

**The Ozarks Environmental and Water Resources Institute (OEWRI)
Missouri State University (MSU)**

YEAR TWO ANNUAL REPORT FOR:

**NUTRIENT TRANSPORT AND FATE FROM
MUNICIPAL BIOSOLIDS LAND APPLICATION**

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SCOPE AND OBJECTIVES

Biosolids is the residual by-product of the municipal treatment of wastewater used to fertilize agricultural fields in southwestern Missouri. Human health risks for land application of biosolids are considered low when the material is properly handled and treated per environmental regulations (USEPA, 1994¹). Regardless, the public perception is that land applied biosolids release nutrients and trace metals during runoff events and contribute to water quality problems in nearby streams and lakes. Land application rates of biosolids are site specific and are based on soil fertility, crop needs, and production goals to avoid over-fertilization where valuable nutrients can move off of fields and into receiving waters (MDNR, 1985).

Like all organic fertilizers (e.g. manure, chicken litter), biosolids are high in phosphorus (P) per unit nitrogen (N) and over-application of P can occur when applied at a rate based on N needs of the crop (Shober and Sims, 2003). Over-application can cause excess P to wash off the landscape into receiving waters during runoff events and is a leading factor in eutrophication of aquatic ecosystems (Correll, 1999; Dodds, 2006). Trace metal concentrations in runoff from biosolids applied fields are influenced by site specific conditions, such as soil type, moisture conditions, and conservation practices (Al-Wabel et. al., 2002; Richards et al, 2004; and Galdos et al, 2009). However, little is known about metals in runoff from other fertilizer sources since concentrations of many trace metals in biosolids are near or below concentrations of metals in poultry litter and inorganic fertilizers (Spicer, 2002).

In the Ozarks, questions still remain on the release of nutrients and metals from biosolids applications during runoff events and the contamination of downstream receiving water bodies under local soil, slope, and crop conditions. Working with the Missouri Department of Natural Resources, NRCS, and MSU, the City of Springfield is conducting a 3-year study to compare the runoff rates of nutrients and metals from fields treated with biosolids to fields treated with traditional inorganic fertilizer. The purpose of this study is to determine the effect of biosolids application on runoff quality under field conditions. The specific objectives of the study are:

1. Implement an experimental field plot monitoring program using runoff auto-samplers to measure the concentrations and loads of nutrients and metals released from fields treated with biosolids;
2. Compare the levels of nutrients and metals in runoff, surface soils, and forage measured in biosolids applied fields to fields treated as control (no application) and with traditional fertilizer;

3. Use this information to support the continued approval of biosolids applications by government regulators and provide information to the general public on the safety of using biosolids as a component in an overall nutrient management plan.

The Ozarks Environmental and Water Resources Institute (OEWRI) at Missouri State University is responsible for providing technical support and implementation of water quality monitoring activities and surface soil sampling and testing activities, and reporting for the project (www.oewri.missouristate.edu). The Darr School of Agriculture at Missouri State University is responsible for the soil morphological classification, forage collection and analysis, and weed control of the site. The Natural Resources Conservation Service Southwest Missouri Water Quality Office provided the nutrient management plan. Specific contributions in data collection, reporting and editing for this report came from the following:

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This report organizes and summarizes data collected for the first two years of sampling from November 2008 through July 2010 and provides detailed methods and results for water quality monitoring, soil testing, and forage analysis. Maps, figures, tables, and photos corresponding to these sections are at the end of the narrative. Appendices of all data collected can also be found at the end of this report.

STUDY AREA

The Biosolids Demonstration site is located in Lawrence County in the Sac River Watershed (hydrologic unit code 10290106). The site is located on a 40 acre tract in the SE $\frac{1}{4}$ of the SE $\frac{1}{4}$ of the northern half of Section 3, Township 29N, Range 27W in northern Lawrence County (Figure 1). This tract is bisected by a small tributary valley flowing north into Limestone Creek, a tributary to Turnback Creek and the Sac River Basin. The surface geology of the area is typical of the Springfield Plateau of the Ozarks which is dominated by cherty Mississippian age limestone along with remnants of Pennsylvanian age sandstones. Generally, upland soils are derived from residuum topped by a thin layer of loess material (Hughes, 1982). On hillslopes, residual soils are capped by a layer of silty and cherty colluvium, which increases in thickness going downslope. Mapped soils for this property are the Viraton silt loam on the top of the uplands, Nixa cherty silt loam on the sideslopes, and the Clarksville cherty silt loam in the

steeper areas below where the Nixa series is located (Figure 2). The Viraton and Nixa series typically contain a fragipan and are classified as moderately well drained while the Clarksville is somewhat excessively drained. Site specific soil descriptions and deviations from the typical profiles will be discussed later on in this report. Previous management included a combination of haying cool season grass fescue each spring followed by grazing of beef cattle for the duration of the season. Land was leased prior to the initiation of the study, cattle were removed off-site and excluded from returning by constructing a fence.

METHODS

Site Selection

This property was chosen based on the uniformity in land cover, landscape position, slope, and soil type as best as could be done under natural conditions. A site assessment was conducted during the initiation phase of planning to determine the feasibility of the experiment and to determine the site suitability for the application of biosolids. Existing conditions were inventoried, populated into the Missouri Phosphorus Index, and determined that application of organic material at nitrogen based rates was permissible.

Four separate catchments were selected in a single field on a Wilderness-Viraton Soil Association (Table 1). Catchments designated for the study plots are located off the east and west facing slopes along a ridge running generally south-to-north with slopes ranging from 3.5% to almost 14%. Sites were located near the top of the watershed to eliminate run-on influences. All sites drained to an identifiable pour point at the base of the slope in a small draw where concentrated flow could be captured. The entire site was surveyed and a topographic map created to identify the drainage area of each catchment ranging from 0.38 acres to 3 acres (Figure 3).

Because of the topography of the site, each watershed generally overlaid two of the four soil map units present on the site (Table 1). Goss soils are classified as a Clayey-skeletal, mixed, active, mesic Typic Paleudalfs and are typically found on side slopes of ridges. Viraton soils are generally located on more level summit landscape positions and are classified as a Fine loamy, siliceous, active, mesic Oxyaquic Fragiudalfs. The Nixa soils are more generally on ridge tops and are classified as a Loamy-skeletal, siliceous, active, mesic Glossic Fragiudults. Clarksville soils are on the steeper slopes of hillsides ranging from 3-20% and are classified as Loamy-skeletal, siliceous, semiactive, mesic Typic Paleudults. Forage suitability classifications for each soil were described as a gravelly upland, gravelly pan, or loamy pan suitability group with an

estimated yield goal of 2-3 tons of grass per acre. All soils do not meet hydric criteria and each contain properties consistent with the karst geology of the Missouri Ozarks region.

Soil morphological classification was performed to assess the variability in soil properties across the site and to compare soil pit field descriptions to the mapping units in the soil survey. Test pit locations on the landscape were determined by using aerial photo maps of the area and comparing them with observations using clinometers to locate proper slopes on the landform for summit, shoulder, back slope and foot slope positions. Pits were dug to a depth of 60 in. to 80 in. (where permitted) to observe horizons of the soil pedons and recorded using field notes as described in USDA (2002). Taxonomy classifications were determined according to USDA (2006). Locations of soil pits can be found in Figure 2.

The dominant parent materials for this site are colluvium over residuum. On the flat uplands, the upper horizon consists of a thin layer of loess up to 8" deep (Table 2, Photo 1). Along the broad head slope, a well formed fragipan is present between 32" and 45" deep, while a shallower, weak fragipan exists on the narrow interfluvium at the crest of the narrow ridge (Photo 2). The presence of redoxamorphic features above the fragipan and within the prismatic seams through the fragipan are indicators of a seasonally high water table (Photo 3). The steeper side slopes are coarser closer to the surface, with sporadic remnants of weathered sandstone present 50" to 60" below the surface (Photos 4 and 5). In the bottom of the colluvial valley there is nearly a 2 foot accumulation of alluvium over colluvium that contains high chert content (Photo 6). Soil morphology descriptions are available at the Missouri Cooperative Soil Survey website at soils.missouri.edu.

The experimental design called for four individual nutrient treatments, each applied to a separate catchment. Details of each catchment are described below:

Site 1 catchment size = 0.38 acres - this site drains the east side of the ridge on the north end of the property. This site drains primarily the backslope and footslope landscape positions. This site was designated as the control.

Site 2 catchment size = 0.65 acres - this site also drains the east side of the ridge and received a commercial fertilizer application. Only a small portion of this catchment drains the summit landscape position, mostly draining the backslope and footslope.

Site 3 catchment size = 3 acres - this site drains from the southern end of the property on the east side of the ridge. The majority of this catchment drains the summit landscape position. This site is designated to receive biosolids application.

Site 4 catchment size = 1.28 acres - this site drains the west side of the ridge running through the property. This site drains the summit and backslope landscape positions. This site will also receive a biosolids application at a rate higher than site 3.

Nutrient Management

In 2008, soil samples were collected at three different landscape positions (summit, back slope, and foot slope) along established transects in each watershed. At each landscape position, in each watershed, individual soil cores were collected at 6-8 inches in depth and bulked to comprise a single sample. Samples were used to establish the general fertility of the site and to determine the lime requirement at 400 Effective Neutralizing Material. Global positioning technology was utilized to assist in subsequent re-sampling each summer. Samples were air dried and sent to the University of Missouri Soil Testing Laboratory for soil analysis (Appendix A).

The City of Springfield, Missouri provided biosolids from its Southwest Wastewater Treatment Plant for the study. Initial analysis of biosolids conducted by the Southwest Wastewater Treatment Plant Laboratory was used to estimate Plant Available Nitrogen (PAN). PAN is estimated using the following equation:

$$\text{PAN} = f_o(\text{organic N (ppm)}) + f_a(\text{NH}_3\text{-N (ppm)}) + \text{NO}_3\text{-N (ppm)}$$

$$f_o \text{ (Availability factor (organic))} = 0.2$$

$$f_a \text{ (Availability factor (ammonia))} = 0.7$$

Using established mineralization rates for anaerobically digested sewage sludge, it was estimated the plant available nitrogen from a single 3 dry t/ac application was roughly equivalent to the annual nitrogen recommendation for a 3 t/ac yield goal of cool season grass (USEPA, 1994²; UM, 2004). At a rate of 6 dry t/ac of biosolids, nearly three growing seasons of nitrogen would be delivered. Because the Southwest Wastewater Treatment Plant is located in a nutrient sensitive watershed, limited phosphorus is allowed in the discharged wastewater. Consequently, large quantities of phosphorus are retained in the biosolids and applied to land with the nitrogen (nearly 600 lbs/ac P₂O₅ at the 6 t/ac rate).

Experimental design was also influenced by the desire to match experimental protocol to local farming practices. Typically, farmers participating in a cooperative program with the City of Springfield receive a single application of biosolids to suitable fields under specified conditions,

including appropriate setback distances from surface features (MDNR, 1985). Repeat applications are infrequent within a three year time frame. Thus, biosolid applications were made only in the first year of the experiment. For the commercial fertilizer treatment, equivalent amounts of nutrients were included in the blend to balance the nutrients delivered from the 3 t/ac biosolid application rate. Similar to the biosolids application, all of the added phosphate and potash from the commercial fertilizer were applied in the first year. However, unlike the biosolid application, the total amount of nitrogen was divided into three annual applications to closer represent local practices. This strategy front loads nitrogen application for the biosolids treatments, but represents reality in the field.

A calcic limestone application was made by a commercial dealer on September 9, 2008 to adjust soil acidity to near neutral levels. The biosolids applications were made with a commercial Terra-Gator 3104 side discharge spreader on October 23, 2008 and the fertilizer applied by a commercial dealer on October 28, 2008. Biosolids samples were collected on the day of application and analyzed by the laboratory to determine actual nutrient concentrations of the processed material from the treatment plant. This analysis, coupled with actual field application measurements, was utilized to determine the actual nutrient application to each catchment area (Table 3).

Site 1 received no treatment and is designated as the control. Site 2 received a commercial fertilizer application based on a 3 t/ac yield goal of 54+299+13 (N+P₂O₅+K₂O) in year 1. In year 2 and 3, a fertilizer application rate of 54+0+0 (N+P₂O₅+K₂O) were applied to mimic the slow release of N from the breakdown of biosolids over that time. These subsequent applications occurred August 5, 2009 and August 30, 2010. Site 3 received 3 t/ac biosolid application, which is equivalent to the commercial fertilizer application. Finally, site 4 received 6 t/ac biosolids application rate, which is the maximum rate allowed.

The biosolid analysis revealed the material spread contained more (37 %) plant available nitrogen, nearly the same (+/- 3.5%) phosphorus and less (76%) potash than the analysis used for planning purposes. Adjustments to the commercial fertilizer rates applied in the second year on August 5, 2009 were made to compensate for variability of the application rate and biosolid concentration applied in the first year. Concerning the comparative treatments, the total nutrient quantities applied over the 3 growing seasons are estimated to be within 1 lbs/ac for nitrogen and phosphorus, but the watershed treated with commercial fertilizer received 10 lbs/ac more K₂O than the watershed treated with biosolids at 3 t/ac.

Hydrology and Water Quality Monitoring

Weir Design and Runoff Measurements

Runoff discharge was measured by weir-calibrated transducer measurements. At each site, a PVC board dam with a one foot tall 90° v-notch weir was constructed to intercept run-off in the individual catchments (Photo 7). The dam and weir allows water to be captured and released at a predictable rate based on standard weir-discharge relationships (French, 1985). Portable auto-samplers (Model # 6712, Teledyne ISCO) equipped with a rain gage and stage recorders were placed at each site to collect rainfall and run-off data. Rain gages measure and record total rainfall in 1/100th inch increments over 5 minutes time periods. A pressure transducer level sensor with datalogger was positioned upstream of the v-notch weir that measures and records water levels every 5 minutes at each site. Stage versus discharge relationships were created for each site based on the position of the pressure transducer to the bottom of the v-notch weir (Table 4 and Photos 7 and 8). Some storm events were able to generate enough runoff to collect behind the dams constructed below each site, but did not fill to a level where it flowed through the weir. In this case, samples were collected and analyzed, and half of the capacity above the weir at the level of the notch was used for the runoff volume estimated by field measurements.

Water Quality Sampling

A strainer was positioned next to the pressure transducer upstream of each dam and was connected to the auto-sampler with a 25 ft. suction line. Initially, each auto-sampler contained twenty-four 1 liter bottles and was programmed to collect 1 liter of water every 10 minutes when the stage recorder detected water behind the weir. However, since June 2009, auto-samplers were fitted with a single 10 L Nalgene composite bottle and reprogrammed to collect single event composite samples. During a storm event, the sampler collected 500 ml samples every fifteen minutes when rainfall rate and level reach set point (0.10 in/30 min and 0.1 ft., respectively). The new configuration saved time and limited error in the field as well as reduced prep time in the lab.

After a sample was collected, composite bottles are removed, and the sample is split for further analysis. Sample were split among three bottles to be analyzed for: (1) metals, preserved with HNO₃ to a pH < 2; (2) nutrients, preserved with H₂SO₄ to a pH < 2; and (3) total suspended solids (TSS), fecal coliform, and pH, no preservative added. In addition, a field duplicate and a field blank were collected for each sampling event to ensure proper sample collection procedure.

Water Quality Analysis

Samples were analyzed at the City of Springfield's Southwest Wastewater Treatment Plant for metals, nutrients, TSS, fecal coliform, and pH following Environmental Protection Agency Methods (EPA) and Standard Methods for the Examination of Water and Wastewater (SM4500) protocol (Table 5). Samples were analyzed at Ozarks Environmental and Water Resources Institute for specific conductivity by a Horiba U22 multi-probe meter. Average field blank concentrations were less than detection limits for metals, ammonia and fecal coliform. Average field blank concentrations for other parameters were 1.1 mg/l TSS, 0.25 mg/l TKN, 0.066 mg/l nitrate, and 0.062 mg/l TP. Median relative percent difference of the duplicate ranged from 4-29% for all parameters. More details on the analyses can be found at <http://www.epa.gov/waterscience/methods/>.

Surface Soil Monitoring

Sampling

Surface soils within each watershed were monitored to measure changes in metals and nutrients over the study period. Surface soils were sampled approximately 1 month after lime was applied, but prior to fertilizer and biosolids applications. Soil samples were collected at each of the 4 sites at the footslope, backslope, and summit landscape positions to determine site variability (Figure 3, Table 6 and Photo 9). To compare variability within each landscape position, four soil samples were collected along a transect at each landscape position; three on a 14 ft. cross-section. These the difference in concentrations in these three samples is used to assess the variability of soil parameters at each site. One randomly selected duplicate was collected to measure sampling variability. A total of twelve samples were collected at each site. Surface soil samples were collected with a trowel by removing vegetation and excavating soil in an area approximately 6 in. long, 6 in. wide, and 2 to 3 in. deep, and placed in a quart Ziploc bag. A total of 48 samples were collected in year one. Data on site and sample variability can be found in Appendix G.

Analysis

Samples were processed at Missouri State University by drying in a 60° C oven for 24 hr. Dried samples were sieved to 2 mm to remove debris, and one cup of sample was placed in a new Ziploc bag and labeled. Soil analysis was conducted by the University of Massachusetts Soil and Plant Tissue Testing Laboratory to determine pH, buffer pH, and concentrations of extractable nutrients, heavy metals, and aluminum (Appendix B).

Forage Analysis

Agronomic response to each of the four treatments was monitored by measuring yield along transects established on different landscape positions in each watershed. Plant and soil nutrient levels were also monitored by collecting annual forage and soil samples. Yield was measured by harvesting a known area of land, taking fresh forage weights, and drying subsamples to determine moisture content. Samples were also collected and sent to a laboratory for analysis of other forage characteristics. Forage sampling sites were selected along a line parallel to the soil sampling transects previously established in each watershed. The beginning and end of each transect were marked with a steel rod, flagged and geo-referenced for subsequent surveys. Forage sampling plots were established at three locations within treated areas of each watershed (1) “Low”, 25 to 65 feet from the steel rod (distances varied in order to assure the sample was collected well within the treated area), (2) “Summit”, 10 to 20 feet downslope from the highest landscape position along the transect (again, distance varied to assure that the samples were collected well within the treated area, and (3) “Mid”, near the midpoint between the low and summit positions. Each plot was 7 ft X 20 ft with the long axis perpendicular to the slope. Plots were mowed using a walk-behind sicklebar mower set to a cut height of 4 inches. The sample (excluding tree coppices and plant material and residues from below the cut height) was carefully raked, bagged and fresh biomass was determined using a precision spring scale. Where the crop had lodged (due to wind or rain), two or three iterations of cutting and raking were required to mow the forage to the desired height. Forage quality analysis was conducted by Custom Laboratory in Golden City, Missouri.

PRELIMINARY RESULTS

Hydrology and Sample Collection

Rainfall Events

Runoff was generated either during relatively short, high intensity storm events, or relatively long, low intensity storm events. Year 1 rainfall totals generating runoff ranged from 0.56 inches on November 6, 2008 to 1.89 inches June 16, 2009 (Table 7). Year 2 rainfall totals ranged from 0.63 inches on January 25, 2010 to 5.1 inches October 9, 2010. Individual storm rainfall totals for year 2 are substantially higher than year 1 with four events having greater totals than the highest event in Year 1.

Runoff Events

Runoff discharge also varied among catchments over the sampling period due to variability in rainfall, drainage area, soils, vegetation, and slope. For the storm events where runoff data was

generated, peak instantaneous discharge measurements ranged from as low as 0.009 ft³/s on Feb. 10, 2009 for site 2 to as high as 0.91 ft³/s on September 22, 2010 at site 3 (Table 8). The maximum capacity of a 1 foot, 90 degree weir is 1 ft³/s.

Storm runoff volumes varied from as low as 1.5 ft³ at site 1 on May 13, 2009 to as high as 33,645 ft³ October 9, 2009 at site 3. Runoff volume as a percentage of total rainfall volume also ranged from <1% during several events up to 81% at site 2. These data show the high variability in runoff volume in these small catchments. Year 1 runoff volume results did not exceed 25% of the total rainfall volume and rainfall did not exceed 2 inches in the events sampled. However, year 2 results had several events where rainfall amounts exceeded 2 inches and runoff volumes reached as high as 80% for site 2. These hydrological characteristics become important in water quality studies because ultimately runoff volume determines the impact of a contaminant leaving a site during a storm event.

Sample Events

A total of 62 composite samples were collected at all four sites over a 21 month period between November 1, 2008 and July 31, 2010. During year 1, from November 1, 2008 to July 31, 2009, 23 composite samples were collected. Of these, 6 were from site 1, 9 from site 2, 5 from site 3, and 3 from site 4 (Table 7). In year 2, between August 1, 2009 to July 31, 2010, a total of 39 composite samples were collected. Of the year 2 samples, 10 were from site 1, 11 from site 2, 9 from site 3, and 9 from site 4. Samples were not collected over that period because:

1. Small catchment area generates low discharge volume
2. Equipment malfunctions (dead batteries, clogged lines, etc.)
3. Height of vegetation and dormancy impact interception and water uptake
4. Soil moisture conditions
5. Dam and weirs needed “seasoning” following installation in year 1

Water Quality

The following section will describe water quality data collected for each site over the November 1, 2008 to August 31, 2010 sampling period. Water quality trends are reported in three ways: (1) comparing site average over the entire sample period to look at overall trends and variability; (2) comparing annual median values for each site to assess yearly changes in water quality parameters; and (3) analysis of time-series plots from each site showing individual sample concentrations from the initial biosolids application date of October 23, 2010 to July 31, 2010, used to compare runoff water quality over the entire sample period.

Average nutrient concentrations were around 2-4 times higher in runoff from the fertilized site 2 compared to the biosolids applied sites and the control for the entire sampling period (Table 9). When comparing the biosolids applied sites, average concentrations of TKN, Nitrate, and TP are higher from the 6 t/ac site 4 compared to the 3 t/ac site 3. However, average ammonia was >5 times in the 6 t/ac site 4 compared to the 3 t/ac site 3. Average ammonia and TKN concentrations in the 3 t/ac site 3 were less than the average concentrations found at the control site 1. Nitrate and TP concentrations at the control site 1 were the lowest among sites. Average TSS concentrations ranged from 14 mg/l at site 1 to 80 mg/l at site 2 over the sample period. Sample pH remained consistent at all sites over the sample period.

Total Phosphorus (TP)

Median TP concentrations dropped significantly at site 2 in year 2 and increased in sites 3 and 4 (Figure 4). Site 2 median TP concentrations decreased 75% from year 1 to year 2. Median TP concentrations in the biosolids applied watersheds increased from year 1 to year 2. This increase is probably due to a combination of factors. One, the breakdown of organic phosphorus in the biosolids is more mobile in year 2 and two, significant rain events that occurred in year 2 physically transported biosolids material down slope. Regardless, median TP concentrations for sites 3 and 4 are less-than half of that from the fertilized site 2. Median TP concentrations at site 1 were similar in years 1 and 2.

Time-series analysis of TP concentrations shows generally decreasing concentrations over time (Figure 5). High concentrations immediately after application of fertilizer at site 2 were extremely high for the first sample collected and then concentrations decrease steadily. Concentrations of TP are more variable for the biosolids applied sites over time again suggesting physical transport by storm event is likely causing higher concentrations over time. All TP concentrations past day 400 are <2 mg/L, which is near the highest TP concentration sampled at control site 1. This suggests that TP concentrations are back to pre-treatment levels.

Total Kjeldahl Nitrogen (TKN)

Concentrations of TKN have proven to be highly variable for this project. Median TKN concentrations decrease at 3 of the 4 sites from year 1 to year 2, while increasing at site 4 (Figure 6). High variability at site 1 suggests high natural variability cannot be distinguished from changes in management. Time-series analysis show TKN concentrations may be event driven. High TKN concentrations at site 2 immediately after application dropped sharply and stayed fairly consistent for the rest of the sampling period (Figure 7). Perhaps particulate fertilizer was sampled in the first event giving such high concentrations. Sites 1, 3 and 4 are

more variable over time that shows storm events may be transporting particulate nitrogen down slope. However, the single high concentration at site 1 suggests this may be natural variability. Given year 1 and year 2 results, TKN variability cannot be attributed to fertilizer or biosolids application.

Ammonia

Median ammonia concentrations remained relatively consistent at sites 1, 2 and 3 between year 1 and 2, while concentrations dropped significantly in year 2 at site 4 (Figure 8). With the acceptance of year 1 sampling at site 4, median ammonia concentrations are higher at the control site 1 compared to the other sites during the sampling period. Time-series analysis again shows extremely high ammonia concentrations for the 1st sample collected after fertilizer application at site 2 (Figure 9). Ammonia concentrations at site 2 then decrease to near the levels at the other sites and stays fairly consistent for the remainder of the sampling period. Ammonia concentrations at site 4 are also elevated in the first sampling after application of 6 dryT/ac biosolids. However, similarly to site 2, ammonia concentrations decrease after that near levels at the other sites.

Nitrate

Median nitrate concentrations varied slightly between year 1 and 2 for sites 1, 3 and 4 and increased significantly in year 2 at site 2 (Figure 10). Changes in nitrate concentrations at sites 3 and 4 are near that of the control site 1, suggesting natural variability is as high as in the biosolids applied sites. However, nitrate concentrations at site 2 nearly double in year 2. Time-series analysis shows nitrate concentrations at site 2 are highly variable throughout the sample period (Figure 11). Nitrate concentrations at other sites are consistently low and have less variability. These data suggest excess nitrate moves off fertilizer sites at greater rates than biosolids applied fields.

Total Suspended Solids (TSS)

Median TSS concentrations varied considerably between years at each site (Figure 12). This variability is due to differences between site characteristics and storm events. Concentrations of TSS increased in year 2 at site 1, 2 and 3 and decreased at site 4. Time-series analysis indicates high median concentrations are influenced by single high events samples and the majority of samples are <100 mg/L for most events (Figure 13).

pH

Median pH reading were similar for all sites between years 1 and 2 (Figure 14). Time series analysis shows site 2 has the most variability among sites over the sampling period (Figure 15).

However, pH varies <1 standard unit over the sampling period. These data indicate variability in runoff pH does not influence water quality differences among sites.

Trace Metals

Trace metals concentrations above the method detection limit were found in only a portion of the 60 samples collected over the sample period. Concentrations of Arsenic, Cadmium, Lead, Mercury, Molybdenum and Silver were all below detection limits for all samples. Nickel and Selenium were found in only 1 of the 60 samples and Chromium was found in only 2 of the samples. Copper (Cu) and Zinc (Zn) were found in multiple samples throughout the period.

Sites where biosolids was applied tend to have higher concentrations of Cu and Zn than sites without. For the control site 1, no Cu was detected over the sample period (Table 10). Of the samples collected at site 2 and site 3, 90% of the samples were below detection limits. However, the highest concentration at site 3 (3 dryT/ac) was 8.2 ppb Cu slightly higher than 5.5 ppb Cu at site 2 (fertilizer). Cu was detected in a quarter of the samples from site 4 (6 dryT/ac). The maximum Cu concentration for the study (19.6 ppb) is from site 4 with 10% of the samples having Cu concentrations that exceed 10 ppb.

Zinc was detected in <10% of the samples collected at site 1 with the maximum concentration of 6.4 ppb (Table 11). At site 2 (fertilizer), Zn was detected in 10% of the samples with a maximum concentration of 17.4 ppb. At site 3 (3 dryT/ac), Zn was detected in <10% of the samples, but the maximum concentration was 50% higher than site 2 at 26.1 ppb. At Site 4 (6 dryT/ac) Zn was detected in 50% of the samples collected and maximum concentration was nearly 4 times higher than the fertilizer site 2 and nearly 10 times greater than the maximum concentration at the control site 1.

