minimal soil water contributed to streamflow, and almost all (>95%) of streamflow was derived from groundwater (Figure 4a,b). By the end of October 2015, upstream NO_3^- concentrations reached ~0.75 mg-N L^{-1}, whereas downstream NO_3^- concentrations were ~0.05 mg-N L^{-1}. Between July and November 2015, downstream NO_3^- concentrations exhibited a much lower range (~0.05 to ~0.15 mg-N L^{-1}) as compared with upstream (~0.1 to ~0.8 mg-N L^{-1}) (Figure 3). This reduction in both magnitude and range of downstream NO_3^- concentrations under baseflow conditions could arise either from dilution of NO_3^-, as a result of downstream accretion of water sources with much lower NO_3^- concentrations, or by removal of NO_3^- through biogeochemical processes, necessitating a mass-balance evaluation (see section 3.3).

The widening gap in NO_3^- concentrations between upstream and downstream sites after mid-July 2015 corresponded with a decline in GPP/ER, which fell below 1, indicating a change to net heterotrophy (Figure 4c). During the low-flow period from mid-July to November 2015, Big Creek was heterotrophic for ~90% of days. Daily streamwater $EpCO_2$ doubled between mid-July and November 2015, from 4.5 to 9.1 times atmospheric pressure, independently confirming an increase in rates of respiration (CO_2 release), relative to photosynthesis (CO_2 uptake).

During the higher-flow period from mid-January to mid-July, Big Creek was predominantly net autotrophic (GPP/ER > 1 for 52% of days). Net heterotrophic conditions prevailed predominantly during lower-flow intervals between storm events, with GPP/ER < 1 typically during and immediately after storm events.

Molar C:N ratios at Carver also increased markedly after mid-July, from ~300 to >800 (Figure 4d). This stoichiometric depletion of N, along with persistence of low NO_3^- concentrations below 0.1 mg-N L^{-1} (falling to <0.04 mg-N L^{-1}), suggests that algal growth may have been limited by low N availability at Carver over the late summer and autumn of 2015.

3.3. Nitrate Reach Mass Balance to Quantify Seasonal Nitrate Removal during Baseflow Conditions. Mean daily NO_3^- mass balances for the eight seasonal quiescent baseflow periods between February and October 2015 are presented in Table 1. Mean daily NO_3^- input loadings to the reach (L_T) increased from 17.3 kg-N d^{-1} in February to 61.7 kg-N d^{-1} in

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Table 2. Seasonal Patterns in Mean Daily NO_3^- Removal Rate (U_T) along the 6.5 km Experimental Reach of Big Creek, Under Low-Flow Conditions, And Mean Daily Assimilatory Uptake of NO_3^- by Photoautotrophs (U_A)[a]

season	date range	instream NO_3^- removal rate (U_T) (mg-N L^{-1} d^{-1})	assimilatory NO_3^- uptake (U_A) (mg-N L^{-1} d^{-1})
winter	4−13 Feb 2015	0.077 (0.006)	0.212 (0.035)
spring 1	5−12 Apr 2015	0.072 (0.017)	0.256 (0.050)
spring 2	24 Apr−5 May 2015	0.082 (0.018)	0.355 (0.067)
early summer	2−10 Jun 2015	0.090 (0.014)	0.269 (0.045)
mid summer	11−21 Jul 2015	0.066 (0.030)	0.259 (0.040)
late summer	7−16 Aug 2015	0.284 (0.026)	0.180 (0.016)
autumn 1	1−14 Sept 2015	0.229 (0.019)	0.115 (0.038)
autumn 2	1−11 Oct 2015	0.656 (0.029)	0.076 (0.028)

[a]Standard deviations are shown in parentheses.

Table 3. Seasonal Patterns in Mean Daily NO_3^- Concentration Gains by Net Nitrification (+) and Losses by Net Denitrification (−) long the Experimental Reach of Big Creek, under Low-Flow Conditions; Mean Daily Values of the Ratio between Gross Primary Production and Ecosystem Respiration (GPP/ER); Excess Partial Pressure of Carbon Dioxide ($EpCO_2$); Dissolved Oxygen (DO); Streamflow; and the Percentage of Groundwater Contribution to Streamflow[a]

season	date range	net nitrification (+) or denitrification (−) (mg-N L^{-1} d^{-1})	GPP/ER	$EpCO_2$ (× atm. press.)	DO (mg-O_2 L^{-1})	flow (m^3 s^{-1})	% groundwater
winter	4−13 Feb 2015	+0.135 (0.032)	1.14 (0.09)	2.80 (0.20)	11.9 (0.49)	1.15 (0.07)	66.5 (1.34)
spring 1	5−12 Apr 2015	+0.184 (0.039)	1.06 (0.13)	3.64 (0.20)	10.2 (0.33)	3.10 (0.37)	58.6 (2.38)
spring 2	24 Apr -5 May 2015	+0.273 (0.058)	1.25 (0.16)	3.81 (0.59)	10.3 (0.50)	2.61 (1.16)	61.7 (5.79)
early summer	2−10 Jun 2015	+0.179 (0.044)	1.34 (0.15)	4.71 (0.49)	9.39 (0.42)	3.30 (1.72)	58.0 (6.48)
mid summer	11−21 Jul 2015	+0.193 (0.024)	1.97 (0.78)	7.15 (0.46)	8.98 (0.29)	2.54 (1.28)	82.8 (7.21)
late summer	7−16 Aug 2015	−0.104 (0.032)	0.78 (0.05)	10.6 (0.83)	6.95 (0.35)	0.23 (0.04)	98.8 (0.98)
autumn 1	1−14 Sept 2015	−0.102 (0.027)	0.62 (0.10)	9.85 (1.65)	6.50 (0.54)	0.24 (0.06)	96.6 (1.42)
autumn 2	1−11 Oct 2015	−0.592 (0.015)	0.57 (0.23)	8.17 (1.50)	7.85 (0.64)	0.04 (0.004)	97.8 (0.64)

[a]Standard deviations are shown in parentheses.

July, then declined rapidly to 7.56 kg-N d^{-1} in August, which also corresponded with an order of magnitude reduction in baseflow discharge. By October, L_T had fallen to only 2.98 kg-N d^{-1}. Instream NO_3^- removal (L_R) followed a similar pattern to L_T, with highest mean daily instream NO_3^- removal during June (24 kg-N d^{-1}), then decreasing during the late summer and autumn, and falling to 2.82 kg-N d^{-1} in October. However, the efficiency of instream NO_3^- removal (U_E, i.e., L_R expressed as a percentage of L_T) increased markedly during the late summer and autumn, from 32% in July to 74−95% between August and October.

