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I am submitting herewith a thesis written by Boone Stephen Hillenbrand entitled "An Investigation for the need of Secondary treatment of Residential Wastewater when applied with a Subsurface Drip Irrigation System." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Biosystems Engineering.

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(Original signatures are on file with official student records)

AN INVESTIGATION FOR THE NEED OF SECONDARY TREATMENT OF RESIDENTIAL WASTEWATER WHEN APPLIED WITH A SUBSURFACE DRIP IRRIGATION SYSTEM

A Thesis Presented for
the Master of Science
Degree
The University of Tennessee, Knoxville

Boone Stephen Hillenbrand
August 2010

DEDICATION

This thesis is dedicated to my parents who supported me much longer than they ever wanted to.

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ABSTRACT

The objective of this study was to investigate the need for domestic wastewater to receive secondary treatment when being applied to the soil by subsurface drip irrigation (SDI). SDI uniformly distributes wastewater into the soil, which optimizes the soil's chemical, physical, and biological capacity to remove waste constituents. Because of these advantages, many regulatory jurisdictions are allowing SDI at sites that previously were prohibited from using conventional trench-based soil application systems because of shallow soil restrictions. However, most of these regulatory agencies also require that the wastewater receives secondary treatment (dissolved organic carbon reduction) before the SDI system. At issue is whether the enhanced soil-based renovation provided by SDI should eliminate the necessity for secondary treatment before SDI.

Two SDI systems were installed and monitored at two sites in Tennessee. These locations were residential developments served by a septic tank effluent pump (STEP) collection system, a recirculating media filter (fine gravel media), and SDI dispersal. At both locations, SDI plots were established to receive primary treated (septic tank effluent) and secondary treated (recirculating media filter effluent) wastewater. In close proximity to randomly selected SDI emitters, soil samples were extracted. Soil cores were analyzed to determine saturated hydraulic conductivity (Ksat), and pore water samples were analyzed for nitrate, total nitrogen, total carbon, and total phosphorus. Results indicate that the primary-treated sites had lower Ksat values, higher nitrate and higher total

nitrogen levels than the secondary-treated side and the background soil. Interestingly, the primary treated side had less total carbon and the background phosphorus concentration was twice that of the primary and secondary treated sides. The primary effluent application site showed a decrease in concentration for all constituents with increased depth. Secondary treatment does result in a higher quality effluent but is not needed when applying effluent with a SDI.

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CHAPTER 1: INTRODUCTION

Background

More than 25% of homes in the United States rely on decentralized wastewater treatment systems for their wastewater dispersal needs (U.S. EPA, 2002). Forty percent of new homes being built are also going to be connected to decentralized wastewater systems (U.S. EPA, 2002). A conventional decentralized wastewater treatment system consists of a septic tank for primary treatment and an absorption field for effluent dispersal (figure 1.1). Due to inadequate soil conditions or to limited availability of land, some homeowners are required to add a secondary-treatment device to the system before applying effluent to the soil. Secondary treatment usually involves an aerobic treatment unit (ATU) or a recirculating media filter (RMF).

The soil has a tremendous ability to renovate domestic wastewater under aerobic and non-saturated conditions. The formation of a clogging zone (biomat) in the soil where the effluent is being applied is beneficial for the removal of viruses and bacteria, but the use of secondary treatment may retard this formation. Utilization of secondary treatment can reduce total suspended solids (TSS) and biochemical oxygen demand (BOD), but may not be an effective means of removing bacteria and viruses. The clogging zone reduces the percolation rate of the effluent allowing for prolonged contact between the wastewater and the soil particles and the adsorption of bacteria and viruses.

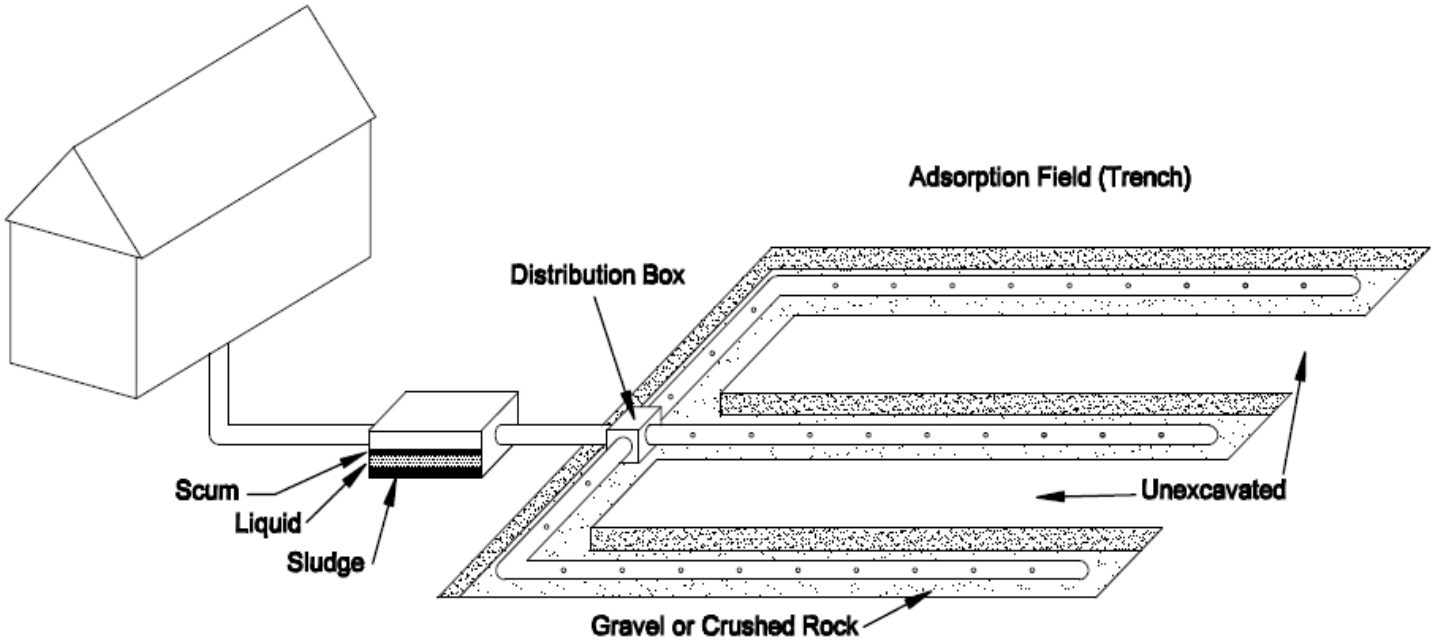

Figure 1.1 - Conventional Subsurface Wastewater Infiltration System

Secondary treated effluent allows for greater hydraulic loading because of the reduced clogging potential. This means that a smaller area absorption field can be used, or a shorter distance between the infiltration zone and a restrictive layer (such as groundwater or bedrock). However this may reduce treatment in the soil due to shorter contact time between the effluent and soil particles.

This study is specifically investigating the comparison of two alternative decentralized wastewater treatment systems. One system utilizes a RSF to provide secondary treatment to the wastewater before it is applied and the second system applies the wastewater directly from the septic tank. The reason these systems are considered “alternative” is because they use subsurface drip irrigation (SDI) to apply the effluent to the soil instead of a conventional gravel filled trench system. The general consensus is that when using SDI, secondary treatment is required to reduce the clogging of emitters and filters due to biological growth and the buildup of particulate matter (Gilbert., et al 1979; Gillespie and Tasato, 1980; Nakayama and Bucks, 1991; Massoud et al., 1994; Ravina et al., 1997). A benefit of subsurface drip irrigation (SDI) is that it allows for adsorption fields to be installed on land where a conventional dispersal system would not be appropriate. SDI can be installed on shallower soils and in poor soil conditions. Soil has a tremendous ability to renovate residential wastewater. SDI applies the effluent to the soil in a way that maximizes soil-based wastewater renovation so that the effluent can meet proper purification

requirements before it reaches the groundwater or surface waters (i.e. rivers and lakes).

Justification

Many studies have been conducted to investigate the effects of irrigating with wastewater, but few have investigated the application of wastewater using SDI. Even fewer researchers have investigated the need for secondary treatment of wastewater when using SDI. Secondary treatment can be very expensive and may not be necessary. This study will compare two systems using SDI, one receiving primary effluent, and the other receiving secondary effluent. Jnad et al. (2001a, 2001b) discusses the effects of irrigating with wastewater using SDI on the soil's chemical and physical properties. This study like Jnad et al. (2001a, 2001b) used both an elemental and a physical approach to analyze the effectiveness of each treatment. This analysis is used to make the comparison.

Hypothesis

The primary hypothesis of this study is that:

- Secondary treatment is not needed to adequately purify residential wastewater, when SDI is used.

This study will prove or disprove this hypothesis by analyzing the soil and soil solution below SDI emitters. By looking at the saturated hydraulic conductivity (Ksat), it can be seen how secondarily treated effluent and primary

effluent change the soil's physical properties. An elemental analysis will also help determine other effects of wastewater dispersal on the soil. The elemental analysis will include nitrate-nitrogen ($NO3^-$), total nitrogen (TN), total phosphorus (TP), and total carbon (TC). These are the main constituents in residential wastewater that may be of concern in the environment. Nitrate making its way into drinking water is of concern because of the potential for disease like methemoglobinemia (blue baby syndrome). Phosphorus runoff into bodies of water can result in eutrophication, destroying habitat for local fish and water wildlife. Measuring TC will provide information on how much oxygen demand the wastewater is adding to the system.

CHAPTER 2: REVIEW OF LITERATURE

Soil's Purification Abilities

Soil based wastewater renovation for onsite and small community applications commonly relies on infiltration and percolation of primary effluent through soil to achieve purification prior to recharge to groundwater (Jenssen and Seigrist, 1990; Crites and Tchobanoglous, 1998; U.S. EPA, 2002; Van Cuyk et al., 2007). The soil removes wastewater constituents through filtration of suspended solids, sorption of phosphorus, transformations of nitrogen, biodegradation of organic matter, die-off of bacteria, and inactivation of viruses (Siegrist and Van Cuyk, 2007). Studies have shown that pathogens can be reduced 99% to 99.9% through 2-3-ft of unsaturated subsoil (Kristiansen, 1981; Van Cuyk et al., 2004). Unsaturated flow conditions promote lengthy contact of the wastewater constituents with the surface of the soil particles and the associated biofilm which is critical for the purification of wastewater (Emerick et al., 1997; Schwagger and Boller, 1997; Van Cuyk et al., 2001b; Siegrist et al., 2000; Beach et al., 2005). Lance and Gerba (1984) found that virus penetration during unsaturated flow is much less than during saturated flow. Van Cuyk (2001a) wrote "extensive and lengthy contact between wastewater constituents and the soil matrix and associated biofilms occurs during unsaturated flow achieved by intermittent dosing of daily loadings limited to a small fraction of the soil's saturated hydraulic conductivity and by spatially uniform application." Meaning that with unsaturated conditions, the wastewater is forced into contact with the biofilm that is attached to the soil particles. Under saturated conditions,

the wastewater can between the soil particles without directly contacting the biofilm. Also, with lengthy contact and unsaturated flow conditions, critical oxygen will be provided to aide micro-organisms (in the soil's biofilm) to consume organic wastewater constituents and more time is allowed for important processes to occur. Subsurface drip irrigation allows uniform application and the intermittent dosing of daily loads (also called dosing cycle) needed for the development and control of the biofilm layer.

Studies show that most of the biological activity occurs within the initial percolation zone (McCoy and Zeibell, 1975; Hagedorn et al., 1981; Gill et al., 2007). The biomat (also called: clogging layer, biological layer, etc…) is the biologically active layer that develops at the infiltrative surface of conventional gravel filled trenches as a result of wastewater application (Beach et al., 2005). Not to be confused with biofilm, the biomat is a result of an accumulation of suspended solids that collect in the soil pores and microbial growth (Jones & Taylor, 1965; Thomas et al., 1966; Bouma, 1975; Siegrist and Boyle, 1987; Tyler et al., 1991; Tyler and Converse, 1994; Beach et al., 2005). The biomat is a biofilm that has become so thick that it can overly restrict the downward flow of effluent.

The influence that residential wastewater has on soil hydraulic properties depends on the effluent quality, application rate, and soil type (Jnad et al., 2001b). These variables control the extent of the biomat developement. If the biomat grows too dense it may cause reduced infiltration at the emitter due to lower hydraulic conductivity. SDI allows for dosing and resting cycles that will

maximize soil-water-oxygen contact such that aerobic conditions can be maintained thus controlling the biomat formation (Buchanan, 2006). Biomat is developed during saturated anaerobic conditions. The dosing and resting cycles of the SDI creates the balance between beneficial biofilm and potentially detrimental biomat growth by providing the oxygen needed to limit the biomat growth. Biofilm is a biologically active layer that develops in the biofilter media, in this case, the soil.

Figure 2.1 illustrates a simple example of biofilm versus biomat. The biofilm aides greatly in the purification of effluent and this zone can be retarded by highly pretreated effluent (e.g. sand filter effluent) (Van Cuyk et al., 2001b). This retardation may limit the soils purification capabilities.

Hepner measured a statistically significant reduction of BOD5, NH4-N, $NO3^{-}$-N, and phosphorus (Hepner et al., 2007). Hepner found that application of septic tank effluent (STE) from 3 single family homes received significant treatment when it was applied using SDI.