Fecal Coliform

Biosolids applied sites tend to have higher fecal coliform concentrations more often than the control and fertilizer sites (Table 12). However, high concentrations were found at all sites. While the control site 1 tended to have lower concentrations during most of the sampling period, the 90th percentile and maximum concentrations were higher than the fertilizer site 2 and 3 T/ac biosolids site. Furthermore, the 90th percentile concentration for the control site is similar to the high 6 T/ac biosolids applied site 4. These data show high fecal coliform concentrations can occur on non-biosolids applied fields. However, there appears to be a tendency for biosolids to yield higher fecal counts than the control and fertilizer sites.

Surface Soils

Site and Sample Variability

Variability in soil parameters was assessed at two different scales, variability within a landscape position and variability. While soil pH has fairly low variability at a site, concentrations of soil Zn and P can have high variability across the landscape. The coefficient of variation percentage (cv%) is the percent difference of the standard deviation compared to the average for the three samples collected at each landscape position. The cv% for pH was <10% at all landscape position reflecting the consistency of pH across the landscape (Table 13). The highest variability within a landscape position is in soil P, having cv% higher than 30% at sites 1, 2, and 3. Interestingly, P concentrations were less variable at site 4, where cv% were <30% among samples. Concentrations of Zn were less variable at a landscape position. The majority of the cv% were < or near 30%. However, one sample at site 2 had extremely high variability with a cv% >200%.

Sample variability was also assessed by collecting a random duplicate at the same location as one of the three samples collected for site variability. The difference is reported as relative percent difference (RPD). Again, pH varied little between samples (Table 14). Most of the duplicate samples of P and Zn had cv% <30%. The higher cv% ranged from 40-84% suggesting sample variability can also be high for P and Zn. These data suggest differences in P and Zn in the soil could be due to high variability of these parameters within the landscape.

Soil pH

Mean soil pH ranged from 5.6 to 7 for all site over the entire sampling period (Figure 16). At each site, soil pH increased every year with the largest increase occurring at site 2. The annual increase in soil pH is due to the breakdown of agriculture lime designed to raise the pH in the soil prior to application of fertilizers and biosolids. Soil pH trends are similar for each landscape position for all sites (Figure 17). These data suggest variations in soil pH are not contributing to soil geochemical trends.

Soil Phosphorus (P)

Mean soil P concentrations increased every year at sites 2, 3 and 4 and decreased at site 1 after the first year (Figure 18). A year 2 increase in P at these sites is due to fertilizer and biosolids application. While site 2 has an overall increase from year to year, it appears this only occurs on the flat, summit landscape position (Figure 19). However, on the steeper backslope and footslope, P concentrations increase in year 2 but drop in year 3. Site 3 also has an increase at the summit and a year 3 loss from the backslope. Site 4 show increase in soil P at the summit and backslope landscape positions. However, the footslope appears to be losing P each year.

Soil Zinc (Zn)

Average soil Zn concentrations are low at all sites, ranging from 1-2.5 ppm (Figure 20). Concentrations of Zn decrease at sites 1 and 2 in each of three consecutive years. Soil Zn increases in year 2 at the two biosolids applied sites 3 and 4 indicating slight enrichment from biosolids application. At these sites, soil Zn decreases in year 3 indicating leaching could be occurring during rain events. Again, concentrations are only slightly higher than the control and fertilizer sites. Annual Zn concentrations decrease in all landscape positions at sites 1 and 2, suggesting possible Zn presence in the pre-application lime is breaking down over time (Figure 21). Concentrations of soil Zn increase in year 2 at the summit and backslope landscape positions at site 3 and the summit of site 4 due to biosolids application. Year 3 Zn increase at the summit of site 3 and decrease at the summit of site 4 and backslope of site 3 indicate Zn maybe mobile in this setting.

Forage Analysis

The amount of nutrients present in forage crops from the fertilized site 2 and biosolids applied sites 3 and 4 are higher in the fall cutting compared to the control site 1 (Figure 22). Nutrients tend to be higher in sites 2, 3 and 4 in the fall cutting compared to the spring cutting. Rainfall, the timing of harvest, and grass species may all factor into the variability in forage nutrient uptake. However, increased nutrient content in post application are evident. The amount of copper and zinc in the forage was variable between sites and between cuttings. These data suggest no significant changes in copper and zinc content in forage harvested from biosolids applied sites compared to the fertilized and control sites.

Forage crop yields from biosolids applied sites were greater in year 1 compared to the fertilized site, but yields dropped in year 2 yet were still higher than the control. Year 1 average forage yield for the fertilized site 2 was 50% greater than the control site 1 (Figure 23). Average year 1 forage yield was 2-2.5 times greater in the biosolids applied sites than in the fertilized site 2. Year 2 yields dropped at all sites, with the biosolids applied sites having similar yields as the fertilized site. However, the fertilized and biosolids applied sites had 50% higher yields than the control in year 2.

Relative feed values (RFV) at site 1 remained fairly consistent over the first three cuttings before dropping in fall 2010 (Table 15). The fertilized and biosolids applied fields did not see benefits in RFV until the fall 2009 cutting where the highest RFV in the entire study came from site 2. The RFV in the spring 2010 cutting was less than the previous cutting in the fall of 2009. However, RFV increased in the biosolids applied sites in fall 2010 and not in the fertilized site 2.

The plots lacked true replication, the results were averaged across landscape positions within each treatment. The results should therefore be considered descriptive statistics rather than results of a properly constructed hypothesis test.

CONCLUSIONS

This section covers the activities over the two years of the Biosolids Runoff Monitoring Project from May 2008 through July 2010. There are 16 main conclusions of this report:

1. Samples sites were chosen based on uniformity of landscape position and land cover typical of agricultural practices in southwest Missouri. The site was surveyed and four small catchments were delineated, ranging from 0.38 to 3 acres.
2. Soil samples were collected and analyzed for fertilizer and liming recommendations. A nutrient management plan was created that outlined specifications for fertilizer based on soil test reports for biosolids and equivalent commercial fertilizer applications. A fertilizer and equivalent biosolids application rate (3 dryT/ac) was applied for a 3 T/ac forage yield goal site 2 and 3. On site 4, the maximum allowable biosolids application rate of 6 dryT/ac was applied. Site 1 was not treated and left as the control.
3. Five individual soil pits were characterized for soil morphology over the study area to access the variability in soil type over multiple landscape positions that may not be represented in published soil surveys. Pedogenic differences in soil parent material, structure, and thickness can impact infiltration rate and infiltration capacity, as well as soil fertility and growth rates.
4. Weirs were constructed in areas of concentrated flow near the bottom of each catchment to capture runoff and estimate discharge. Automatic samplers were deployed and fitted with rain gages and stage recorders programmed to sample when runoff occurred. A 500 mL sample was collected at the first flush and then a subsequent 500 mL sample was collected every 15 minutes over the duration of the storm.
5. Over the year 1, 9 month sampling period (November 1st, 2008 – July 31st, 2009) covered by this report, 23 individual composite samples were collected and analyzed. Rainfall intensities capable of producing runoff ranged from quick, high intensity rain events lasting < 1 hour to long, slow rain events that last several hours.

6. Over the year 2, 12 month sampling period (August 1, 2009 – July 31, 2010) covered by this report, 39 individual composite samples were collected and analyzed. Rainfall intensities capable of producing runoff ranged from quick, high intensity rain events lasting < 1 hour to long, slow rain events that last >24 hours.
7. The amount of runoff volume generated from different storm events varied with rainfall intensity and duration. Maximum runoff volume measured over the sampling period was as high as 80% of the recorded rainfall measured as runoff for the larger storm events during the year 2 sampling period. Higher rainfall amounts were recorded in the year 2 sample period compared to year 1.
8. Sites treated with fertilizer and biosolids had higher concentrations of nutrients in runoff than the control. Concentrations of nutrients in runoff from the fertilized site 2 were greater than the biosolids applied sites 3 and 4.
9. While concentrations of TKN, nitrate and TP were similar in runoff from sites 3 and 4, ammonia was >5 times higher in the 6 t/ac applied site 4.
10. Annual median nutrient concentrations in runoff decrease over time.
11. Concentrations of Cu and Zn tend to be detectable more often in the 6 t/ac biosolids applied site 4 and at higher concentrations compared to the other 3 sites.
12. The highest fecal coliform concentration over the sampling period came from the biosolids applied site 4, but fecal concentrations were high at all sites over the entire sample period.
13. Surface soil samples can be highly variable for P and Zn at a site suggesting differences that are <50% cannot be attributed to management.
14. Surface soil data shows an increase in soil P after fertilizer and biosolids application and no significant soil Zn was measured after application. Soil pH is very consistent over the three sampling periods.
15. Forage crop quality and yields tended to be higher in the biosolids applied sites compared to the fertilizer applied site. Nutrient uptake by the plants tended to be higher in the fall cutting compared to the spring in forage harvested from the fertilized and biosolids applied sites. No distinction could be made between concentrations of Cu and Zn in

forage harvested from the biosolids applied sites compared to forage harvested from the fertilized or control sites.

16. Forage plots lacked true replication, the results were averaged across landscape positions within each treatment. The results should therefore be considered descriptive statistics rather than results of a properly constructed hypothesis test.

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TABLES

Table 1. Watershed and Nutrient Management Treatment Details at the Study Site

| Site | Nutrient Treatment | Soil Map Units Present (Hughes, 1982) | Forage Suitability Group |
|------|--|--|---------------------------------|
| 1 | Control | Goss very cobbly silt loam, 15-35% slopes Nixa very gravelly silt loam, 3-8% slopes | Gravelly Upland Gravelly Pan |
| 2 | Commercial Fertilizer | Nixa very gravelly silt loam, 3-8% slopes Viraton silt loam, 2-5% slopes | Gravelly Pan Loamy Pan |
| 3 | Biosolids at Commercial Fertilizer Equivalent | Nixa-Clarksville complex, 3-20% slopes Viraton silt loam, 2-5% slopes | Gravelly Upland Loamy Pan |
| 4 | Biosolids at Double Commercial Fertilizer Equivalent | Viraton silt loam, 2-5% slopes Nixa very gravelly silt loam, 3-8% slopes | Loamy Pan Gravelly Pan |

Table 2. Summary of Soil Morphology Analysis

| Pit # | Landscape Position | Parent Material | Elevation (feet) | Slope | % Coarse Rock Frag. | Notes |
|-------|--------------------|--------------------------|------------------|-------|---------------------|--|
| 1 | Head Slope | Loess/Colluvium/Residuum | 1,215 | 1% | 0-25 | 8" Loess (10 YR4/3) Fragipan (32"- 45") Redox features |
| 2 | Interfluve | Colluvium/Residuum | 1,199 | 2% | 10-60 | Weak fragipan (20"-35") Redox features |
| 3 | Side Slope | Colluvium/Residuum | 1,195 | 4% | 5-50 | Weathered sandstone present (50"-60") |
| 4 | Side Slope | Colluvium/Residuum | 1,176 | 12% | 5-60 | |
| 5 | Colluvial Valley | Alluvium/Colluvium | 1,166 | 6% | 40-50 | Alluvium (0"-23") |

Table 3. Watershed and Nutrient Management Details at the Study Site

| Site | Treatment Name | Experimental Year | Planned Nutrient Application (lbs/a) | Actual Nutrient Application (lbs/a) |
|------|--|-------------------|--|--|
| | | | N + P ₂ O ₅ + K ₂ O | N + P ₂ O ₅ + K ₂ O |
| 1 | Control | 1 | 0 + 0 + 0 | 0 + 0 + 0 |
| | | 2 | 0 + 0 + 0 | 0 + 0 + 0 |
| | | 3 | 0 + 0 + 0 | 0 + 0 + 0 |
| 2 | Commercial Fertilizer | 1 | 54 + 299 + 13 | 54 + 299 + 13 |
| | | 2 | 54 + 0 + 0 | 82 + 20 + 0 |
| | | 3 | 54 + 0 + 0 | 82 + 0 + 0 * |
| 3 | Commercial Fertilizer Equivalent Biosolids @ 3 dry tons/a | 1 | 111 + 299 + 13 | 160 + 319 + 3 |
| | | 2 | 34 + 0 + 0 | 38 + 0 + 0 |
| | | 3 | 17 + 0 + 0 | 19 + 0 + 0 |
| 4 | Double Commercial Fertilizer Equivalent Biosolids @ 6 dry tons/a | 1 | 222 + 598 + 26 | 303 + 558 + 6 |
| | | 2 | 68 + 0 + 0 | 64 + 0 + 0 |
| | | 3 | 34 + 0 + 0 | 32 + 0 + 0 |

Table 4. Drainage Area, Weir Geometry, and Discharge Equations

| Site | Ad (acres) | Weir | | | Rating Curve Equation |
|------|------------|----------------|-------------|---------------------------------------|--|
| | | Top Width (ft) | Height (ft) | Height of Notch ab. Ground Level (ft) | |
| 1 | 0.38 | 1.23 | 0.61 | 0.22 | $Q = 1.9069(d_w)^3 - 0.4207(d_w)^2 - 0.0981(d_w) + 0.0206$ |
| 2 | 0.65 | 1.18 | 0.6 | 0.22 | $Q = 1.4413(d_w)^3 + 0.3164(d_w)^2 - 0.4538(d_w) + 0.0733$ |
| 3 | 3 | 1.18 | 0.6 | 0.26 | $Q = 1.626(d_w)^3 - 0.5969(d_w)^2 - 0.2461(d_w) + 0.091$ |
| 4 | 1.28 | 1.19 | 0.64 | 0.23 | $Q = 1.3331(d_w)^3 + 0.4238(d_w)^2 - 0.5228(d_w) + 0.0855$ |

Ad = drainage area

Q = Discharge in cubic feet per second (cfs)

d_w = depth of water (feet)

Table 5. Test Parameters, Methods, Method Detection Limits, Method Accuracy and Precision, and Project Accuracy and Precision

| Nutrient | Method | Method Detection Limit (mg/L) | Method Accuracy (mg/L) | Method Precision (mg/L) | Project Accuracy (mg/L) | Project Precision (mg/L) |
|-------------------------|--------------|-------------------------------|------------------------|-------------------------|-------------------------|--------------------------|
| Total Kjeldahl Nitrogen | EPA 351.2 | 0.03 | ±10 | ±10 | ±15 | ±10 |
| Total Phosphorus | EPA 365.4 | 0.01 | ±10 | ±5 | ±15 | ±7 |
| Nitrate | EPA 300.0 | 0.01 | ±10 | ±5 | ±15 | ±10 |
| Ammonia | SM4500-NH3-D | 0.1 | ±20 | ±10 | ±20 | ±10 |
| Metal | | Method Detection Limit (µg/L) | Method Accuracy (µg/L) | Method Precision (µg/L) | Project Accuracy (µg/L) | Project Precision (µg/L) |
| Arsenic | EPA 200.7 | 15 | ±10 | ±5 | ±10 | ±5 |
| Cadmium | EPA 200.7 | 5 | ±10 | ±5 | ±10 | ±5 |
| Chromium | EPA 200.7 | 10 | ±10 | ±5 | ±10 | ±5 |
| Copper | EPA 200.7 | 5 | ±10 | ±5 | ±10 | ±5 |
| Lead | EPA 200.7 | 15 | ±10 | ±5 | ±10 | ±5 |
| Nickel | EPA 200.7 | 10 | ±10 | ±5 | ±10 | ±5 |
| Molybdenum | EPA 200.7 | 20 | ±10 | ±5 | ±10 | ±5 |
| Potassium | EPA 200.7 | 50 | ±10 | ±5 | ±10 | ±5 |
| Selenium | EPA 200.7 | 20 | ±10 | ±5 | ±10 | ±5 |
| Silver | EPA 200.7 | 5 | ±10 | ±5 | ±10 | ±5 |
| Zinc | EPA 200.7 | 5 | ±10 | ±5 | ±10 | ±5 |
| Mercury | EPA 245.1 | 0.2 | ±10 | ±5 | ±10 | ±5 |
| Other | | Method Detection Limit | Method Accuracy | Method Precision | Project Accuracy | Project Precision |
| Total Suspended Solids | SM2540 D | 1 mg/L | ±10 mg/L | ±5 mg/L | ±10 mg/L | ±4 mg/L |
| pH | SM4500-H+B | 0.1 std units | ±20 std units | ±20 std units | ±10 std units | ±5 std units |
| Fecal Coliform/100mL | SM 9222 D | 1 coli/100mL | ±10 coli/100mL | ±10 coli/100mL | ±20 coli/100mL | ±14 coli/100mL |

Table 6. Landscape Position and Surface Soil Sample Locations Upstream of Weir

| Site | Landscape Position | Distance of Slope Break Upstream of Weir (ft) | Distance Upstream of Weir (ft) |
|--------|--------------------|---|--------------------------------|
| Site 1 | Footslope | 0 – 98 | 26 |
| | Backslope | 98 - 180 | 131 |
| | Summit | > 180 | 295 |
| Site 2 | Footslope | 0 – 131 | 53 |
| | Backslope | 131 - 213 | 131 |
| | Summit | > 213 | 279 |
| Site 3 | Footslope | 0 – 131 | 66 |
| | Backslope | 131 - 253 | 197 |
| | Summit | > 253 | 459 |
| Site 4 | Footslope | 0 – 98 | 69 |
| | Backslope | 98 - 246 | 164 |
| | Summit | > 246 | 328 |

Table 7. Rainfall Totals, Duration, and Sites Collected for Storm Events

| Date | Total Rainfall (in) | Rainfall Duration (hrs) | Peak Intensity (in/5 min) | Avg. Intensity (in/hr) | Sites Collected |
|----------------------|---------------------|-------------------------|---------------------------|------------------------|-----------------|
| <u>Year 1</u> | | | | | |
| 11/6/09 | 0.56 | 0.63 | 0.13 | 0.88 | 1 & 2 |
| 2/11/09 | 1.74 | 15.2 | 0.24 | 0.11 | 1 & 2 |
| 4/12/09 | 1.25 | 14.4 | 0.05 | 0.09 | 1, 2, & 3 |
| 4/20/09 | 1.27 | 21.5 | 0.09 | 0.06 | 2 & 3 |
| 5/1/09 | 1.68 | 11.9 | 0.25 | 0.14 | 1, 2, 3, & 4 |
| 5/13/09 | 0.94 | 0.79 | 0.20 | 1.19 | 1, 2, 3, & 4 |
| 6/16/09 | 1.77 | 9.0 | 0.16 | 0.20 | 1, 2, 3, & 4 |
| 6/30/09 | 1.10 | 6.6 | 0.03 | 0.17 | 2 |
| 7/20/09 | 1.83 | 23.4 | 0.18 | 0.08 | 2 |
| <u>Year 2</u> | | | | | |
| 8/11/2009 | 1.38 | 6.0 | 0.16 | 0.23 | 4 |
| 8/19/2009 | 1.44 | 14.6 | 0.17 | 0.10 | 4 |
| 9/10/2009 | 1.21 | 13.3 | 0.11 | 0.09 | 4 |
| 9/20/2009 | 1.27 | 17.1 | 0.03 | 0.07 | 4 |
| 9/22/2009 | 2.80 | 16.4 | 0.22 | 0.18 | 1, 2, 3, & 4 |
| 10/9/2009 | 5.07 | 26.5 | 0.12 | 0.20 | 1, 2, 3, & 4 |
| 10/30/2009 | 0.98 | 14.9 | 0.09 | 0.07 | 1, 2, 3, & 4 |
| 1/22/2009 | 0.54 | 22.4 | 0.04 | 0.02 | 2 |
| 1/25/2010 | 0.63 | 20.3 | 0.06 | 0.03 | 1, 2, & 3 |
| 2/22/2010 | 0.83 | 23.4 | 0.04 | 0.04 | 1, 2, & 3 |
| 3/22/2010 | 0.82 | 44.9 | 0.15 | 0.02 | 1 & 2 |
| 3/25/2010 | 1.37 | 19.8 | 0.06 | 0.07 | 1, 2, 3, & 4 |
| 5/14/2010 | 1.95 | 12.3 | 0.11 | 0.16 | 1, 2, 3, & 4 |
| 7/12/2010 | 2.24 | 7.5 | 0.22 | 0.33 | 1, 2, & 3 |

Table 8. Rainfall Volume and Discharge Data

| Date | Total Rainfall Volume (ft3) | Peak Q (cfs) | Total Runoff Vol. (ft3) | Est. Runoff % | Est. Infiltration % |
|----------------------|-----------------------------------|-----------------|-------------------------------|------------------|------------------------|
| <u>Site 1</u> | | | | | |
| <u>Year 1</u> | | | | | |
| 11/6/2008 | 772 | 0.01 | 3 | 0.3 | 99.7 |
| 2/11/2009 | 2,373 | 0.009 | 66 | 2.8 | 97.2 |
| 4/12/2009 | 1,779 | 0.02 | 145 | 8.2 | 91.8 |
| 5/1/2009 | 2,193 | 0.11 | 466 | 21.2 | 78.8 |
| 5/13/2009 | 1,283 | 0.003 | 1.5 | 0.1 | 99.9 |
| 6/16/2009 | 2,400 | 0.18 | 318 | 13.3 | 86.8 |
| <u>Year 2</u> | | | | | |
| 9/22/2009 | 2,621 | 0.36 | 748 | 28.5 | 71.5 |
| 10/9/2009 | 7,173 | 0.11 | 1,996 | 27.8 | 72.2 |
| 10/30/2009 | 1,283 | 0.03 | 78 | 6 | 94 |
| 1/25/2010 | 883 | 0 | 0.37 | <1 | >99 |
| 2/22/2010 | 1,021 | 0 | 0.37 | <1 | >99 |
| 3/22/2010 | 924 | 0 | 0.37 | <1 | >99 |
| 3/25/2010 | 1,917 | 0.007 | 30 | 1.6 | 98.4 |
| 5/14/2010 | 2,566 | 0.07 | 368 | 14.3 | 85.7 |
| 7/12/2010 | 2,897 | 0.06 | 41.7 | 1.4 | 98.6 |
| <u>Site 2</u> | | | | | |
| <u>Year 1</u> | | | | | |
| 11/6/2009 | 1,321 | 0 | 0.66 | <1 | >99 |
| 2/10/2009 | 4,153 | 0 | 0.66 | <1 | >99 |
| 4/12/2009 | 2,831 | 0 | 0.66 | <1 | >99 |
| 4/20/2009 | 3,044 | 0 | 0.66 | <1 | >99 |
| 5/1/2009 | 3,940 | 0.06 | 396 | 10.1 | 89.9 |
| 5/13/2009 | 2,218 | 0.019 | 17 | 0.8 | 99.2 |
| 6/16/2009 | 4,058 | 0.29 | 757 | 18.7 | 81.3 |
| 6/30/2009 | 2,595 | 0.08 | 39 | 1.5 | 98.5 |
| 7/20/2009 | 4,318 | 0 | 0 | <1 | >99 |
| <u>Year 2</u> | | | | | |
| 9/22/2009 | 6,866 | 0.62 | 263 | 38.2 | 61.8 |
| 10/9/2009 | 12,954 | 0.42 | 10,544 | 81.4 | 18.6 |
| 10/30/2009 | 2,501 | 0.13 | 275 | 11 | 89 |
| 1/22/2010 | 1,274 | 0 | 0.66 | <1 | >99 |
| 1/25/2010 | 1,581 | 0.015 | 25 | 1.6 | 98.4 |
| 2/22/2010 | 2,242 | 0 | 0.66 | <1 | >99 |
| 3/22/2010 | 2,265 | 0.065 | 957 | 42.3 | 57.7 |
| 3/25/2010 | 3,468 | 0.096 | 1,841 | 53.1 | 46.9 |
| 5/14/2010 | 4,790 | 0.020 | 100 | 2.1 | 97.9 |
| 7/12/2010 | 5,450 | 0.130 | 126 | 2.3 | 97.7 |

| <u>Site 3</u> | | | | | |
|---------------|--------|-------|--------|------|------|
| <u>Year 1</u> | | | | | |
| 4/12/2009 | 13,830 | 0.09 | 984 | 7.1 | 92.9 |
| 4/20/2009 | 13,504 | 0.04 | 406 | 3 | 97 |
| 5/1/2009 | 18,077 | 0.41 | 4,358 | 24.1 | 75.9 |
| 5/13/2009 | 10,128 | 0.02 | 90 | 0.9 | 99.1 |
| 6/16/2009 | 18,731 | 0.58 | 3,112 | 16.6 | 83.4 |
| <u>Year 2</u> | | | | | |
| 9/22/2009 | 29,839 | 0.91 | 17,300 | 58 | 42 |
| 10/9/2009 | 52,381 | 0.78 | 33,645 | 64.2 | 35.8 |
| 10/30/2009 | 9,801 | 0.29 | 5,539 | 56.5 | 43.5 |
| 1/25/2010 | 6,207 | 0.17 | 1,591 | 25.6 | 74.4 |
| 2/22/2010 | 8,821 | 0.13 | 1,101 | 12.5 | 87.5 |
| 3/25/2010 | 14,048 | 0.60 | 7,632 | 54.3 | 45.7 |
| 5/14/2010 | 20,691 | 0.20 | 573 | 2.8 | 97.2 |
| 7/12/2010 | 25,156 | 0.17 | 51 | 0.2 | 99.8 |
| <u>Site 4</u> | | | | | |
| <u>Year 1</u> | | | | | |
| 5/1/2009 | 8,271 | 0.02 | 128.5 | 1.6 | 98.4 |
| 5/13/2009 | 4,414 | 0 | 0.27 | <1 | >99 |
| 6/16/2009 | 8,782 | 0.02 | 86.5 | 1 | 99 |
| <u>Year 2</u> | | | | | |
| 8/11/2009 | 6,412 | 0 | 0.27 | <1 | >99 |
| 8/19/2010 | 6,691 | 0 | 0.27 | <1 | >99 |
| 9/10/2009 | 5,622 | 0 | 0.27 | <1 | >99 |
| 9/20/2009 | 5,901 | 0 | 0.27 | <1 | >99 |
| 9/22/2009 | 12,824 | 0.17 | 1,295 | 10.1 | 89.9 |
| 10/9/2009 | 22,163 | 0.25 | 4,732 | 21.3 | 78.7 |
| 10/30/2009 | 4,693 | 0 | 0.27 | <1 | >99 |
| 3/25/2010 | 6,226 | 0.08 | 875 | 14.1 | 85.9 |
| 5/14/2010 | 9,246 | 0.003 | 14.8 | 0.2 | 99.8 |

Table 9. Water Quality Summary Statistics

| | | TSS (mg/l) | TKN (mg/l) | NH3-N (mg/l) | NO3-N (mg/l) | TP (mg/l) | pH (Std Units) |
|------------------------|------|-----------------------|-----------------------|-------------------------|-------------------------|----------------------|---------------------------|
| Site 1 (control) | n | 16 | 16 | 16 | 16 | 16 | 16 |
| | mean | 14 | 2.71 | 0.281 | 0.166 | 0.364 | 7.1 |
| | sd | 13 | 2.34 | 0.243 | 0.177 | 0.355 | 0.1 |
| Site 2 (fertilizer) | n | 20 | 20 | 20 | 20 | 20 | 20 |
| | mean | 80 | 6.40 | 2.05 | 0.788 | 4.06 | 7.2 |
| | sd | 136 | 14.2 | 8.32 | 0.916 | 7.46 | 0.2 |
| Site 3 (3T Bio) | n | 14 | 14 | 14 | 14 | 14 | 14 |
| | mean | 59 | 2.56 | 0.169 | 0.170 | 0.631 | 7.2 |
| | sd | 161 | 1.76 | 0.098 | 0.117 | 0.645 | 0.1 |
| Site 4 (6T Bio) | n | 12 | 12 | 11 | 12 | 12 | 12 |
| | mean | 31 | 3.43 | 0.952 | 0.216 | 0.878 | 7.2 |
| | sd | 49 | 3.96 | 2.34 | 0.105 | 2.03 | 0.1 |