The fluvial mass balance therefore confirmed that the observed downstream reductions in NO_3^- concentrations under baseflow were a result of net instream removal of NO_3^- by biogeochemical processes, rather than a dilution effect.

Although L_T and L_R were greatest during the winter to early summer period, U_E and the instream NO_3^- removal rate (U_T) increased dramatically during the low flows of the late summer and autumn; U_T increased from ≤0.09 mg-N L^{-1} d^{-1} (February through July), to >0.2 mg-N L^{-1} d^{-1} in August and September, and 0.66 mg-N L^{-1} d^{-1} in October (Table 2). By autumn 2015, >75% of the NO_3^- inputs were removed by biogeochemical processes (Table 1).

We also assessed the efficiency of NO_3^- removal under the alternative scenario, where the increase in flow along the experimental reach was solely from direct groundwater input (S1.6.2). This made relatively little difference to the U_E, which also increased markedly during the late summer and autumn, from 46% in July to 72−94% between August and October (Table SI3). The sensitivity analysis (Tables SI1 and SI3) showed that a 50% increase or decrease in either Left Fork or groundwater NO_3^- concentrations made little difference to these findings: a consistent increase in efficiency of NO_3^- removal was observed after July, with August to October U_E values consistently ∼70−95%.

3.4. Biogeochemical Controls on Nitrate Delivery: Accounting for Assimilatory Nitrate Uptake to Calculate Net Nitrification and Net Denitrification. From February to July, assimilatory NO_3^- uptake by photosynthesizing plants (U_A) consistently exceeded U_T (Table 2) indicating, first, that assimilation of NO_3^- by photoautotrophs was the dominant process removing NO_3^- from the water column; and second that assimilation was partially balanced by net nitrification NO_3^- gains. In contrast, from August to October, U_T exceeded U_A, indicating that heterotrophic NO_3^- removal through direct uptake and denitrification was removing NO_3^- along the reach in late summer and autumn.

Table 3 shows that net nitrification gains to the reach ranged from 0.135 mg-N L^{-1} d^{-1} in February to 0.273 mg-N L^{-1} d^{-1} in April/May. However, after July, a pronounced switch from net nitrification gains to net denitrification losses occurred. During late summer and autumn, denitrification losses of NO_3^- increased from ∼0.100 mg-N L^{-1} d^{-1} in August and September to 0.592 mg-N L^{-1} d^{-1} in October. These estimates were based on using an average periphyton C:N molar ratio of 12 for U.S.A. streams.[35,38] We also evaluated the effects of using an average periphyton molar C:N ratio of 8.6, from research in northern European streams.[17] This increased U_A values by ∼39%, but did not alter our findings of a switch between net nitrification between February and July, to net denitrification from August to October. By changing the C:N stoichiometry from 12 to 8.6, net nitrification ranged from

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+0.218 mg-N L^{-1} d^{-1} in February to +0.414 mg-N L^{-1} d^{-1} in April/May, with net denitrification ranging from −0.033 mg-N L^{-1} d^{-1} in August to −0.562 mg-N L^{-1} d^{-1} in October.

Net nitrification and denitrification rates were compared with mean daily GPP/ER, $EpCO_2$, streamflow and percentage groundwater discharge (Table 3). The shift from net nitrification to net denitrification corresponded directly with (1) a change in stream metabolism from net autotrophic (GPP/ER in July was 1.97) to net heterotrophic (GPP/ER fell below 1, to 0.78 in August, 0.62 in September, and 0.57 in October); and (2) an increase in $EpCO_2$ and a reduction in DO arising from the increases in microbial respiration relative to photosynthesis.

The alternative scenario where flow accretion between Mt Judea and Carver was attributed to direct groundwater discharge to Big Creek also had no effect on the timing of the shift from net nitrification to denitrification (S1.6.2, Table SI4). Sensitivity analysis (Tables SI2 and SI4) also showed that, irrespective of a 50% increase or decrease in either Left Fork or groundwater NO_3^- concentrations, the same consistent switch between net nitrification and net denitrification was observed after July.

The consistency in this observed switch between instream NO_3^- production and instream NO_3^- removal, and its synchronicity with measured changes in stream metabolism, provides compelling evidence that the marked change in instream NO_3^- processing and delivery after July was linked to changes in stream metabolism from net autotrophy to net heterotrophy.

The karst streams of the Ozarks are characterized by a large hyporheic zone,[42,43] a hotspot of nitrogen transformation.[44] Water residence times and redox conditions provide a key control on changes between NO_3^- removal and NO_3^- production with hyporheic zone sediments.[45−48] In Big Creek, the winter to midsummer period was characterized by higher baseflows (at least an order of magnitude greater than late summer/autumn baseflows), and net autotrophy resulting in higher instream DO concentrations. Rapid movement of well-oxygenated water throughout the water column, and into the hyporheic zone, promotes aerobic metabolism of organic matter and release of NO_3^- through nitrification.[46,49] From winter to midsummer, net nitrification was observed in Big Creek, and nitrification in the hyporheic zone may have been responsible for buffering the effects of photosynthetic assimilatory uptake of NO_3^-.

Under the more sluggish flow conditions during late summer and autumn, available oxygen is depleted as a result of increased heterotrophic activity. The reduced movement of water and oxygen through the hyporheic zone favors a shift to respiratory pathways with denitrification (conversion of nitrate to N_2O and/or N_2 gas).[50,51] Unlike assimilation of NO_3^- into plant biomass, which retains N temporarily, denitrification results in a permanent loss of bioavailable N. The low baseflows of late summer and autumn 2015, resulted in higher water residence times and a greater proportion of flow moving through the hyporheic zone. This provides greater exposure and water contact time with microbial biofilms where denitrification occurs.[51] The death and breakdown of biomass during the late summer and autumn contribute to the availability of organic matter for microbial decomposition, promoting higher rates of microbial respiration relative to photosynthesis, losses of DO, and greater availability of organic carbon as a resource for denitrifying bacteria.[45,52,53] Denitrification within the hyporheic zone may therefore be responsible for losses of NO_3^- in Big Creek during the late summer and autumn. Although denitrification can also occur on suspended sediments within the water column,[54,55] this is likely to be a second order effect under baseflow conditions in a groundwater-fed stream, where suspended solids concentrations are low (typically <5 mg L^{-1}).

Under baseflow conditions, instream assimilatory NO_3^- uptake by photosynthesizing plants and hyporheic-zone denitrification along the experimental reach removed between ∼30 and ∼90% of the NO_3^- input load. During the period of monitoring (spring 2014 to spring 2017) NO_3^- loading to the upstream section of Big Creek (at Mt Judea) was attenuated by instream processing such that no CAFO-related impacts on either stream nutrient concentrations or metabolism were discernible at the downstream location (Carver), and thus, to the Buffalo River. Future monitoring will be needed to detect whether long-term changes in nutrients and organic carbon inputs may occur, whether this stimulates higher rates of heterotrophic and/or autotrophic activity, and any longer-term effects on the capacity of assimilation and denitrification processes to remove and buffer any increase in nutrient loadings.