Gill et al. (2007) performed a study was conducted at 4 sites, two receiving STE, and two receiving sand filter effluent (SFE because they did not specify if it was recirculated). They found that STE achieved equivalent purification as secondary effluent after it had percolated through 2-ft of unsaturated soil. The effluent was applied using conventional percolation trenches. Samples for effluent evaluation were collected using suction lysimeters placed at 1, 2, and 3 feet below the invert of the percolation trenches. Gill also found that SFE received no further substantial treatment in

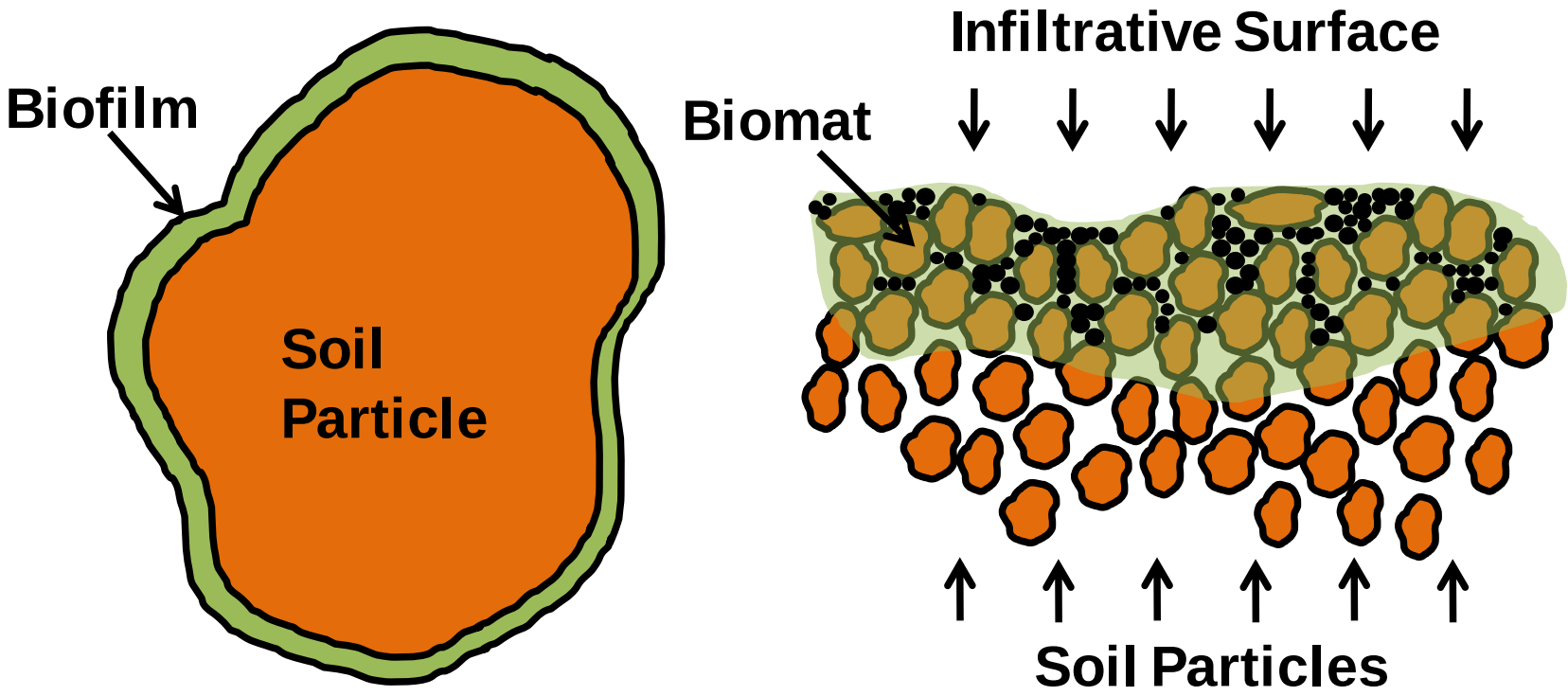

Figure 2.1 –Biofilm vs. Biomat

the subsoil, except for P which was dependent on the characteristics of the soil. Due to the reduced treatment from the soil, Gill stated that N loading was higher (resulting in higher N loads moving toward groundwater because of less nitrification/denitrification taking place in the soil). Bohrer (2000) found that levels of fecal coliform and E. coli from 3 STE only sites were below detection levels at a depth of 45 cm below the drip line. Lance (1976) found that most viruses used in their study were removed within the first few centimeters of soil. Once the sewage travelled past the first 2 cm of soil the rate of virus removal is dramatically reduced leading the authors to believe that absorption of the viruses onto soil particles is not the only factor in virus removal. Lance suggests that an increase in microbial activity near the infiltrative surface might have led to optimum conditions for virus removal. Maybe the increased biomat reduced the infiltration rate such that the viruses have more time to absorb to the soil particles.

Similar Study

Jnad et al (2001a) conducted a study concentrating on the soil's physical and chemical characteristics and how they changed when residential effluent was applied through subsurface drip tubing. The study was conducted at four sites in which residential effluent flowed through an artificial wetland and was then delivered to a subsurface drip irrigation system. Samples were collected by using an Uhland soil core sampler (Blake and Hartge, 1986). They found that the quantity and distribution of chemical constituents in the soil profile were influenced by soil properties, soil structure that affected water movement

patterns, crop uptake, concentration of the chemical in applied effluent, concentration of the chemical in the original soil, and distance from the emitter. They found no significant change in the concentrations of soil TN, Ca, Mg, K, EC, and TOC. This study concluded that the most important effect of wastewater irrigation using SDI was the increase of Na in the soil when the applied effluent had a high Na concentration. Increased soil sodium concentration in the soil is a concern with all wastewater irrigation methods. Jnad (2001a) found an increase in sodium where Ca and Mg concentrations were reduced and they found an increase in P concentrations near the surface. An increase in Na could create a saline environment that would leave the fields barren. Also an increase in P near the surface could lead to surface water pollution.

The soil physical properties investigated include; the soil water retention curve around the emitters, the pore size distribution around the emitters, and the saturated hydraulic conductivity around the emitters. Results show that as the soil depth increased, the number of pores increased and the pore size decreased. Also, the saturated hydraulic conductivities tended to decrease compared to the control, as the soil depth increases underneath the emitters, but was greater above the emitters.

Although the Ksat decreased as the soil got deeper, the Ksat values where still within an order of magnitude of the original soils. Jnad's (2001b) study shows some of the parameters that will be used to assess the performance of purification of residential effluent for each system in this study.

Nitrogen and Phosphorus Removal

Research has shown that the soil can remove greater than 90% of the suspended solids (SS) and BOD in wastewater through filtration, sorption, and biodegradation processes but the removal of nitrogen and phosphorus can be more limited (Viraraghavan and Warnock, 1976; U.S. EPA, 1980; Jenssen and Siegrist, 1990; Van Cuyk et al., 2001b; Rodgers et al., 2004; Beal et al., 2005; Gill et al., 2007). Common nutrients contained in wastewater that may limit the amount of water that can be added to the soil hydraulic loading are usually nitrogen and phosphorus (Vasquez-Montiel et al., 1996). Wastewater irrigation can significantly increase the amount of N, P, and potassium (K) in the soil (Jnad et al., 2001a; Munir et al., 2006). The nitrogenous organic matter in the wastewater undergoes different complex processes, such as decomposition, nitrification and denitrification, micelle fixation to soil particles, nitrate ($NO3^-$) leaching, and volatilization in the soil water system (Kunjikutty et al., 2007). Nitrogen removal is vital to reduce the risk of human consumption of polluted water at potentially toxic levels. The U.S. EPA has set a limit of 10 mg/kg for $NO3^-$ in drinking water with the Safe Drinking Water Act. Consumption of water with $NO3^-$ levels exceeding 10 mg/kg can result in methoglobinemia (blue baby syndrome) in infants (Majundar, 2003). Blue Baby Syndrome is caused by the ingestion on N in the form of nitrate. $NO3^-$ is reduced in the body to nitrite ($NO2^-$) in the intestine. Nitrite forms methemoglobin which is a substance that prevents oxygen from being transported to tissues causing asphyxiation.

Nitrogen is removed by the nitrification/denitrification process. For wastewater infiltration systems, nitrification occurs beneath the biomat in the unsaturated zone (Pell and Nyberg, 1989; Van Cuyk et al., 2001b). The oxidation of wastewater ammonium in aerobic and unsaturated conditions form nitrite ($NO2^-$) then nitrate ($NO3^-$). Denitrification takes place in oxygen depleted environments, *during the saturated period,* and produces gaseous forms of nitrogen that evolve to the atmosphere.

Phosphorus pollution leads to eutrophication of surface waters (Mamo, 2005; Bowden et al., 2008). Phosphorus can be removed from the wastewater before it reaches groundwater by Fe, Al, or Ca retention in the soil (Mamo, 2005). Significant leaching of phosphorus can occur via leaching through sandy soils (Mamo, 2005). Sandy soils do not have Fe, Al, and Ca and are therefore subject to P leaching. Mamo (2005), states that the agricultural practice that is most conducive to the significant downward phosphorus movement is the long-term application of organic wastes. Application of organic wastes increases the saturation of P in the soil causing increased leaching.

CHAPTER 3: MATERIALS AND METHODS

Site Description

This research was conducted at two residential subdivisions, each being serviced by a decentralized wastewater management system. At both locations, wastewater from each home flows into a septic tank (primary treatment). On a demand basis, a pump transfers the filtered effluent into a small diameter pressurized effluent sewer. The effluent sewer transfers the effluent to a recirculating media filter for secondary treatment. The highly renovated effluent is then dispersed to the soil using subsurface drip irrigation.

At each location, two 1000-ft² SDI plots were constructed (figure 3.1) with the objective of conducting side-by-side trials with septic tank effluent (STE) and recirculating sand filter effluent (RSFE). A diversion valve was installed in the effluent sewer just prior to the media filter in order to collect primary treated water for this investigation. For the purposes of this experiment the STE is considered high-strength effluent and RSFE is considered low-strength effluent. The research plots in each location are nearly identical. Each plot has 1000-ft of drip tubing installed. Each plot is made up of drip tubing that is laid out in lines spaced 2-ft from each other (figure 3.2). The drip tubing has emitters placed 2-ft apart so that every 4-ft² of the plot has an emitter delivering water to it. The soil receives 0.1 gallons of wastewater per day per square-foot. Thus, each field receives 200 gallons per day every day.

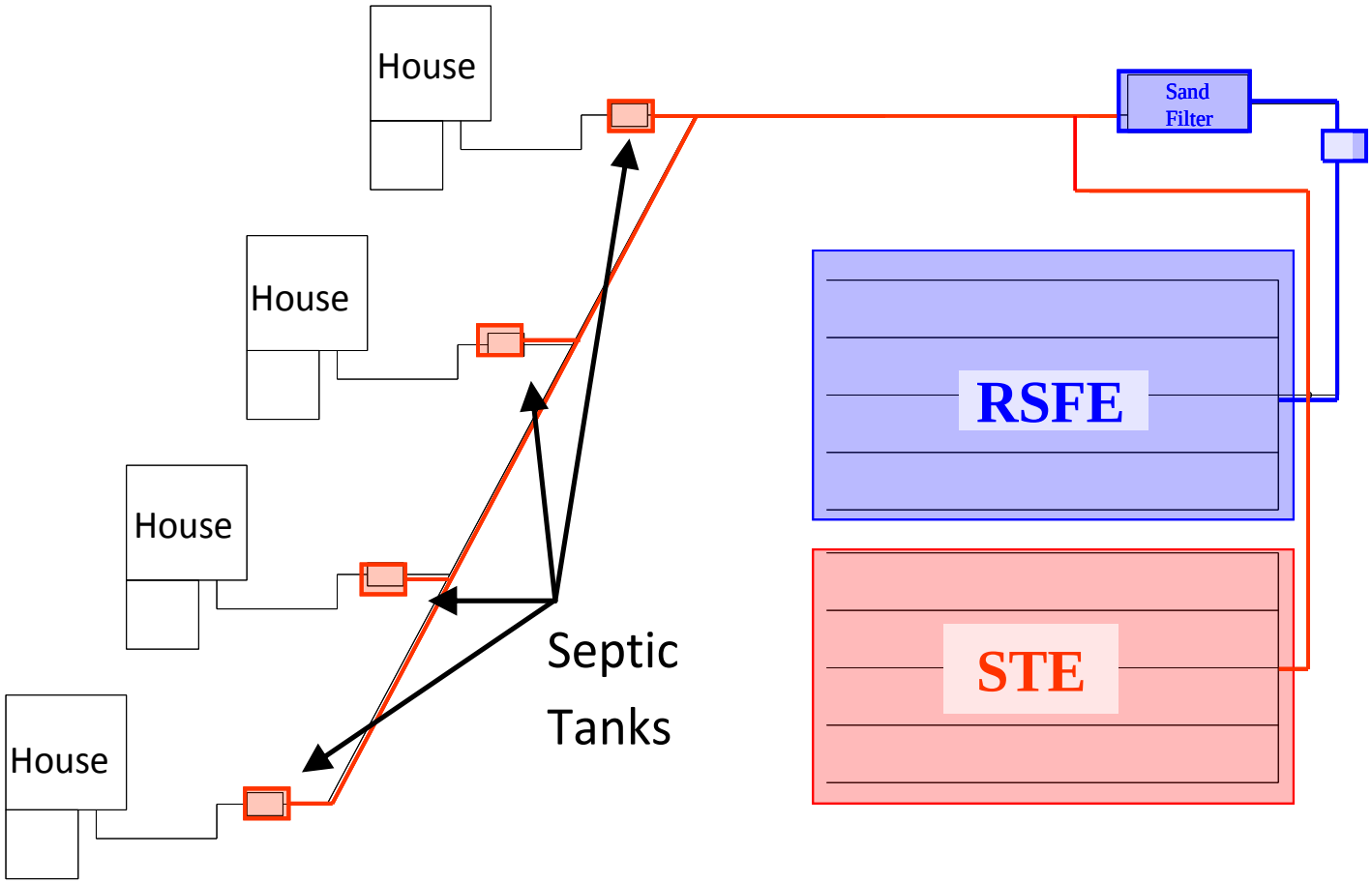

Figure 3.1 - Study Site Layout

The first site, Jackson Bend (JB), is located in Blount County, Tenn. The soil in JB is primarily a sandy loam and is 4-8-ft to groundwater. Jackson Bend is made up of high-end housing with large lots. The second site, Crescent Glen (CG), is located in Rutherford County, Tenn. The soil in CG is primarily a clay loam with about 2-ft to bedrock. The homes in Crescent Glen are mainly starter homes with small lots. Figures 3.3a and 3.3b show satellite images of the two sites. The highlighted areas show the locations of the test plots and RSFs.

Sample Collection and Analysis

Four rounds of sampling were completed beginning in August of 2009 and ending in April, 2010. Soil samples were collected from the area surrounding the test plots as a control. The samples were collected in a similar manner as Jnad (2001a, 2001b), and were collected from each subplot within each site. Soil samples were collected with a coring device and transported to the laboratory to be analyzed. The cores had 2-in diameters and were 3-in long*. Samples were obtained from two depths; 12-in below the emitter level, and 24-in below the emitter level. At each depth, samples were collected at six locations relative to the emitter. Each core location was labeled with a number 1-14 depending on its location relative to the drip emitter. Locations 1-12 were located near the emitter while locations 13 and 14 were the control samples. The control samples were used to determine the background properties of the soil.

* Klute (1986) describes the standard diameter and length for soil core samples that are going to be analyzed in the laboratory. The diameter of the core sample should be between 2 and 10 cm and the length should be between 5 and 25 cm (Klute, pg. 691).