Table 10. Frequency Distribution for Cu Samples

| Cu (ppb) | min | 10% | 25% | 50% | 75% | 90% | max |
|-----------------|------------|------------|------------|------------|------------|------------|------------|
| Site 1 (n=15) | <DL | <DL | <DL | <DL | <DL | <DL | <DL |
| Site 2 (n=19) | <DL | <DL | <DL | <DL | <DL | <DL | 5.5 |
| Site 3 (n=14) | <DL | <DL | <DL | <DL | <DL | <DL | 8.2 |
| Site 4 (n=12) | <DL | <DL | <DL | <DL | 3.7 | 11.3 | 19.6 |

Table 11. Frequency Distribution for Zn Samples

| Zn (ppb) | min | 10% | 25% | 50% | 75% | 90% | max |
|-----------------|------------|------------|------------|------------|------------|------------|------------|
| Site 1 (n=15) | <DL | <DL | <DL | <DL | <DL | <DL | 6.4 |
| Site 2 (n=19) | <DL | <DL | <DL | <DL | <DL | 7.7 | 17.4 |
| Site 3 (n=14) | <DL | <DL | <DL | <DL | <DL | <DL | 26.1 |
| Site 4 (n=12) | <DL | <DL | <DL | 4.4 | 7.3 | 15.3 | 69.1 |

Table 12. Frequency Distribution for Fecal Coliform

| Fecal (col/100 ml) | min | 10% | 25% | 50% | 75% | 90% | max |
|-------------------------------|------------|------------|------------|------------|------------|------------|------------|
| Site 1 (n=16) | <DL | 5.3 | 28 | 141 | 834 | 5,650 | 29,000 |
| Site 2 (n=20) | <DL | 4.6 | 28 | 182 | 1,014 | 1,591 | 8,000 |
| Site 3 (n=14) | <DL | 9.3 | 105 | 641 | 1,070 | 5,260 | 9,000 |
| Site 4 (n=12) | <DL | 1.5 | 18 | 670 | 3,070 | 5,800 | 190,000 |

Table 13. Annual soil sample variability in pH, P, and Zn from each landscape position by site. Coefficient of variation percentage (cv%) of three samples collected from each position each year.

| Site | Year | pH (cv%) | | | P (cv%) | | | Zn (cv%) | | |
|------|------|----------|-----------|-----------|---------|-----------|-----------|----------|-----------|-----------|
| | | Summit | Backslope | Footslope | Summit | Backslope | Footslope | Summit | Backslope | Footslope |
| 1 | 1 | 2.1 | 2.6 | 1.7 | 49 | 11 | 28 | 11 | 13 | 46 |
| | 2 | 7.1 | 2.7 | 4.5 | 46 | 8.3 | 41 | 26 | 5.6 | 27 |
| | 3 | 8.3 | 7.1 | 1.4 | 69 | 17 | 18 | 29 | 7.5 | 27 |
| 2 | 1 | 1.1 | 3.5 | 1.6 | 28 | 17 | 23 | 14 | 22 | 23 |
| | 2 | 3.7 | 2.5 | 4.6 | 68 | 35 | 25 | 2.8 | 221 | 22 |
| | 3 | 0.9 | 2.6 | 3.6 | 3 | 20 | 28 | 8.7 | 20 | 6.7 |
| 3 | 1 | 2.6 | 2.7 | 4.0 | 30 | 17 | 48 | 13 | 25 | 23 |
| | 2 | 1.7 | 0.9 | 2.7 | 21 | 37 | 31 | 28 | 24 | 45 |
| | 3 | 0.8 | 1.8 | 1.5 | 31 | 5.3 | 33 | 11 | 11 | 31 |
| 4 | 1 | 2.4 | 0.9 | 1.6 | 25 | 17 | 27 | 12 | 17 | 31 |
| | 2 | 3.3 | 6.1 | 1.8 | 6.9 | 23 | 6.0 | 23 | 34 | 19 |
| | 3 | 1.5 | 5.8 | 2.3 | 16 | 37 | 27 | 16 | 9.1 | 30 |

Table 14. Annual average relative percent difference (RPD) from randomly selected duplicates to assess soil sample variability.

| Site | Year | n | pH (RPD) | P (RPD) | Zn (RPD) |
|------|------|---|----------|---------|----------|
| 1 | 1 | 3 | 2.3 | 23 | 18 |
| | 2 | 3 | 3.0 | 25 | 13 |
| | 3 | 3 | 1.0 | 19 | 19 |
| 2 | 1 | 3 | 1.2 | 27 | 22 |
| | 2 | 3 | 2.7 | 40 | 1.6 |
| | 3 | 3 | 2.5 | 19 | 13 |
| 3 | 1 | 3 | 1.6 | 27 | 12 |
| | 2 | 3 | 4.2 | 25 | 5.1 |
| | 3 | 3 | 1.0 | 21 | 13 |
| 4 | 1 | 3 | 1.5 | 16 | 19 |
| | 2 | 3 | 3.6 | 16 | 4.9 |
| | 3 | 3 | 5.6 | 66 | 84 |

Table 15. Forage Relative Feed Value (RFV)

| Cutting | Site 1 (Control) | Site 2 (Fert) | Site 3 (3T Bio) | Site 4 (6T Bio) |
|----------------|-----------------------------|--------------------------|----------------------------|----------------------------|
| Spring 2009 | 79 | 73 | 76 | 78 |
| Fall 2009 | 82 | 97 | 90 | 90 |
| Spring 2010 | 79 | 77 | 78 | 80 |
| Fall 2010 | 66 | 76 | 89 | 96 |

FIGURES

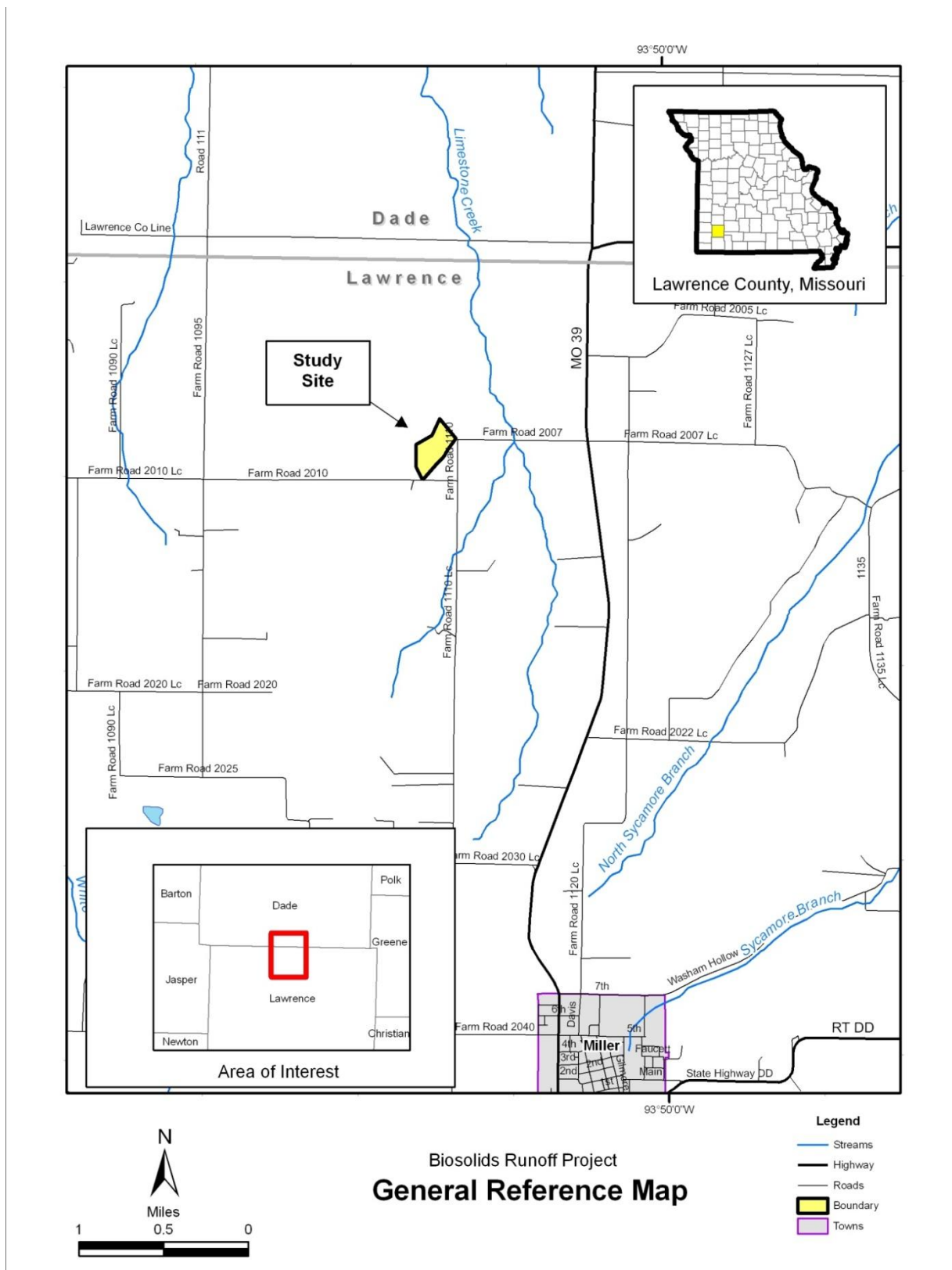


Figure 1. Study site location

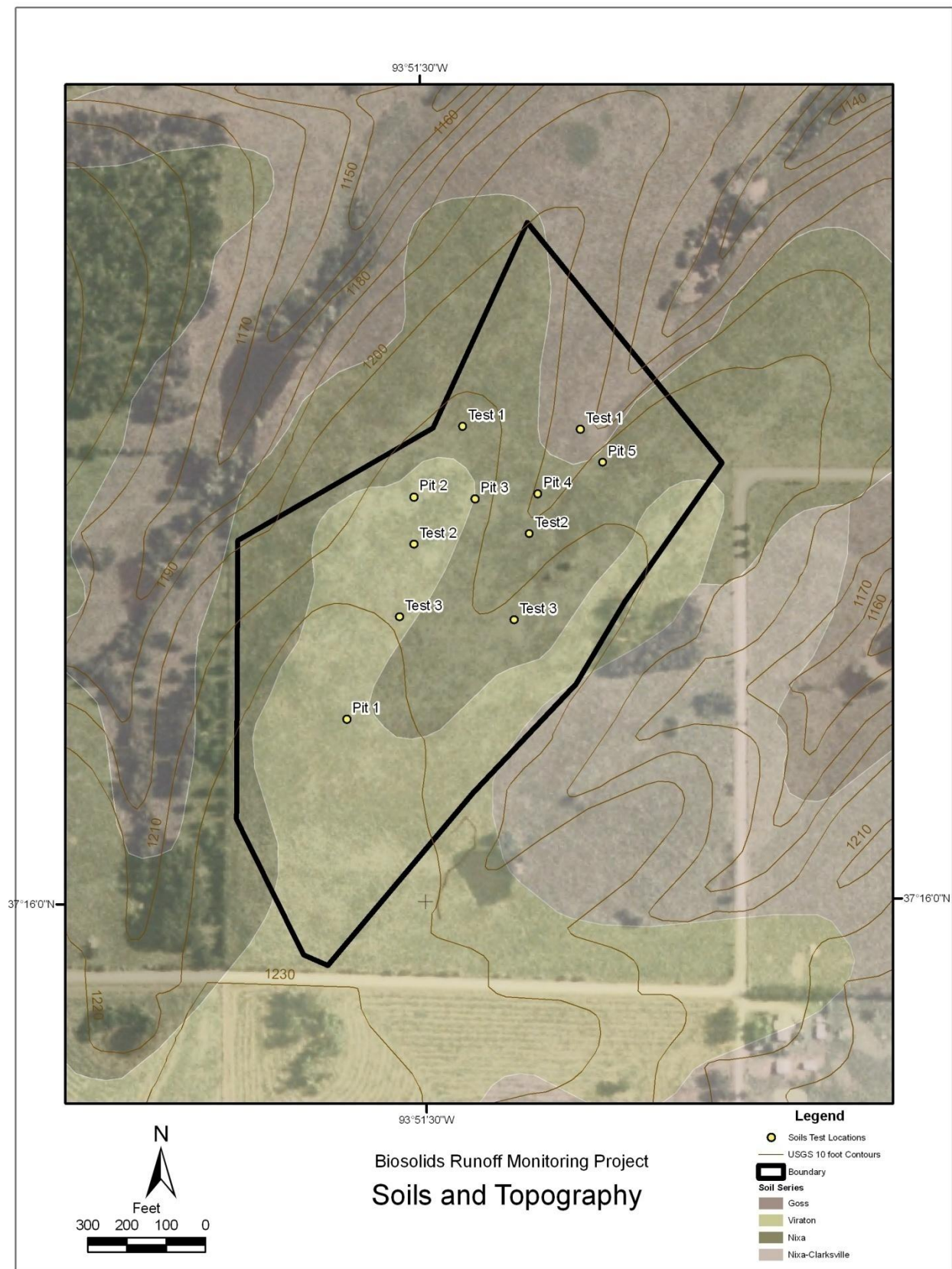


Figure 2. Mapped soils with soil test and soil morphology soil pit locations

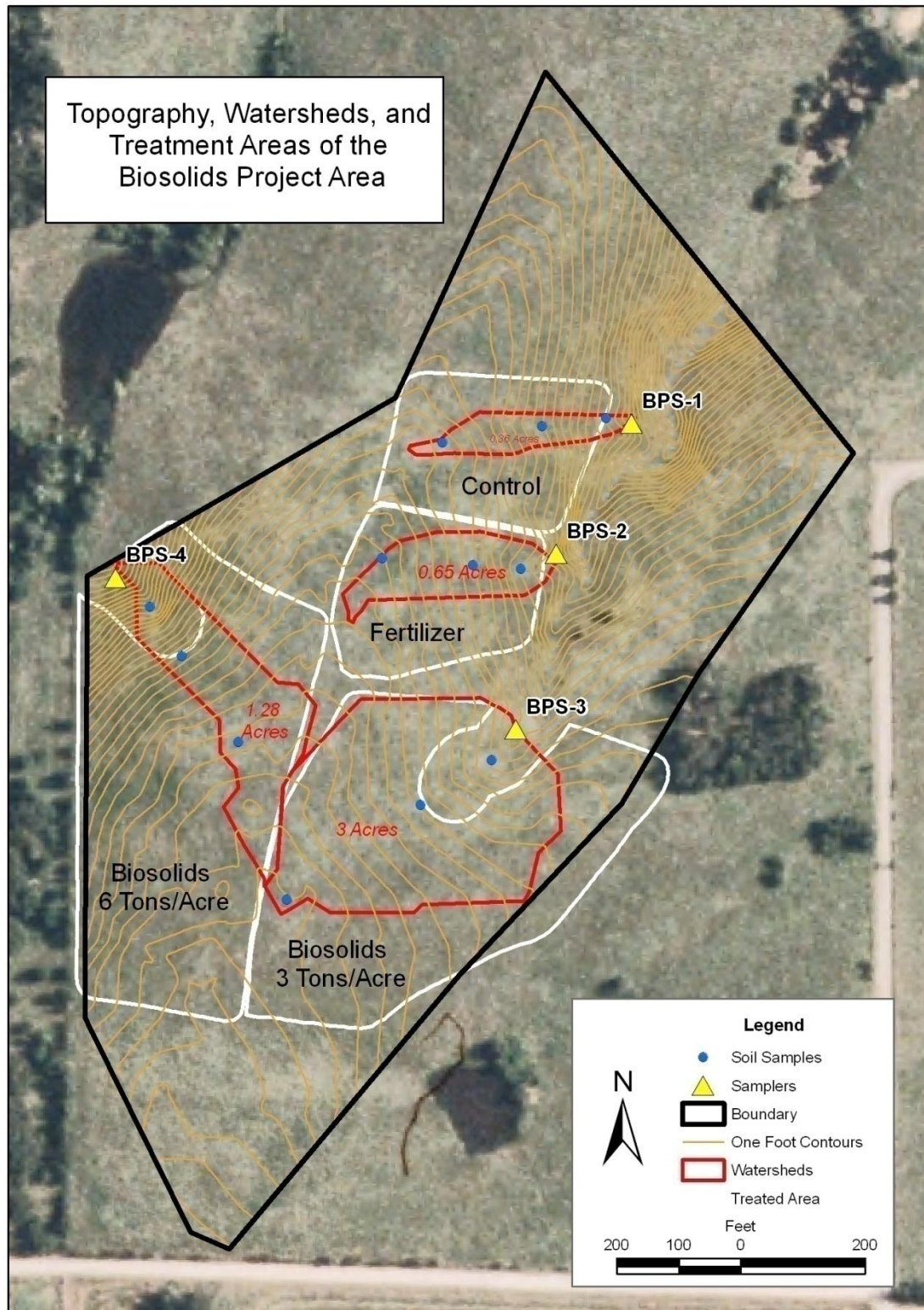


Figure 3. Site topography, watershed areas, surface soil sample locations, and treatment zones