The novelty of this research is the combination of continuous, high-frequency in situ stream metabolism and nitrate measurements, to apportion the net effects of assimilation, nitrification, and denitrification on changes in baseflow nitrate fluxes at the river-reach to watershed scale. In this case, we found that, during winter to midsummer periods, NO_3^- uptake in Big Creek was dominated by assimilation by photoautotrophs, which was partially compensated by release of NO_3^- from nitrification. In late summer, the predominant metabolic pathway switched to net heterotrophy and heterotrophic NO_3^- removal through direct uptake and denitrification became the dominant process of nitrate removal. Removal of NO_3^- by assimilation and denitrification provides an important "self-cleansing" ecosystem service, resulting in a pronounced shift in C:N stoichiometry and decreasing NO_3^- concentrations to low levels which would be expected to limit algal growth.[56]

This approach provides a means of scaling up, from microscale and mesoscale process experiments and measurements, which are, by necessity, short-term and localized, to explore how river nitrate delivery responds to shifts in stream metabolism, from day-to-day and seasonal to interannual variability. This research, and the methods presented here, are applicable along the river continuum, from headwaters to large-scale fluvial systems (with large spatial and temporal variability in nutrient fluxes), and offer a valuable way forward in quantifying net process controls on the fate and transport of nitrogen in fluvial systems.

■ ASSOCIATED CONTENT

Ⓢ Supporting Information

The Supporting Information is available free of charge on the ACS Publications website at DOI: 10.1021/acs.est.8b03074.

S1, Methods: Land use and cover data; site hydrogeology; high-frequency water-quality monitoring; streamflow measurement; hydrograph separation; analysis of diurnal dissolved oxygen curves to calculate primary production and respiration; calculation of DIC and $EpCO_2$; nitrate mass-balance calculations; and S2, Results: Figure SI1 time series of nitrate and flow and nitrate plotted against stream flow for Mt Judea; Tables SI1 and SI2, sensitivity analysis based on estimates of NO_3^- load inputs from Left Fork; Tables SI3 and SI4, alternative scenario sensitivity analysis based on estimates of NO_3^- load inputs from groundwater; and additional references (PDF)

AUTHOR INFORMATION

Corresponding Author

*E-mail: hpj@ceh.ac.uk.

ORCID

Helen P. Jarvie: 0000-0002-4984-1607

Phillip D. Hays: 0000-0001-5491-9272

Notes

The authors declare no competing financial interest.

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E. COLI IN FLOWING WATERS

Mary Savin and BCRET members

I. Why is *Escherichia coli* (*E. coli)* being monitored? What is the concern?

Fecal pollution (from excrement of humans or animals) in the environment is of concern for many reasons, not least of which is human health risks and disease control. Other concerns related to fecal pollution of our natural waters include potential changes in the nutrient status of water, introduction of antibiotic resistance and chemical contaminants, changes in the ecological condition of waters, and degradation of natural resources on which rural economies depend.

People are concerned that the land application of swine effluent (pig excrement) will increase *Escherichia coli* in Big Creek and consequently, the Buffalo River, the first National Scenic River in the U.S. This document aims to provide better understanding of

1) what is involved in *E. coli* monitoring;
2) what the numbers mean;
3) some limitations in interpreting values; and
4) provide a context for further research that may be needed to better interpret the *E. coli* numbers being measured in flowing waters such as Big Creek and Buffalo River.

II. What is *E. coli*? Why and how is it used as an indicator?

E. coli is a species of bacteria from the coliform group - bacteria that are rod-shaped, gram negative, non-spore forming facultative anaerobes, commonly found in the feces of humans and warm blooded animals. *E. coli* occurs in human intestines - many strains with no ill effects, although certain *E. coli* cause serious human illnesses. Thus, while many *E. coli* do not harm us, there are important variants that do. There are also other species of bacteria, viruses, and other small organisms that cause disease, which if present in fecal sources polluting our waters, can make humans sick. Depending on whether *E. coli* survive as long in the environment as these other pathogens, *E. coli* may or may not adequately warn us about a disease causing agent in our waters. To date, *E. coli* is the most reliable test we have, although other indicators and tests are being investigated.

E. coli cannot be seen in streams by the human eye. Thus, it is important to determine if there is a problem of elevated *E. coli* numbers by careful water sampling and using U.S. Environmental Protection Agency (EPA) standardized methods. *E. coli* is counted in water because of the extensive studies and relationships established between the presence of *E. coli* and the number of human illnesses occurring from contact with the water (e.g. swimming) containing the bacteria. From these relationships, there have been upper limits established for bacterial numbers that correspond to the acceptable risk of people getting sick from exposure to water containing them.

Water quality standards for *E. coli* are established by the state in Arkansas Department of Environmental Quality (ADEQ) Regulation 2 (see Table 1). The *E. coli* numbers must remain below a threshold in a specified number of total samples collected. The exact upper limit that is allowed depends on the designation of the waterbody and time of year (primary or secondary contact season). ***Primary***

Table 1. Upper limits for *Escherichia coli* counts defined in Regulation 2 of the Arkansas Department of Environmental Quality (ADEQ) as specified by contact season and waterbody designation for both single samples and geometric mean.

Contact season	Water designation	Limit of *E. coli* (MPN/100mL)	
		Single sample[1]	Geometric mean[2]
Primary (May 1-Sept. 30)	Extraordinary Resource Water Ecologically Sensitive Waterbody Natural & Scenic Waterway Lakes Reservoirs	298	126
	All other water	410	NA[3]
Secondary (Oct. 1-April 30)	Extraordinary Resource Water Ecologically Sensitive Waterbody Natural & Scenic Waterway Lakes Reservoirs	1490	630
	All other water	2050	NA

[1] No more than 25% of samples from no less than 8 samples per contact season may exceed the limit

[2]Geometric mean is calculated from at least 5 samples collected within 30 days at evenly spaced time intervals during that 30-day period

[3]Not applicable

contact recreation is a designation given to a waterbody where full body contact occurs and occurs from May 1 through September 30. The ADEQ also designates any stream with a watershed (e.g. drainage basin in the landscape) exceeding 10 square miles and those with smaller watersheds on individual cases (i.e. after site verification) for primary contact recreation. *Secondary contact recreation* designates waterbodies where activities such as boating, fishing, and wading take place and occurs from October 1 through April 30.