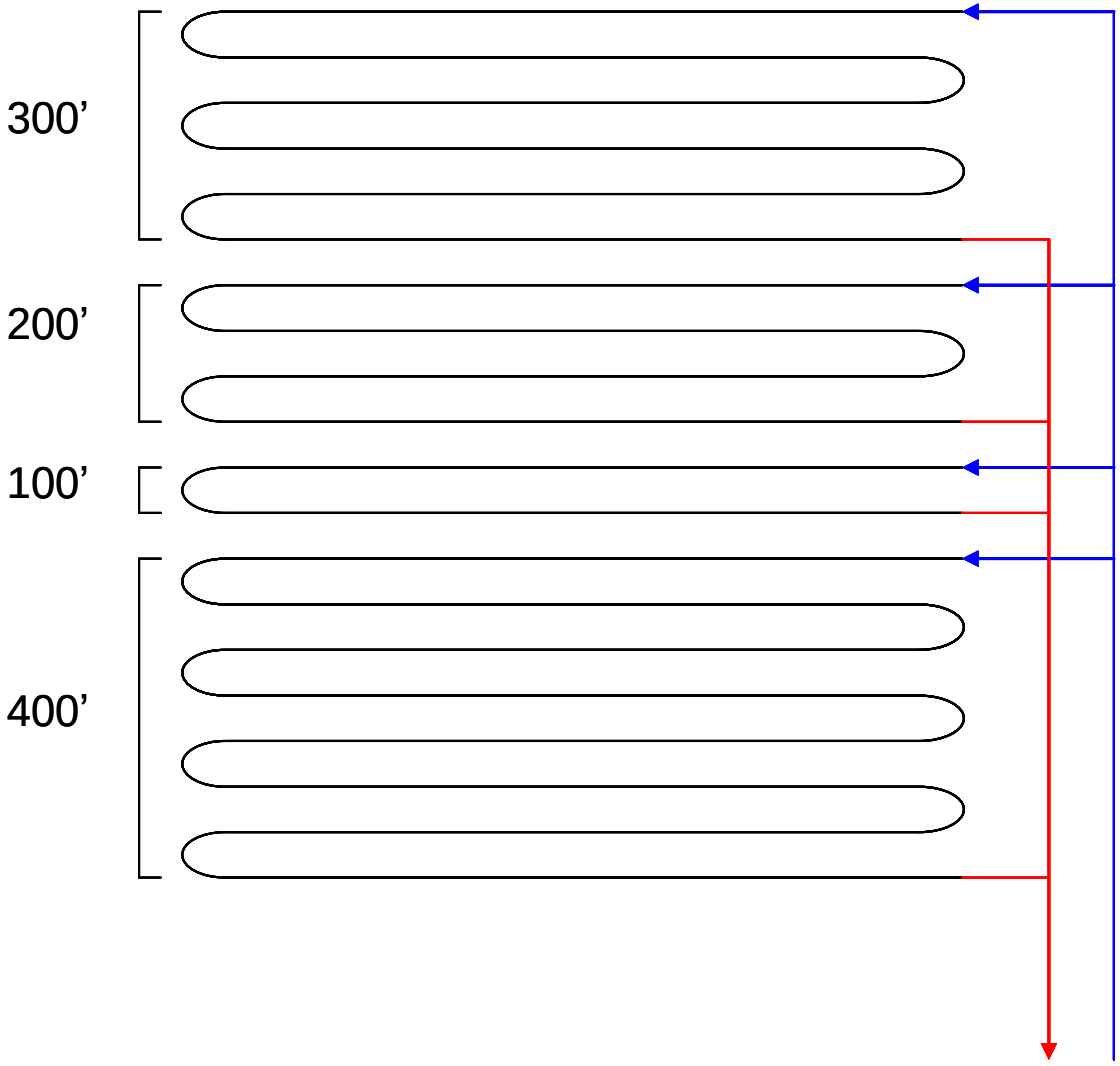

Figure 3.2 - Subplot Tubing Layout

Figure 3.3a - Jackson Bend, Blount County, TN

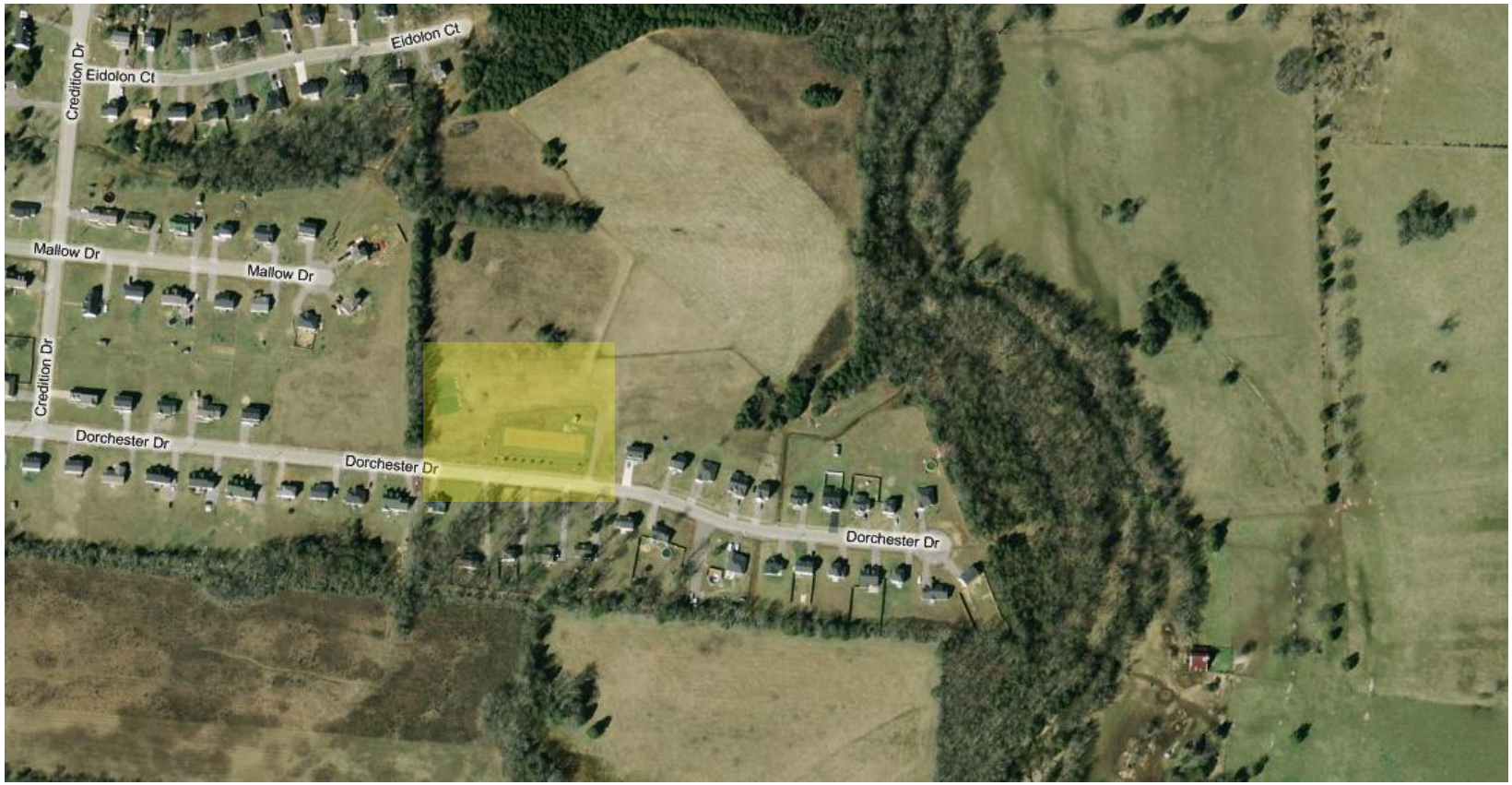

Figure 3.3b - Crescent Glenn, Rutherford County, TN

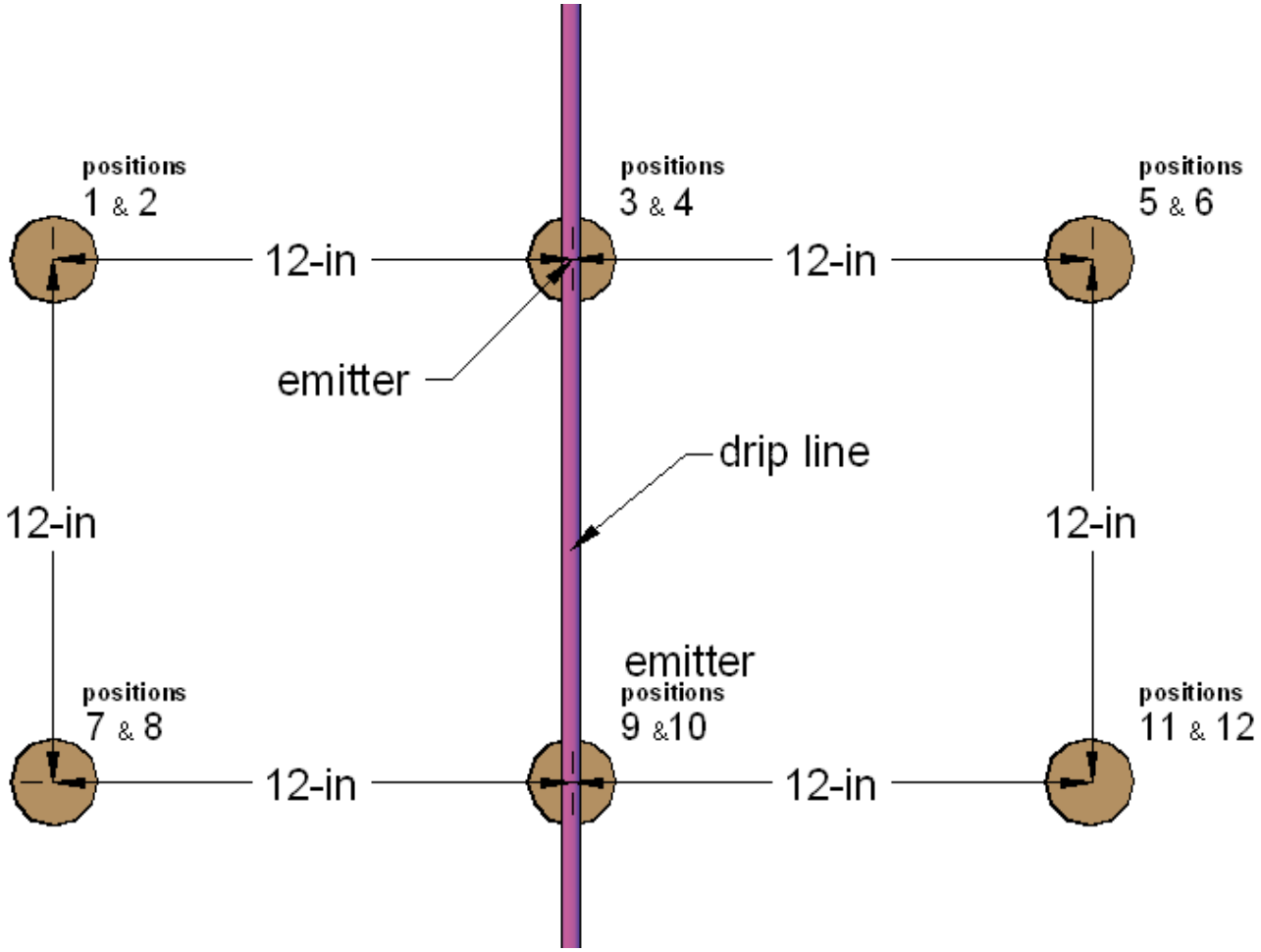

Figure 3.4 - Location of the Core Samples

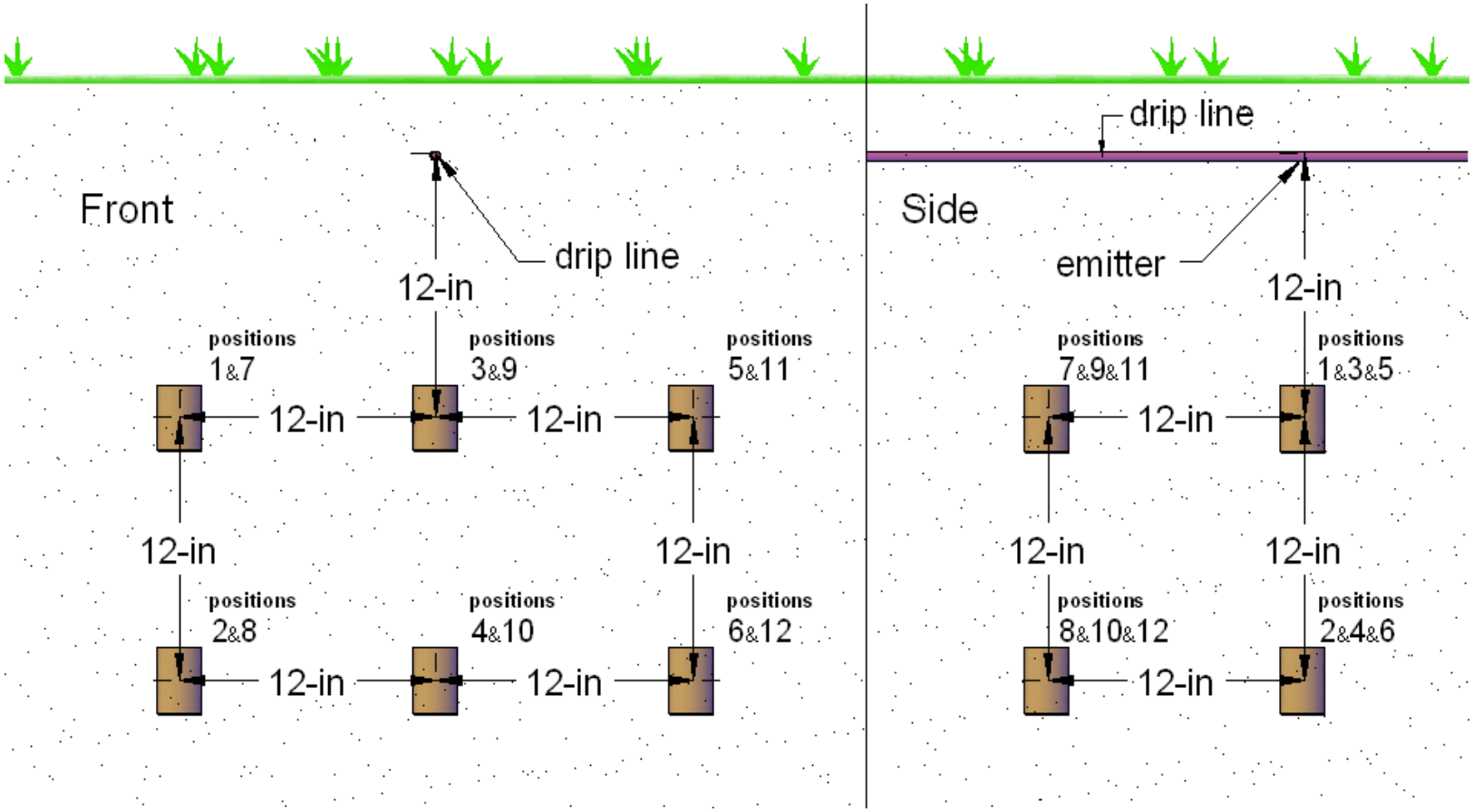

Figure 3.5 – Front and Side View of Sample Placement

Figure 3.4 shows the locations of the core samples relative to the emitter. The odd numbered cores correspond with samples taken from the 12-in depth and even numbered cores correspond with samples taken from the 24-in depth. Figure 3.5 show a front and side view of the locations where the samples were taken. Samples are collected directly below the drip emitter and at 12-in to either side of the drip later and 12-in down the drip lateral. The same pattern is repeated at 24-in below the drip lateral. A picture from an actual sampling site is shown in figure 3.6. This picture was taken from the RSFE side of the Crescent Glen location on September 1, 2009.

An initial rectangular hole was excavated to the depth of the drip tubing. The holes seen in Figure 3.6 were made using a 6-in diameter drive sampler. Each hole was initially excavated to a depth of 10-in so that the coring sampler could extract grab a sample with the 12-in depth in the middle of the core. Once the first core was taken, a loose soil sample was collected for soil solution extraction. The hole was then extended to a depth of 22-in and a core sample and another loose soil sample was collected. The process was then repeated for the next 5 locations around the drip tubing. Locations 3 and 4 are located directly beneath the drip emitter. The same sampling process was repeated for control samples collected from an area adjacent to the drip field that does not receive effluent. This whole process was completed in both plots (STE and RSFE) at both locations (JB and CG). Fifty-six samples were collected for each round resulting in 224 samples collected for the entire experiment.

Figure 3.6 – Sample Site, Crescent Glen, RSFE, September 1, 2009

Physical Analysis

A falling head permeameter setup was used to determine the saturated hydraulic conductivity (Ksat) of each core sample. Figure 3.7 shows the basic setup. Fourteen permeameters were installed in a rack to run all 14 samples for each sampling event at one time. Preliminary testing showed that the saturated hydraulic conductivity for the samples ranged from 0.3 to 0.8 cm/day. Equation 3.1 was used to calculate the Ksat (Klute, 1986). The cross sectional area in inches of the standpipe (a), the cross sectional area of the sample in inches (A), the length of the samplein inches (L), time in seconds (t), and the heights of the water levels, in inches, relative to the bottom of the sample (H1 and H2) were used to calculate the Ksat for each core.