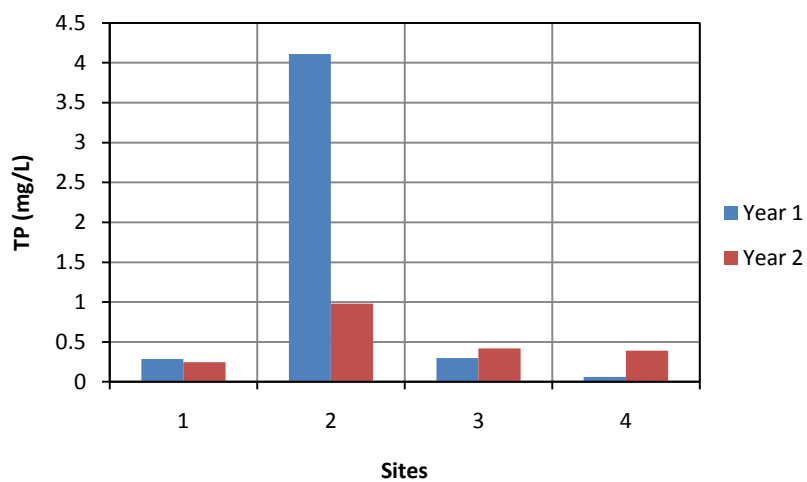


Figure 4. Annual median TP by site

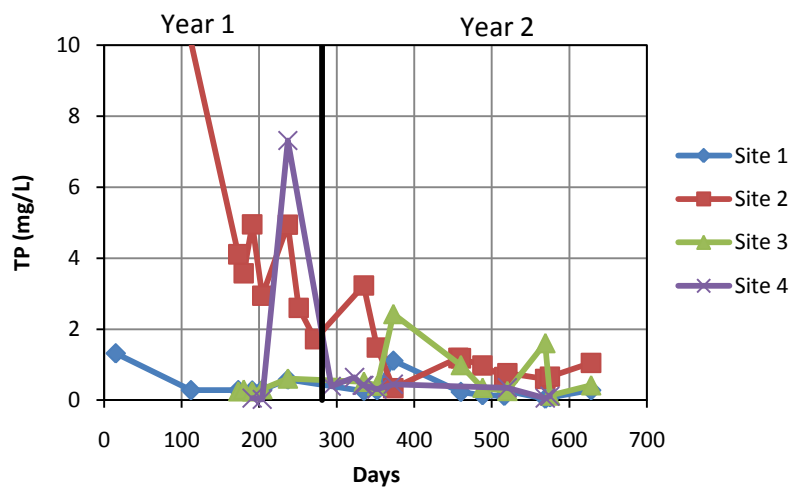


Figure 5. Time-series plot of TP over the sample period

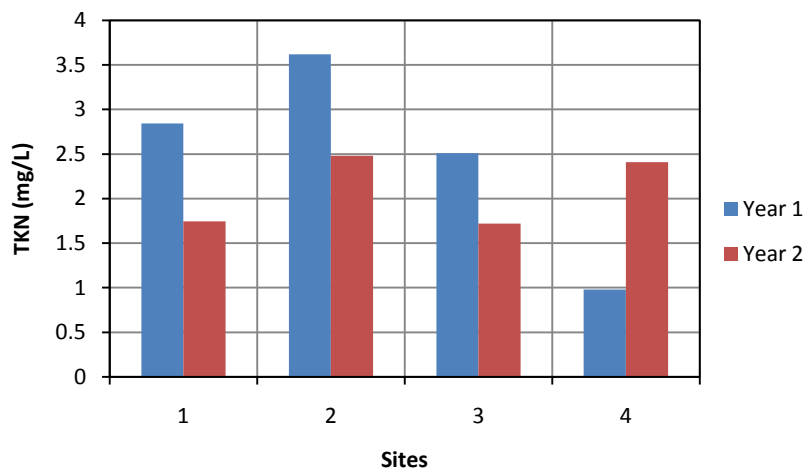


Figure 6. Annual median TKN by site

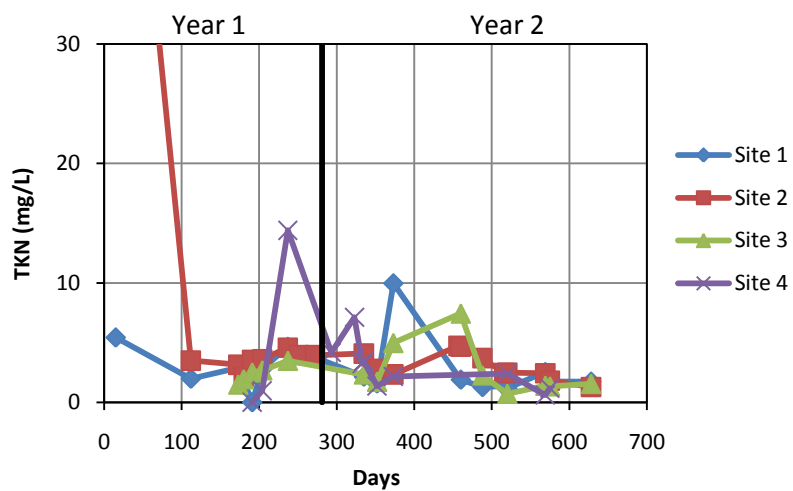


Figure 7. Time-series plot of TKN over the sample period

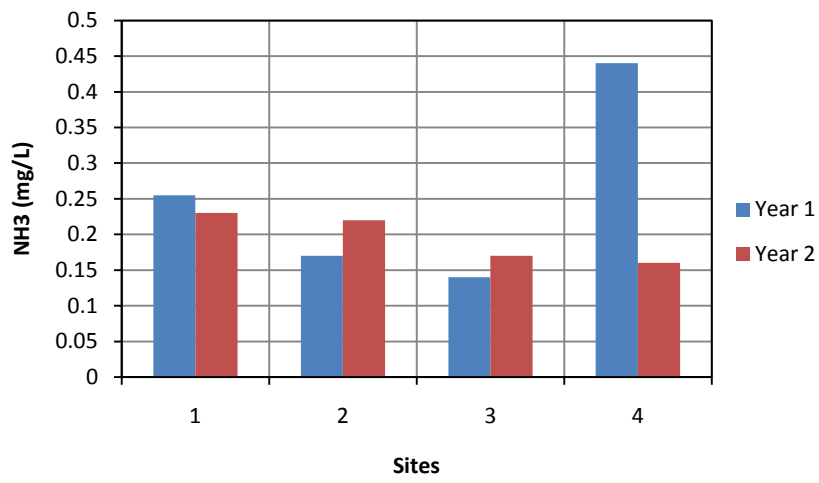


Figure 8. Annual median ammonia by site

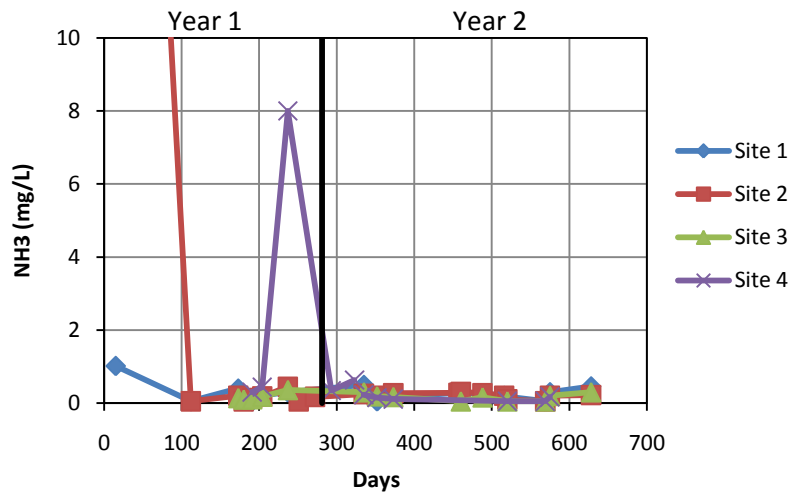


Figure 9. Time-series plot of ammonia over the sample period

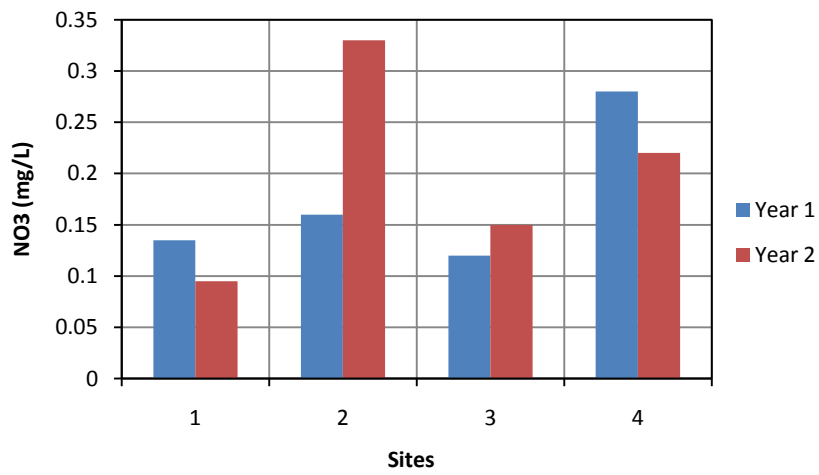


Figure 10. Annual median nitrate over time

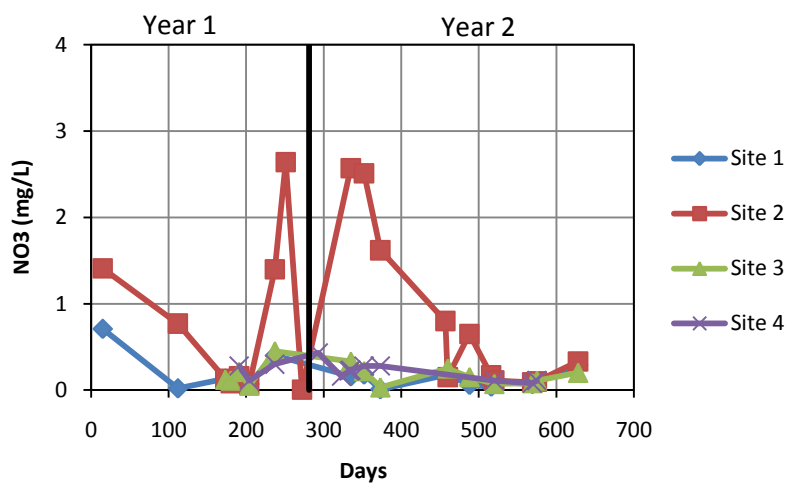


Figure 11. Time-series plot of nitrate over the sample period

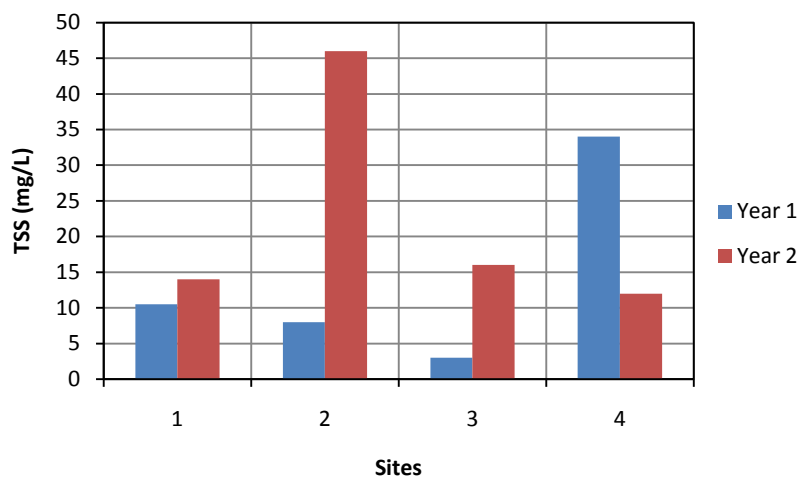


Figure 12. Annual median TSS by site

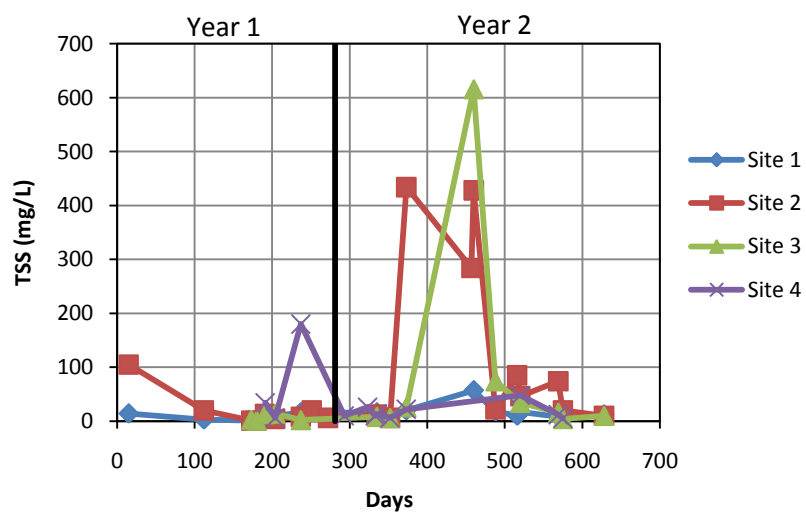


Figure 13. Time-series plot of TSS over the sample period

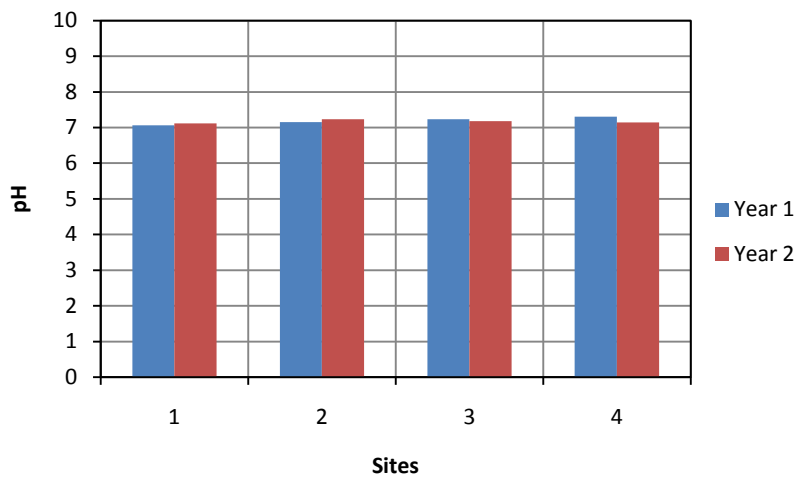


Figure 14. Annual median pH by site

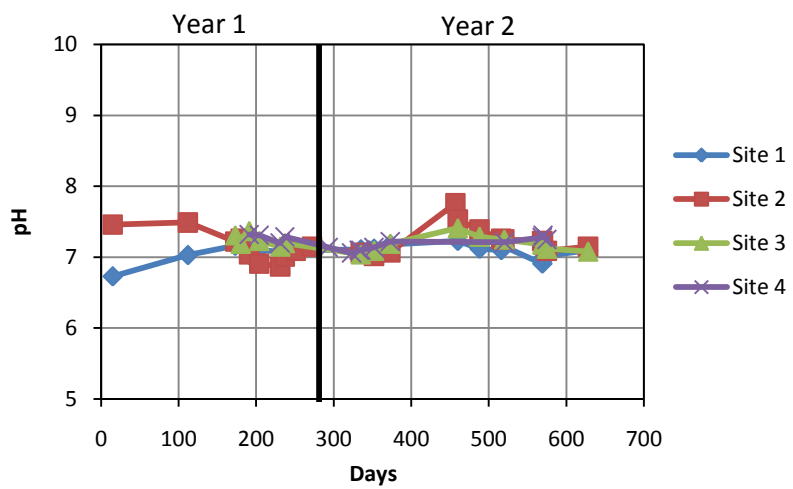


Figure 15. Time-series plot of pH over the sample period

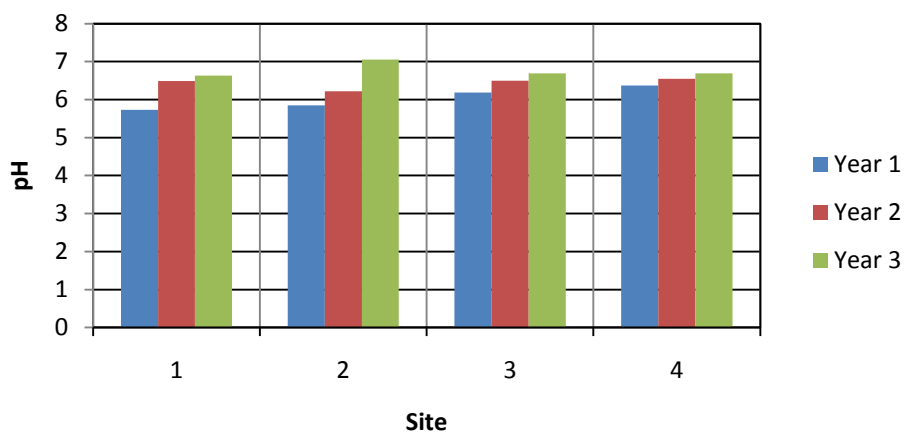


Figure 16. Annual mean soil pH by site



Figure 17. Annual mean soil pH by landscape position

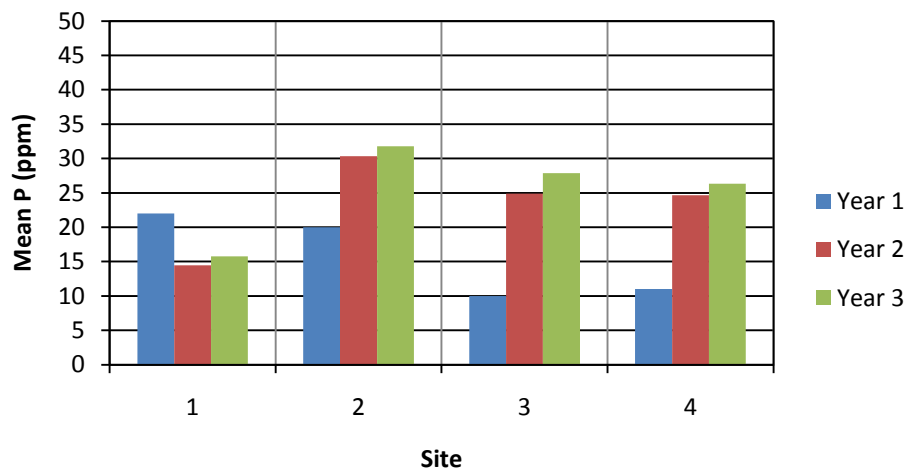


Figure 18. Annual mean soil P by site

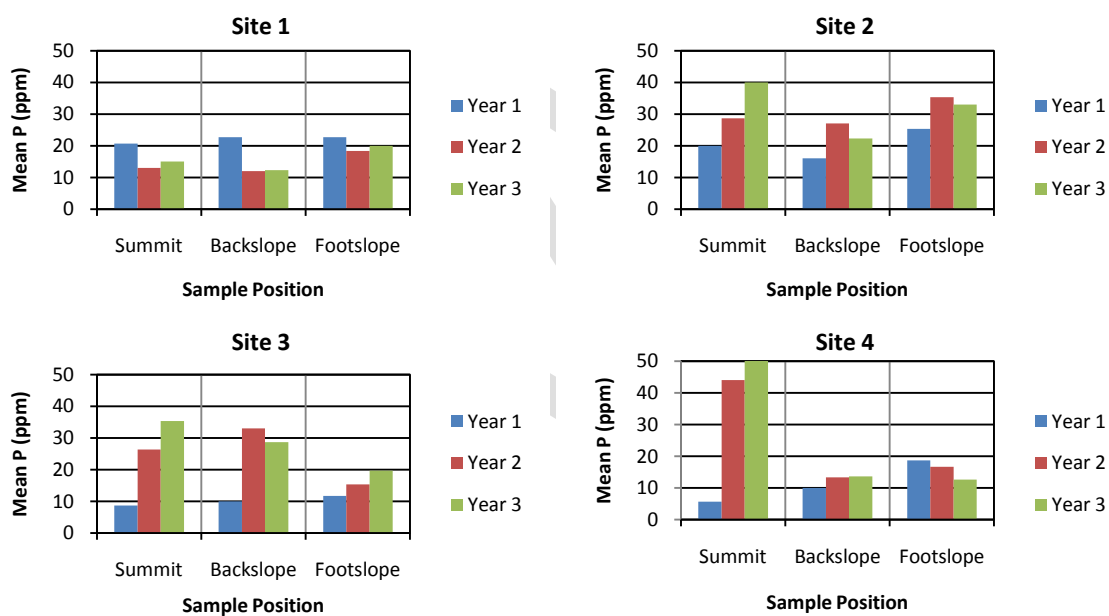


Figure 19. Annual mean soil P by landscape position

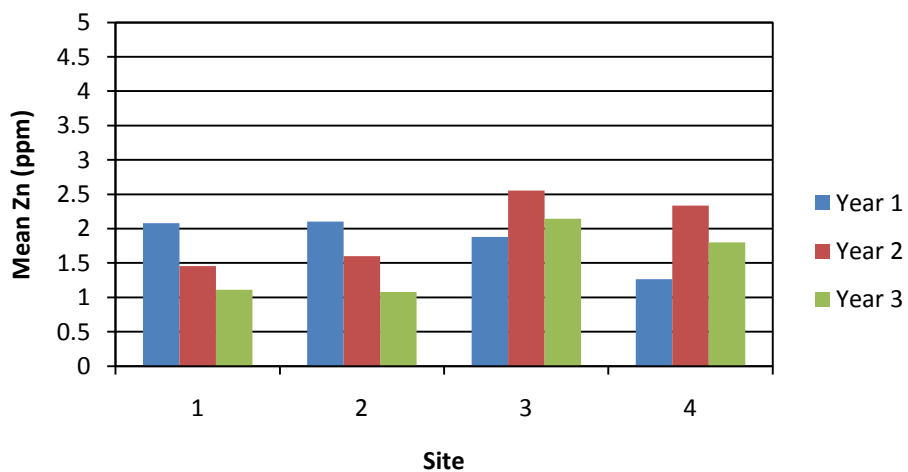


Figure 20. Annual mean soil Zn by site

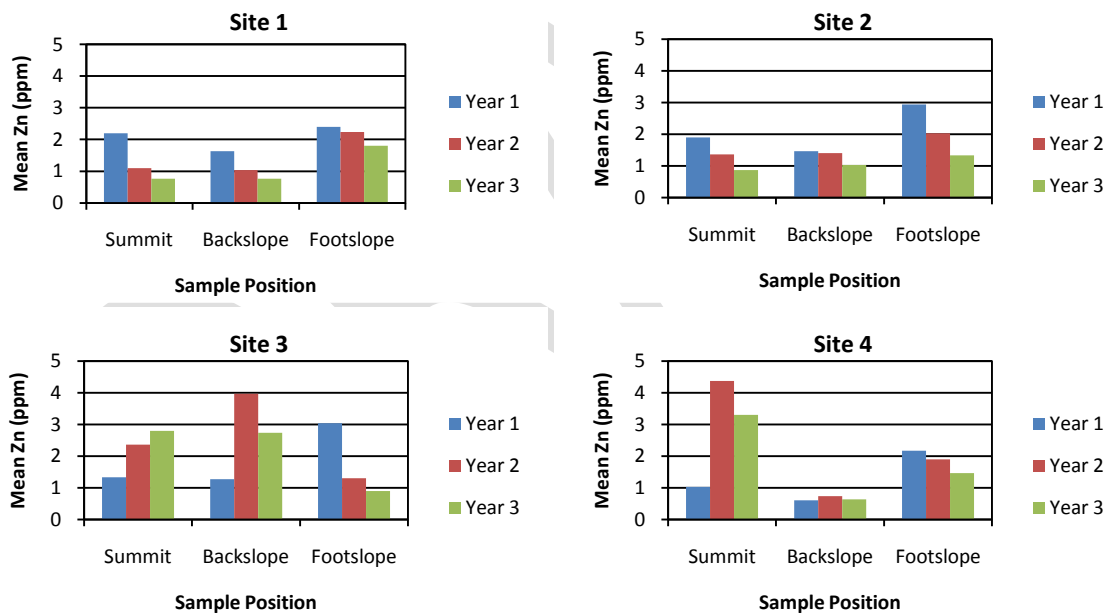


Figure 21. Annual mean soil Zn by landscape position

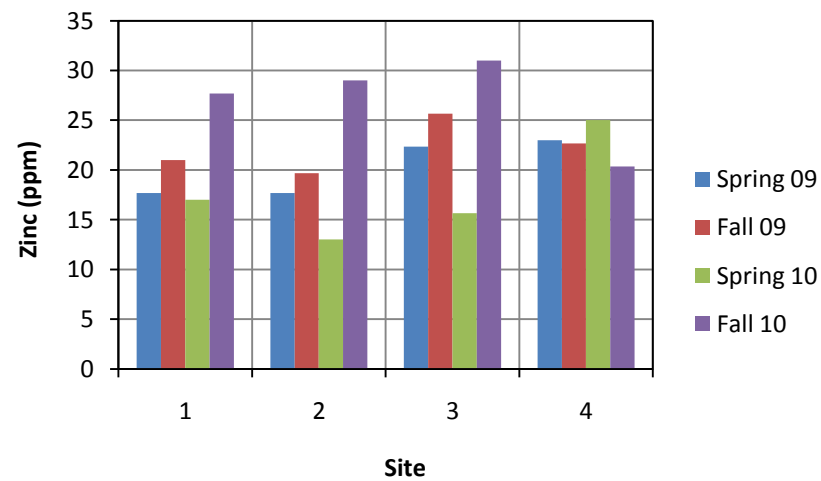
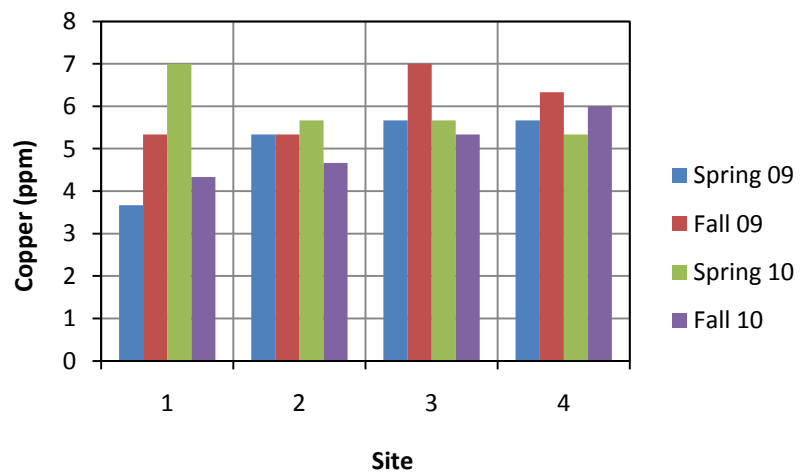
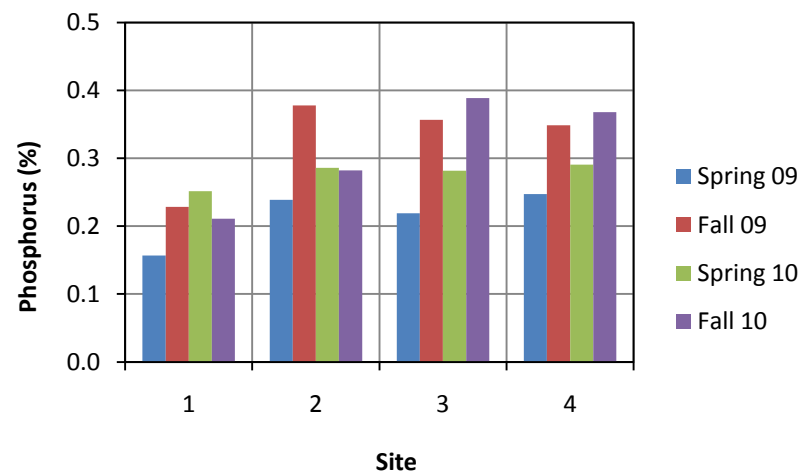
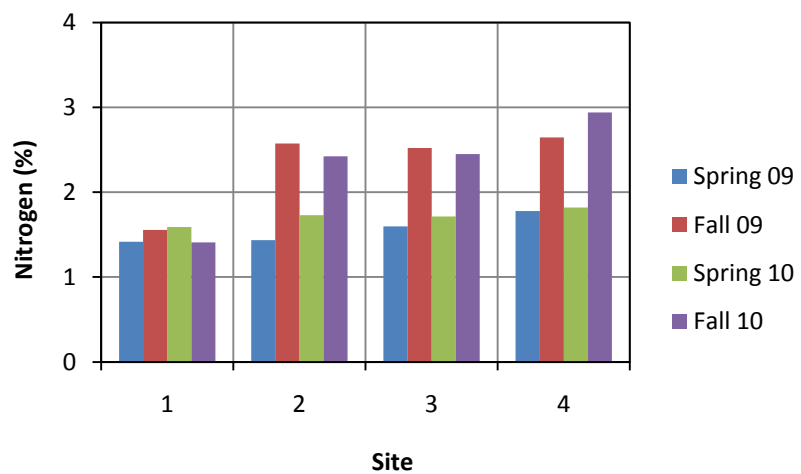


Figure 22. Annual Nitrogen, Phosphorus, Copper and Zn in forage harvest

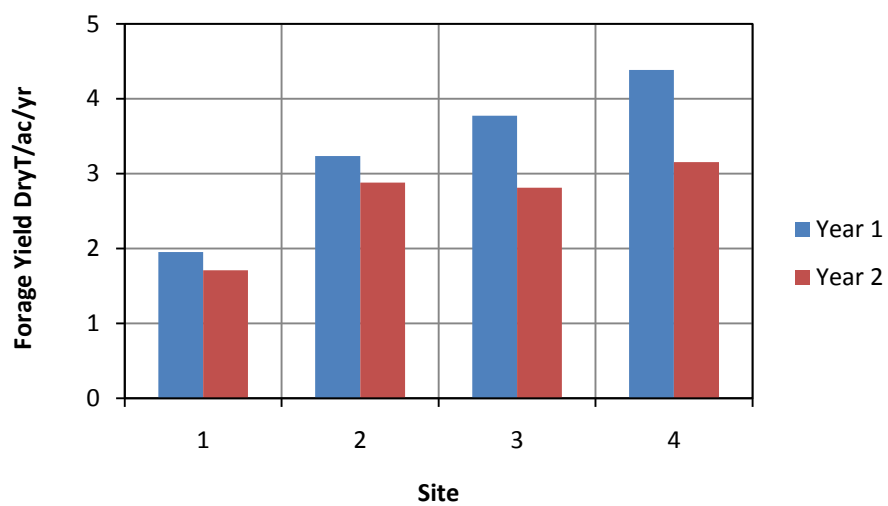


Figure 23. Annual average forage yield by site

PHOTOS



Photo 1. Soil pit #1 from the head slope landscape position showing silty texture from loess parent material over older reworked loess sitting on top of a fragipan.



Photo 2. Soil pit #2 from the narrow interfluvial position between sites 1 and 4 showing colluvial material over a weak fragipan over red residuum below.



Photo 3. Prismatic structure and gray seams indicative of fragipan pedology in SW Missouri.



Photo 4. Soil pit #3 from the slightly steeper shoulder side slope with rocky colluvium over cherty red clay residuum.



Photo 5. Top 15 inches of pit #4 similar to pit #3 above.



Photo 6. Soil pit from the valley bottom landscape position with unconsolidated rocky colluvial parent material that may be result of past land clearing.



Photo 7. V-Notch Weir, Pressure Transducer, and Strainer Location



Photo 8. Pressure Transducer and Strainer Location



Photo 9. Surface Soil Sample Transect



Photo 10. Sampler housing along main draw on the project site (October 2008)



Photo 11. Auto-sampler and Rain Gage Installation (October 2008)



Photo 12. Tom Dewitt Soil Coring Along the Ridge with Class (October 2008)



Photo 13. Example of a Soil Profile at the Project Site (Loess over Colluvium over Residuum) (October 2008)

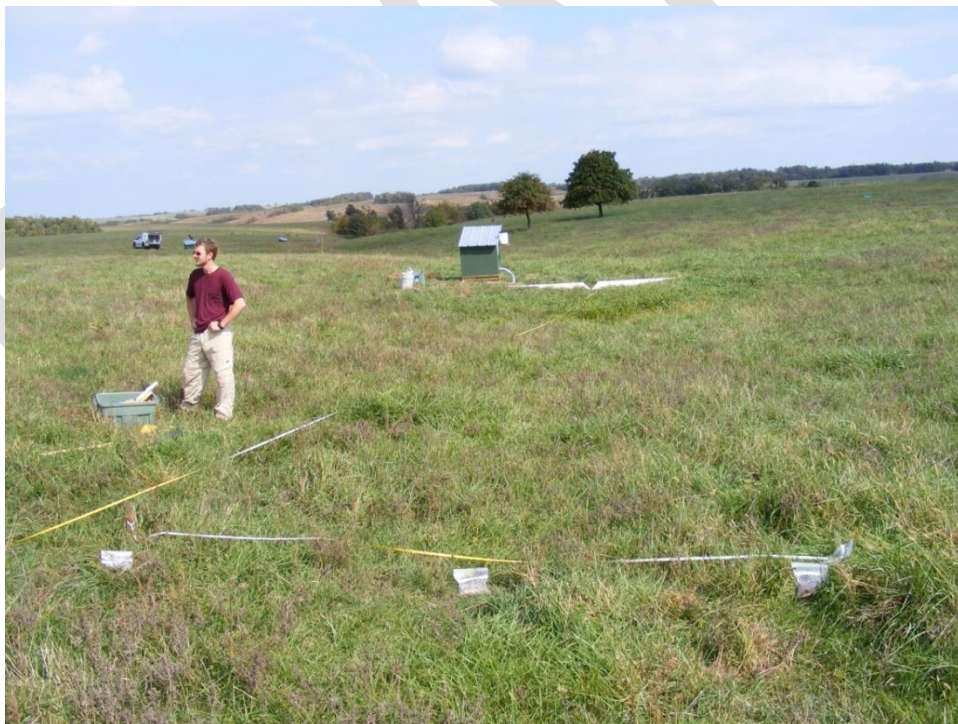


Photo 14. Surface Soil Sampling (October 2008)



Photo 15. Watershed divide between the 6 t/ac biosolids applied site 4 (right) and control site 1 (left).

APPENDIX A: Soil Test Results

**University
Extension**
University of Missouri-Columbia

Soil Test Report

Soil Testing Laboratory
23 Mumford Hall, MU
Columbia, MO 65211
Phone: (573) 882-0623

or Soil Testing Laboratory
P.O. Box 160
Portageville, MO 63873
Phone: (573)379-5431

<http://www.soiltest.psu.missouri.edu/>

| FIELD INFORMATION | | | |
|-------------------|--------------------------|-----------|----|
| Field ID BIO 1 | Sample no 1 | | |
| Acres | Last Limed unknown | Irrigated | No |
| Last crop | 18 COOL SEASON GRASS HAY | FSA Copy | N |

This report is for:

MSU-GGP
901 NATIONAL
SPRINGFIELD MO 65802

| | |
|----------------------------|-------------------------|
| Serial no. S41722-1 | Lab no. C0810745 |
| County Greene | Region 6 |
| Submitted 8/1/2008 | Processed 8/6/2008 |

Soil sample submitted by: Firm Number: Outlet:

| SOIL TEST INFORMATION | | | RATING | | | | | |
|------------------------------|----------------------|------------|-------------------------|-------------------------------|------------------|-----------------------|-----------|--|
| | | | Very Low | Low | Medium | High | Very High | Excess |
| pH _s | (salt pH) | 5.7 | ***** | | | | | |
| Phosphorus | (P) | 29 lbs/A | ***** | | | | | |
| Potassium | (K) | 173 lbs/A | ***** | | | | | |
| Calcium | (Ca) | 1987 lbs/A | ***** | | | | | |
| Magnesium | (Mg) | 131 lbs/A | ***** | | | | | |
| Sulfur | (SO ₄ -S) | ppm | | | | | | |
| Zinc | (Zn) | ppm | | | | | | |
| Manganese | (Mn) | ppm | | | | | | |
| Iron | (Fe) | ppm | | | | | | |
| Copper | (Cu) | ppm | | | | | | |
| Organic matter | 3.7 | % | Neutralizable acidity | 3.0 | meq/100g | Cation Exch. Capacity | 8.7 | meq/100g |
| PH in water | | | Electrical Conductivity | | Mmho/cm | Sodium (Na) | | lbs/A |
| Nitrate (NO ₃ -N) | Topsoil | ppm | Subsoil | ppm | Sampling Depth | Top | Inches | Subsoil |
| | | | | | | | | Inches |
| NUTRIENT REQUIREMENTS | | | | | | | | |
| Cropping options | | Yield goal | Pounds per acre | | | | | LIMESTONE SUGGESTIONS |
| | | | N | P ₂ O ₅ | K ₂ O | Zn | S | |
| 18 COOL SEASON GRASS HAY | | 3 T/A | 120 | 40 | 115 | | | |
| 18 COOL SEASON GRASS HAY | | 5 T/A | 200 | 60 | 180 | | | |
| | | | | | | | | Effective Neutralizing Material (ENM) |
| | | | | | | | | Effective magnesium (EMg) |
| | | | | | | | | 0 |
| | | | | | | | | *** |

Comments

---For hay production apply nitrogen just before spring growth begins (typically March). Consider splitting nitrogen applications if the rate exceeds 90 lbs N/acre, applying 60% in March and the balance in mid August.

---Some herbicide labels list restrictions based on soil pH in water. This sample has an estimated pH in water of 6.2 . Use this estimated pH in water as a guide. If you wish to have soil pH in water analyzed, contact your dealer or Extension specialist listed below.

***Limestone is not currently recommended. For a future limestone application, suggest using dolomitic limestone if readily available, but yield response to magnesium is not likely.

I normally suggest no more than 120 lbs nitrogen per year on cool season grass hay fields. I suggest split applications of this amount with 60-80 lbs in the early spring and the balance in the early fall.