E. coli is measured in samples of water collected strictly following EPA guidelines. The measurement of *E. coli* starts within 8 hours of collection. This method provides an estimate of *E. coli* presence in the sampled water that is the most probable number (MPN) of *E. coli*. Using an EPA method provides numbers that are theoretically comparable to other labs using the same method. The MPN depends on growing bacteria in the laboratory in “culture” and is an approach used routinely in microbiology. This measurement is subject to high variability because of the nature of environmental bacteria; thus, variability in the data in *E. coli* counts from streams is not unusual. For this reason, it is important to establish background levels of *E. coli* in any water resulting from various wildlife, human (e.g., septic tanks, sewers), and agricultural (e.g. pig, chicken, cattle) sources.

E. coli thresholds are lower in late spring through summer (primary contact season) when more people are expected to be in contact with streams and lakes. More stringent limits also apply to Extraordinary Resource Waters (e.g., Buffalo River), Ecologically Sensitive Waterbodies, and Natural Scenic Waterways. During the primary contact season (May 1- Sept. 30), we do not want *E. coli* to exceed 298 MPN/100 mL, and during secondary contact season (Oct. 1 – Apr. 30) *E. coli* counts should not exceed 1490 MPN/100 mL in single samples.

III. How does the *E. coli* measurement "fit" into the context of the landscape?

While monitoring one bacterial species to assess the biological quality of water may seem simple, determining the actual ecological condition of a system is complicated. Measurement of *E. coli* is an indicator for potential fecal pollution and potential pathogen problems, but by itself, does not identify the source(s) of the bacteria.

E. coli is present in intestines (and feces) and is not supposed to grow in the environment; thus, the presence and abundance should indicate pollution and be directly related to human and animal sources. However, because *E. coli* is in many different animals (e.g. human, wildlife, agricultural) and because of the different pathways that bacteria may travel throughout the environment before ending up in water where we can measure it, the presence of *E. coli* does not identify the source of pollution.

IV. Why is *E. coli* monitoring important and why is it complicated?

There are many of factors that affect whether *E. coli* survives in the environment, for how long, and whether it moves to other locations. *E. coli* is adapted to living in intestines. After deposition from an animal, cells have to survive rapidly changing environmental conditions (e.g. temperature and moisture), exposure to harmful UV rays in sunlight, outcompete other organisms, and avoid predators. All these factors make it difficult to estimate how long *E. coli* will survive in lagoon, soil, and river environments. However, there is evidence that *E. coli* can persist in soil and sediments.

V. What are the numbers?

E. coli is measured weekly in Big Creek upstream and downstream of the C&H Farm, Mt. Judea, Newton County, Arkansas. Water sample collection for *E. coli* analysis began Sept 12, 2013, prior to manure from C&H Farm application to fields, either in fields adjacent to or distant from Big Creek. Manure application began in 2014 to fields distant from Big Creek, and then adjacent to Big Creek in March 2014. So far in the period following manure applications by C&H Farms (Jan 2 through May 19, 2014), no trends in *E. coli* with time or between sampling locations are apparent (Table 2).

The Table 2 data are detailed in the Big Creek Research and Extension Team Quarterly Reports and demonstrate the week-to-week variability in *E. coli* at upstream and downstream sites. The *E. coli* counts are expected to continue to be variable. Clearly, it is important to quantify the variability in *E. coli* concentrations long-term in order to determine if changes occur as a result of C&H operation.

The MPN is expected to increase with increases in flow, and the recent installation of a USGS gauge to measure flow will allow for the determination of the relationship between measured flow in the stream and *E. coli* concentrations. Because of the dangers during high flows, most contact recreation is expected during base flow, and thus sampling during base flow may provide more meaningful data.

Table 2. Geometric mean of *E. coli* (and range of sample MPN) before (Sept 12 - Dec 17, 2013) and after manure applications began on the C&H Farm (Jan 2 - May 19, 2014).

C&H location	Before any manure application	After manure application
	Sept. 12 - Dec. 17, 2013	Jan. 2 - May 19, 2014
	(MPN/100mL)	
Upstream	82 (6 – 4080)	83 (ND[a] – 921)
Downstream	111 (5 – 3500)	39 (ND – 1553)

[a]Not detected.

Regulation

Arkansas Pollution Control and Ecology Commission # 014.00-002 2014. Regulation Establishing Water Quality Standards for Surface Waters of the State of Arkansas as revised, effective March 24, 2014. Arkansas Department of Environmental Quality (ADEQ). Available at http://www.adeq.state.ar.us/regs/files/reg02_final_140324.pdf. Last accessed 20 Aug 2014.

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Research Letter

Nutrient Concentrations in Big Creek Correlate to Regional Watershed Land Use

A. N. Sharpley,* B. E. Haggard, L. Berry, K. Brye, J. Burke, M. B. Daniels, E. Gbur, T. Glover, P. Hays, T. Kresse, and K. W. VanDevender

Core Ideas

- Nutrient concentrations are low at Big Creek relative to expected biological-response thresholds.
- Nutrient concentrations at Big Creek are typical of streams draining watersheds with similar land use.
- Flow-adjusted nutrient concentrations at Big Creek have not increased over the short-term.
- Nutrient concentrations in streams increase as watershed land area in pasture and urban uses increases.

Abstract: Nutrient concentrations in several streams of the Boston and Ozark Mountains region of Arkansas, including the Buffalo National River and its tributaries, have garnered tremendous interest. In particular, Big Creek has been the center of attention within the Buffalo River watershed because of a permitted concentrated animal feeding operation (CAFO). The objectives of this paper were to put nutrient concentrations of Big Creek into the context of the stream nutrient and watershed land-use relationship and develop a framework to evaluate regional land-use impacts on regional water quality. Nutrient concentrations in streams draining the Boston and Ozark Mountains region were related to the intensity of watershed land use. Concentrations in Big Creek were similar to other watersheds in the ecoregion with similar land use, suggesting limited impact of the CAFO on Big Creek at the present time. However, this does not preclude future impacts, and longer-term monitoring continues.

Nutrient impairment of surface waters continues despite widespread conservation efforts to reduce losses from urban, rural, and agricultural land uses (Scavia et al., 2014). Land use within watersheds influences the quality and quantity of water in streams draining the landscape. As land disturbance increases and use intensifies, an increase in stormwater runoff and nutrient inputs that lead to a greater potential for transport to receiving water is generally observed (Dubrovsky et al., 2010; Rebich et al., 2011). This has led to efforts to identify and quantify nutrient sources within watersheds, strategically target, and apportion nutrient loss reduction (Reckhow et al., 2011).