Soil Solution Extraction

After preliminary testing, it was determined that pore water cannot be reliably collected from soil samples directly taken from the field. Even when soil solution samples could be collected the field, the concentrations were highly variable between different samples due to the differing moisture contents. Soil samples collected in the same area but on different dates produce solutions that have differing concentrations because the moisture contents are constantly fluctuating.

$$K_{sat} = \left(\frac{aL}{At}\right)\log_e\left(\frac{H1}{H2}\right)$$

Equation 3.1-Falling Head Permeameter Equation

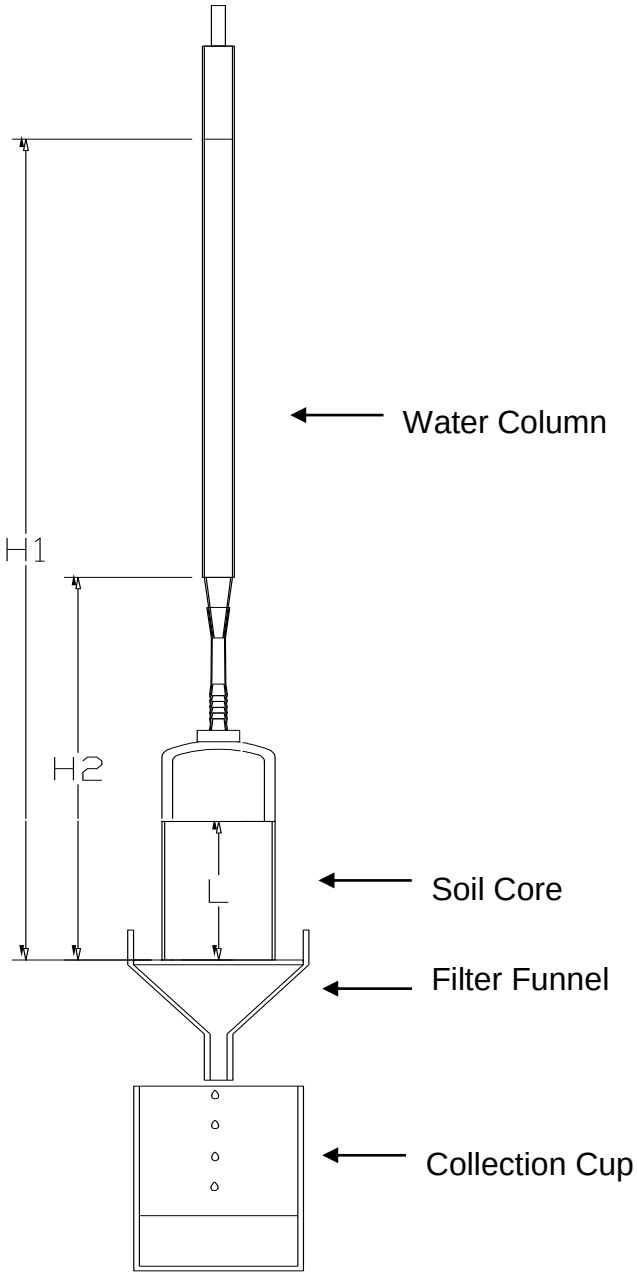

Figure 3.7 – Falling Head Permeameter Setup

This is influenced by several factors but the most influential with samples collected at the same site is the intensity and the time since the last rainfall event. To standardize the analysis, many researchers recommend drying the soil and rewetting it to some fraction of field capacity for water. This was not done because the drying process alters the chemical makeup of the soil so it will not be exactly the same as in field condition. Drying methods release phosphorus in the soil solution when rewetted (Blackwell et al 2009). Many researchers show the effects of drying and rewetting of the soil with the nitrogen and carbon (Birch, 1958; Merckx et al., 2000; Kruse et al., 2004; Dyer et al., 2007; Blackwell et al., 2009). The effects of drying and rewetting the soil, on the soil solution, are different for different soils. Preliminary testing showed an increase in phosphorus and nitrate concentrations for a soil sample that was separated and solution collected directly from part of the sample and the other part was dried, ground to pass through a 2-mm sieve, and rewetted, and then centrifuged to collect a soil solution sample.

To more accurately determine the difference in effluent purification between the two test plots at each location (JB and CG), as many variables need to be made constant as possible. In this study, 100-g of each soil sample was measured for weight in grams and added to a bottle with 50-g of deionized water. The leftover sample was dried at 105°C for 24 hours and weighed to determine the moisture content. This method provided a means to collect a soil solution volume, which could be reliably collected, and the final solution concentration

could be corrected for dilution. Equation 3.2 was used to calculate the concentration on an mg-constituent / kg-soil basis.

$$Concentration = \left(\left| \frac{C\left(W/1000\right)}{S} \right| \right) 1000$$

where :

$Concentration$ = concentration of constituent in soil $\left(mg/kg\right)$

C = concentration of constituent in solution $\left(mg/kg\right)$

W = amount of water in solution $\left(g\right)$

S = amount of soil in solution $\left(g\right)$

Equation 3.2 – Equation used to correct for dilution for final concentration

Total kjeldahl phosphorus (TKP) and total kjeldahl nitrogen (TKN) and soluble nitrogen were determined by the Block Digestor Method in the Biosystems Water Quality Lab (APHA, 2005). Total organic carbon (TOC) was determined using the Combustion Method in the same lab (APHA, 2005). TKN measures the organic nitrogen and ammonium in the sample. Soluble nitrogen, includes nitrate and nitrite, was determined by using the difference in the TKN method and the persulfate oxidation method (APHA, 2005). Most soil elemental analysis does not include soluble nitrogen due to the ease of the TKN method and the concentration of nitrate and nitrite in most soils is very limited. Because wastewater is being applied to this soil, the concentrations of soluble nitrogen should be greater and is important to this study. Nitrogen is reported on a “as N” basis.

Statistical Analysis

Each plot was sampled 4 times. The experimental design used is a randomized block design – split-plot (RBD-SP). The analysis of variance (ANOVA) using the mixed models procedure for RBD split-plot design (SAS version 8.0, University of Tennessee, Knoxville) was used to analyze the data. Each location (Jackson Bend and Crescent Glen) was divided into two whole plots receiving either STE or RSFE. Depth is the second factor that was tested by the split-plot design. The control samples were also analyzed as a whole plot, giving a third main treatment factor. Log transformations were performed on Ksat, NO3, TP and a square root transformation was done on TN. The estimated means reported are the back transformed means.

The position of the soil sample relative to the emitter is of interest to determine the pathway of the effluent once it is introduced into the soil. For this analysis, STE and RSFE are the only treatments and the Control is identified by its position number (13 and 14). This was done so that a statistical analysis could be performed on the location (JB and CG) by treatment (STE and RSFE) by position (1-14) interaction. If Control were still a treatment, the statistical procedure could not compare all fourteen positions across all treatments because positions 13 and 14 are only Controls and positions 1-12 are either STE or RSFE. The code used for the SAS analysis and the SAS output for each analysis is attached in appendix B.

CHAPTER 4: RESULTS AND DISCUSSION

Hydraulic Conductivity

The hydraulic conductivity differences at Jackson Bend with the STE and RSFE treatments were not significantly* different however the RSFE side did have a significantly lower Ksat than the control. The estimated Ksat values for STE, RSFE, and the Control are as follows: 0.041, 0.036, and 0.073 cm/day respectively (figure 4.1). The Ksat differences for 1-ft and 2-ft depths were not significant (0.049 and 0.050 cm/day respectively).

The hydraulic conductivity of the STE at Crescent Glen was not significantly different than the RSFE (0.042 and 0.027 cm/day respectively). The STE at a depth of 2-ft was significantly lower than the Control at a depth of 1-ft but not significantly different than RSFE at either 1-ft or 2-ft or STE at 1-ft (figure 4.1)

Nitrate

Jackson Bend shows no significant difference for nitrate with the STE, RSFE, and Control treatments (figure 4.2). The nitrate concentrations for the RSFE and Control are much lower at Crescent Glen than at Jackson Bend but the CG STE nitrate concentration is nearly twice as the JB STE nitrate concentration (11.300 mg/kg and 5.804 mg/kg respectively). Depth was a significant factor for nitrate concentration at JB with the concentration getting higher nearer the emitter (3.970 mg/kg at 1-ft and 2.602 mg/kg at 2-ft). Depth did not matter at CG but the greatest difference in depth occurred with the CG STE

* All significance is based on an alpha=0.05 significance level

samples. The concentration of $NO3^-$ at 1-ft below the emitter for the STE side at CG was 14.6 mg/kg but by 2 ft below the emitter, the concentration was 8.725 mg/kg.

Total Carbon

The concentration of total carbon at JB for the STE treatment was lower than with the RSFE and Control treatments but not significant due to the variability in the data, it was not statistically different (figure 4.3). The differences were smaller with the CG samples, the TC concentrations from CG range from 25.6 to 29.8 mg/kg for the STE, RSFE and Control treatments, all of these are less than the RSFE and Control Concentrations from JB. The depth did not seem to impact the concentration of TC found in the soil at either location.

Total Nitrogen

The total nitrogen concentration at JB was not significantly different between the 3 treatments. The treatment means ranged from 6.4 to 8.4 mg/kg (figure 4.4). At JB, the Control at the 1-ft depth has a significantly higher concentration of TN than at the 2-ft depth but these concentrations are not significantly different compared to the STE and RSFE samples and either depth. The STE-TN concentrations at Crescent Glen were significantly different from the RSFE and Control concentrations (9.80, 2.80, and 2.81 mg/kg resp.). Depth at Crescent Glen was not a significant factor.

Total Phosphorus

The overall treatment differences in TP at Jackson Bend and Crescent Glen were not significantly different but there were differences when the trt*depth interactions are examined. The control samples from JB at the 1-ft depth are significantly higher than the STE and RSFE samples (figure 4.5). The means for RSFE at JB are higher than the means for STE but are not significant. The RSFE samples at CG have a lower TP concentration than the STE and Control samples.