Regional Agronomy Specialist Tim Schnakenberg

Phone 417-357-6812

Tim Schnakenberg

White-Farmer, Yellow-FSA, Blue-Firm, Pink-Extension

MP 189 Revised 1/96

Signature

University of Missouri, Lincoln University, U.S. Department of Agriculture & Local University Extension Councils Cooperating
Equal opportunity institutions

Columbia

<http://www.soiltest.psu.missouri.edu/>

| FIELD INFORMATION | | | |
|------------------------------------|--------------------|-----------|----|
| Field ID BIO 3 | Sample no 3 | | |
| Acres | Last Limed unknown | Irrigated | No |
| Last crop 18 COOL SEASON GRASS HAY | FSA Copy N | | |

This report is for:

MSU-GGP
901 NATIONAL
SPRINGFIELD MO 65802

| | |
|----------------------------|-------------------------|
| Serial no. S41722-3 | Lab no. C0810747 |
| County Greene | Region 6 |
| Submitted 8/1/2008 | Processed 8/6/2008 |

Soil sample submitted by: Firm Number: Outlet:

| SOIL TEST INFORMATION | | RATING | | | | | |
|--------------------------------------|------------|-------------------------|-----|----------------|-----------------------|-----------|----------|
| | | Very Low | Low | Medium | High | Very High | Excess |
| pH _s (salt pH) | 5.5 | ***** | | | | | |
| Phosphorus (P) | 18 lbs/A | ***** | | | | | |
| Potassium (K) | 171 lbs/A | ***** | | | | | |
| Calcium (Ca) | 2156 lbs/A | ***** | | | | | |
| Magnesium (Mg) | 106 lbs/A | ***** | | | | | |
| Sulfur (SO ₄ -S) | ppm | | | | | | |
| Zinc (Zn) | ppm | | | | | | |
| Manganese (Mn) | ppm | | | | | | |
| Iron (Fe) | ppm | | | | | | |
| Copper (Cu) | ppm | | | | | | |
| Organic matter | 5.1 % | Neutralizable acidity | 4.0 | meg/100g | Cation Exch. Capacity | 10.1 | meg/100g |
| PH in water | | Electrical Conductivity | | Mmho/cm | Sodium (Na) | | lbs/A |
| Nitrate (NO ₃ -N) Topsoil | ppm | Subsoil | ppm | Sampling Depth | Top | Inches | Subsoil |
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<http://www.soiltest.psu.missouri.edu/>

| FIELD INFORMATION | | | |
|------------------------------------|--------------------|-----------|----|
| Field ID BIO 5 | Sample no 5 | | |
| Acres | Last Limed unknown | Irrigated | No |
| Last crop 18 COOL SEASON GRASS HAY | FSA Copy N | | |

This report is for:

MSU-GGP
901 NATIONAL
SPRINGFIELD MO 65802

| | |
|----------------------------|-------------------------|
| Serial no. S41722-5 | Lab no. C0810749 |
| County Greene | Region 6 |
| Submitted 8/1/2008 | Processed 8/6/2008 |

Soil sample submitted by: Firm Number: Outlet:

| SOIL TEST INFORMATION | | | RATING | | | | | | |
|--------------------------------------|----------------------|------------|-------------------------|-------------------------------|------------------|-----------------------|-----------------------|---------------------------------------|-----|
| | | | Very Low | Low | Medium | High | Very High | Excess | |
| pH _s | (salt pH) | 5.4 | ***** | | | | | | |
| Phosphorus | (P) | 10 lbs/A | ***** | | | | | | |
| Potassium | (K) | 155 lbs/A | ***** | | | | | | |
| Calcium | (Ca) | 2080 lbs/A | ***** | | | | | | |
| Magnesium | (Mg) | 125 lbs/A | ***** | | | | | | |
| Sulfur | (SO ₄ -S) | ppm | | | | | | | |
| Zinc | (Zn) | ppm | | | | | | | |
| Manganese | (Mn) | ppm | | | | | | | |
| Iron | (Fe) | ppm | | | | | | | |
| Copper | (Cu) | ppm | | | | | | | |
| Organic matter | 2.7 | % | Neutralizable acidity | 3.5 | meq/100g | Cation Exch. Capacity | 9.4 | meq/100g | |
| PH in water | | | Electrical Conductivity | | Mmho/cm | Sodium (Na) | | lbs/A | |
| Nitrate (NO ₃ -N) Topsoil | ppm | | Subsoil | ppm | Sampling Depth | Top | Inches | Subsoil | |
| NUTRIENT REQUIREMENTS | | | | | | | LIMESTONE SUGGESTIONS | | |
| Cropping options | | Yield goal | Pounds per acre | | | | | | |
| | | | N | P ₂ O ₅ | K ₂ O | Zn | S | | |
| 18 COOL SEASON GRASS HAY | | 3 T/A | 120 | 70 | 120 | | | Effective Neutralizing Material (ENM) | 640 |
| 18 COOL SEASON GRASS HAY | | 5 T/A | 200 | 90 | 190 | | | Effective magnesium (EMg) | *** |
| | | | | | | | | | |
| | | | | | | | | | |

Comments

---For hay production apply nitrogen just before spring growth begins (typically March). Consider splitting nitrogen applications if the rate exceeds 90 lbs N/acre, applying 60% in March and the balance in mid August.

---Some herbicide labels list restrictions based on soil pH in water. This sample has an estimated pH in water of 5.9 . Use this estimated pH in water as a guide. If you wish to have soil pH in water analyzed, contact your dealer or Extension specialist listed below.

---To determine limestone needed in tons/acre, divide your ENM requirement by the guarantee of your limestone dealer.

***Suggest using dolomitic limestone if readily available, but yield response to magnesium is not likely.

Regional Agronomy Specialist Tim Schnakenberg

Phone 417-357-6812

Tim Schnakenberg

White-Farmer, Yellow-FSA, Blue-Firm, Pink-Extension

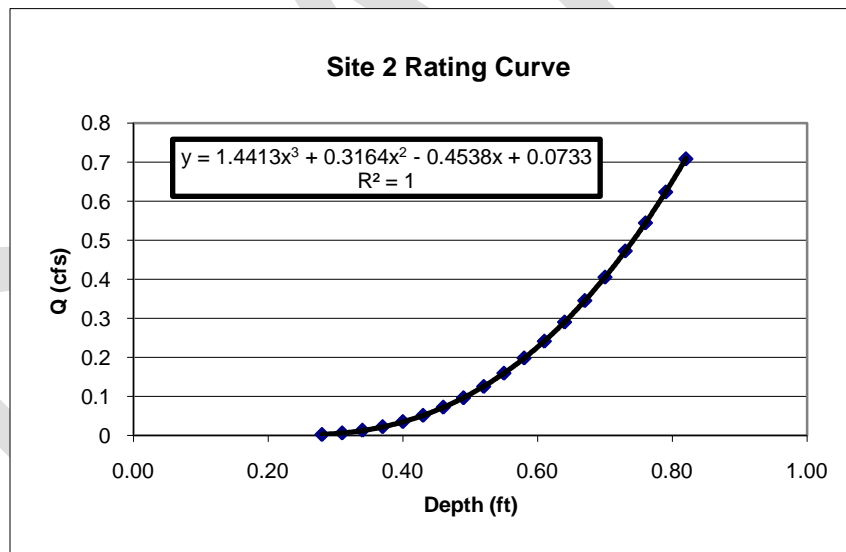
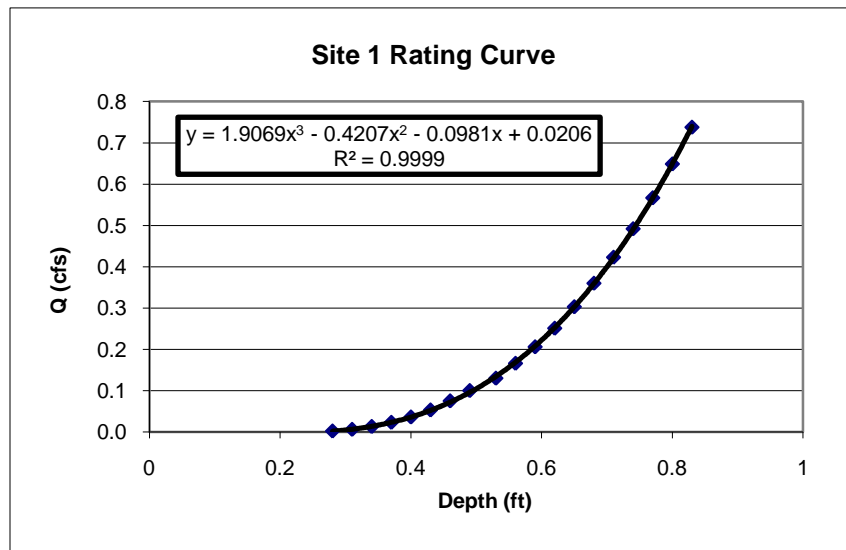
MP 189 Revised 1/96

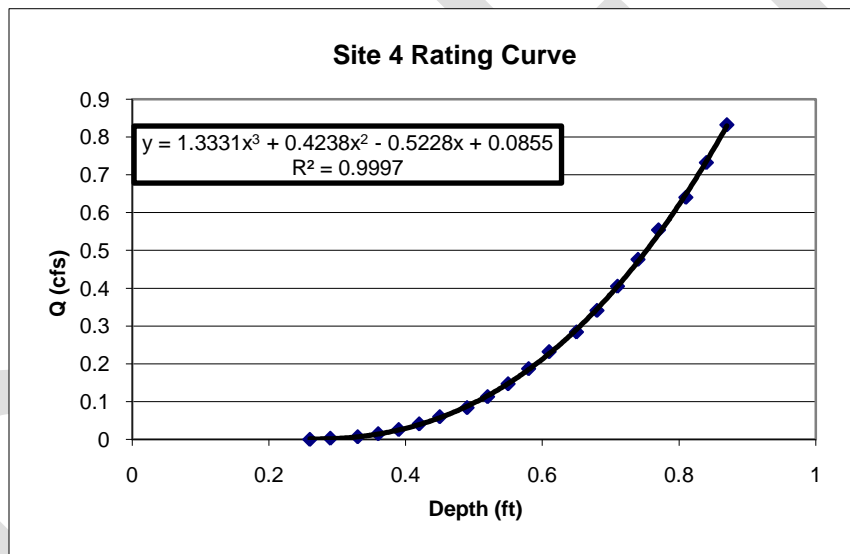
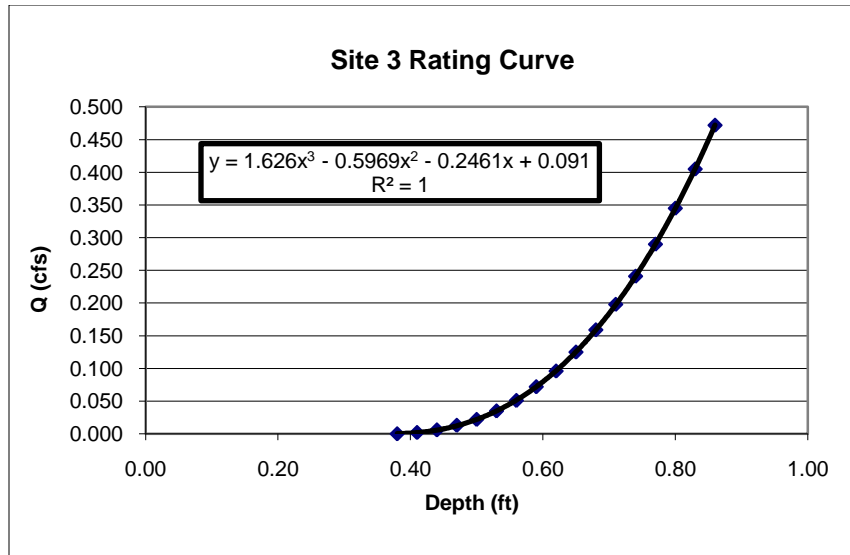
Signature

University of Missouri, Lincoln University, U.S. Department of Agriculture & Local University Extension Councils Cooperating
Equal opportunity institutions

Columbia

APPENDIX B: Discharge Rating Curves





APPENDIX C: Raw Fertilizer and Biosolids Nutrient and Metals Analysis

| Location | Nutrients (mg/L) | | | | % Total Solids | Fecal coliform (coli/100 mL) | pH (std units) | Metals (µg/L) | | | | | | | | | | | |
|------------------------|------------------|--------|--------|--------|----------------|------------------------------|----------------|---------------|-----|------|------|-----|------|-----|------|--------|-----|----|-----|
| | TKN | NH3-N | NO3-N | TP | | | | As | Cd | Cr | Cu | Pb | Hg | Mo | Ni | K | Se | Ag | Zn |
| Commercial Fertilizer | 83,979 | 19,800 | 14,364 | 36,166 | - | NS | NS | <15 | 5.8 | 125 | 8.2 | <15 | <0.2 | <20 | 15.4 | 25,300 | <20 | <5 | 230 |
| Biosolids - 3 Dry Tons | 78,400 | 18,430 | 136 | 21,860 | 22.3 | 100,500 | NS | <15 | <5 | 10.7 | 61.5 | <15 | 0.24 | <20 | <10 | 408 | <20 | <5 | 101 |
| Biosolids - 6 Dry Tons | 76,340 | 21,410 | 195 | 20,990 | 22.9 | 99,200 | NS | <15 | <5 | 10.6 | 59.7 | <15 | 0.23 | <20 | <10 | 417 | <20 | <5 | 99 |

APPENDIX D: Surface Soil Sample Data

Year 1 Soil Data collected October 13, 2008

| Sample Name | Site | Distance from Weir (ft) | Cross Section Distance (ft) | Weight (g/5cc) | Soil pH | Buffer pH | Al | P | K | Ca | NO ₃ -N | Mg | B | Mn | Zn | Cu | Fe | S | Pb* | Total Pb** | Cd | Ni | Cr |
|-------------|------|-------------------------|-----------------------------|----------------|---------|-----------|----|----|-----|-------|--------------------|-----|-----|------|-----|-----|------|------|-----|------------|-----|-----|-----|
| BIO 1 | 1 | 26.2 | 0 | 4.35 | 5.6 | 6.7 | 12 | 24 | 125 | 2,290 | 0 | 169 | 0.3 | 110 | 2.2 | 0.2 | 3.5 | 49.3 | 1 | 37 | 0.1 | 0.1 | 0 |
| BIO 2 | 1 | 26.2 | 0-D | 4.19 | 5.7 | 6.7 | 11 | 24 | 125 | 2,474 | 0 | 151 | 0.4 | 127 | 2 | 0.2 | 3.6 | 54.2 | 0 | 33 | 0.1 | 0.1 | 0.1 |
| BIO 3 | 1 | 26.2 | 6.6 | 4.95 | 5.4 | 6.7 | 19 | 11 | 66 | 1,467 | 0 | 104 | 0.3 | 123 | 2.3 | 0.2 | 6.3 | 39.4 | 1 | 33 | 0.1 | 0.1 | 0 |
| BIO 4 | 1 | 26.2 | 13.1 | 4.18 | 5.6 | 6.7 | 12 | 33 | 187 | 2,465 | 0 | 166 | 0.4 | 190 | 2.7 | 0.2 | 3.1 | 59.7 | 0 | 32 | 0.1 | 0.1 | 0.1 |
| BIO 5 | 1 | 131.2 | 0 | 4.26 | 5.8 | 6.8 | 11 | 25 | 129 | 3,935 | 0 | 207 | 0.3 | 114 | 1.8 | 0.2 | 3.3 | 70.9 | 0 | 32 | 0.1 | 0.1 | 0.1 |
| BIO 6 | 1 | 131.2 | 6.6 | 4.22 | 5.9 | 6.9 | 14 | 23 | 152 | 3,548 | 0 | 165 | 0.4 | 174 | 1.4 | 0.2 | 4.1 | 68 | 1 | 33 | 0.1 | 0.1 | 0.1 |
| BIO 7 | 1 | 131.2 | 13.1 | 4.69 | 5.6 | 6.8 | 19 | 20 | 141 | 3,003 | 0 | 147 | 0.3 | 96.6 | 1.7 | 0.2 | 7.6 | 63.6 | 1 | 33 | 0.1 | 0.1 | 0.1 |
| BIO 8 | 1 | 131.2 | 13.1-D | 4.39 | 5.7 | 6.8 | 20 | 17 | 383 | 3,712 | 0 | 122 | 0.3 | 123 | 1.5 | 0.2 | 7.5 | 73 | 1 | 33 | 0.1 | 0.1 | 0.1 |
| BIO 9 | 1 | 295.3 | 0 | 4.8 | 5.8 | 6.9 | 13 | 14 | 79 | 3,127 | 0 | 110 | 0.3 | 128 | 1.3 | 0.2 | 8.3 | 58.4 | 0 | 31 | 0.1 | 0.1 | 0.1 |
| BIO 10 | 1 | 295.3 | 0-D | 4.49 | 6 | 7 | 13 | 24 | 75 | 3,161 | 0 | 131 | 0.4 | 172 | 1.8 | 0.2 | 5.8 | 63.1 | 0 | 30 | 0.1 | 0.1 | 0.1 |
| BIO 11 | 1 | 295.3 | 6.6 | 4.36 | 6 | 6.8 | 14 | 23 | 198 | 5,024 | 0 | 131 | 0.4 | 308 | 3.3 | 0.2 | 6.3 | 90.2 | 0 | 30 | 0.1 | 0.2 | 0.1 |
| BIO 12 | 1 | 295.3 | 13.1 | 4.54 | 5.9 | 6.9 | 13 | 25 | 87 | 2,671 | 0 | 117 | 0.5 | 378 | 2 | 0.2 | 4.8 | 59.6 | 0 | 28 | 0.1 | 0.1 | 0.1 |
| BIO 13 | 2 | 52.5 | 0 | 4.46 | 5.5 | 6.6 | 19 | 24 | 169 | 2,867 | 0 | 131 | 0.3 | 131 | 3 | 0.2 | 8 | 63 | 1 | 38 | 0.1 | 0.1 | 0.1 |
| BIO 14 | 2 | 52.5 | 0-D | 4.56 | 5.3 | 6.7 | 25 | 18 | 138 | 2,054 | 0 | 108 | 0.3 | 170 | 2.4 | 0.2 | 8.4 | 53.3 | 1 | 41 | 0.1 | 0.2 | 0.1 |
| BIO 15 | 2 | 52.5 | 6.6 | 4.54 | 5.5 | 6.7 | 21 | 19 | 109 | 2,903 | 0 | 112 | 0.3 | 183 | 2.5 | 0.3 | 10.5 | 65.2 | 1 | 37 | 0.1 | 0.2 | 0.1 |
| BIO 16 | 2 | 52.5 | 13.1 | 4.03 | 5.4 | 6.6 | 14 | 33 | 317 | 2,127 | 0 | 188 | 0.3 | 153 | 3.3 | 0.2 | 5 | 55.5 | 1 | 37 | 0.1 | 0.1 | 0.1 |
| BIO 17 | 2 | 131.2 | 0 | 4.73 | 6.2 | 7 | 8 | 17 | 213 | 4,104 | 0 | 123 | 0.4 | 97.9 | 1.1 | 0.2 | 4.5 | 70.1 | 0 | 29 | 0.1 | 0.1 | 0.1 |
| BIO 18 | 2 | 131.2 | 6.6 | 4.52 | 5.9 | 6.8 | 10 | 18 | 106 | 4,478 | 0 | 144 | 0.3 | 78.4 | 1.7 | 0.2 | 4.1 | 73.2 | 0 | 32 | 0.1 | 0.1 | 0.1 |
| BIO 19 | 2 | 131.2 | 6.6-D | 4.59 | 5.9 | 6.9 | 14 | 17 | 97 | 4,427 | 0 | 148 | 0.3 | 96.9 | 1.9 | 0.2 | 5.1 | 73.9 | 0 | 33 | 0.1 | 0.1 | 0.1 |
| BIO 20 | 2 | 131.2 | 13.1 | 4.66 | 5.8 | 6.7 | 27 | 13 | 214 | 3,233 | 0 | 133 | 0.3 | 83.3 | 1.6 | 0.2 | 8.5 | 60.2 | 1 | 35 | 0.1 | 0.2 | 0.1 |
| BIO 21 | 2 | 278.9 | 0 | 4.4 | 6.1 | 6.9 | 13 | 24 | 137 | 3,737 | 0 | 197 | 0.4 | 102 | 2.2 | 0.2 | 3.7 | 65.5 | 0 | 31 | 0.1 | 0.1 | 0.1 |
| BIO 22 | 2 | 278.9 | 6.6 | 4.41 | 6 | 6.8 | 13 | 21 | 160 | 4,264 | 0 | 153 | 0.4 | 134 | 2.1 | 0.2 | 4.9 | 73.6 | 0 | 31 | 0.1 | 0.1 | 0.1 |
| BIO 23 | 2 | 278.9 | 6.6-D | 4.45 | 6 | 6.9 | 14 | 13 | 156 | 3,419 | 0 | 138 | 0.3 | 116 | 1.5 | 0.2 | 4.4 | 58.9 | 0 | 32 | 0.1 | 0.1 | 0.1 |
| BIO 24 | 2 | 278.9 | 13.1 | 4.58 | 6.2 | 6.9 | 19 | 15 | 120 | 5,339 | 0 | 136 | 0.3 | 75.4 | 1.4 | 0.2 | 4.8 | 82.6 | 1 | 35 | 0.1 | 0.2 | 0.1 |
| BIO 25 | 3 | 65.6 | 0 | 4.55 | 6.1 | 6.7 | 10 | 15 | 208 | 3,901 | 9 | 205 | 0.3 | 53.2 | 3.4 | 0.2 | 1.5 | 57.6 | 0 | 30 | 0.1 | 0.1 | 0.1 |

| | | | | | | | | | | | | | | | | | | | | | | | |
|--------|---|-------|--------|------|-----|-----|----|----|-----|-------|----|-----|-----|------|-----|-----|-----|------|---|----|-----|-----|-----|
| BIO 26 | 3 | 65.6 | 6.6 | 4.69 | 5.8 | 6.6 | 19 | 8 | 74 | 2,435 | 9 | 78 | 0.2 | 53.9 | 2.6 | 0.2 | 2.6 | 39.3 | 0 | 32 | 0.1 | 0.1 | 0 |
| BIO 27 | 3 | 65.6 | 13.1 | 4.2 | 5.9 | 6.7 | 15 | 12 | 180 | 2,939 | 9 | 139 | 0.3 | 65.2 | 3.1 | 0.2 | 3.5 | 49.1 | 0 | 31 | 0.1 | 0.2 | 0.1 |
| BIO 28 | 3 | 65.6 | 13.1-D | 4.51 | 5.8 | 6.6 | 17 | 8 | 141 | 2,048 | 8 | 111 | 0.2 | 57.1 | 2.8 | 0.2 | 3.3 | 36.1 | 0 | 31 | 0.1 | 0.1 | 0 |
| BIO 29 | 3 | 196.9 | 0 | 4.1 | 6.5 | 7 | 6 | 11 | 193 | 2,443 | 15 | 178 | 0.3 | 22.3 | 1.5 | 0.2 | 0.9 | 39.6 | 0 | 29 | 0.1 | 0.1 | 0 |
| BIO 30 | 3 | 196.9 | 0-D | 4.69 | 6.4 | 7 | 7 | 9 | 128 | 2,695 | 10 | 148 | 0.3 | 24.3 | 1.4 | 0.2 | 1 | 40.8 | 0 | 28 | 0 | 0.1 | 0 |
| BIO 31 | 3 | 196.9 | 6.6 | 4.54 | 6.2 | 6.9 | 10 | 8 | 350 | 1,988 | 13 | 144 | 0.3 | 33.2 | 1.4 | 0.3 | 1.8 | 34 | 0 | 29 | 0 | 0.1 | 0 |
| BIO 32 | 3 | 196.9 | 13.1 | 4.37 | 6.5 | 7 | 6 | 11 | 153 | 2,798 | 11 | 161 | 0.3 | 34.8 | 0.9 | 0.2 | 1 | 42.8 | 0 | 28 | 0.1 | 0.1 | 0 |
| BIO 33 | 3 | 459.3 | 0 | 4.63 | 6 | 6.8 | 12 | 10 | 88 | 2,462 | 0 | 141 | 0.2 | 40.5 | 1.4 | 0.2 | 3.1 | 40.7 | 0 | 30 | 0.1 | 0.1 | 0 |
| BIO 34 | 3 | 459.3 | 0-D | 4.57 | 5.9 | 6.8 | 15 | 8 | 117 | 1,685 | 0 | 123 | 0.2 | 42.3 | 1.7 | 0.2 | 4.3 | 31.2 | 0 | 32 | 0.1 | 0.1 | 0 |
| BIO 35 | 3 | 459.3 | 6.6 | 4.24 | 6.5 | 7 | 8 | 12 | 196 | 4,578 | 1 | 193 | 0.3 | 49.9 | 1.6 | 0.2 | 2.7 | 69.2 | 0 | 28 | 0.1 | 0.1 | 0.1 |
| BIO 36 | 3 | 459.3 | 13.1 | 5.11 | 6.2 | 7 | 16 | 4 | 88 | 2,172 | 1 | 103 | 0.2 | 38.6 | 1 | 0.3 | 6.8 | 33.4 | 0 | 28 | 0 | 0.1 | 0 |
| BIO 37 | 4 | 68.9 | 0 | 4.16 | 6.5 | 7 | 5 | 15 | 110 | 3,280 | 12 | 86 | 0.4 | 78.6 | 1.9 | 0.2 | 0.7 | 49.7 | 0 | 27 | 0.1 | 0.1 | 0 |
| BIO 38 | 4 | 68.9 | 6.6 | 4.3 | 6.2 | 6.8 | 8 | 17 | 108 | 2,680 | 10 | 108 | 0.3 | 103 | 2.4 | 0.2 | 0.9 | 44.2 | 0 | 27 | 0.1 | 0.1 | 0 |
| BIO 39 | 4 | 68.9 | 6.6-D | 4.17 | 6.2 | 6.8 | 8 | 17 | 108 | 2,477 | 10 | 117 | 0.3 | 93.1 | 2.1 | 0.2 | 0.9 | 42 | 0 | 30 | 0.1 | 0.1 | 0 |
| BIO 40 | 4 | 68.9 | 13.1 | 4.31 | 6.4 | 6.9 | 5 | 24 | 103 | 2,714 | 11 | 136 | 0.4 | 77.1 | 2.2 | 0.2 | 0.7 | 44.2 | 0 | 27 | 0.1 | 0.1 | 0 |
| BIO 41 | 4 | 164.0 | 0 | 4.21 | 6.5 | 7 | 11 | 11 | 137 | 4,513 | 1 | 114 | 0.3 | 56.7 | 0.5 | 0.2 | 1.3 | 64.4 | 0 | 30 | 0.1 | 0.1 | 0.1 |
| BIO 42 | 4 | 164.0 | 6.6 | 4.42 | 6.6 | 7 | 7 | 8 | 91 | 3,319 | 10 | 86 | 0.3 | 56.5 | 0.6 | 0.2 | 1 | 49.4 | 0 | 29 | 0.1 | 0.1 | 0.1 |
| BIO 43 | 4 | 164.0 | 13.1 | 4.28 | 6.5 | 7 | 9 | 11 | 145 | 2,624 | 5 | 133 | 0.3 | 65.9 | 0.7 | 0.2 | 1 | 43.8 | 0 | 28 | 0.1 | 0.1 | 0 |
| BIO 44 | 4 | 164.0 | 13.1-D | 4.26 | 6.7 | 7.1 | 6 | 18 | 217 | 4,907 | 7 | 161 | 0.4 | 63.7 | 0.9 | 0.2 | 1 | 70.1 | 0 | 28 | 0.1 | 0.1 | 0.1 |
| BIO 45 | 4 | 328.1 | 0 | 4.33 | 6.3 | 7 | 12 | 7 | 186 | 1,814 | 8 | 135 | 0.3 | 38.2 | 0.9 | 0.2 | 1.6 | 33 | 0 | 28 | 0 | 0.1 | 0 |
| BIO 46 | 4 | 328.1 | 0-D | 4.45 | 6.2 | 6.9 | 14 | 7 | 118 | 2,332 | 1 | 130 | 0.3 | 53 | 1.1 | 0.2 | 2.1 | 36.5 | 0 | 27 | 0.1 | 0.1 | 0 |
| BIO 47 | 4 | 328.1 | 6.6 | 4.78 | 6.1 | 6.9 | 19 | 4 | 84 | 1,913 | 1 | 73 | 0.2 | 47.5 | 0.8 | 0.2 | 1.9 | 32 | 0 | 29 | 0 | 0.1 | 0 |
| BIO 48 | 4 | 328.1 | 13.1 | 4.57 | 6.2 | 6.8 | 11 | 6 | 81 | 1,821 | 3 | 88 | 0.2 | 33.3 | 1.4 | 0.2 | 1.7 | 31.4 | 0 | 31 | 0.1 | 0.1 | 0 |

Notes: D refers to duplicate sample.