Many factors influence the relationship between land use in a given watershed and nutrient transport downstream from that watershed. With an increase in percentage of the drainage area in pasture, row crop, and/or urban use, a general trend of increasing nutrient concentrations in storm and base flows will manifest (Buck et al., 2004; Giovannetti et al., 2013; Haggard et al., 2003; Migliaccio et al., 2007). Thus, nutrient concentrations in streams draining forested lands tend to be less than in watersheds with considerable anthropogenic land use.

For a range of reasons, great interest has been expressed in nutrient concentrations in several streams of the Boston and Ozark Mountains region of northwest Arkansas, including the Buffalo National River and its tributaries. In particular, Big Creek has been the center of attention within the Buffalo National River watershed (BRW) because of a permitted concentrated animal feeding operation (CAFO). The objectives of this letter are to put nutrient concentrations of Big Creek into the context of the stream nutrient and watershed land use relationship and assess whether stream nutrient concentrations have

A.N. Sharpley, L. Berry, K. Brye, J. Burke, and T. Glover, Dep. of Crop, Soil, and Environmental Sciences, Univ. of Arkansas, 115 Plant Sciences Building , Fayetteville, AR 72701; B.E. Haggard, Biological and Agricultural Engineering, Univ. of Arkansas, BENGR201 , Fayetteville, AR 72701; M.B. Daniels and K.W. VanDevender, Biological and Agricultural Engineering, Cooperative Extension, Univ. of Arkansas, 2301 South University Ave., Little Rock, AR 72203; E. Gbur, Agricultural Statistics Laboratory, Univ. of Arkansas, 101 Agricultural Annex, Fayetteville, AR 72701; P. Hays, Dep. of Geosciences, Univ. of Arkansas, 216 Ozark Hall, Fayetteville, AR 72701; T. Kresse (retired), USGS, Arkansas Water Science Center, 401 Hardin Rd., Little Rock, AR 72211.

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*Corresponding author (sharpley@uark.edu).

Abbreviations: BRW, Buffalo River watershed; CAFO, concentrated animal feeding operation; LOESS, locally weighted regression; SRP, soluble reactive phosphorus; TN, total N; TP, total P; UIRW, Upper Illinois River watershed; UWRW, Upper White River watershed.

changed over the short term (3 yr of monitoring). The goal is to understand if, how, and why stream nutrient concentrations change downstream at Big Creek and whether the permitted swine CAFO has influenced water quality during the 3 yr since extensive monitoring began in September 2013.

Methods

Water samples have been collected over varying periods at the outlet of subwatersheds of the BRW, Upper Illinois River watershed (UIRW), and Upper White River watershed (UWRW; Fig. 1). Land use and cover (i.e., forest, pasture, and urban) for each subwatershed was obtained from high-resolution (4-m) imagery from the USGS National Elevation Dataset (USGS, 2015; Gesch et al., 2002), National Land Cover Dataset (USGS, 2017b), and National Hydrologic Dataset (USGS, 2017a). In the UWRW, Giovannetti et al. (2013) monitored 20 sites monthly for 1 yr (June 2005–July 2006), collecting water samples during base-flow conditions. In the UIRW, Haggard et al. (2010) monitored 29 sites monthly during calendar year 2009, also collecting water samples during base-flow conditions.

In the BRW, the National Park Service in partnership with the Arkansas Department of Environmental Quality periodically collected water samples and measured nutrient concentrations at 20 stream sites from 1985 through 2015. Nitrate-nitrogen (NO_3–N), total N (TN), soluble reactive phosphorus (SRP), and total P (TP) concentrations were obtained directly from these data. Forest, pasture, and urban land-use areas were determined from 2006 high-resolution (4-m) land use–land cover imagery.

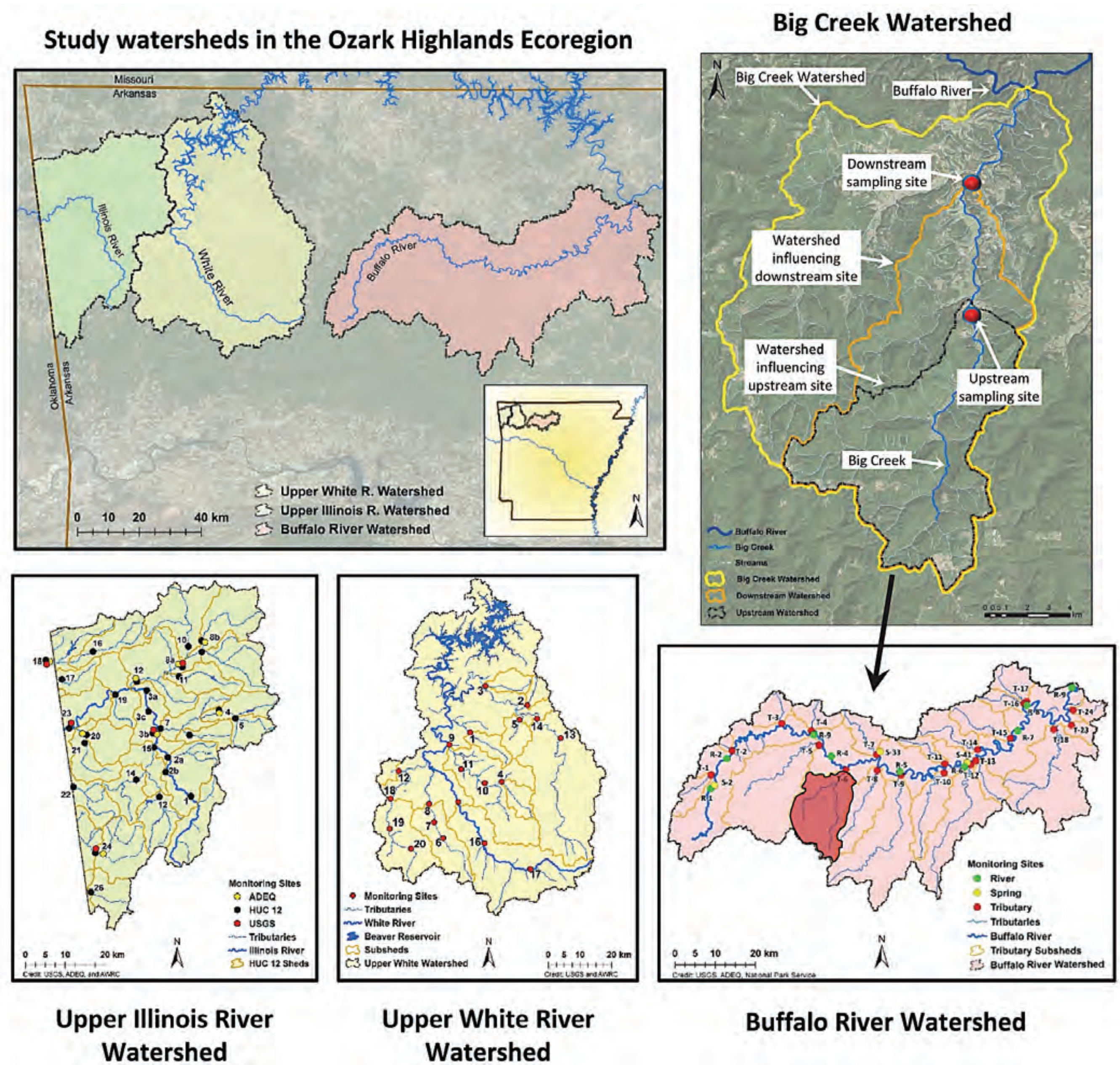

Fig. 1. Location of the Big Creek, Buffalo River, Upper Illinois River and Upper White River watersheds in the Boston Mountains and Ozark Highlands ecoregion. Information from USGS, Environmental Systems Research Institute (ESRI), and NASA.