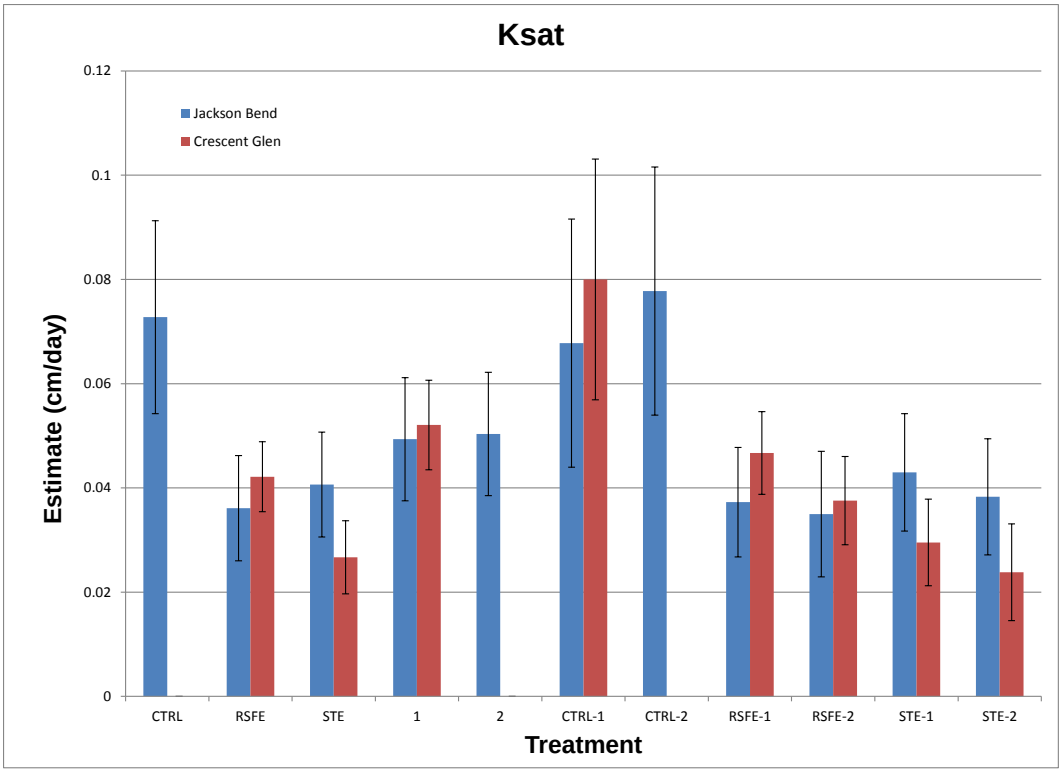

Figure 4.1 – Ksat concentrations for Jackson Bend and Crescent Glen

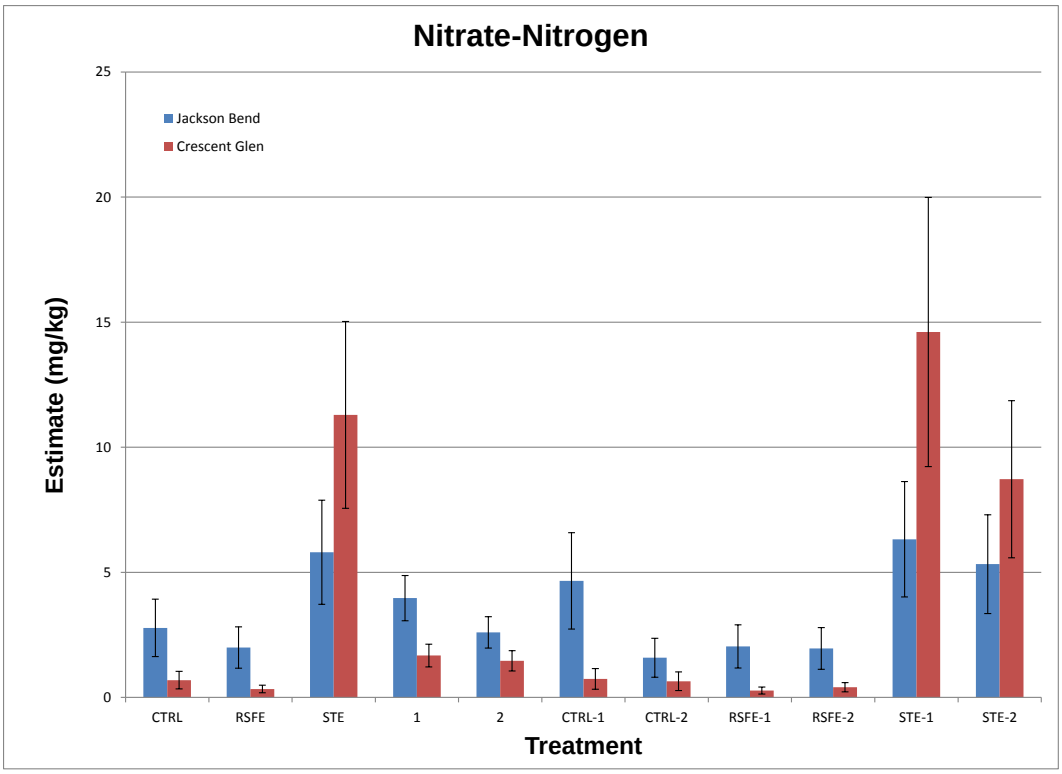

Figure 4.2 – Nitrate concentrations for Jackson Bend and Crescent Glen

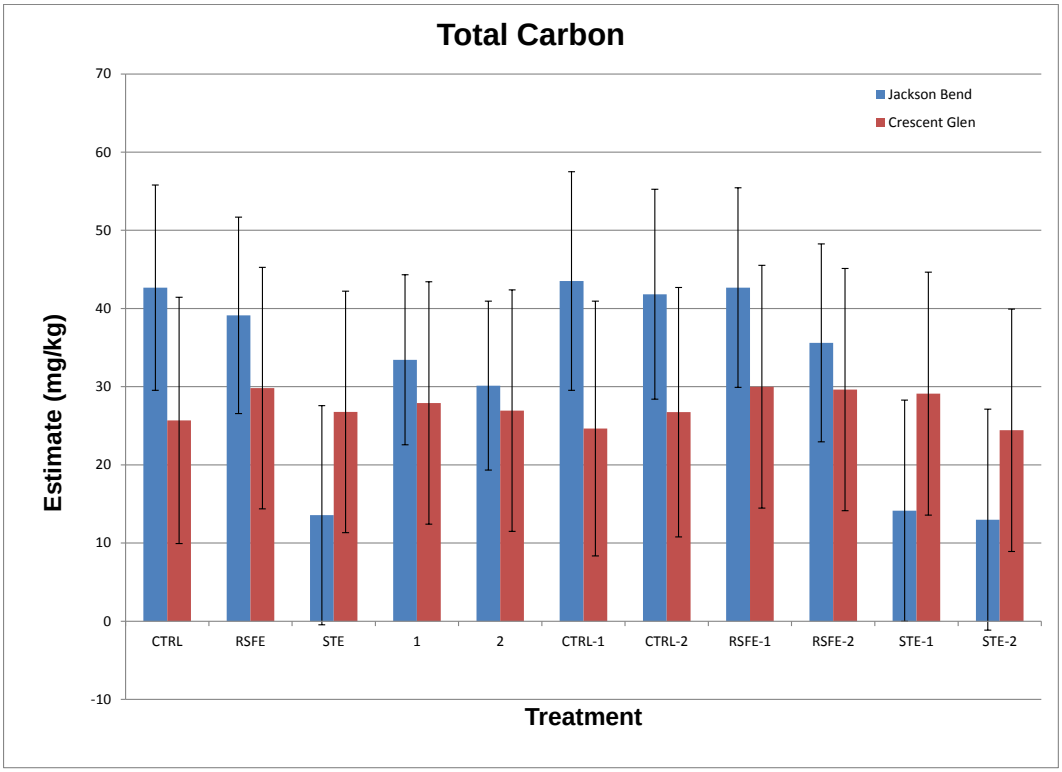

Figure 4.3 – Total Carbon concentrations for Jackson Bend and Crescent Glen

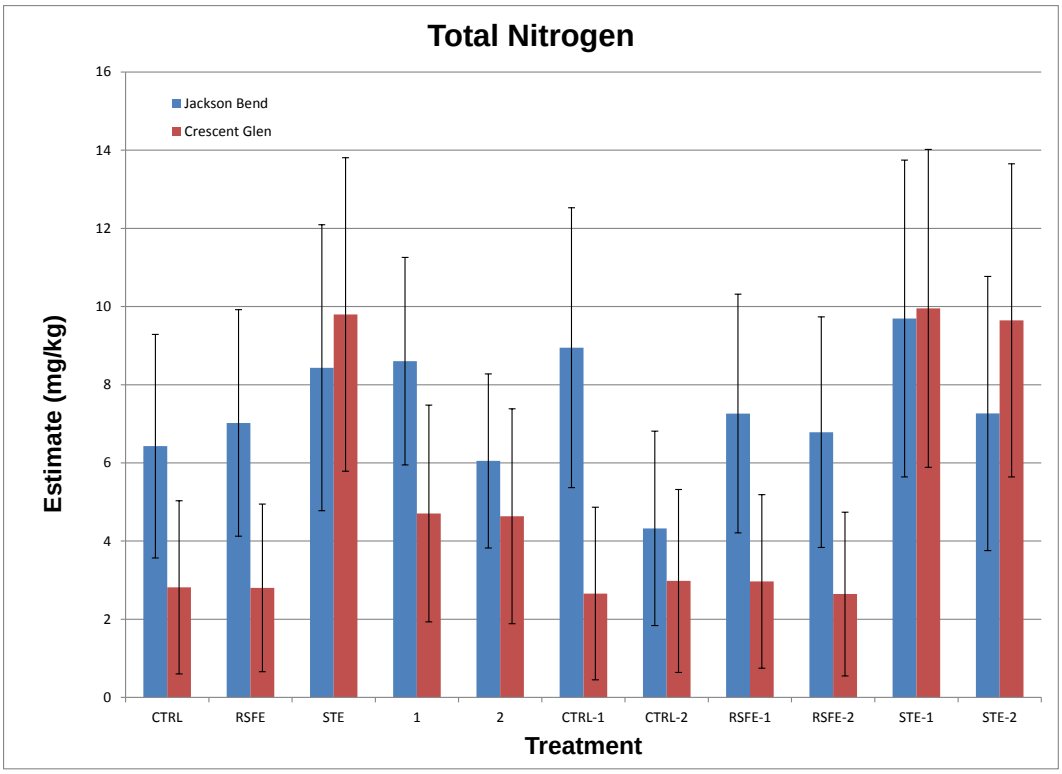

Figure 4.4 – Total Nitrogen concentrations for Jackson Bend and Crescent Glen

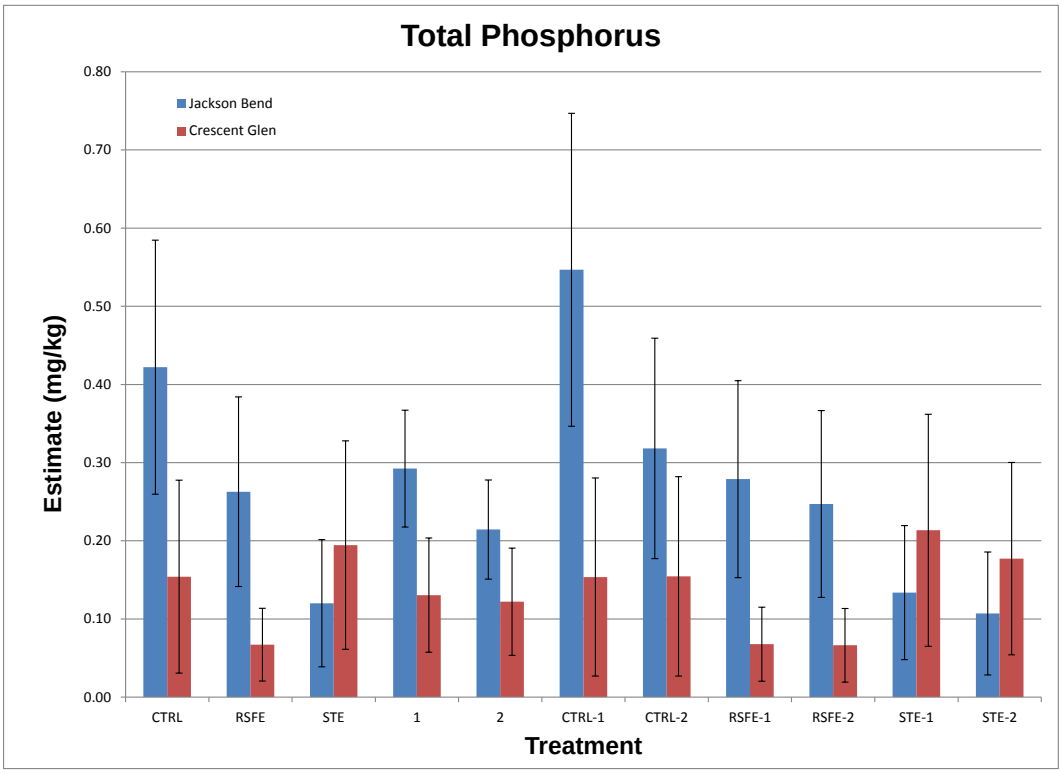

Figure 4.5 Total Phosphorus concentrations for Jackson Bend and Crescent Glen

Position Analysis

The analysis of positions was conducted to investigate impact of wastewater with SDI to the area around the emitter. It was expected to find samples in the positions closest to the emitter to have greater changes with respect to the background. For example, position 3, the closest sample to the emitter, should experience the greatest change in concentrations of NO3, TC, TN, and TP. Also, position 3 should have the lowest Ksat values on the STE side. Literature shows that the greatest effects of wastewater irrigation with SDI occur directly beneath the emitter or laterally along the drip tube itself due to preferential flow caused by the installation process (Jnad et. al., 2001a, Jnad et al., 2001b). Figures 4.6 to 4.10 show the results of the statistical analysis of positions. The tables show the interactions between the location, treatment, and position. Each estimate represents the means of 4 sampling events from that position in that subplot and that location. For example, the first estimate in figure 4.6a (0.100 cm/day) represents the mean of the 4 sampling events that took place at Jackson Bend, on the STE treated subplot, and the 2nd position.

Hydraulic Conductivity Position Analysis

It was expected that because position 3 is located directly beneath the emitter it would have the lowest Ksat meaning that the effluent moved more slowly in this area due to the increased growth of a constrictive layer. This effect was expected to be greatest with the application of STE. The analysis showed very little differences with Ksat based on position relative to the emitter. No

pattern was detected with the data from Jackson Bend (figure 4.6a). The estimates range from 0.097 cm/day to 0.024 cm/day. The estimates from Crescent Glen show a larger difference between the STE side and the RSFE side (figure 4.6b). Again no pattern was detected for the positioning of the samples and the rank of Ksat. The STE estimates at CG range from 0.060 cm/day to 0.010cm/day. The estimates for RSFE at CG range from 0.082 cm/day to 0.019 cm/day. This shows a more constrictive trend on the side irrigated with STE but not with the position relative to the emitter. This may be because the biological growth and accumulation of solids in the restrictive layer should be greatest within a few cm of the emitter however it should lessen with distance from the emitter.

Nitrate Position Analysis

It is believed that position 12 for Jackson Bend, STE shows an apparent outlier because it is located the furthest distance from the emitter. Position 13 for Jackson Bend, RSFE is a more obvious outlier due to its being significantly different from the other positions. These apparent outliers may be due to some anomaly taking place in the environment. Because these estimates are made up of the average for 4 points, an outlier would have to be exceptionally large to causing these estimates to be so great. Looking past these two points, the rest of figure 4.7a makes more sense. Position 3 is ranked the highest for NO3 concentration in both STE and RSFE sides (9.945 and 3.758 mg/kg respectively). The STE side at Crescent Glen show that preferential flow may be occurring along the drip tube itself (figure 4.7b). The top two concentrations