All elements are in parts per million (ppm).

* Extracted Pb

**Estimated total Pb

Year 2 Soil Data Collected July 16, 2009

| Sample Name | Site | Distance from Weir (ft) | Cross Section Distance (ft) | Weight (g/5cc) | Soil pH | Buffer pH | Al | P | K | Ca | NO ₃ -N | Mg | B | Mn | Zn | Cu | Fe | Pb* | Total Pb** | Cd | Ni | Cr |
|-------------|------|-------------------------|-----------------------------|----------------|---------|-----------|----|----|-----|-------|--------------------|-----|-----|------|-----|-----|-----|-----|------------|-----|-----|-----|
| BIO 49 | 1 | 26.2 | 0 | 3.34 | 6.8 | 7.1 | 9 | 28 | 262 | 3,758 | 29 | 197 | 0.2 | 40.8 | 1.8 | 0.3 | 1.2 | 1 | 33 | 0.1 | 0.1 | 0.1 |
| BIO 50 | 1 | 26.2 | 0D | 3.51 | 6.6 | 7.1 | 8 | 19 | 202 | 3,300 | 31 | 172 | 0.2 | 28.3 | 1.6 | 0.3 | 1 | 1 | 34 | 0.1 | 0.1 | 0.1 |
| BIO 51 | 1 | 26.2 | 6.6 | 3.82 | 6.3 | 6.9 | 9 | 15 | 258 | 2,251 | 35 | 182 | 0.2 | 27.9 | 2 | 0.4 | 2.2 | 0 | 33 | 0.1 | 0.1 | 0.1 |
| BIO 52 | 1 | 26.2 | 13.1 | 4.03 | 5.9 | 6.6 | 12 | 12 | 196 | 2,027 | 36 | 149 | 0.1 | 40.3 | 2.9 | 0.4 | 2.1 | 1 | 34 | 0.1 | 0.1 | 0.1 |
| BIO 53 | 1 | 131.2 | 0 | 4.31 | 6.3 | 6.9 | 9 | 11 | 202 | 1,949 | 22 | 126 | 0.1 | 26.4 | 1 | 0.4 | 1.1 | 0 | 32 | 0.1 | 0.1 | 0 |
| BIO 54 | 1 | 131.2 | 6.6 | 4.11 | 6.3 | 6.9 | 9 | 12 | 125 | 2,505 | 13 | 107 | 0.2 | 25.5 | 1.1 | 0.3 | 2 | 0 | 32 | 0.1 | 0.1 | 0 |
| BIO 55 | 1 | 131.2 | 6.6D | 4.23 | 6.4 | 7.0 | 9 | 11 | 126 | 2,158 | 14 | 96 | 0.1 | 20.4 | 0.9 | 0.3 | 1.6 | 0 | 32 | 0.1 | 0.1 | 0 |
| BIO 56 | 1 | 131.2 | 13.1 | 4.19 | 6.6 | 6.9 | 9 | 13 | 154 | 3,355 | 30 | 162 | 0.2 | 28 | 1 | 0.2 | 1.7 | 1 | 35 | 0.1 | 0.1 | 0.1 |
| BIO 57 | 1 | 295.2 | 0 | 4.49 | 6.4 | 6.9 | 9 | 7 | 103 | 1,975 | 11 | 104 | 0.1 | 29 | 1.1 | 0.2 | 1.8 | 0 | 32 | 0.1 | 0.1 | 0 |
| BIO 58 | 1 | 295.2 | 6.6 | 4.38 | 7.0 | 7.1 | 8 | 15 | 118 | 4,082 | 27 | 124 | 0.2 | 37.2 | 0.8 | 0.2 | 1.2 | 0 | 31 | 0.1 | 0.1 | 0.1 |
| BIO 59 | 1 | 295.2 | 13.1 | 4.08 | 6.8 | 7.0 | 8 | 17 | 279 | 3,101 | 43 | 164 | 0.2 | 37.3 | 1.4 | 0.2 | 1.7 | 0 | 31 | 0.1 | 0.1 | 0.1 |
| BIO 60 | 1 | 295.2 | 13.1D | 4.22 | 6.5 | 7.0 | 7 | 13 | 273 | 2,650 | 36 | 157 | 0.2 | 42.6 | 1.5 | 0.2 | 1.1 | 0 | 31 | 0.1 | 0.1 | 0 |
| BIO 61 | 2 | 52.5 | 0 | 3.9 | 6.3 | 6.9 | 11 | 22 | 187 | 4,098 | 30 | 172 | 0.2 | 38.2 | 2 | 0.2 | 2.4 | 1 | 34 | 0.1 | 0.1 | 0.1 |
| BIO 62 | 2 | 52.5 | 6.6 | 4.43 | 5.9 | 6.7 | 15 | 21 | 95 | 2,150 | 32 | 102 | 0.1 | 43.7 | 2 | 0.2 | 3.4 | 1 | 36 | 0.1 | 0.1 | 0.1 |
| BIO 63 | 2 | 52.5 | 13.1 | 3.6 | 6.3 | 6.9 | 10 | 63 | 166 | 2,555 | 38 | 172 | 0.2 | 27.8 | 2.1 | 0.2 | 2.8 | 0 | 32 | 0.1 | 0.1 | 0.1 |
| BIO 64 | 2 | 52.5 | 13.1D | 3.96 | 6.0 | 6.8 | 11 | 46 | 126 | 2,178 | 22 | 151 | 0.2 | 28.1 | 2.2 | 0.2 | 2.9 | 0 | 33 | 0.1 | 0.1 | 0.1 |
| BIO 65 | 2 | 131.2 | 0 | 4.06 | 6.4 | 6.9 | 11 | 38 | 156 | 3,094 | 21 | 172 | 0.2 | 25.4 | 1.4 | 0.2 | 2.2 | 0 | 32 | 0.1 | 0.1 | 0.1 |
| BIO 66 | 2 | 131.2 | 6.6 | 4.21 | 6.2 | 6.9 | 13 | 21 | 155 | 2,417 | 8 | 115 | 0.1 | 32.1 | 1.1 | 0.2 | 2.5 | 1 | 35 | 0.1 | 0.1 | 0 |
| BIO 67 | 2 | 131.2 | 6.6D | 4.34 | 6.3 | 6.9 | 14 | 16 | 133 | 2,430 | 9 | 113 | 0.1 | 29.6 | 1.1 | 0.2 | 2.7 | 1 | 35 | 0.1 | 0.1 | 0.1 |
| BIO 68 | 2 | 131.2 | 13.1 | 4.12 | 6.1 | 6.8 | 16 | 22 | 126 | 2,643 | 10 | 102 | 0.1 | 29 | 1.7 | 0.2 | 2.8 | 1 | 35 | 0.1 | 0.1 | 0.1 |
| BIO 69 | 2 | 278.8 | 0 | 4.54 | 6.1 | 6.9 | 13 | 22 | 76 | 2,001 | 10 | 101 | 0.1 | 41.3 | 1.3 | 0.2 | 2.7 | 0 | 32 | 0.1 | 0.1 | 0 |
| BIO 70 | 2 | 278.8 | 6.6 | 4.33 | 6.1 | 6.9 | 12 | 36 | 95 | 2,432 | 11 | 119 | 0.1 | 48.8 | 1.7 | 0.2 | 3.1 | 0 | 33 | 0.1 | 0.1 | 0.1 |
| BIO 71 | 2 | 278.8 | 0D | 4.65 | 6.2 | 6.9 | 12 | 42 | 93 | 2,472 | 13 | 107 | 0.1 | 47.7 | 1.3 | 0.2 | 3.2 | 0 | 31 | 0.1 | 0.1 | 0.1 |
| BIO 72 | 2 | 278.8 | 13.1 | 4.49 | 6.6 | 7.0 | 10 | 28 | 246 | 2,766 | 12 | 116 | 0.1 | 59.1 | 1.1 | 0.2 | 2 | 0 | 30 | 0.1 | 0.1 | 0.1 |
| BIO 73 | 3 | 65.6 | 0 | 4.18 | 6.7 | 7.0 | 10 | 13 | 127 | 3,064 | 11 | 112 | 0.1 | 40.6 | 1.4 | 0.2 | 1.3 | 0 | 33 | 0.1 | 0.1 | 0.1 |
| BIO 74 | 3 | 65.6 | 6.6 | 3.98 | 6.7 | 7.0 | 8 | 19 | 165 | 2,254 | 12 | 135 | 0.2 | 48.8 | 1.6 | 0.2 | 1.2 | 0 | 31 | 0.1 | 0.1 | 0.1 |
| BIO 75 | 3 | 65.6 | 6.6D | 4.3 | 6.2 | 6.9 | 10 | 13 | 131 | 2,178 | 13 | 126 | 0.1 | 46.9 | 1.7 | 0.2 | 1.6 | 0 | 32 | 0.1 | 0.1 | 0.1 |
| BIO 76 | 3 | 65.6 | 13.1 | 4.31 | 6.9 | 7.1 | 8 | 14 | 130 | 2,782 | 7 | 108 | 0.2 | 30.9 | 0.9 | 0.2 | 1.2 | 0 | 32 | 0.1 | 0.1 | 0 |
| BIO 77 | 3 | 196.8 | 0 | 4.18 | 6.4 | 6.9 | 13 | 26 | 160 | 3,417 | 45 | 183 | 0.3 | 51.5 | 3.8 | 0.3 | 2 | 0 | 31 | 0.1 | 0.1 | 0.1 |
| BIO 78 | 3 | 196.8 | 6.6 | 4.1 | 6.5 | 7.0 | 8 | 47 | 297 | 2,327 | 38 | 239 | 0.3 | 66.5 | 3.1 | 0.3 | 1.3 | 0 | 31 | 0.1 | 0.1 | 0.1 |
| BIO 79 | 3 | 196.8 | 6.6D | 4.39 | 6.3 | 6.9 | 9 | 32 | 278 | 2,009 | 56 | 198 | 0.2 | 80.3 | 3 | 0.2 | 1.3 | 0 | 30 | 0.1 | 0.1 | 0.1 |
| BIO 80 | 3 | 196.8 | 13.1 | 4.25 | 6.4 | 7.0 | 9 | 26 | 176 | 2,104 | 38 | 199 | 0.2 | 42.9 | 5 | 0.3 | 1.4 | 0 | 30 | 0.1 | 0.1 | 0.1 |

| | | | | | | | | | | | | | | | | | | | | | | |
|--------|---|-------|-------|------|-----|-----|----|----|-----|-------|----|-----|-----|------|-----|-----|-----|---|----|-----|-----|-----|
| BIO 81 | 3 | 459.2 | 0 | 4.17 | 6.2 | 6.9 | 10 | 35 | 128 | 2,581 | 45 | 178 | 0.3 | 47.5 | 3.6 | 0.3 | 2.2 | 0 | 31 | 0.1 | 0.1 | 0.1 |
| BIO 82 | 3 | 459.2 | 6.6 | 4.31 | 6.2 | 6.9 | 10 | 19 | 104 | 2,221 | 36 | 141 | 0.2 | 31.5 | 1.7 | 0.2 | 1.6 | 0 | 31 | 0.1 | 0.1 | 0 |
| BIO 83 | 3 | 459.2 | 6.6D | 4.34 | 6.3 | 7.0 | 10 | 19 | 113 | 1,965 | 15 | 145 | 0.2 | 32.3 | 1.6 | 0.3 | 1.6 | 0 | 31 | 0.1 | 0.1 | 0 |
| BIO 84 | 3 | 459.2 | 13.1 | 4.17 | 6.5 | 7.0 | 10 | 25 | 159 | 2,594 | 16 | 144 | 0.2 | 31 | 1.8 | 0.2 | 2.3 | 0 | 30 | 0.1 | 0.1 | 0.1 |
| BIO 85 | 4 | 68.9 | 0 | 3.82 | 6.5 | 6.9 | 8 | 18 | 124 | 2,670 | 14 | 95 | 0.2 | 137 | 2.2 | 0.2 | 0.9 | 0 | 30 | 0.1 | 0.1 | 0.1 |
| BIO 86 | 4 | 68.9 | 6.6 | 3.96 | 6.4 | 6.9 | 8 | 16 | 107 | 2,470 | 15 | 113 | 0.2 | 108 | 2.1 | 0.2 | 0.8 | 0 | 31 | 0.1 | 0.1 | 0.1 |
| BIO 87 | 4 | 68.9 | 13.1 | 4.09 | 6.1 | 6.9 | 10 | 16 | 106 | 1,786 | 11 | 112 | 0.1 | 98.6 | 1.4 | 0.2 | 1.2 | 0 | 32 | 0.1 | 0.1 | 0.1 |
| BIO 88 | 4 | 68.9 | 0D | 3.81 | 6.7 | 7.0 | 9 | 18 | 141 | 2,802 | 14 | 111 | 0.2 | 169 | 1.9 | 0.2 | 0.9 | 0 | 30 | 0.1 | 0.1 | 0.1 |
| BIO 89 | 4 | 164.0 | 0 | 4.03 | 7.2 | 7.1 | 9 | 16 | 180 | 4,023 | 16 | 94 | 0.2 | 35.7 | 0.5 | 0.2 | 0.9 | 0 | 31 | 0.1 | 0.1 | 0.1 |
| BIO 90 | 4 | 164.0 | 6.6 | 4.17 | 7.0 | 7.1 | 11 | 14 | 214 | 3,430 | 6 | 106 | 0.2 | 78.7 | 0.7 | 0.2 | 0.9 | 0 | 31 | 0.1 | 0.1 | 0.1 |
| BIO 91 | 4 | 164.0 | 13.1 | 4.28 | 6.4 | 6.9 | 12 | 10 | 147 | 2,472 | 10 | 107 | 0.1 | 97.4 | 1 | 0.2 | 1.3 | 0 | 32 | 0.1 | 0.1 | 0.1 |
| BIO 92 | 4 | 164.0 | 0D | 4.14 | 7.1 | 7.2 | 9 | 15 | 170 | 3,746 | 36 | 89 | 0.2 | 39.5 | 0.5 | 0.2 | 1 | 0 | 31 | 0.1 | 0.1 | 0.1 |
| BIO 93 | 4 | 328.0 | 0 | 4.1 | 6.3 | 6.9 | 9 | 45 | 177 | 2,680 | 38 | 183 | 0.3 | 50.2 | 4.9 | 0.5 | 2.1 | 0 | 30 | 0.1 | 0.1 | 0.1 |
| BIO 94 | 4 | 328.0 | 6.6 | 4.08 | 6.5 | 7.0 | 9 | 41 | 140 | 2,553 | 34 | 171 | 0.3 | 41.6 | 3.4 | 0.3 | 1.9 | 0 | 30 | 0.1 | 0.1 | 0.1 |
| BIO 95 | 4 | 328.0 | 13.1 | 4.14 | 6.5 | 6.9 | 10 | 46 | 166 | 2,812 | 45 | 194 | 0.3 | 47.2 | 4.8 | 0.5 | 2.3 | 0 | 30 | 0.1 | 0.1 | 0.1 |
| BIO 96 | 4 | 328.0 | 13.1D | 4.44 | 6.1 | 6.8 | 12 | 30 | 131 | 2,427 | 36 | 161 | 0.2 | 59.6 | 4.8 | 0.4 | 2.8 | 0 | 31 | 0.1 | 0.1 | 0.1 |

Notes: D refers to duplicate sample.

All elements are in parts per million (ppm).

* Extracted Pb

**Estimated total Pb

Year 3 Soil Data Collected June 18, 2010

| Sample Name | Site | Distance from Weir (ft) | Cross Section Distance (ft) | Weight (g/5cc) | Soil pH | Buffer pH | Al | P | K | Ca | NO ₃ -N | Mg | B | Mn | Zn | Cu | Fe | Pb* | Total Pb** | Cd | Ni | Cr |
|-------------|------|-------------------------|-----------------------------|----------------|---------|-----------|----|----|-----|-------|--------------------|-----|-----|------|-----|------|-----|-----|------------|-----|----|-----|
| BIO 97 | 1 | 26.2 | 0.0 | 4.01 | 6.0 | 6.7 | 7 | 11 | 130 | 1,812 | 2.0 | 134 | 0.2 | 56.3 | 2.4 | 0.10 | 1.6 | 1 | 41 | 0.1 | 0 | 0 |
| BIO 98 | 1 | 26.2 | 6.6 | 3.51 | 6.2 | 6.8 | 5 | 13 | 133 | 1,818 | 2.0 | 125 | 0.2 | 52.7 | 1.6 | 0.10 | 2.4 | 1 | 40 | 0 | 0 | 0.1 |
| BIO 99 | 1 | 26.2 | 13.1 | 3.49 | 7.0 | 7.1 | 3 | 36 | 201 | 4,026 | 2.0 | 178 | 0.5 | 59.8 | 1.4 | 0.10 | 1.3 | 1 | 42 | 0 | 0 | 0.1 |
| BIO 100 | 1 | 26.2 | 6.6 | 3.85 | 6.3 | 6.8 | 5 | 13 | 142 | 2,087 | 2.0 | 135 | 0.2 | 50 | 1.6 | 0.00 | 2.2 | 1 | 36 | 0 | 0 | 0 |
| BIO 101 | 1 | 131.2 | 0.0 | 3.67 | 6.0 | 6.9 | 6 | 10 | 146 | 1,497 | 0.0 | 94 | 0.2 | 46.7 | 0.8 | 0.00 | 1.7 | 1 | 35 | 0 | 0 | 0 |
| BIO 102 | 1 | 131.2 | 6.6 | 3.73 | 6.9 | 7.1 | 3 | 13 | 136 | 2,716 | 0.0 | 113 | 0.3 | 39.9 | 0.8 | 0.10 | 1.2 | 1 | 35 | 0 | 0 | 0 |
| BIO 103 | 1 | 131.2 | 13.1 | 3.78 | 6.6 | 7.1 | 4 | 14 | 138 | 2,591 | 0.0 | 101 | 0.2 | 33.7 | 0.7 | 0.00 | 1.6 | 1 | 35 | 0 | 0 | 0 |
| BIO 104 | 1 | 131.2 | 6.6 | 3.78 | 7.0 | 7.1 | 3 | 21 | 194 | 3,442 | 0.0 | 128 | 0.3 | 50.2 | 1.2 | 0.00 | 1.2 | 1 | 37 | 0 | 0 | 0.1 |
| BIO 105 | 1 | 295.2 | 0.0 | 3.75 | 7.1 | 7.2 | 3 | 17 | 182 | 3,306 | 0.0 | 135 | 0.3 | 10.3 | 0.6 | 0.00 | 2.7 | 0 | 33 | 0 | 0 | 0 |
| BIO 106 | 1 | 295.2 | 6.6 | 3.76 | 6.9 | 7.1 | 3 | 16 | 137 | 3,675 | 0.0 | 124 | 0.3 | 30.8 | 1 | 0.10 | 2.9 | 1 | 35 | 0 | 0 | 0 |
| BIO 107 | 1 | 295.2 | 13.1 | 3.67 | 7.0 | 7.2 | 2 | 12 | 292 | 3,274 | 0.0 | 104 | 0.3 | 39.5 | 0.7 | 0.00 | 104 | 1 | 35 | 0 | 0 | 0 |
| BIO 108 | 1 | 295.2 | 13.1 | 3.82 | 7.0 | 7.2 | 2 | 11 | 350 | 2,973 | 0.0 | 95 | 0.3 | 45.3 | 0.6 | 0.10 | 1.2 | 1 | 34 | 0 | 0 | 0 |
| BIO 109 | 2 | 52.5 | 0.0 | 3.59 | 6.6 | 7.0 | 5 | 34 | 122 | 2,405 | 7.0 | 119 | 0.2 | 20.5 | 1.4 | 0.00 | 2.6 | 1 | 35 | 0 | 0 | 0 |
| BIO 110 | 2 | 52.5 | 6.6 | 3.79 | 6.5 | 7.0 | 7 | 32 | 124 | 2,191 | 5.0 | 103 | 0.2 | 42.9 | 1.4 | 0.10 | 2 | 1 | 37 | 0.1 | 0 | 0.1 |
| BIO 111 | 2 | 52.5 | 13.1 | 3.36 | 6.5 | 7.0 | 6 | 33 | 94 | 2,714 | 0.0 | 79 | 0.1 | 23.9 | 1.2 | 0.10 | 2.2 | 1 | 39 | 0 | 0 | 0 |
| BIO 112 | 2 | 52.5 | 0.0 | 3.96 | 6.5 | 7.0 | 5 | 36 | 130 | 2,334 | 2.0 | 117 | 0.2 | 26.9 | 1.3 | 0.00 | 2.8 | 1 | 35 | 0 | 0 | 0 |
| BIO 113 | 2 | 131.2 | 0.0 | 3.83 | 6.7 | 7.1 | 4 | 27 | 106 | 2,576 | 0.0 | 104 | 0.2 | 29.9 | 1.1 | 0.10 | 1.9 | 1 | 33 | 0 | 0 | 0 |
| BIO 114 | 2 | 131.2 | 6.6 | 4.02 | 6.7 | 7.1 | 6 | 18 | 99 | 2,803 | 2.0 | 94 | 0.2 | 33.7 | 0.8 | 0.10 | 1.6 | 1 | 33 | 0 | 0 | 0 |
| BIO 115 | 2 | 131.2 | 13.1 | 3.65 | 6.4 | 7.0 | 9 | 22 | 158 | 2,599 | 2.0 | 111 | 0.2 | 35.1 | 1.2 | 0.00 | 2.5 | 1 | 34 | 0 | 0 | 0 |
| BIO 116 | 2 | 131.2 | 6.6 | 4.02 | 6.4 | 7.0 | 8 | 19 | 122 | 2,393 | 0.0 | 100 | 0.2 | 32.1 | 0.9 | 0.00 | 2.2 | 1 | 33 | 0 | 0 | 0 |
| BIO 117 | 2 | 278.8 | 0.0 | 3.98 | 7.2 | 7.2 | 3 | 52 | 103 | 3,629 | 1.0 | 101 | 0.2 | 40.2 | 0.9 | 0.00 | 1.8 | 0 | 31 | 0 | 0 | 0 |
| BIO 118 | 2 | 278.8 | 6.6 | 4.07 | 6.9 | 7.0 | 4 | 38 | 92 | 2,416 | 1.0 | 93 | 0.2 | 32.3 | 0.8 | 0.00 | 1.6 | 0 | 31 | 0 | 0 | 0 |
| BIO 119 | 2 | 278.8 | 13.1 | 3.78 | 6.7 | 7.1 | 5 | 30 | 110 | 2,659 | 0.0 | 94 | 0.2 | 36.7 | 0.9 | 0.00 | 2.2 | 0 | 32 | 0 | 0 | 0 |
| BIO 120 | 2 | 278.8 | 13.1 | 3.83 | 6.6 | 7.0 | 6 | 48 | 115 | 3,019 | 0.0 | 120 | 0.2 | 41.1 | 1.1 | 0.00 | 2 | 1 | 33 | 0 | 0 | 0 |
| BIO 121 | 3 | 65.6 | 0.0 | 3.69 | 7.1 | 7.2 | 3 | 26 | 142 | 3,181 | 10.0 | 116 | 0.2 | 24.9 | 0.9 | 0.00 | 1.2 | 1 | 33 | 0 | 0 | 0 |
| BIO 122 | 3 | 65.6 | 6.6 | 3.7 | 7.0 | 7.1 | 2 | 14 | 147 | 2,603 | 4.0 | 129 | 0.2 | 21.7 | 0.8 | 0.00 | 0.9 | 0 | 31 | 0 | 0 | 0 |
| BIO 123 | 3 | 65.6 | 13.1 | 3.66 | 7.0 | 7.1 | 2 | 19 | 166 | 2,471 | 2.0 | 143 | 0.2 | 22.2 | 1 | 0.00 | 1.1 | 0 | 32 | 0 | 0 | 0 |
| BIO 124 | 3 | 65.6 | 0.0 | 3.53 | 7.1 | 7.1 | 2 | 25 | 152 | 3,217 | 7.0 | 131 | 0.2 | 22.8 | 1.1 | 0.00 | 1.5 | 1 | 33 | 0 | 0 | 0 |
| BIO 125 | 3 | 196.8 | 0.0 | 4.1 | 6.3 | 7.0 | 5 | 30 | 87 | 2,059 | 10.0 | 114 | 0.2 | 37.5 | 2.8 | 0.10 | 2 | 0 | 31 | 0 | 0 | 0 |
| BIO 126 | 3 | 196.8 | 6.6 | 4.15 | 6.5 | 7.0 | 5 | 27 | 117 | 2,143 | 3.0 | 107 | 0.2 | 27.9 | 2.4 | 0.10 | 1.8 | 0 | 31 | 0 | 0 | 0 |
| BIO 127 | 3 | 196.8 | 13.1 | 4.08 | 6.5 | 7.0 | 5 | 29 | 119 | 2,255 | 9.0 | 111 | 0.3 | 33.2 | 3 | 0.20 | 1.8 | 0 | 30 | 0 | 0 | 0 |

| Sample Name | Site | Distance from Weir (ft) | Cross Section Distance (ft) | Weight (g/5cc) | Soil pH | Buffer pH | Al | P | K | Ca | NO ₃ -N | Mg | B | Mn | Zn | Cu | Fe | Pb* | Total Pb** | Cd | Ni | Cr |
|-------------|------|-------------------------|-----------------------------|----------------|---------|-----------|----|----|-----|-------|--------------------|-----|-----|------|-----|------|-----|-----|------------|-----|----|-----|
| BIO 128 | 3 | 196.8 | 6.6 | 4.22 | 6.3 | 6.9 | 8 | 20 | 157 | 1,999 | 0.0 | 98 | 0.2 | 38.9 | 2.4 | 0.10 | 2 | 0 | 31 | 0 | 0 | 0 |
| BIO 129 | 3 | 459.2 | 0.0 | 3.77 | 6.5 | 7.0 | 6 | 46 | 110 | 2,447 | 13.0 | 122 | 0.3 | 60.3 | 3.6 | 0.20 | 1.6 | 0 | 30 | 0 | 0 | 0 |
| BIO 130 | 3 | 459.2 | 6.6 | 3.76 | 6.7 | 7.0 | 5 | 37 | 94 | 2,256 | 12.0 | 109 | 0.3 | 54 | 2.9 | 0.10 | 1.3 | 0 | 30 | 0 | 0 | 0 |
| BIO 131 | 3 | 459.2 | 13.1 | 4.45 | 6.6 | 7.0 | 8 | 23 | 67 | 1,729 | 2.0 | 35 | 0.2 | 35.6 | 1.9 | 0.10 | 1.4 | 0 | 29 | 0 | 0 | 0 |
| BIO 132 | 3 | 459.2 | 13.1 | 4.17 | 6.6 | 7.0 | 7 | 31 | 75 | 2,228 | 13.0 | 82 | 0.2 | 45.2 | 2.3 | 0.20 | 1.6 | 0 | 30 | 0 | 0 | 0 |
| BIO 133 | 4 | 68.9 | 0.0 | 4.17 | 6.7 | 7.0 | 3 | 12 | 89 | 2,272 | 0.0 | 93 | 0.2 | 148 | 1.2 | 0.00 | 0.4 | 1 | 37 | 0.1 | 0 | 0.1 |
| BIO 134 | 4 | 68.9 | 6.6 | 3.8 | 6.8 | 7.1 | 2 | 15 | 91 | 2,771 | 12.0 | 69 | 0.3 | 84.1 | 1.6 | 0.00 | 0.6 | 1 | 35 | 0.1 | 0 | 0 |
| BIO 135 | 4 | 68.9 | 13.1 | 4.39 | 6.6 | 6.9 | 3 | 11 | 111 | 2,587 | 3.0 | 88 | 0.3 | 83.3 | 1.6 | 0.00 | 0.5 | 0 | 32 | 0.1 | 0 | 0 |
| BIO 136 | 4 | 68.9 | 13.1 | 4.03 | 6.7 | 6.9 | 3 | 13 | 110 | 2,569 | 3.0 | 85 | 0.3 | 111 | 1.8 | 0.00 | 33 | 0 | 33 | 0.1 | 0 | 0 |
| BIO 137 | 4 | 164.0 | 0.0 | 3.88 | 7.7 | 7.1 | 4 | 19 | 165 | 4,211 | 1.0 | 101 | 0.3 | 66.4 | 0.6 | 0.00 | 0.9 | 1 | 35 | 0 | 0 | 0 |
| BIO 138 | 4 | 164.0 | 6.6 | 4.19 | 6.9 | 7.0 | 6 | 9 | 144 | 3,141 | 12.0 | 102 | 0.3 | 55.8 | 0.7 | 0.00 | 0.6 | 1 | 35 | 0 | 0 | 0 |
| BIO 139 | 4 | 164.0 | 13.1 | 4.06 | 7.1 | 7.1 | 4 | 13 | 153 | 4,029 | 11.0 | 73 | 0.3 | 53.4 | 0.6 | 0.00 | 0.9 | 1 | 35 | 0 | 0 | 0 |
| BIO 140 | 4 | 164.0 | 0.0 | 3.94 | 6.8 | 7.1 | 4 | 41 | 119 | 3,527 | 17.0 | 119 | 0.3 | 47.5 | 2.7 | 0.10 | 1.3 | 1 | 33 | 0 | 0 | 0 |
| BIO 141 | 4 | 328.0 | 0.0 | 3.21 | 6.9 | 7.1 | 4 | 62 | 229 | 3,799 | 18.0 | 133 | 0.4 | 29.3 | 3 | 0.20 | 1.8 | 1 | 34 | 0 | 0 | 0 |
| BIO 142 | 4 | 328.0 | 6.6 | 4.46 | 6.7 | 7.0 | 5 | 36 | 126 | 2,536 | 17.0 | 128 | 0.3 | 28.5 | 2.5 | 0.10 | 1.3 | 0 | 31 | 0 | 0 | 0 |
| BIO 143 | 4 | 328.0 | 13.1 | 4.36 | 6.6 | 7.0 | 5 | 60 | 172 | 3,324 | 17.0 | 143 | 0.4 | 36.4 | 4.4 | 0.30 | 1.7 | 0 | 32 | 0 | 0 | 0 |
| BIO 144 | 4 | 328.0 | 6.6 | 4.14 | 6.9 | 7.0 | 6 | 11 | 143 | 3,394 | 7.0 | 108 | 0.3 | 68.7 | 0.7 | 0.00 | 0.5 | 1 | 33 | 0 | 0 | 0 |

Notes: D refers to duplicate sample.