Big Creek is monitored by the Big Creek Research and Extension Team, a partnership between the University of Arkansas System's Division of Agriculture and USGS. Water samples have been collected upstream and downstream of the swine CAFO on a near-weekly basis since September 2013 (Fig. 1). The water samples were analyzed at an Arkansas Department of Environmental Quality certified water quality laboratory within the Arkansas Water Resources Center (http://arkansas-water-center.uark.edu/water-quality-lab.php), according to methods detailed in Table 1. The data collected is made publicly available at https://bigcreekresearch.org/.

The geometric mean of nutrient concentrations of base-flow samples collected between September 2013 and April 2017 were determined in order to compare with base-flow nutrient concentrations available for BRW, UIRW, and UWRW. Base-flow conditions in Big Creek were classified from hydrograph inspection when flow had not increased or decreased within 3 d of sample collection. McCarty and Haggard (2016) suggested that stream nutrient concentrations under base flow can be used to identify nonpoint sources and target remedial measures in Boston Mountains and Ozark Highland watersheds.

Using all above-listed data sources, the geometric means of nutrient concentrations for streams in the BRW, UIRW, and UWRW were used to develop a relationship with human development within the watershed. Human development is defined as the percentage of pasture plus urban land use within the watershed. Exponential relationships with 95% confidence bands around the observations were developed for NO_3–N, TN, SRP, and TP concentrations to put nutrient concentration at Big Creek into the context of regional stream nutrients and watershed land use.

Data from Big Creek were paired with discharge available from a gaging station just downstream from the swine CAFO, where the USGS developed the rating curve; discharge information was only available from May 2014 through April 2017. The data were then used in a simple three-step process (White et al., 2004) to look at monotonic changes in the nutrients at Big Creek: (i) log-transform concentration (mg L^{-1}) and associated instantaneous discharge (m^3 s^{-1}); (ii) use locally weighted regression (LOESS) to smooth the data with a sampling proportion (n) of 0.5; and (iii) plot the residuals from LOESS (i.e., the flow-adjusted concentrations) over time and use linear regression to evaluate monotonic trends.

Results and Discussion

Putting Stream Nutrient Concentrations into Context at Big Creek

In Big Creek, upstream of the swine CAFO, the geometric mean concentrations of base flow sampled at weekly intervals from September 2013 for NO_3–N, TN, SRP and TP were 0.098, 0.205, 0.009, and 0.030 mg L^{-1}, respectively. Directly downstream of the CAFO, geometric mean concentrations at Big Creek during base flow conditions during the same period were 0.242, 0.356, 0.011, and 0.031 mg L^{-1} for NO_3–N, TN, SRP and TP, respectively. Arkansas has narrative criteria for nutrient concentrations in streams (Arkansas Pollution Control and Ecology Commission, 2016), but its proposed assessment methodology has numeric screening concentrations for TN (0.450–2.430 mg L^{-1}) and TP (0.040–0.100 mg L^{-1}) in the Boston Mountains and Ozark Highlands. The geometric mean concentrations at Big Creek upstream and downstream from the CAFO were below these values for the Boston Mountains and Ozark Highlands ecoregion.

Nutrient concentrations in Big Creek upstream and downstream from the CAFO are low with respect to nutrient–biological response thresholds for algae, macroinvertebrates and fish. Evans-White et al. (2014) reviewed the literature, summarizing nutrient–biological response thresholds across the United States:

- *Algal metric responses.* TN: 0.38–1.79 mg L^{-1}; TP: 0.011–0.28 mg L^{-1}
- *Macroinvertebrate metric responses.* TN: 0.61–1.92 mg L^{-1}; TP: 0.04–0.15 mg L^{-1}
- *Fish metric responses.* TN: 0.54–1.83 mg L^{-1}; TP: 0.06–0.14 mg L^{-1}

Total N concentrations at Big Creek upstream and downstream of the swine CAFO were well below thresholds that result in some expected biological response, whereas TP concentrations were below thresholds for expected macroinvertebrate and fish response and on the low end of the range for expected algal response. However, these lower TP thresholds (0.006–0.026 mg L^{-1}; Stevenson et al., 2008) were focused on shifts in diatom species and metrics rather than nuisance algal biomass. A recent study on the Illinois River Watershed showed that stream TP thresholds with *Cladophora* biovolume and nuisance taxa proportion of biovolume were observed between 0.032 and 0.058 mg L^{-1} (Joint Study

Table 1. Minimum detection limits for each chemical and biological constituent.

Constituent	Analytical method†	Minimum detection limit‡	Reporting limit§
Soluble reactive P, mg L^{-1}	EPA 365.2	0.002	0.010
Total P, mg L^{-1}	APHA 4500-P J; EPA 365.2	0.012	0.020
Nitrate–N, mg L^{-1}	EPA 300.0	0.004	0.050
Total N, mg L^{-1}	APHA 4500-P J; EPA 353.2	0.006	0.050
Total suspended solids, mg L^{-1}	EPA 160.2	No detection limit	4.0

† EPA = Approved CWA Chemical Test Methods (USEPA, 2017); APHA = American Public Health Association from the *Wadeable Streams Assessment, Water Chemistry Laboratory Manual* (USEPA, 2004).

‡ The minimum detection limit of an analyte is the value, which can be measured and reported with 99% confidence that the analyte concentration is greater than zero. Further information is available at USGS (1999).

§ The reporting limit is the least (non-zero) calibrated standard used in analysis, or as defined by method for total suspended solids.

Committee, 2017). Thus, TP concentrations at Big Creek upstream and downstream of the CAFO were in the range in which the natural assemblage of algae is shifting, but these concentrations would likely not be indicative of problematic nuisance algae in this ecoregion.