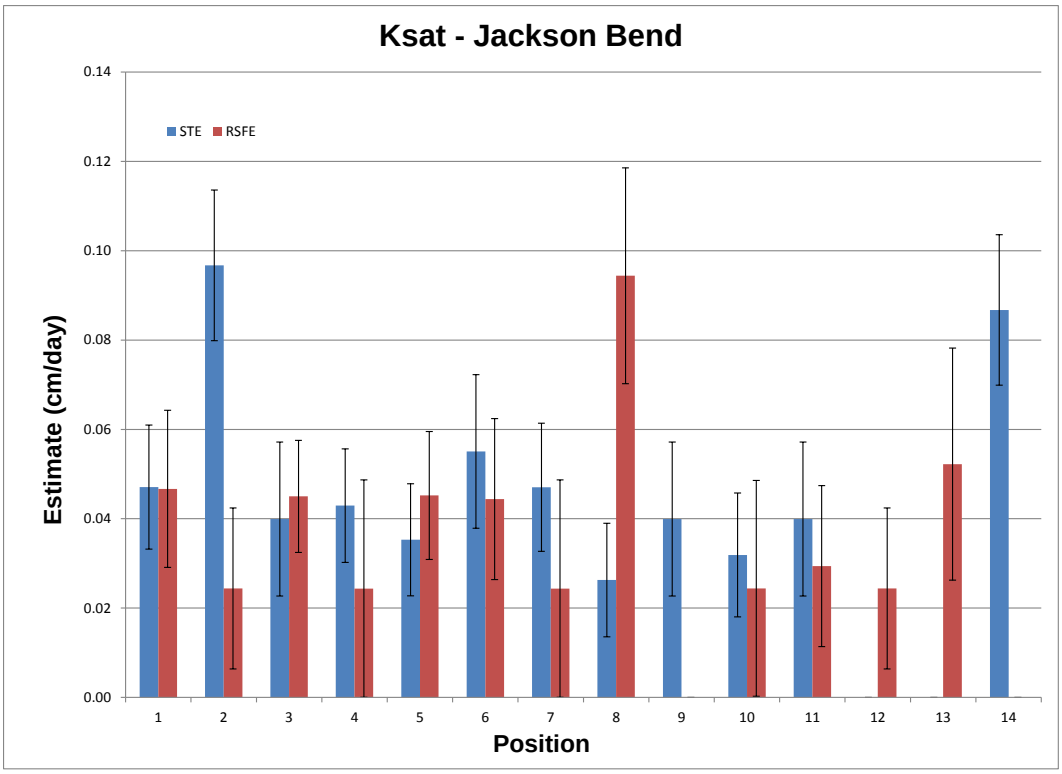

Figure 4.6a – Ksat, Jackson Bend treatment by position interaction analysis

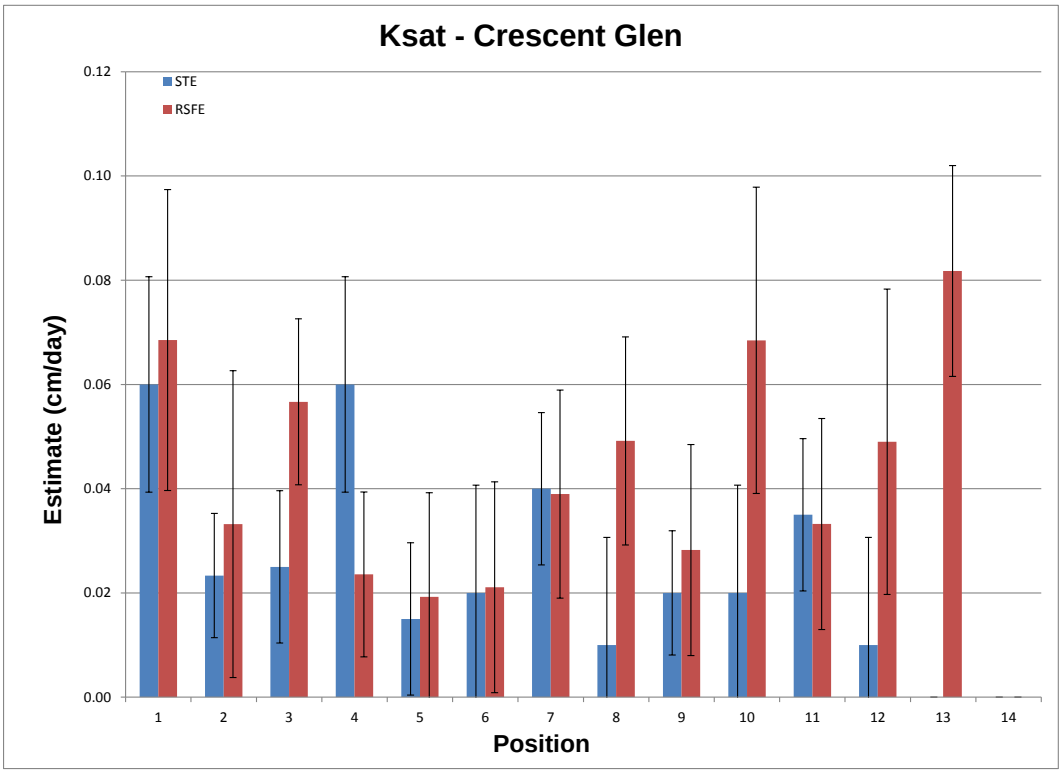

Figure 4.6b – Ksat, Crescent Glen treatment by position interaction analysis

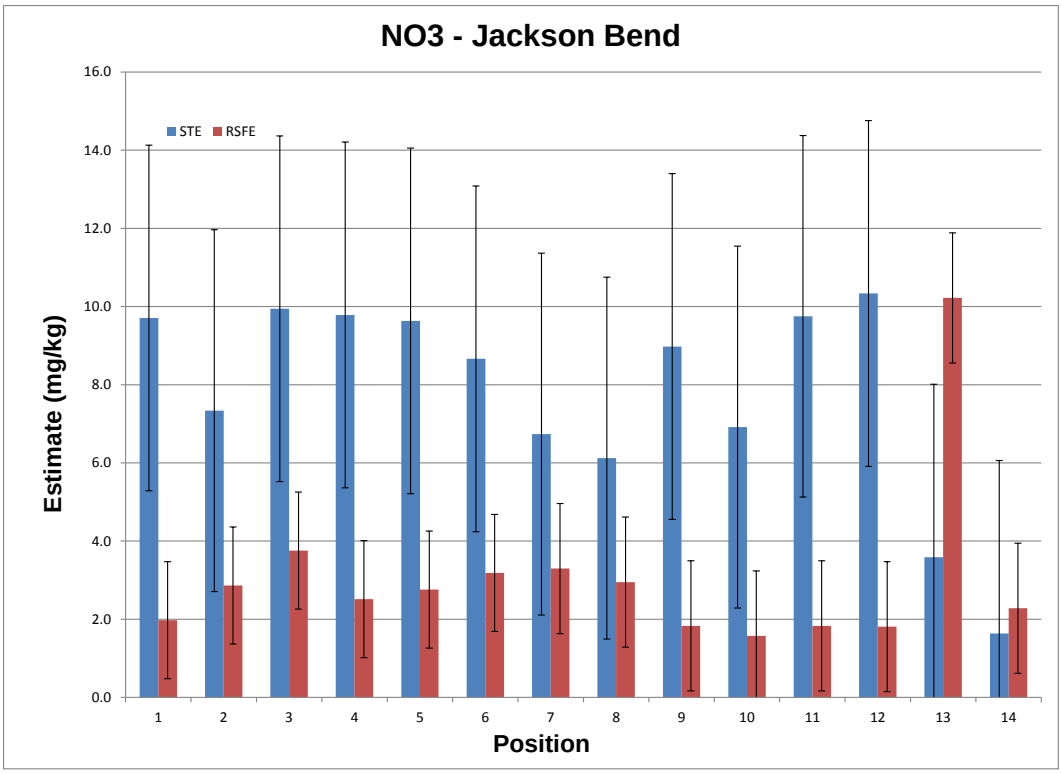

Figure 4.7a – NO3, Jackson Bend treatment by position interaction analysis

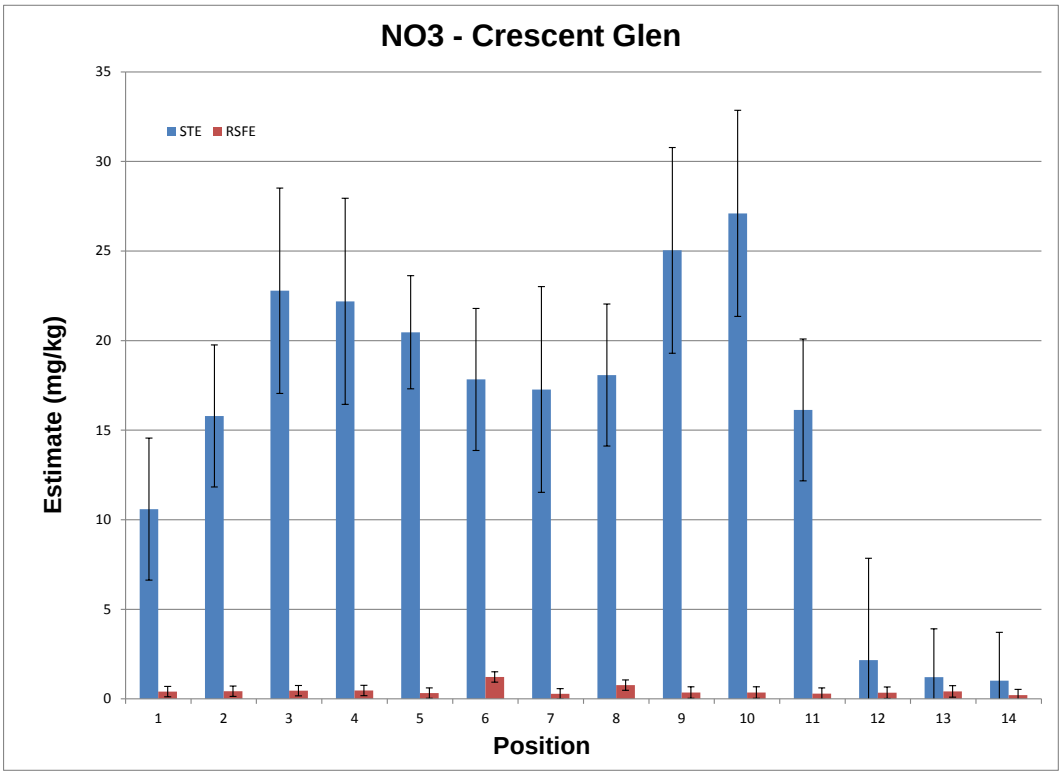

Figure 4.7b – NO3, Crescent Glen treatment by position interaction analysis

come from positions 10 and 9 (27.101 and 25.041 mg/kg respectively) which occurs 1-ft along the drip lateral from the emitter. The next two positions are 3 and 4 (22.783 and 22.191 mg/kg respectively) which occur directly below the emitter. The Crescent Glen, RSFE side does not show much of a pattern for strength of NO3 on position but positions 3 and 4 (0.453 and 0.468 mg/kg respectively) are ranked among the top four.

Total Carbon Position Analysis

The control samples had the highest concentration of TC for the STE side at Jackson Bend (figure 4.8a). Position 14 had 18.65 mg/kg TC and position 13 had 13.94 mg/kg TC. Position 3 (9.752 mg/kg) was not significantly different than any other position in this group. The RSFE side from Jackson Bend showed no signs of a pattern. Theoretically, the control samples from the STE side and the RSFE side should have the same concentration, but this is not the case. The RSFE control concentration at JB is 48.4 mg/kg for position 13 and 44.8 mg/kg for position 14.

The control samples from the Crescent Glen, STE and RSFE sides are more similar (figure 4.8b). The STE side at Crescent Glen shows a trend in TC concentrations were the higher concentrations tend to be 1-ft beneath the level of the emitter and the lower concentrations are 2-ft beneath the emitter. Horizontal distance from the emitter was not as much of a factor; however, the two highest concentrations come from position 9 (39.753 mg/kg) and position 3 (31.544 mg/kg) which are located along the drip lateral. The RSFE side at Crescent Glen

does not show as much of a pattern, but position 3 (41.003 mg/kg) and 9 (35.928 mg/kg) still are ranked in the top 3.

Total Nitrogen Position Analysis

Jackson Bend shows an apparent pattern for TN concentrations (figure 4.9a). Position 3 (10.247 mg/kg) was the second highest rank for the STE side. The top five TN concentration positions were all located at the 1-ft depth beneath the drip lateral. The control samples had the same trend for both the STE and RSFE sides at Jackson Bend. Four of the top six positions on the RSFE side were at the 2-ft depth, confirming what was found in figure 4.4a, that depth did have a significant role in TN concentration at Jackson Bend.

The total nitrogen concentration at Crescent Glen did not show a positional pattern (figure 4.9b) however position 3 ranks the highest in TN concentration for the RSFE side.

Total Phosphorus Position Analysis

The concentrations of total phosphorus with respect to the emitter at Jackson Bend follow a loose pattern. Position 13 had a higher concentration on both sides (STE and RSFE); it was significantly higher than all others in the STE side (figure 4.10a). Positions 3 and 4 were ranked 11 and 14 respectively on both sides. The phosphorus concentration seems to be lower closer to the emitter.