All elements are in parts per million (ppm).

* Extracted Pb

**Estimated total Pb

APPENDIX E: Water Quality Analysis Results

| | | Nutrients (mg/L) | | | | | | | Metals (µg/L) | | | | | | | | | | | |
|------------------|------------|------------------|-------|-------|-------|------------|------------------------------|----------------|---------------|----|------|----|-----|------|-----|------|--------|------|----|-----|
| Location | Date | TKN | NH3-N | NO3-N | TP | TSS (mg/L) | Fecal coliform (coli/100 mL) | pH (std units) | As | Cd | Cr | Cu | Pb | Hg | Mo | Ni | K | Se | Ag | Zn |
| Site 1 | | | | | | | | | | | | | | | | | | | | |
| Site 1 Year 1 | 11/6/2008 | 5.44 | 1.0 | 0.71 | 1.32 | 14 | 790 | 6.7 | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| | 2/11/2009 | 1.99 | <0.1 | 0.02 | 0.28 | 3 | 30 | 7.0 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 6,250 | <20 | <5 | <5 |
| | 4/13/2009 | 2.89 | 0.4 | 0.13 | 0.28 | 1 | 10 | 7.2 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 1,600 | <20 | <5 | <5 |
| | 4/13/2009* | 1.86 | 0.14 | 0.11 | 0.19 | 2 | 30 | 7.2 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 1,540 | <20 | <5 | <5 |
| | 5/1/2009 | <0.03 | <0.1 | 0.14 | 0.27 | 11 | | 7.0 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 2,690 | <20 | <5 | <5 |
| | 5/14/2009 | 2.80 | 0.2 | 0.07 | 0.29 | 10 | | 7.1 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 1,850 | <20 | <5 | <5 |
| | 6/16/2009 | 4.65 | 0.3 | 0.40 | 0.58 | 16 | 29,000 | 7.1 | <15 | <5 | 14.2 | <5 | <15 | <0.2 | <20 | 10.8 | 8,700 | <20 | <5 | <5 |
| | 6/16/2009* | 5.72 | 0.3 | 0.46 | 0.57 | 14 | 29,000 | 7.1 | <15 | <5 | 15 | <5 | <15 | <0.2 | <20 | 10.9 | 8,860 | <20 | <5 | <5 |
| Site 1 | | | | | | | | | | | | | | | | | | | | |
| Site 1 Year 2 | 9/22/2009 | 2.16 | 0.5 | 0.16 | 0.26 | 16 | 2,300 | 7.1 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 9,000 | <20 | <5 | 6.4 |
| | 10/9/2009 | 1.59 | <0.1 | 0.18 | 0.28 | 10 | 520 | 7.1 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 5,180 | <20 | <5 | <5 |
| | 10/30/2009 | 9.97 | 0.2 | 0.01 | 1.11 | 20 | 200 | 7.2 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 7,680 | <20 | <5 | <5 |
| | 1/25/2010 | 1.91 | 0.3 | 0.18 | 0.23 | 57 | 50 | 7.2 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 3,400 | <20 | <5 | <5 |
| | 2/22/2010 | 1.29 | 0.3 | 0.06 | 0.14 | 18 | 20 | 7.1 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 3,610 | <20 | <5 | <5 |
| | 3/22/2010 | 1.38 | 0.2 | 0.04 | 0.12 | 10 | 30 | 7.1 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 1,460 | 20.2 | <5 | <5 |
| | 3/26/2010 | 1.18 | 0.2 | 0.09 | 0.26 | 17 | 82 | 7.2 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 1,750 | <20 | <5 | <5 |
| | 5/14/2010 | 2.54 | <0.1 | 0.07 | 0.04 | 8 | 227 | 6.9 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 1,440 | <20 | <5 | <5 |
| | 5/20/2010 | 1.75 | 0.3 | 0.10 | 0.08 | 5 | 964 | 7.0 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 810 | <20 | <5 | <5 |
| | 7/12/2010 | 1.74 | 0.5 | 0.29 | 0.28 | 12 | 9,000 | 7.1 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 5,080 | <20 | <5 | <5 |
| Site 2 | | | | | | | | | | | | | | | | | | | | |
| Site 2 Year 1 | 11/6/2008 | 66.70 | 37.4 | 1.41 | 34.20 | 105 | 250 | 7.5 | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| | 2/11/2009 | 3.50 | <0.1 | 0.77 | 10.10 | 20 | 30 | 7.5 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 12,600 | <20 | <5 | <5 |
| | 4/13/2009 | 3.15 | 0.2 | 0.13 | 4.11 | 1 | 70 | 7.2 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 2,580 | <20 | <5 | <5 |
| | 4/20/2009 | 2.15 | <0.1 | 0.08 | 3.57 | <2 | 20 | 7.3 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 2,120 | <20 | <5 | <5 |

| Location | Date | Nutrients (mg/L) | | | | | | | Metals (µg/L) | | | | | | | | | | | |
|------------------|------------|------------------|-------|-------|------|------------|------------------------------|----------------|---------------|----|-----|-----|-----|------|-----|-----|--------|-----|----|------|
| | | TKN | NH3-N | NO3-N | TP | TSS (mg/L) | Fecal coliform (coli/100 mL) | pH (std units) | As | Cd | Cr | Cu | Pb | Hg | Mo | Ni | K | Se | Ag | Zn |
| Site 2 Year 1 | 4/20/2009* | 2.02 | <0.1 | 0.08 | 3.73 | 2 | <1 | 7.3 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 1,970 | <20 | <5 | <5 |
| | 5/1/2009 | 3.57 | 0.1 | 0.16 | 4.95 | 13 | NR | 7.0 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 3,280 | <20 | <5 | <5 |
| | 5/14/2009 | 3.62 | 0.2 | 0.06 | 2.94 | 4 | NR | 6.9 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 2,740 | <20 | <5 | <5 |
| | 6/16/2009 | 4.58 | 0.5 | 1.40 | 4.94 | 8 | 8,000 | 7.0 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 12,200 | <20 | <5 | <5 |
| | 6/30/2009 | 3.96 | <0.1 | 2.64 | 2.60 | 20 | 1,545 | 7.1 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 10,600 | <20 | <5 | <5 |
| | 7/21/2009 | 3.95 | 0.2 | <0.01 | 1.72 | 6 | 1,000 | 7.2 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 10,700 | <20 | <5 | 6.4 |
| Site 2 Year 2 | 9/22/2009 | 4.09 | 0.3 | 2.57 | 3.23 | 12 | 2,000 | 7.1 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 12,600 | <20 | <5 | <5 |
| | 10/9/2009 | 2.82 | 0.2 | 2.51 | 1.48 | 6 | 890 | 7.0 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 10,800 | <20 | <5 | <5 |
| | 10/30/2009 | 2.34 | 0.3 | 1.62 | 0.34 | 434 | 190 | 7.1 | <15 | <5 | <10 | 5.5 | <15 | <0.2 | <20 | <10 | 11,050 | <20 | <5 | 17.4 |
| | 1/22/2010 | 4.73 | 0.3 | 0.80 | 1.19 | 284 | 40 | 7.8 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 7,080 | <20 | <5 | 6.9 |
| | 1/25/2010 | 4.66 | 0.3 | 0.15 | 1.18 | 428 | 50 | 7.5 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 3,600 | <20 | <5 | 10.9 |
| | 2/22/2010 | 3.71 | 0.3 | 0.65 | 0.98 | 22 | 5 | 7.4 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 5,570 | <20 | <5 | <5 |
| | 3/22/2010 | 2.46 | 0.2 | 0.17 | 0.65 | 85 | 5 | 7.3 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 2250 | <20 | <5 | <5 |
| | 3/26/2010 | 2.48 | 0.1 | 0.11 | 0.76 | 46 | 173 | 7.3 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 1,050 | <20 | <5 | <5 |
| | 5/14/2010 | 2.44 | 0.1 | 0.09 | 0.60 | 74 | 1,129 | 7.2 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 2,240 | <20 | <5 | <5 |
| | 5/20/2010 | 1.82 | 0.2 | 0.10 | 0.66 | 20 | 1,054 | 7.1 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 1,170 | <20 | <5 | <5 |
| | 7/12/2010 | 1.28 | 0.2 | 0.33 | 1.05 | 10 | 624 | 7.2 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 5,600 | <20 | <5 | <5 |
| Site 3 | | | | | | | | | | | | | | | | | | | | |
| Site 3 Year 1 | 4/13/2009 | 1.49 | 0.1 | 0.12 | 0.25 | 3 | 370 | 7.3 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 839 | <20 | <5 | <5 |
| | 4/20/2009 | 1.94 | 0.1 | 0.11 | 0.30 | <2 | 30 | 7.2 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 1,050 | <20 | <5 | <5 |
| | 5/1/2009 | 2.51 | 0.1 | 0.21 | 0.25 | 13 | NR | 7.4 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 1,890 | <20 | <5 | <5 |
| | 5/1/2009* | 5.23 | <0.1 | 0.2 | 0.18 | 12 | NR | 7.4 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 1,840 | <20 | <5 | <5 |
| | 5/14/2009 | 2.69 | 0.2 | 0.05 | 0.31 | 14 | NR | 7.2 | <15 | <5 | <10 | 8.2 | <15 | <0.2 | <20 | <10 | 2,440 | <20 | <5 | <5 |
| | 6/16/2009 | 3.48 | 0.4 | 0.45 | 0.61 | 2 | 9,000 | 7.2 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 10,100 | <20 | <5 | <5 |

| Location | Date | Nutrients (mg/L) | | | | | | | Metals (µg/L) | | | | | | | | | | | |
|------------------|------------|------------------|-------|-------|-------|------------|------------------------------|----------------|---------------|----|------|------|-----|------|-----|------|--------|-----|----|------|
| | | TKN | NH3-N | NO3-N | TP | TSS (mg/L) | Fecal coliform (coli/100 mL) | pH (std units) | As | Cd | Cr | Cu | Pb | Hg | Mo | Ni | K | Se | Ag | Zn |
| Site 3 Year 2 | 9/22/2009 | 2.34 | 0.3 | 0.33 | 0.52 | 8 | 4,700 | 7.0 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 7500 | <20 | <5 | <5 |
| | 10/9/2009 | 1.72 | 0.2 | 0.22 | 0.41 | 6 | 760 | 7.1 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 5500 | <20 | <5 | <5 |
| | 10/30/2009 | 4.97 | 0.2 | 0.03 | 2.43 | 26 | 609 | 7.2 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 6290 | <20 | <5 | <5 |
| | 1/25/2010 | 7.44 | <0.1 | 0.25 | 0.99 | 616 | 50 | 7.4 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 5800 | <20 | <5 | 26.1 |
| | 2/22/2010 | 2.26 | 0.2 | 0.15 | 0.35 | 74 | 270 | 7.3 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 4410 | <20 | <5 | <5 |
| | 3/26/2010 | 0.72 | <0.1 | 0.07 | 0.26 | 34 | 1,173 | 7.3 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 1200 | <20 | <5 | <5 |
| | 5/14/2010 | 1.39 | <0.1 | 0.08 | 1.61 | 16 | 730 | 7.2 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 3200 | <20 | <5 | <5 |
| | 5/20/2010 | 1.34 | 0.2 | 0.11 | 0.13 | 4 | 5,500 | 7.1 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 902 | <20 | <5 | <5 |
| | 7/12/2010 | 1.55 | 0.3 | 0.20 | 0.42 | 10 | 673 | 7.1 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 4170 | <20 | <5 | <5 |
| Site 4 | | | | | | | | | | | | | | | | | | | | |
| Site 4 Year 1 | 5/1/2009 | <0.03 | 0.3 | 0.28 | 0.06 | 34 | NR | 7.3 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 1,330 | <20 | <5 | 6.3 |
| | 5/14/2009 | 0.98 | 0.4 | 0.11 | 0.02 | 6 | NR | 7.3 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 807 | <20 | <5 | <5 |
| | 5/14/2009* | 1.08 | 0.45 | 0.82 | 0.08 | 4 | NR | 7.4 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 638 | <20 | <5 | <5 |
| | 6/16/2009 | 14.40 | 8.0 | 0.30 | 7.31 | 180 | 190,000 | 7.3 | <15 | <5 | <10 | 19.6 | <15 | <0.2 | <20 | 13.7 | 190000 | <20 | <5 | 69.1 |
| Site 4 Year 2 | 8/11/2009 | 4.18 | 0.3 | 0.43 | 0.390 | 10 | 2,000 | 7.1 | <15 | <5 | <10 | 7.3 | <15 | <0.2 | <20 | <10 | 5410 | <20 | <5 | 9.4 |
| | 9/10/2009 | 7.12 | 0.6 | 0.16 | 0.640 | 26 | 20 | 7.1 | <15 | <5 | 12.7 | 11.7 | <15 | <0.2 | <20 | <10 | 12600 | <20 | <5 | 16 |
| | 9/20/2009 | 3.25 | | 0.22 | 0.420 | 10 | 3,060 | 7.1 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 10000 | <20 | <5 | 6.6 |
| | 9/22/2009 | 3.45 | 0.2 | 0.23 | 0.420 | 13 | 6,100 | 7.1 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | <500 | <20 | <5 | 6.2 |
| | 10/9/2009 | 1.36 | 0.2 | 0.28 | 0.310 | 6 | 940 | 7.1 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 4330 | <20 | <5 | <5 |
| | 10/30/2009 | 2.17 | 0.1 | 0.28 | 0.450 | 22 | 3,100 | 7.2 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 7400 | <20 | <5 | <5 |
| | 3/26/2010 | 2.41 | <0.1 | 0.11 | 0.350 | 48 | 60 | 7.2 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 1810 | <20 | <5 | <5 |
| | 5/14/2010 | 0.61 | <0.1 | 0.08 | 0.060 | 12 | 10 | 7.3 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 1620 | <20 | <5 | <5 |
| | 5/20/2010 | 1.18 | 0.2 | 0.11 | 0.110 | 5 | 400 | 7.3 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 1070 | <20 | <5 | <5 |
| Field Blanks | | | | | | | | | | | | | | | | | | | | |
| | 11/6/2008 | 0.14 | <0.1 | <0.05 | <0.01 | <1 | <1 | 6.5 | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| | 2/11/2009 | 0.36 | <0.1 | 0.02 | 0.01 | <1 | <1 | 6.6 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | <50 | <20 | <5 | <5 |

| Location | Date | Nutrients (mg/L) | | | | | | | Metals (µg/L) | | | | | | | | | | | |
|---------------------------|------------|------------------|-------|-------|-------|------------|------------------------------|----------------|---------------|----|-----|----|-----|------|-----|-----|------|-----|----|----|
| | | TKN | NH3-N | NO3-N | TP | TSS (mg/L) | Fecal coliform (coli/100 mL) | pH (std units) | As | Cd | Cr | Cu | Pb | Hg | Mo | Ni | K | Se | Ag | Zn |
| Field Blanks Year 1 | 4/13/2009 | 0.45 | <0.1 | 0.12 | 0.15 | <1 | <1 | 6.5 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | <50 | <20 | <5 | <5 |
| | 4/20/2009 | <0.03 | <0.1 | 0.07 | 0.22 | <2 | <1 | 6.2 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | <50 | <20 | <5 | <5 |
| | 5/1/2009 | 0.17 | <0.1 | 0.14 | 0.02 | <1 | | 6.3 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | <50 | <20 | <5 | <5 |
| | 5/14/2009 | 0.19 | <0.1 | <0.01 | <0.01 | <1 | | 6.8 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | <50 | <20 | <5 | <5 |
| | 6/16/2009 | 0.62 | <0.1 | 0.38 | 0.08 | <1 | <1 | 6.8 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | <50 | <20 | <5 | <5 |
| | 6/30/2009 | 0.36 | <0.1 | <0.01 | 0.11 | <1 | <1 | 6.8 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | <50 | <20 | <5 | <5 |
| | 7/21/2009 | 0.40 | <0.1 | <0.01 | <0.01 | <1 | <50 | 6.7 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | <50 | <20 | <5 | <5 |
| Field Blanks Year 2 | 8/11/2009 | <0.03 | <0.1 | 0.14 | 0.14 | <1 | <1 | 6.9 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | <50 | <20 | <5 | <5 |
| | 9/10/2009 | <0.03 | <0.1 | 0.12 | 0.08 | <1 | <1 | 6.9 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | <50 | <20 | <5 | <5 |
| | 9/20/2009 | 0.08 | ns | 0.17 | 0.04 | <1 | | 6.9 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | <50 | <20 | <5 | <5 |
| | 9/22/2009 | 0.09 | <0.1 | <0.05 | 0.03 | <1 | <1 | 6.9 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | <50 | <20 | <5 | <5 |
| | 10/9/2009 | 0.29 | <0.1 | <0.05 | 0.21 | <1 | <1 | 7.0 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | <50 | <20 | <5 | <5 |
| | 10/30/2009 | | <0.1 | <0.01 | | <1 | <1 | 7.0 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | <50 | <20 | <5 | <5 |
| | 1/22/2010 | <0.03 | <0.1 | <0.01 | 0.12 | <1 | <2 | 6.9 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | <50 | <20 | <5 | <5 |
| | 1/25/2010 | <0.03 | <0.1 | <0.01 | 0.10 | <1 | <1 | 7.0 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | <50 | <20 | <5 | <5 |
| | 2/22/2010 | <0.03 | <0.1 | <0.01 | <0.01 | <1 | <1 | 6.8 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | <50 | <20 | <5 | <5 |
| | 3/22/2010 | 0.32 | <0.1 | <0.01 | 0.04 | <1 | <1 | 6.5 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | <50 | <20 | <5 | <5 |
| | 3/26/2010 | 0.36 | <0.1 | 0.06 | 0.10 | <1 | <1 | 6.5 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | <50 | <20 | <5 | <5 |
| | 5/14/2010 | <0.03 | <0.1 | 0.07 | <0.01 | 4 | <1 | 6.6 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | <50 | <20 | <5 | <5 |
| | 5/15/2010 | <0.03 | <0.1 | 0.12 | <0.01 | <1 | <1 | 6.6 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 88.6 | <20 | <5 | <5 |
| | 5/20/2010 | 0.45 | <0.1 | 0.10 | <0.01 | <1 | <1 | 6.6 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | 87.8 | <20 | <5 | <5 |
| | 7/12/2010 | 0.41 | <0.1 | 0.01 | <0.01 | <1 | <1 | 6.8 | <15 | <5 | <10 | <5 | <15 | <0.2 | <20 | <10 | <50 | <20 | <5 | <5 |

APPENDIX F: Water Quality Sampling Field Duplicate and Field Blank Data

| Date | TKN RPD | NH3-N RPD | NO3-N RPD | TP RPD | TSS RPD | Fecal RPD | pH RPD |
|------------|------------|--------------|--------------|-----------|------------|--------------|-----------|
| Year 1 | | | | | | | |
| 4/13/2009 | 43 | 96 | 17 | 38 | 67 | 100 | 0.1 |
| 6/16/2009 | 6.2 | 0.0 | 0.0 | 4.4 | 67 | 0.0 | 0.8 |
| 4/20/2009 | 70 | 75 | 4.9 | 33 | 8.0 | 190 | 0.3 |
| 5/1/2009 | 9.7 | 2.2 | 153 | 120 | 40 | | 0.7 |
| 6/10/2009 | 196 | 0.0 | 11 | 3.3 | 120 | 0.0 | 0.4 |
| 5/14/2009 | 21 | 0.0 | 14 | 1.7 | 13 | | 0.3 |
| Year 2 | | | | | | | |
| 8/11/2009 | 21 | 3.0 | 4.8 | 0.0 | 18 | 133 | 0.7 |
| 9/10/2009 | 5.5 | 4.7 | 55 | 1.6 | 18 | 0.0 | 0.9 |
| 9/22/2009 | 6.6 | 67 | 6.3 | 1.9 | 22 | 65 | 0.1 |
| 10/9/2009 | 3.4 | 17 | 0.0 | 2.4 | 0.0 | 9.7 | 0.1 |
| 10/30/2009 | | 43 | 0.0 | | 89 | 42 | 0.1 |
| 2/22/2010 | 0.0 | 36 | 18 | 0.0 | 77 | 0.0 | 0.3 |
| 3/22/2010 | 21 | 29 | 0.0 | 8.0 | 22 | 50 | 0.3 |
| 3/26/2010 | 99 | 32 | 12 | 21 | 124 | 0.0 | 0.4 |
| 5/14/2010 | 40 | 0.0 | 0.0 | 0.0 | 13 | 126 | 0.0 |
| 5/15/2010 | 11 | 115 | 8.7 | 156 | 67 | 111 | 2.7 |
| 5/15/2010 | 29 | 32 | 8.7 | 67 | 100 | 3.2 | 0.3 |
| 5/20/2010 | 58 | 67 | 120 | 13 | 22 | 17 | 0.3 |
| 7/12/2010 | 1.9 | 31 | 4.9 | 2.4 | 33 | 13 | 0.3 |