Geometric mean nutrient concentrations varied upstream and downstream of the swine CAFO at Big Creek, and Kosič et al. (2015) used the publicly available data to allude to the N increase being from human activities on the landscape, such as the CAFO. However, the historic land use and how stream nutrient concentrations during base-flow conditions increase with human development within the Boston Mountain and Ozark Highland watersheds need to be considered (e.g., see Giovannetti et al., 2013; Haggard et al., 2003; Migliaccio et al., 2007). In the Big Creek watershed, the percentage of land influenced by human activities (i.e., pasture plus urban) doubles from ~10 to ~20% in the drainage area upstream and downstream of the CAFO. Nutrient concentrations in Big Creek upstream and downstream of the CAFO are within the range typical of streams draining similar land uses (Fig. 2).

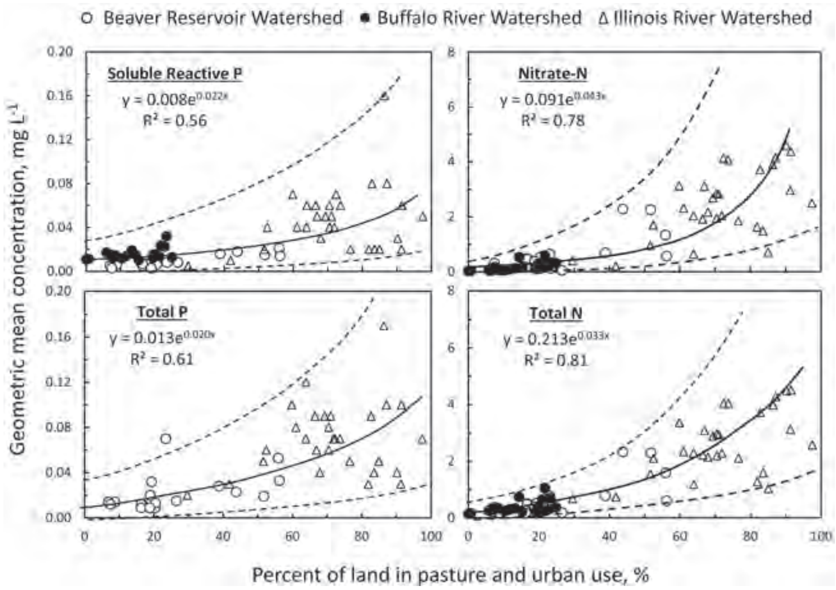

Fig. 2. Relationship between land use and the geometric mean N and P concentrations (mg L^{-1}) in the Buffalo, Upper Illinois, and Upper White River watersheds (no total P data available for the Buffalo River watershed). Dashed lines represent the 95% confidence intervals for the estimated mean (solid line).

At this time, nutrient concentrations in Big Creek upstream and downstream from the swine CAFO are consistent with the range in concentrations for other watersheds with similar pasture and urban land use characteristics (Fig. 2), as well as less than most nutrient thresholds for nuisance water-quality conditions (Omernik and Griffith, 2014). However, this does not preclude the possibility that nutrient concentrations at Big Creek may increase over time, especially if human development and activity in the drainage areas increase. The most important observation is that nutrient concentrations were low in Big Creek, providing the ability to detect changes over time.

Have Nutrient Concentrations Changed in the Short Term at Big Creek?

Understanding that long-term (e.g., decadal-scale) water-quality data are needed to reliably assess how stream nutrient concentrations have changed in response to watershed management and climate variations is of critical importance (Hirsch et al., 2015). The literature shows that stream nutrient concentrations can change relatively quickly in response to effluent management (e.g., Haggard, 2010; Scott et al., 2011), but seeing a response (i.e., decrease in concentrations) from landscape management can take decades or more (Green et al., 2014; Sharpley et al., 2013). A myriad of factors may influence observed nutrient concentrations in streams, including discharge (Petersen et al., 1998), biological processes and climactic conditions (i.e., drought and floods; Jones and Stanley, 2016), and dominant transport pathways (Sharpley et al., 2013). Thus, we need to use caution when interpreting trends in water quality over databases that only cover a limited timeframe.

Three years of flow-adjusted nutrient concentration data at Big Creek downstream from the swine CAFO (May 2014–April 2017) show different relationships with flow for the various constituents:

- Nitrate-nitrogen was greatest (~0.5 mg L^{-1}) during the lowest flows sampled, and concentrations decreased with increasing flow;
- Total N generally decreased with increasing flow until a minimal value occurred; then TN increased with increasing flow;
- Soluble reactive P concentrations did not change much during base-flow conditions, and the greater concentrations (~0.100 mg L^{-1}) sporadically occurred at larger flows, indicating that enrichment from stormflow may have been influenced by availability of source or other nontransport factors; and
- Total P concentrations were also relatively stable during base-flow conditions and then increased in association with rainfall-runoff events, with only a few samples having concentrations >0.100 mg L^{-1}, indicating relatively small enrichment from the landscape.

Flow-adjusted concentrations (White et al., 2004), showed no monotonic (i.e., increasing or decreasing) trends in SRP, TP, or TN ($P > 0.16$) over the current monitoring period (Fig. 3). However, flow-adjusted NO_3–N concentrations decreased over time ($R^2 = 0.05$, $P = 0.01$) by 7% yr^{-1} (Fig. 3c).

Nutrient concentrations at Big Creek upstream and downstream of the swine CAFO, and indeed most tributaries of the Buffalo River, are low relative to other watersheds in this ecoregion (Fig. 2). This provides a starting point to build a framework to evaluate changes in nutrient concentrations of streams as a function of land use and management. The evaluation of flow-adjusted concentrations over time showed that nutrients in Big Creek were not increasing over the short duration of monitoring for which concentration and discharge data were available (May 2014–April 2017). At this point in time (April 2014–April 2017), it is evident that nutrient concentrations in Big Creek have not increased at the monitored site. However, flow and nutrient concentration data over a longer period are needed to reliably quantify water-quality trends and characterize sources, and monitoring needs to continue for at least a decade to evaluate how discharge, season, and time influence nutrient fluxes (Hirsch et al., 2010).

This research details a process by which regional monitoring networks can be developed to establish baseline, in-stream nutrient concentrations and by which time and/or land use and management impacts can be determined.