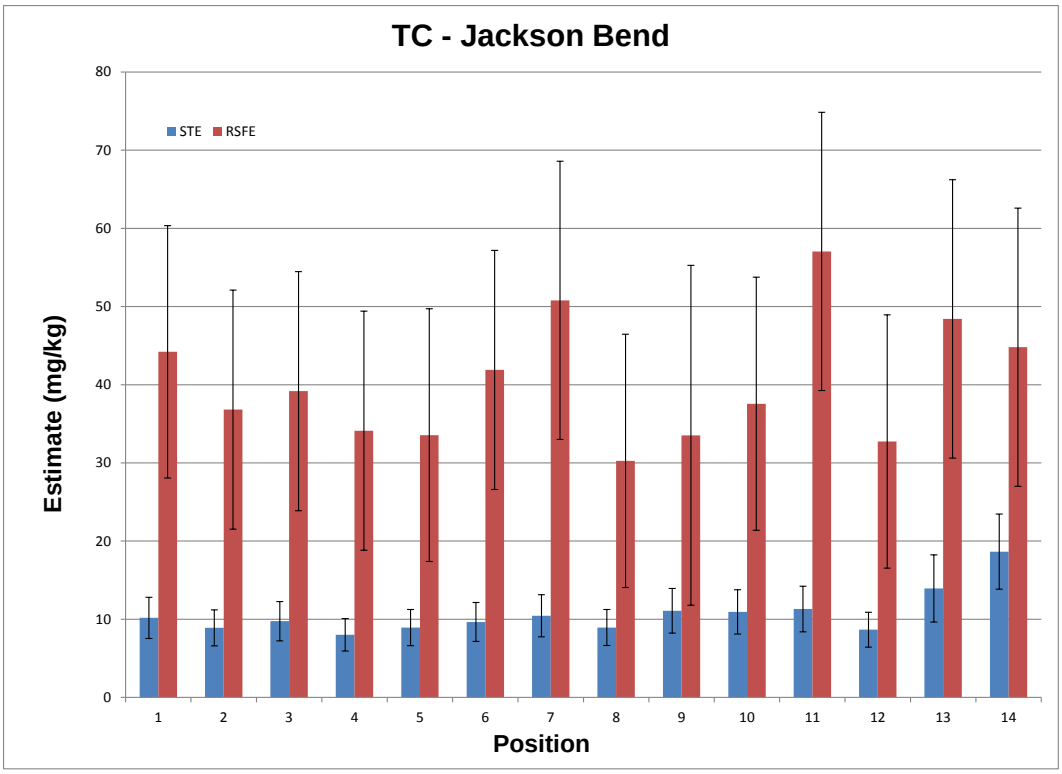

Figure 4.8a – TC, Jackson Bend treatment by position interaction analysis

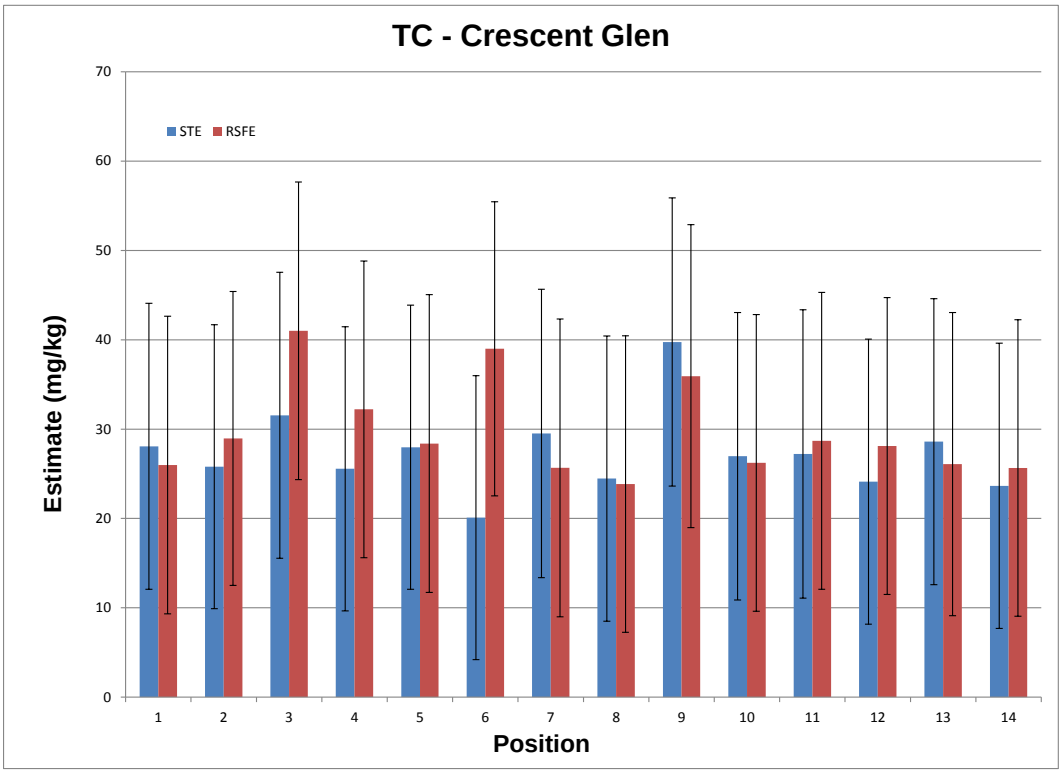

Figure 4.8b – TC, Crescent Glen treatment by position interaction analysis

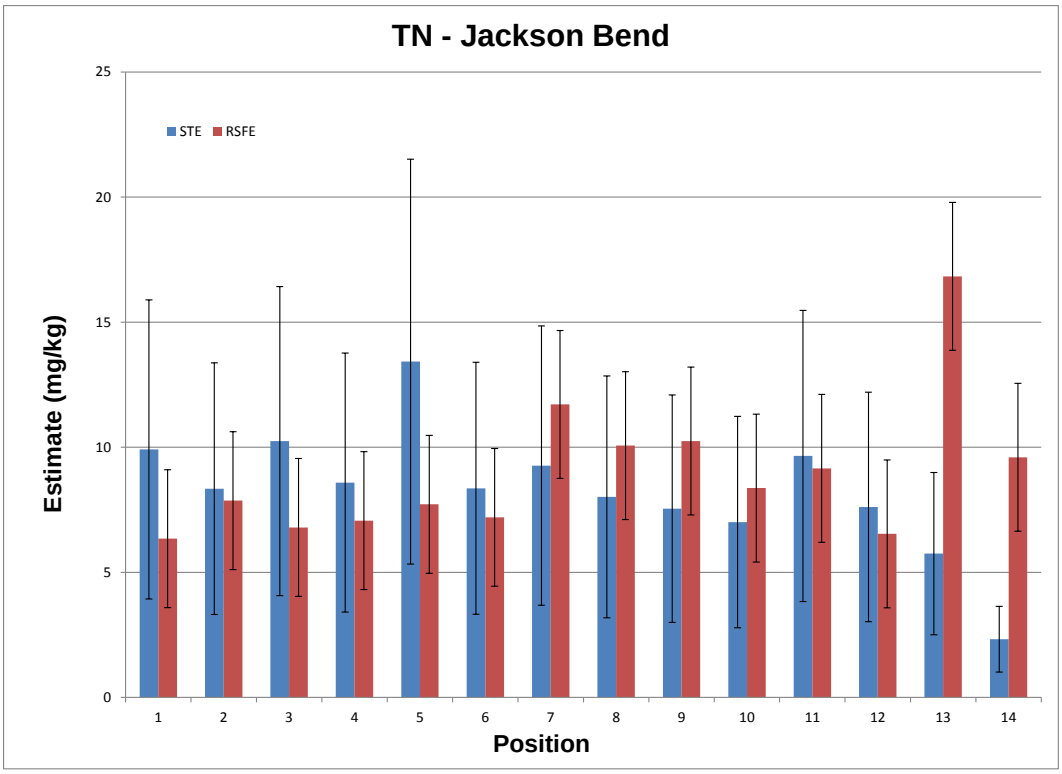

Figure 4.9a – TN, Jackson Bend treatment by position interaction analysis

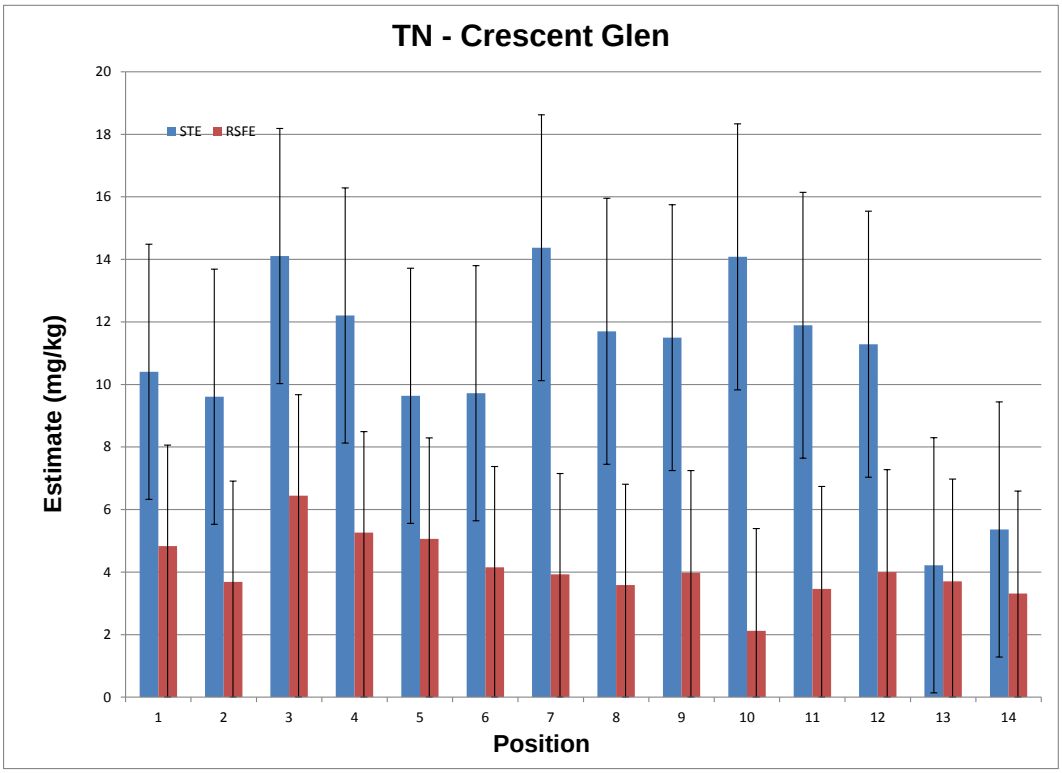

Figure 4.9b – TN, Crescent Glen treatment by position interaction analysis

There was no apparent pattern for the phosphorus concentrations with respect to the emitter at Crescent Glen although position 3 had the highest ranking concentration on the RSFE side (figure 4.10b).

Seasonal Variation

Some seasonal variation was measured during this experiment. Total carbon concentrations at Crescent Glen decreased with the temperature and increased slightly during the warmer temperatures in the spring (figure 4.11b)[*]. Except for the first set of samples the total carbon concentration at Jackson Bend showed the same trend (figure 4.11a). It was expected to see greater concentrations of total carbon in the soil during colder temperatures because of reduced biological and microbial activity during cooler temperatures but this data shows that something else is taking place. The total nitrogen concentrations at Jackson Bend and Crescent Glen showed the same trend. The concentrations decreased as the temperature decreased (figures 4.12a and 4.12b).

[*] Graphs 4.11a – 4.12b were developed from control data.