APPENDIX G: Soil Morphology Data

| Owner: Biosolid Project | | County: Lawrence, MO | | Soil Drainage Class: | | | | Date: 11/19/2008 | | | |
|---|--------------------------------------|--|--|--|-----------|-----------------------------------|------------------------|---------------------------------------|-----------------------------|-----------------------------------|---|
| Depth to Bedrock: | | Pit #: 1 | | Up Slope: Convex, Across Slope: Convex | | | Geomorphic: Head Slope | | | | |
| GPS Location: 37° 16.073' N: 93° 51.542' W +/-12ft | | Described By: Recorded By: Doug Gisselbeck Tom DeWitt | | Excavation Depth: 60' | | Landscape Position: Summit | | Aspect: Elevation: N 1215' | | % Slope: 1 | |
| Vegetation: Grass (Pasture- fescue) | | Parent Material: Loess / Colluvium / Residuum | | | | | Geology: Mo | | | | |
| Horizon | | Munsell Color (moist) | P/V Surface Features ⁽²⁾ | Texture | | % Coarse Fragment By Volume | | Consi stenc e ⁽⁴⁾ | Structure ⁽⁵⁾ | Roots/ Pores ⁽⁶⁾ | RMF /or Notes |
| Design ation | Depth/ Boundary ⁽¹⁾ | | | USDA ⁽³⁾ | % Clay | | | | | | |
| | | | | | | < 3" | > 3" | | | | |
| Ap | 0 – 5" (13cm) | 10YR 4/3 | | SIL | 12 | 0 | 0 | VFR | 1 F GR 1 F SBK | MF/M | 1% F/FMM |
| | AS | | | | | | | | | MF/M | |
| BE | 5 – 8" (20cm) | 10YR 5/4 | | SIL | 14 | 0 | 0 | FR | 2 F SBK | MF | 1% F/FMM |
| | CS | | | | | | | | | CF | |
| Bt1 | 8 – 18" (45cm) | 7.5YR 5/4 | 5% 10YR 5/4 CLF/APF | SIL | 25 | 1 | 0 | FR | 2 M SBK | MF | 2% F/FMM |
| | CW | | | | | | | | | CF | |
| Bt2 | 18 – 25" (64cm) | 7.5YR 4/4 | 10YR 4/3 CLF/HPF | SICL | 36 | 2 | 0 | FI | 2 M PR → 2 M SBK | FF | 5% F/FMM |
| | CW | | | | | | | | | FF | |
| Bt3 | 25 – 32" (89cm) | 7.5YR 4/4 | 10YR 4/2 CLF/VPF | SICL | 30 | 5 | 0 | FI | 2 M PR → 2 M SBK | FF | 5% D/FMM |
| | CW | | | | | | | | | FF | |
| 2Btx1 | 32 – 38" (97cm) | 7.5YR 4/6 | 10YR 4/2 CLF/VPF | GR SICL | 32 | 20 | 0 | FI | 1 M PR → 3 M SBK | VFF | 10YR 5/2 FED 2% D/FMN Clay films on vertical prism faces. Vert. seams <3" apart |
| | CW | | | | | | | | | VFF | |
| 2Btx2 | 38 – 45" (114cm) | 5YR 4/6 | ↓ | GR SICL | 38 | 25 | 0 | VFI | 1 M PR → 3 M SBK | VFF | ↓ |
| | CW | | | | | | | | | VFF | |
| 3Bt | 45 – 60" (152cm) | 2.5YR 4/6 | ↓ | GR SICL | 36 | 20 | 0 | FI | 1 M PR → 2 F SBK | VFF | ↓ |
| | ---- | | | | | | | | | VFF | |

| Owner: BioSolid Project | | County: Lawrence, MO | | Soil Drainage Class: | | | | Date: 11/19/2008 | | | |
|---|--------------------------------------|--|--|----------------------------|-----------|-----------------------------------|------|---------------------------------------|-----------------------------|-----------------------------------|--|
| Depth to Bedrock: | | Pit #: 2 | | Up Slope: Convex Convex | | Across Slope: | | Geomorphic: Interfluve | | | |
| GPS Location: 37° 16.173' N: 93° 51.507' W +/-12ft | | Described By: Recorded By: Doug Gisselbeck Tom DeWitt | | Excavation Depth: 60" | | Landscape Position: Summit | | Aspect: Elevation: N 1199' | | % Slope: 2 | |
| Vegetation: Grass (Pasture-fescue) | | Parent Material: Colluvium / Residuum | | | | Geology: Mo | | | | | |
| Horizon | | Munsell Color (moist) | P/V Surface Features ⁽²⁾ | Texture | | % Coarse Fragment By Volume | | Consi stenc e ⁽⁴⁾ | Structure ⁽⁵⁾ | Roots/ Pores ⁽⁶⁾ | RMF /or Notes |
| Design ation | Depth/ Boundary ⁽¹⁾ | | | USDA ⁽³⁾ | % Clay | | | | | | |
| | | | | | | < 3" | > 3" | | | | |
| Ap | 0 – 4" (10cm) | 10YR 3/3 | | SIL | 14 | 10 | | VFR | 2 M GR | MF/M | |
| | CS | | | | | | | | | MVF/F | |
| BE or Ap2 | 4 – 7" (18cm) | 10YR 5/3 | | SIL | 12 | 10 | | VFR | 2 F SBK → 1 F GR | MF/M | (SLF?) |
| | CS | | | | | | | | | MVF/F | |
| Bt1 | 7 – 11" (28cm) | 7.5YR 5/3 | | GR SIL | 18 | 20 | | FR | 2 M SBK | MVF/F | F/F CLF |
| | CW | | | | | | | | | MVF/F | |
| Bt2 | 11 - 20" (51cm) | 5YR 4/4 | | GRV SICL | 36 | 25 | 15 | FR | 2 M SBK | CF | |
| | CW | | | | | | | | | CF | |
| 2Btx1 | 20 - 29" (74cm) | 2.5YR 4/6 | 10YR 5/2 CLF/VPF 10YR 5/3 SLF F/F | GRX SICL | 32 | 40 | 20 | BR | 1 M PR → 2 M SBK | CF | Weak fragipan; 7.5YR 6/2 FED in gray seams. Gray seams 2 – 3" apart |
| | CW | | | | | | | | | CF | |
| 2Btx2 | 29 - 38" (97cm) | 2.5YR 4/6 | 10YR 5/2 CKF/VPF 2.5YR 3/6 CLF | GRX SICL | 36 | 40 | 20 | BR | 1 M PR → 3 M SBK | FF | ↓ |
| | CW | | | | | | | | | FF | |
| 3Bt | 38 - 60" (152cm) | 10R 3/6 | 10YR 5/2 CLF/VPF | GRV C | 60 | 15 | 15 | EF | 2 M PR → 2 M SBK | FF | ↓ |
| | ---- | | | | | | | | | FF | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

| Owner: BioSolid Project | | County: Lawrence, MO | | Soil Drainage Class: | | | | Date: 11/19/2008 | | | |
|---|--------------------------------------|---|---|----------------------------|-----------|-----------------------------------|-----------|---------------------------------------|-----------------------------|-----------------------------------|---|
| Depth to Bedrock: | | Pit #: 3 | | Up Slope: Convex Convex | | Across Slope: | | Geomorphic: Side Slope | | | |
| GPS Location: 37° 16.173' N: 93° 51.471' W +/-12ft | | Described By: Recorded By: Doug Gisselbeck Tom DeWitt | | Excavation Depth: 60" | | Landscape Position: Shoulder | | Aspect: Elevation: E 1195' | % Slope: 4 | | |
| Vegetation: Grass (Pasture=fescue) | | Parent Material: Colluvium / Residuum | | | | Geology: Mo | | | | | |
| Horizon | | Munsell Color (moist) | P/V Surface Features ⁽²⁾ | Texture | | % Coarse Fragment By Volume | | Consi stenc e ⁽⁴⁾ | Structure ⁽⁵⁾ | Roots/ Pores ⁽⁶⁾ | RMF /or Notes |
| Design ation | Depth/ Boundary ⁽¹⁾ | | | USDA ⁽³⁾ | % Clay | | | | | | |
| | | | | | | < 3" | > 3" | | | | |
| Ap | 0 – 3" (8cm) | 10YR 3/3 | | SIL | 12 | 5 | | VFR | 2 F GR | M F/M | |
| | CS | | | | | | | | | M F/M | |
| Ap2 | 3 – 7" (18cm) | 10YR 4/3 | | SIL | 12 | 10 | | VFR | 2 M SBK → 1 F GR | M F/M | |
| | CS | | | | | | | | | M F/M | |
| Bt1 | 7 – 16" (41cm) | 7.5YR 5/4 | 10YR 6/3 SLF 10YR 4/2 CLF/APF | SICL | 28 | 15 | | FR | 2 M SBK | CF | F/F FMM |
| | CS | | | | | | | | | CF | |
| Bt2 | 16 - 28" (71cm) | 5YR 4/4 | 10YR 6/3 SLF 10YR 4/2 CLF/APF | GR SICL | 36 | 25 | 5 | FR | 2 M SBK | CF | F/F FMM |
| | CW | | | | | | | | | FF | |
| 2Bt3 | 28 - 36" (91cm) | 2.5YR 4/4 | 10YR 6/3 SLF 10YR 4/2 CLF/APF | GR SICL | 39 | 20/5 G/PG | 5 | FI | 1 M PL → 2 M SBK | FF | Vertical Seams Para-rock frag. 1 M sandstone channers |
| | CW | | | | | | | | | FF | |
| 2Bt4 | 36 - 43" (109cm) | 2.5YR 4/6 | 40% 10YR 4/2 CLF/VPF | GR C | 55 | 20/5 G/PG | 5 | EF | 2 M PL → 2 M SBK | FF | 20% 2.5Y 7/2 FED |
| | CW | | | | | | | | | FF | |
| 3Bt5 | 43 - 50" (127cm) | 2.5YR 4/6 | 30% 10YR 4/2 CLF/VPF 20% 10YR 6/2 | GR SIC | 45 | 15 | 10 | VFI | 1 M PR → 1M PL | ---- | 20% 2.5Y 7/2 FED |
| | GW | | | | | | | | | ---- | |
| 3Bt | 50 – 60" (152cm) | 2.5YR 4/6 | | CNV SICL | 38 | 25 PGR | 25 PCN | FI | 1 M PL | ---- | 30% 2.5Y 7/2 FED Masses of Weathered sandstone |
| | ---- | | | | | | | | | ---- | |

| | | | | | | | | | |
|---|--|--|--|----------------------------|--|-----------------------------------|------------------|--------------------------------|--|
| Owner: BioSolid Project | | County: Lawrence, MO | | Soil Drainage Class: | | | Date: 11/19/2008 | | |
| Depth to Bedrock: | | Pit #: 4 | | Up Slope: Convex Convex | | Across Slope: | | Geomorphic: Side Slope | |
| GPS Location: 37° 16.173' N: 93° 51.443' W +/-12ft | | Described By: Recorded By: Doug Gisselbeck Tom DeWitt | | Excavation Depth: 80" | | Landscape Position: Back Slope | | Aspect: Elevation: 1176' | |
| Vegetation: Grass (Pasture-fescue) | | Parent Material: Colluvium / Residuum | | | | Geology: Mo | | | |

| Horizon | | Munsell Color (moist) | P/V Surface Features ⁽²⁾ | Texture | | % Coarse Fragment By Volume | | Consi stenc e ⁽⁴⁾ | Structure ⁽⁵⁾ | Roots/ Pores ⁽⁶⁾ | RMF /or Notes |
|-----------------|--------------------------------------|-----------------------------|--|------------------------|-----------|-----------------------------------|------|---------------------------------------|-----------------------------|-----------------------------------|---|
| Design ation | Depth/ Boundary ⁽¹⁾ | | | USDA ⁽³⁾ | % Clay | < 3" | > 3" | | | | |
| | | | | | | | | | | | |
| Ap2 | 4 – 8" (20cm) CS | 10YR 4/3 | | SIL | 12 | 10 | | VFR | 1 F SBK → 1 F GR | M F/M M F/M | |
| Bt1 | 8 – 18" (46cm) CS | 7.5YR 4/4 | 10YR 4/2 CLF/APF | SICL | 28 | 15 | | FR | 2 M SBK | CF CF | |
| Bt2 | 18 - 25" (64cm) CW | 7.5YR 5/3 15% 5YR 4/4 | (CRK or RPO?) ↑ | GR SICL | 38 | 20 | | FI | 2 M SBK | CF CF | (SLF?) |
| Bt3 | 25 - 32" (81cm) CW | 2.5YR 3/6 | ↓ | GR SIC | 42 | 30 | | VFI | 2 M PR → 3 M SBK | FF FF | 10YR 5/2 FED Roots in vertical seams |
| 2Bt4 | 32 – 62" (157cm) CW | 2.5YR 3/6 | ↓ | GRV SIC | 48 | 45 | 15 | VFI | 2 M PR → 3 M SBK | FF FF | ↓ |
| 2Bt5 | 62 – 80" (203cm) ----- | 2.5YR 3/6 | ↓ | GRV C | 55 | 20 | 20 | EF | 2 M PR → 3 M SBK | FF FF | ↓ |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

| Owner: BioSolid Project | | | County: Lawrence, MO | | | Soil Drainage Class: | | | Date: 11/19/2008 | | | |
|---|--------------------------------------|-----------------------------|--|------------------------|-----------|-----------------------------------|------|------------------------------------|-----------------------------|--------------------------------------|---|---------------|
| Depth to Bedrock: | | | Pit #: 5 | | | Up Slope: Concave Concave | | | Across Slope: | | Geomorphic: Head Slope | |
| GPS Location: 37° 16.184' N: 93° 51.406' W +/-12ft | | | Described By: Recorded By: Doug Gisselbeck Tom DeWitt | | | Excavation Depth: 60" | | Landscape Position: Footslope | | Aspect: Elevation: NE 1166' | | % Slope: 6 |
| Vegetation: Grass (Pasture-fescue) | | | Parent Material: Local Alluvium / Colluvium | | | | | | Geology: Mo | | | |
| Horizon | | Munsell Color (moist) | P/V Surface Features ⁽²⁾ | Texture | | % Coarse Fragment By Volume | | Consi stenc e ⁽⁴⁾ | Structure ⁽⁵⁾ | Roots/ Pores ⁽⁶⁾ | RMF /or Notes | |
| Design ation | Depth/ Boundary ⁽¹⁾ | | | USDA ⁽³⁾ | % Clay | | | | | | | |
| | | | | | | < 3" | > 3" | | | | | |
| Ap | 0 – 12" (30cm) | 10YR 3/2 | | GRV SIL | 14 | 35 | 5 | VFR | 3 F GR | M F/M | | |
| | CS | | | | | | | | | M F/M | | |
| Ap2 | 12 - 23" (58cm) | 10YR 3/3 | | GRV SIL | 16 | 40 | 20 | VFR | 1 F SBK → 2 F GR | M F/M | | |
| | CW | | | | | | | | | M F/M | | |
| 2Bt1 | 23 – 47" (119cm) | 5YR 4/4 | 10YR 4/3 CLF/VPF | GRV SICL | 38 | 35 | 5 | FI | 2 M SBK | FF | 5% FMM Vertical Gray Seams | |
| | AW | | | | | | | | | C F/M | | |
| 2Bt2 | 47 – 60" (152cm) | 2.5YR 3/6 | 10YR 4/2 CLF/VPF | GRV SIC | 45 | 45 | 5 | VFI | 1 M PR → 2 M SBK | FF | 8% FMM Irregular shaped 20% 10yr 5/2 FED | |
| | ---- | | | | | | | | | FF | | |

Comments: Alluvial / Colluvial mix, pit is in a narrow drainage way.

Taxonomy/Series: **Clayey-Skeletal Pachic Paleudolls**

Notations used to describe soil profile descriptions.

(1) Boundary: (A = abrupt, C = clear, G = gradual, D = diffuse) (S = smooth, W = wavy, I = irregular)

(2) NASIS Code: [(RMF and P & V Surface Features: (Amount class = %) (Distinctness class, F = faint, D = distinct, P = prominent) (Continuity class, D = discontinuous) (Kind, SAF = clean sand or silt over clay, CLF = clay films) (Location code, APF = on faces of peds, LPO = lining pores, RPO = on surfaces along root channels, SPO = on surfaces along pores)]

(3) Texture: (texture modifier, fragment content % by volume, GR = 15 to < 35 %, GRV = 35 to < 60 %, GRX = 60 to < 90 %) (SIL = silt loam, SICL = silty clay loam, C = clay, SIC = silty clay, L = loam, CL = clay loam)

(4) Consistence, moist conditions (VFR = very friable, FR = friable, FI = firm, VFI = very firm, EFI = extremely firm)

(5) Structure [(grade, 1 = weak, 2 = moderate, 3 = strong)(size, VF = very fine, F = fine, M = medium, C = coarse) (shape, GR = granular, SBK = subangular blocky, ABK = angular blocky, PR = prismatic, M = massive)

(6) Roots/Pores (abundance, F = few, C = common, M = many) (size, VF = very fine, F = fine, M = medium, C = coarse)

APPENDIX H: Forage Data

Spring 2009

| Parameter | Site 1 | | Site 2 | | Site 3 | | Site 4 | |
|--------------------------|----------|-------|----------|-------|----------|-------|----------|-------|
| | AVG | SEM | AVG | SEM | AVG | SEM | AVG | SEM |
| Dry Matter % | 29.61 | 1.02 | 27.60 | 0.77 | 28.68 | 0.35 | 27.33 | 1.94 |
| Protein % | 8.84 | 0.67 | 8.97 | 0.50 | 9.98 | 0.40 | 11.11 | 0.72 |
| A D Fiber % | 43.40 | 1.14 | 45.93 | 0.83 | 44.53 | 0.28 | 43.63 | 1.56 |
| N D Fiber(a) % | 64.72 | 1.19 | 68.08 | 1.27 | 66.37 | 0.31 | 65.62 | 2.07 |
| Crude Fiber % | | | | | | | | |
| Lignin % | | | | | | | | |
| T D N % | 52.15 | 0.94 | 50.06 | 0.68 | 51.21 | 0.23 | 51.96 | 1.29 |
| NE Lactation MCAL/LB | 0.513 | 0.011 | 0.489 | 0.008 | 0.502 | 0.003 | 0.511 | 0.015 |
| NE Gain MCAL/LB | 0.222 | 0.014 | 0.192 | 0.010 | 0.209 | 0.003 | 0.220 | 0.019 |
| NE Maint ... MCAL/LB | 0.473 | 0.015 | 0.440 | 0.011 | 0.458 | 0.004 | 0.470 | 0.020 |
| Digst Energy MCAL/LB | 0.473 | 0.015 | 0.440 | 0.011 | 0.458 | 0.004 | 0.470 | 0.020 |
| Nitrogen % | 1.415 | 0.108 | 1.435 | 0.080 | 1.596 | 0.065 | 1.777 | 0.116 |
| Calcium % | 0.340 | 0.069 | 0.317 | 0.040 | 0.280 | 0.035 | 0.330 | 0.061 |
| Phosphorus % | 0.157 | 0.015 | 0.239 | 0.010 | 0.219 | 0.006 | 0.247 | 0.018 |
| Ca:P 1.5 to 2.0 | 2.2 | | 1.3 | | 1.3 | | 1.3 | |
| Magnesium % | 0.123 | 0.012 | 0.123 | 0.006 | 0.143 | 0.015 | 0.143 | 0.021 |
| Potassium % | 1.647 | 0.061 | 1.980 | 0.125 | 1.787 | 0.055 | 1.807 | 0.191 |
| Sodium % | 0.006 | 0.002 | 0.008 | 0.003 | 0.009 | 0.006 | 0.015 | 0.010 |
| Iron PPM | 80.00 | 17.32 | 70.00 | 0.00 | 100.00 | 43.59 | 103.33 | 5.77 |
| Copper PPM | 3.67 | 0.58 | 5.33 | 1.53 | 5.67 | 1.15 | 5.67 | 0.58 |
| Manganese PPM | 40.00 | 14.18 | 63.67 | 6.66 | 44.33 | 8.50 | 46.00 | 7.21 |
| Zinc PPM | 17.67 | 2.89 | 17.67 | 2.08 | 22.33 | 1.15 | 23.00 | 2.65 |
| RFV/Quality Standrd | 79 | [4] | 73 | [5] | 76 | [4] | 78 | [4] |
| Nitrate (NO3) | Negative | | Negative | | Negative | | Negative | |
| Yield | | | | | | | | |
| fresh lbs/plot (140sqft) | 19.0 | | 38.7 | | 46.3 | | 63.8 | |
| dry lbs/plot | 5.6 | | 10.7 | | 13.3 | | 17.4 | |
| dry tons/A (extrap) | 0.9 | | 1.7 | | 2.1 | | 2.7 | |

Fall 2009

| Parameter | Site 1 | | Site 2 | | Site 3 | | Site 4 | |
|--------------------------|----------|-------|----------|-------|----------|--------|----------|------|
| | AVG | SEM | AVG | SEM | AVG | SEM | AVG | SEM |
| Moist / Dry Matter % | 40.11 | 1.16 | 29.61 | 0.71 | 32.29 | 0.76 | 29.36 | 2.08 |
| Protein % | 9.73 | 0.98 | 16.08 | 0.88 | 15.76 | 1.06 | 16.54 | 1.79 |
| A D Fiber % | 42.63 | 0.93 | 37.72 | 0.35 | 40.12 | 0.63 | 40.29 | 2.03 |
| N D Fiber(a) % | 63.17 | 0.54 | 57.15 | 0.65 | 59.11 | 0.45 | 58.50 | 2.37 |
| Crude Fiber % | | | | | | | | |
| Lignin % | | | | | | | | |
| T D N % | 52.78 | 0.77 | 56.84 | 0.28 | 54.86 | 0.52 | 54.71 | 1.68 |
| NE Lactation MCAL/LB | 0.52 | 0.01 | 0.57 | 0.00 | 0.54 | 0.01 | 0.54 | 0.02 |
| NE Gain MCAL/LB | 0.23 | 0.01 | 0.29 | 0.00 | 0.26 | 0.01 | 0.26 | 0.02 |
| NE Maint ... MCAL/LB | 0.48 | 0.01 | 0.55 | 0.00 | 0.52 | 0.01 | 0.51 | 0.03 |
| Digst Energy MCAL/LB | 0.48 | 0.01 | 0.55 | 0.00 | 0.52 | 0.01 | 0.51 | 0.03 |
| Nitrogen % | 1.56 | 0.16 | 2.57 | 0.14 | 2.52 | 0.17 | 2.65 | 0.29 |
| Calcium % | 0.44 | 0.04 | 0.52 | 0.03 | 0.53 | 0.04 | 0.50 | 0.09 |
| Phosphorus % | 0.23 | 0.01 | 0.38 | 0.03 | 0.36 | 0.02 | 0.35 | 0.03 |
| Magnesium % | 0.14 | 0.03 | 0.23 | 0.02 | 0.27 | 0.03 | 0.24 | 0.02 |
| Potassium % | 1.91 | 0.11 | 3.10 | 0.16 | 2.88 | 0.19 | 3.22 | 0.33 |
| Sodium % | 0.01 | 0.00 | 0.01 | 0.00 | 0.01 | 0.00 | 0.01 | 0.00 |
| Iron PPM | 80.00 | 17.32 | 90.00 | 17.32 | 236.67 | 228.11 | 106.67 | 5.77 |
| Copper PPM | 5.33 | 1.15 | 5.33 | 0.58 | 7.00 | 1.73 | 6.33 | 0.58 |
| Manganese PPM | 36.67 | 13.61 | 62.00 | 8.00 | 47.33 | 3.21 | 43.67 | 7.51 |
| Zinc PPM | 21.00 | 4.00 | 19.67 | 4.16 | 25.67 | 2.52 | 22.67 | 3.06 |
| RFV/Quality Standrd | 82 [4] | | 97 [3] | | 90 [3] | | 90 [3] | |
| Nitrate (NO3) | Negative | | Negative | | Negative | | Negative | |
| Yield | | | | | | | | |
| fresh lbs/plot (140sqft) | 17.3 | | 34.2 | | 34.0 | | 36.5 | |
| dry lbs/plot | | | | | | | | |
| dry tons/A (extrap) | 1.1 | | 1.6 | | 1.7 | | 1.7 | |

Spring 2010

| Parameter | Site 1 | | Site 2 | | Site 3 | | Site 4 | |
|--------------------------|----------|-------|----------|-------|----------|-------|----------|-------|
| | AVG | SEM | AVG | SEM | AVG | SEM | AVG | SEM |
| Dry Matter % | 27.14 | 1.01 | 26.53 | 1.73 | 27.20 | 0.15 | 26.33 | 0.96 |
| Protein % | 9.94 | 0.97 | 10.81 | 1.08 | 10.70 | 0.42 | 11.37 | 1.08 |
| A D Fiber % | 41.03 | 0.90 | 41.49 | 1.20 | 41.47 | 0.21 | 40.31 | 0.42 |
| N D Fiber(a) % | 66.92 | 1.79 | 68.08 | 1.49 | 67.69 | 0.59 | 66.49 | 0.30 |
| Crude Fiber % | | | | | | | | |
| Lignin % | | | | | | | | |
| T D N % | 54.10 | 0.74 | 53.73 | 0.99 | 53.74 | 0.18 | 54.70 | 0.34 |
| NE Lactation MCAL/LB | 0.536 | 0.009 | 0.532 | 0.012 | 0.532 | 0.002 | 0.543 | 0.004 |
| NE Gain MCAL/LB | 0.251 | 0.011 | 0.245 | 0.014 | 0.246 | 0.003 | 0.259 | 0.005 |
| NE Maint ... MCAL/LB | 0.504 | 0.012 | 0.498 | 0.016 | 0.498 | 0.003 | 0.513 | 0.005 |
| Digst Energy MCAL/LB | 0.504 | 0.012 | 0.498 | 0.016 | 0.498 | 0.003 | 0.513 | 0.005 |
| Nitrogen % | 1.590 | 0.155 | 1.729 | 0.174 | 1.713 | 0.067 | 1.820 | 0.172 |
| Calcium % | 0.423 | 0.023 | 0.360 | 0.036 | 0.373 | 0.031 | 0.357 | 0.015 |
| Phosphorus % | 0.251 | 0.008 | 0.286 | 0.031 | 0.282 | 0.006 | 0.291 | 0.012 |
| Ca:P 1.5 to 2.0 | 1.7 | | 1.3 | | 1.3 | | 1.2 | |
| Magnesium % | 0.157 | 0.006 | 0.153 | 0.015 | 0.163 | 0.015 | 0.150 | 0.010 |
| Potassium % | 1.573 | 0.152 | 1.640 | 0.207 | 1.540 | 0.052 | 1.707 | 0.137 |
| Sodium % | 0.005 | 0.000 | 0.005 | 0.000 | 0.012 | 0.013 | 0.005 | 0.000 |
| Iron PPM | 160.00 | 30.00 | 110.00 | 10.00 | 103.33 | 5.77 | 106.67 | 11.55 |
| Copper PPM | 7.00 | 2.65 | 5.67 | 0.58 | 5.67 | 0.58 | 5.33 | 0.58 |
| Manganese PPM | 37.00 | 3.00 | 41.33 | 4.73 | 27.67 | 5.86 | 31.33 | 0.58 |
| Zinc PPM | 17.00 | 1.00 | 13.00 | 6.93 | 15.67 | 1.53 | 25.00 | 3.46 |
| RFV/Quality Standrd | 79 [4] | | 77 [4] | | 78 [4] | | 80 [4] | |
| Nitrate (NO3) | Negative | | Negative | | Negative | | Negative | |
| Yield | | | | | | | | |
| fresh lbs/plot (140sqft) | 19.2 | | 38.2 | | 47.8 | | 58.7 | |
| dry lbs/plot | 5.2 | | 10.1 | | 13.0 | | 15.5 | |
| dry tons/A (extrap) | 0.8 | | 1.6 | | 2.0 | | 2.4 | |

Fall 2010

| Parameters | Site 1 | | Site 2 | | Site 3 | | Site 4 | |
|--------------------------|--------|-------|----------|-------|----------|-------|--------|-------|
| | AVG | SEM | AVG | SEM | AVG | SEM | AVG | SEM |
| Dry Matter % | 37.78 | 1.89 | 32.11 | 1.17 | 28.91 | 1.67 | 29.81 | 1.58 |
| Protein % | 8.81 | 0.37 | 15.15 | 3.13 | 15.30 | 1.30 | 18.38 | 1.98 |
| A D Fiber % | 46.57 | 1.36 | 42.70 | 2.31 | 38.28 | 0.96 | 35.98 | 1.48 |
| N D Fiber(a) % | 73.88 | 2.26 | 68.22 | 3.32 | 61.74 | 0.21 | 59.43 | 1.82 |
| Crude Fiber % | | | | | | | | |
| Lignin % | | | | | | | | |
| T D N % | 49.53 | 1.12 | 52.73 | 1.91 | 56.38 | 0.79 | 58.27 | 1.22 |
| NE Lactation MCAL/LB | 0.483 | 0.013 | 0.520 | 0.022 | 0.563 | 0.009 | 0.585 | 0.014 |
| NE Gain MCAL/LB | 0.184 | 0.017 | 0.231 | 0.028 | 0.283 | 0.011 | 0.310 | 0.017 |
| NE Maint ... MCAL/LB | 0.431 | 0.018 | 0.482 | 0.030 | 0.539 | 0.012 | 0.568 | 0.019 |
| Digst Energy MCAL/LB | 0.431 | 0.018 | 0.482 | 0.030 | 0.539 | 0.012 | 0.568 | 0.019 |
| Nitrogen % | 1.410 | 0.059 | 2.423 | 0.501 | 2.447 | 0.208 | 2.940 | 0.317 |
| Calcium % | 0.463 | 0.065 | 0.440 | 0.020 | 0.537 | 0.032 | 0.623 | 0.071 |
| Phosphorus % | 0.211 | 0.021 | 0.282 | 0.027 | 0.389 | 0.018 | 0.368 | 0.029 |
| Ca:P 1.5 to 2.0 | 2.2 | | 1.6 | | 1.4 | | 1.7 | |
| Magnesium % | 0.103 | 0.015 | 0.137 | 0.006 | 0.200 | 0.030 | 0.207 | 0.012 |
| Potassium % | 1.043 | 0.172 | 1.537 | 0.210 | 1.713 | 0.358 | 1.797 | 0.111 |
| Sodium % | 0.005 | 0.000 | 0.005 | 0.000 | 0.005 | 0.000 | 0.005 | 0.000 |
| Iron PPM | 113.33 | 23.09 | 93.33 | 11.55 | 100.00 | 0.00 | 46.67 | 40.41 |
| Copper PPM | 4.33 | 0.58 | 4.67 | 0.58 | 5.33 | 0.58 | 6.00 | 0.00 |
| Manganese PPM | 38.00 | 14.73 | 45.00 | 20.07 | 52.33 | 10.26 | 40.00 | 11.79 |
| Zinc PPM | 27.67 | 4.04 | 29.00 | 11.36 | 31.00 | 6.56 | 20.33 | 0.58 |
| RFV/Quality Standrd | 66 [5] | | 76 [4] | | 89 [3] | | 96 [3] | |
| Nitrate (NO3) | Trace | | Negative | | Negative | | 0.90% | |
| <u>Yield</u> | | | | | | | | |
| fresh lbs/plot (140sqft) | 15.3 | | 26.2 | | 17.5 | | 16.25 | |
| dry lbs/plot | 5.8 | | 8.4 | | 5.1 | | 4.8 | |
| dry tons/A (extrap) | 0.9 | | 1.3 | | 0.8 | | 0.8 | |