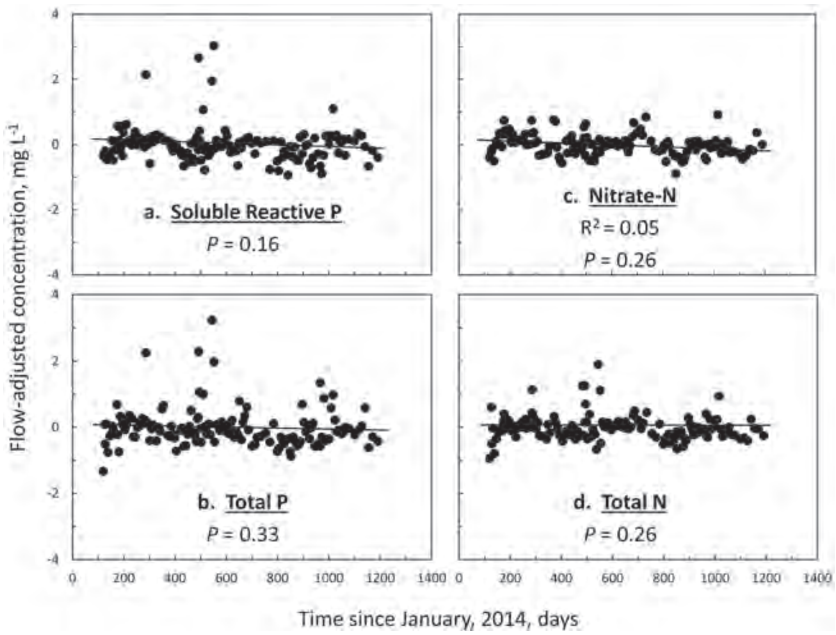

Fig. 3. Flow-adjusted concentration of (a) soluble reactive P, (b) total P, (c) nitrate-N, and (d) total N over time since January 2014, when monitoring in Big Creek started.

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UNIVERSITY OF ARKANSAS
DIVISION OF AGRICULTURE
Cooperative Extension Service

Sampling Liquid Manure

Karl VanDevender, Ph.D., P.E.
Professor, Extension Engineer

Liquid animal manure sampling can be an important management tool. Proper sampling provides the producer with nutrient analysis results that can be used in a sound farm fertilization program. Nutrient analysis of manure, in conjunction with soil sampling, helps determine how much manure should be applied to fields to maintain adequate fertility while minimizing potential environmental problems such as ground and surface water pollution. However manure applications should not exceed the maximum application rates in a manure management plan until sufficient data can be collected to justify revising the plan.

When to Sample

Liquid animal manure should be sampled for nutrient analysis as close to land application time as possible. This helps ensure that the reported nutrient content accurately reflects what is being applied to the land. If the manure is sampled as it is being land applied, the results will not be available to govern present application rates. It does, however, provide information for future land applications of animal manure, if the manure management remains fairly constant over time.

How to Collect a Liquid Manure Sample

During Land Application

The easiest way to collect liquid animal manure samples is to collect the manure as it is being land applied. This approach ensures what is sample reflects what is applied. Randomly place catch pans in the field to collect the liquid manure as it is land applied by an irrigation system or honey wagon. Flexible rubber feed pans work well. Immediately after the manure has been applied, collect the manure from the catch pans, combine in a bucket to make one composite sample and mix well by stirring. This bucket will be the source of the manure sent for analysis.

From a Storage Facility

If collecting liquid animal manure samples during land application is not possible, collect the samples from the storage facility. Liquid animal manure storage facilities have a tendency for the manure to stratify with the solids settling to the bottom and the liquids remaining on top. It is also not uncommon for some solids to form a floating crust. This stratification affects the manure nutrient concentrations in the storage facility. The nitrogen and potassium will be more concentrated in the top liquid, while the phosphorus will be more concentrated in the settled solids. This stratification of nutrient concentrations increases the challenge of getting samples that represent what will be applied to a particular field. If the liquids from the top and middle of the profile will be applied, only this material should be sampled. If the settled solids will be applied, then they should be sampled. However, if the manure is to be agitated before pumping, as has been the traditional recommendation, the sample should contain representative proportions of manure from the top, middle, and bottom. The idea is to collect a sample of an entire column of manure to represent the manure after agitation.

If agitating the manure prior to sampling is not possible, an alternative approach is to make a sampler to collect the required sub-samples. The sub-samples are then mixed to represent the manure after agitation. The easiest to construct is simply a container such as a cup, attached to the end of a pole. Liquids from the manure surface can be simply scooped up. To collect liquids from the middle depths, or settled solids, the container is held up side down, trapping air, until the desired sampling depth is reached. Then the container is rotated, releasing the air and collecting the sample. When collecting a sample of the entire profile of the manure, sub-samples are collected and mixed in a bucket.

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A sampler design that automatically collects a sample of the entire profile uses 10 foot, 1 ½ inch PVC pipe with a PVC ball valve at the bottom. The handle of the ball valve is replaces with a lever arm about 2 feet long. The free end of the lever arm is attached to the end of a 10 foot, 1 inch PVC pipe. The lever arm and smaller pipe allow the ball valve to be operated while holding to top of the sampler. To use the sampler the valve is opened and the sampler is inserted (in a line, not and arc) into the manure. When the foot of the valve is at the bottom of the settled solids, it is closed. Then the sample of the entire manure profile can be removed from the manure and placed in a bucket.

Sketch of Cup Sampler

Sketch of Foot Valve Sampler

Whichever sampler is used, at least 8 locations around the manure storage unit should be sampled and mixed in a bucket to serve as a final composite sample. This bucket will be the source of the manure sent for analysis

Getting the Sample Analyzed

After thoroughly mixing the final composite sample, fill a one liter plastic bottle half full. These bottles may be obtained from your county Extension office. Never fill the bottle more than half full to allow for gas expansion of the sample and to prevent the bottle from exploding. Keep the samples as cool as possible until you can take them to your county Extensions office for shipping to the University of Arkansas lab for analysis. There you will get assistance in filling out an information sheet on your manure sample. There is a fee to have the sample analyzed. While the sample can be sent to a private lab, the fees are often higher. If you are required by the Arkansas Department of Environmental Equality (ADEQ) to sample your liquid animal manure as part of your Regulation No. 5 permit, make sure that you inform the individual helping you with the paperwork so the correct set of analyses can be performed. In addition to the analyses to determine the fertilizer value of manure, it is recommended to analyze for the amount of phosphorus in the manure that is water soluble. Water soluble phosphorus is needed to evaluate the potential environmental risk associated with phosphorus application rates specified in manure management plans. Having good farm based information should help planners develop plans tailored to and individual farm.

Key Points to Remember

The important things to remember in collecting a liquid animal manure sample are:

- Collect a sample that best represents the nutrient content of the manure in that storage facility and what will be applied. If only the top water is to be applied it should be sampled. If the storage unit will be agitated prior to application the sample should contain material from the entire depth profile.
- Only fill the sample bottle ½ full.
- Keep the sample cool prior to shipping.
- Ship the sample to the lab as soon as possible.

Handout, April 27, 2010