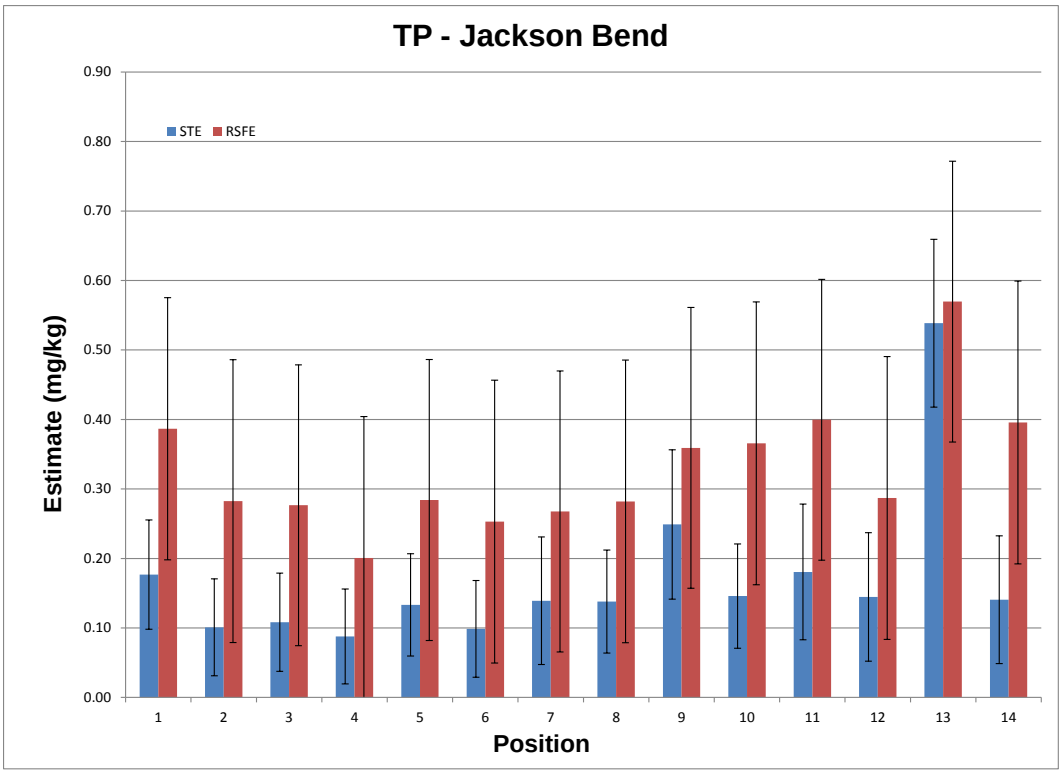

Figure 4.10a – TP, Jackson Bend treatment by position interaction analysis

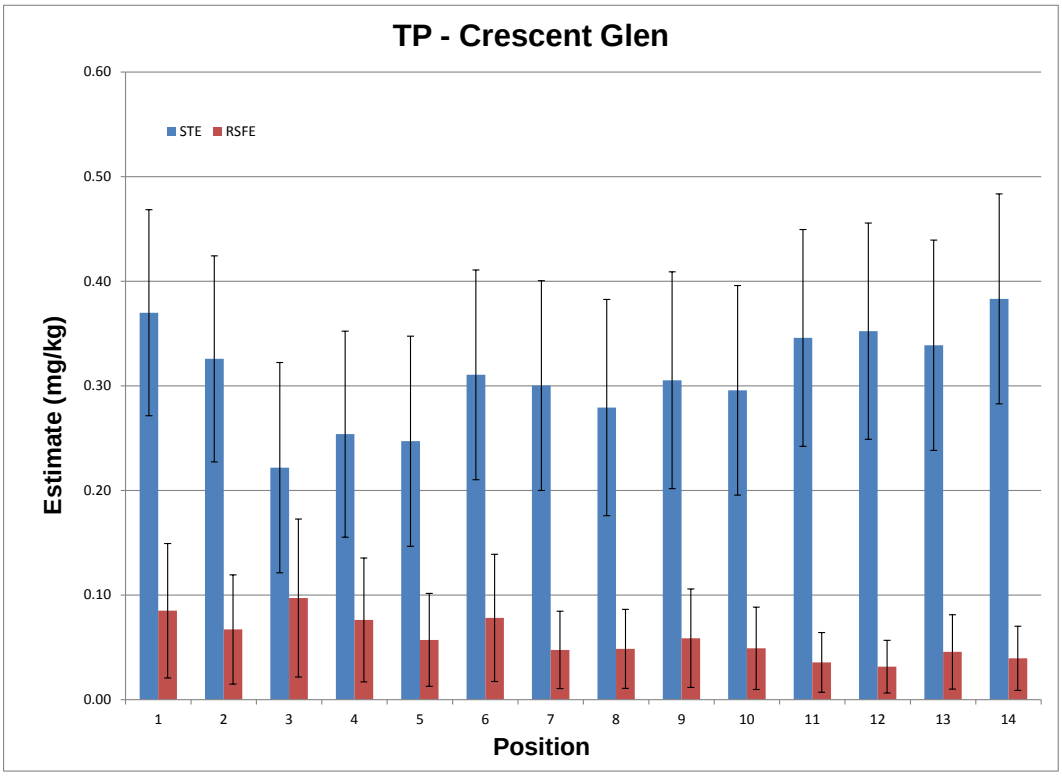

Figure 4.10b – TP, Crescent Glen treatment by position interaction analysis

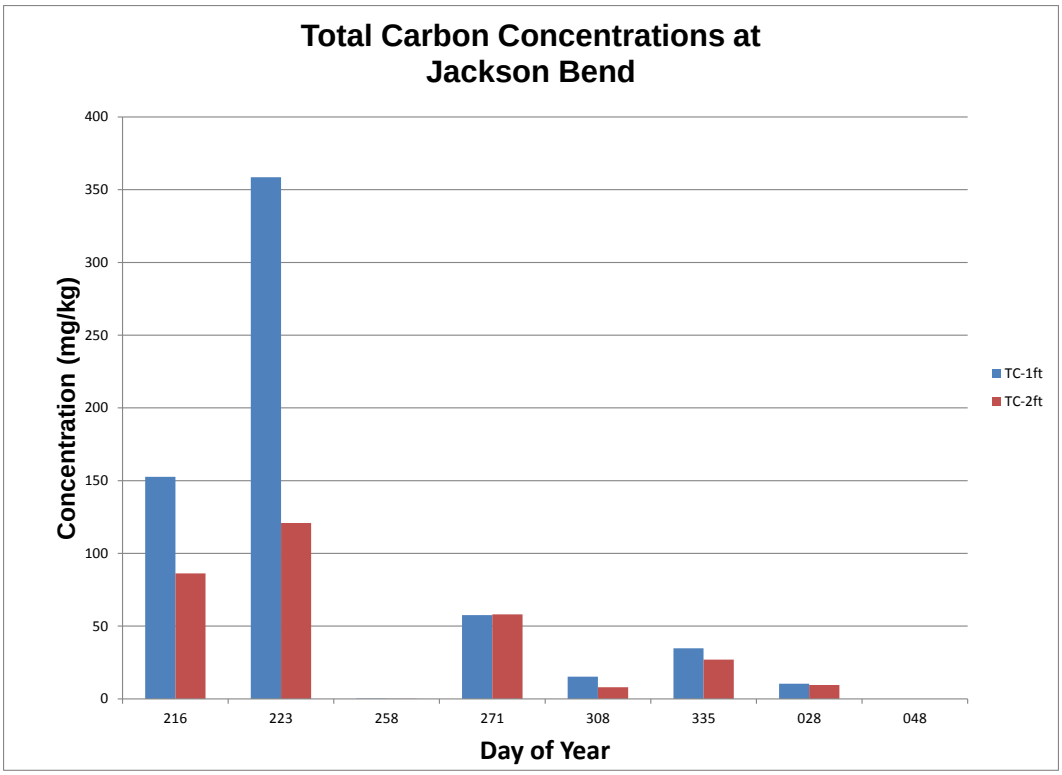

Figure 4.11a – Seasonal Variation for TC at Jackson Bend

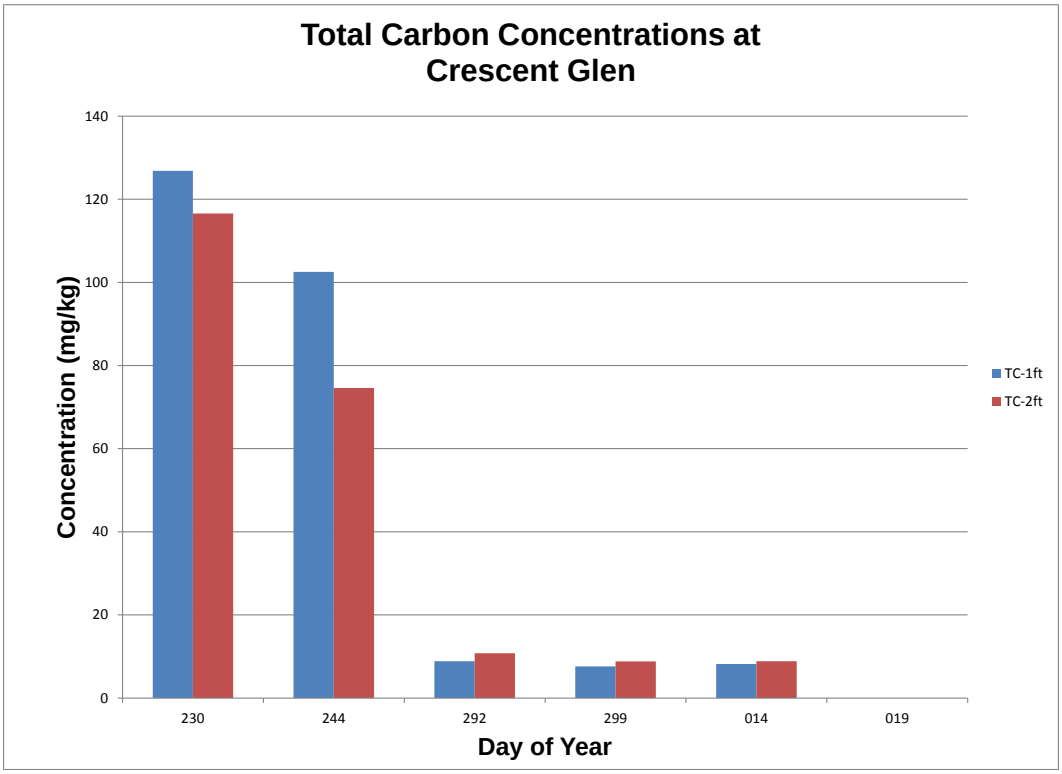

Figure 4.11b – Seasonal Variation for TC at Crescent Glen

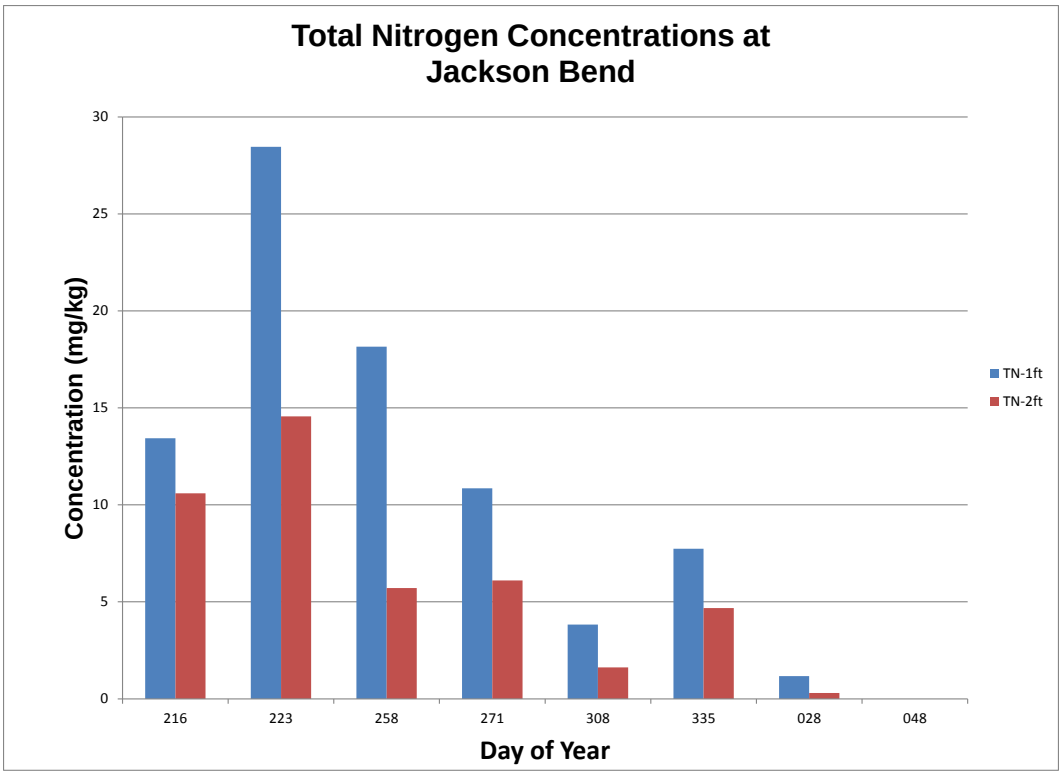

Figure 4.12a – Seasonal Variation for TN at Jackson Bend

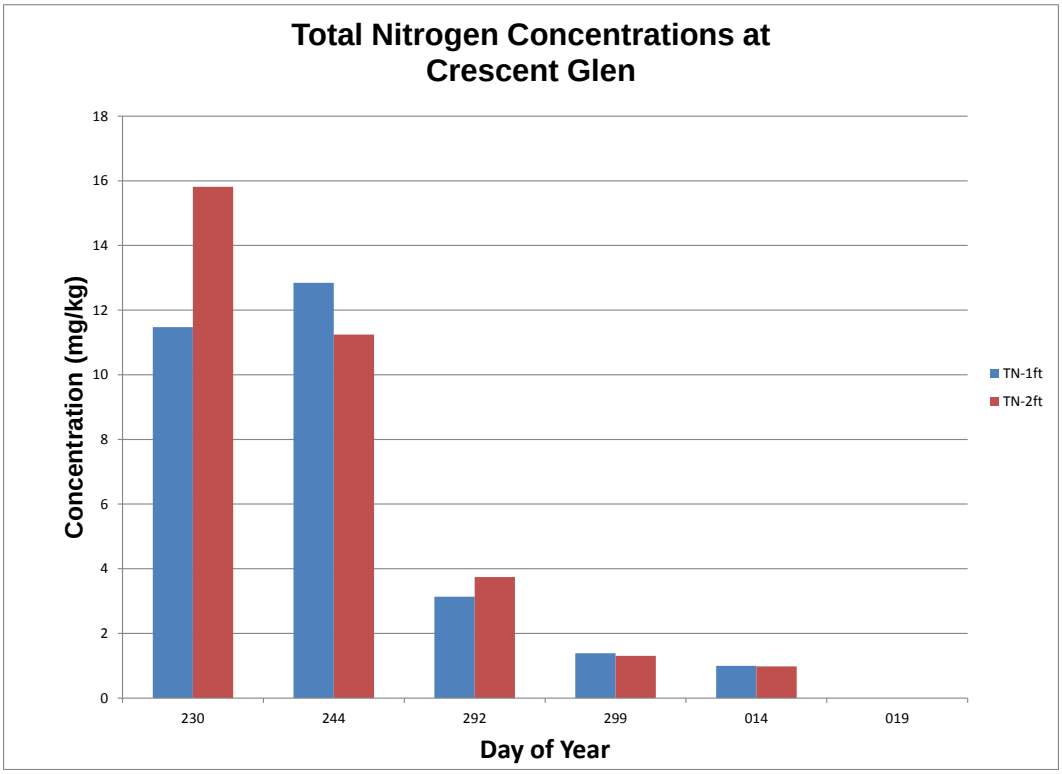

Figure 4.12b – Season Variation for TN at Crescent Glen

CONCLUSION

The purpose of this study was to evaluate two strengths of wastewater (STE and RSFE) being applied by SDI to determine the need for secondary treatment. The purpose was not to evaluate the performance of SDI as a whole. The soil has a tremendous ability to treat wastewater but its full potential may be retarded by the use of a costly RSF. Physical and chemical properties of the soil were measured to make the comparison. It was found that the pore water in the soil that had been irrigated with the low strength wastewater (RSFE) was of slightly higher quality than the pore water in the STE side. At Jackson Bend, the hydraulic conductivity of the STE side show significant reduction as compared to the RSFE and control areas and this is beneficial for the treatment of the wastewater. Nitrate and total nitrogen were significantly higher in the STE treated areas but showed a decrease with depth. TC and TP showed no significant differences. The benefits of an RSF are not enough to make it necessary when using a SDI. The soil acts much the same as the RSFE and a SDI is designed to fully utilize these characteristics.

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APPENDICES

Appendix A: List of Collected Data

Loc	Rnd	Pos	Depth ft	Trt	Ksat cm/day	NO3 mg/kg_soil	TC mg/kg_soil	TN mg/kg_soil	TP mg/kg_soil	MC	Jul Day
JB	1	1	1	STEE	0.835	4.785	15.052	129.917	0.340	.	216
JB	1	2	2	STEE	1.511	4.577	12.358	68.200	0.150	.	216
JB	1	3	1	STEE	.	4.793	13.723	125.267	0.160	.	216
JB	1	4	2	STEE	2.315	3.905	6.213	50.150	0.138	.	216
JB	1	5	1	STEE	0.018	4.937	10.287	102.967	0.198	.	216
JB	1	6	2	STEE	6.057	4.320	12.363	74.467	0.120	.	216
JB	1	7	1	STEE	21.550	4.093	12.793	100.550	0.087	.	216
JB	1	8	2	STEE	.	4.615	8.108	53.617	0.298	.	216
JB	1	9	1	STEE	1.723	4.015	11.680	98.833	0.250	.	216
JB	1	10	2	STEE	9.640	4.397	14.380	83.650	0.257	.	216
JB	1	11	1	STEE	0.132	4.673	16.648	107.033	0.212	.	216
JB	1	12	2	STEE	2.376	4.388	7.280	54.900	0.112	.	216
JB	1	13	1	CTRL	2.404	3.958	152.567	13.433	0.213	.	216
JB	1	14	2	CTRL	0.224	3.827	86.267	10.597	0.143	.	216
JB	1	1	1	RSFE	0.209	3.008	86.880	10.579	0.645	.	223
JB	1	2	2	RSFE	0.019	2.805	39.867	6.083	0.424	.	223
JB	1	3	1	RSFE	0.018	3.027	69.600	7.605	0.402	.	223
JB	1	4	2	RSFE	.	3.117	53.805	10.411	0.307	.	223
JB	1	5	1	RSFE	0.018	3.094	92.853	12.509	0.462	.	223
JB	1	6	2	RSFE	0.012	4.709	88.587	11.285	0.418	.	223
JB	1	7	1	RSFE	0.000	3.139	124.827	15.981	0.440	.	223
JB	1	8	2	RSFE	0.079	3.508	69.867	10.901	0.471	.	223
JB	1	9	1	RSFE	0.000	4.227	135.173	13.712	0.642	.	223
JB	1	10	2	RSFE	0.006	3.750	65.147	14.509	0.554	.	223
JB	1	11	1	RSFE	0.025	3.321	115.707	9.021	0.662	.	223
JB	1	12	2	RSFE	0.010	3.872	51.208	7.363	0.476	.	223
JB	1	13	1	CTRL	6.516	8.681	358.613	28.464	1.012	.	223
JB	1	14	2	CTRL	4.029	3.289	120.880	14.565	0.689	.	223
CG	1	1	1	STEE	0.064	31.494	143.333	23.725	0.605	.	230
CG	1	2	2	STEE	0.021	37.648	70.427	19.360	0.417	.	230
CG	1	3	1	STEE	0.014	46.265	106.987	27.536	0.362	.	230
CG	1	4	2	STEE	0.124	42.025	75.200	21.715	0.395	.	230
CG	1	5	1	STEE	0.021	37.682	83.760	19.213	0.399	.	230
CG	1	6	2	STEE	29.584	40.333	52.587	19.147	0.449	.	230
CG	1	7	1	STEE	0.072	33.184	105.760	22.707	0.471	.	230
CG	1	8	2	STEE	.	17.365	67.733	15.659	0.468	.	230
CG	1	9	1	STEE	0.013	30.821	125.307	21.429	0.510	.	230
CG	1	10	2	STEE	.	45.352	99.013	29.283	0.497	.	230
CG	1	11	1	STEE	0.028	39.176	158.027	28.120	0.572	.	230
CG	1	12	2	STEE	0.255	41.015	59.573	19.456	0.461	.	230
CG	1	13	1	CTRL	27.598	1.584	126.827	11.475	0.564	.	230
CG	1	14	2	CTRL	23.448	1.585	116.587	15.816	0.503	.	230
CG	1	1	1	RSFE	0.193	0.980	112.800	16.360	0.450	.	244
CG	1	2	2	RSFE	0.366	1.068	82.213	11.675	0.387	.	244
CG	1	3	1	RSFE	0.307	0.859	131.200	18.301	0.378	.	244
CG	1	4	2	RSFE	.	1.437	105.627	17.976	0.381	.	244
CG	1	5	1	RSFE	0.010	0.960	100.640	17.469	0.393	.	244

CG	1	6	2	RSFE	0.296	1.338	72.480	9.141	0.330	.	244
CG	1	7	1	RSFE	0.052	0.827	101.173	13.293	0.377	.	244
CG	1	8	2	RSFE	0.010	0.993	167.787	10.952	0.425	.	244
CG	1	9	1	RSFE	9.252	0.897	97.600	13.643	0.454	.	244
CG	1	10	2	RSFE	14.892	0.763	71.787	7.733	0.420	.	244
CG	1	11	1	RSFE	10.123	0.739	83.200	12.424	0.371	.	244
CG	1	12	2	RSFE	0.958	0.954	76.621	13.315	0.375	.	244
CG	1	13	1	CTRL	0.083	0.696	102.533	12.843	0.396	.	244
CG	1	14	2	CTRL	15.379	0.690	74.613	11.245	0.328	.	244
JB	2	1	1	STEE	0.040	1.319	86.190	21.848	0.165	.	258
JB	2	2	2	STEE	0.077	1.412	0.066	8.643	0.143	.	258
JB	2	3	1	STEE	0.000	3.239	0.131	16.923	0.179	.	258
JB	2	4	2	STEE	0.021	1.353	0.071	9.861	0.125	.	258
JB	2	5	1	STEE	0.019	1.873	0.291	36.400	0.213	.	258
JB	2	6	2	STEE	0.000	1.678	0.070	11.627	0.168	.	258
JB	2	7	1	STEE	0.374	2.281	0.193	17.835	0.237	.	258
JB	2	8	2	STEE	0.010	1.602	0.104	11.645	0.138	.	258
JB	2	9	1	STEE	0.735	5.057	0.136	13.925	0.292	.	258
JB	2	10	2	STEE	0.010	3.756	0.085	9.581	0.183	.	258
JB	2	11	1	STEE	.	.	0.213	17.840	0.189	.	258
JB	2	12	2	STEE	0.370	2.351	0.058	7.765	0.219	.	258
JB	2	13	1	CTRL	0.985	1.198	0.234	18.160	0.429	.	258
JB	2	14	2	CTRL	0.069	0.922	0.101	5.715	0.176	.	258
JB	2	1	1	RSFE	0.402	0.000	0.000	0.000	0.000	0.168	271
JB	2	2	2	RSFE	29.380	6.344	84.635	11.615	2.174	0.190	271
JB	2	3	1	RSFE	0.078	9.395	53.579	7.823	1.923	0.167	271
JB	2	4	2	RSFE	16.868	5.537	57.926	7.483	1.790	0.200	271
JB	2	5	1	RSFE	0.039	5.186	49.528	6.588	1.886	0.164	271
JB	2	6	2	RSFE	0.748	6.646	58.594	7.762	1.942	0.184	271
JB	2	7	1	RSFE	0.000	6.579	51.144	6.462	1.366	0.161	271
JB	2	8	2	RSFE	0.568	5.498	2.445	7.061	1.724	0.193	271
JB	2	9	1	RSFE	2.301	1.320	94.665	12.505	1.662	0.165	271
JB	2	10	2	RSFE	11.862	1.250	60.643	6.448	2.041	0.192	271
JB	2	11	1	RSFE	0.000	2.621	68.357	7.338	1.868	0.152	271
JB	2	12	2	RSFE	0.771	1.750	60.073	7.523	1.881	0.190	271
JB	2	13	1	CTRL	0.058	19.721	57.489	10.850	1.555	0.155	271
JB	2	14	2	CTRL	2.162	3.790	58.046	6.099	1.939	0.204	271
CG	2	1	1	STEE	29.767	33.695	13.562	11.097	0.133	0.208	292
CG	2	2	2	STEE	.	30.600	11.911	10.501	0.005	0.208	292
CG	2	3	1	STEE	1.232	47.610	13.714	15.673	.	0.205	292
CG	2	4	2	STEE	0.000	47.802	10.043	14.249	0.016	0.207	292
CG	2	5	1	STEE	0.000	22.765	9.238	8.740	.	0.206	292
CG	2	6	2	STEE	0.440	14.425	9.650	6.861	.	0.190	292
CG	2	7	1	STEE	0.014	80.591	14.883	20.204	0.020	0.208	292
CG	2	8	2	STEE	0.014	68.556	10.035	19.170	.	0.196	292
CG	2	9	1	STEE	0.014	37.019	26.777	11.050	.	0.208	292
CG	2	10	2	STEE	0.197	32.852	18.497	10.884	0.037	0.197	292
CG	2	11	1	STEE	4.137	7.714	10.040	5.190	.	0.214	292
CG	2	12	2	STEE	0.620	1.931	16.585	4.245	.	0.209	292
CG	2	13	1	CTRL	76.603	0.394	8.848	3.132	.	0.196	292
CG	2	14	2	CTRL	0.307	1.982	10.755	3.743	.	0.208	292

CG	2	1	1	RSFE	0.084	0.008	5.703	1.188	0.096	0.190	299
CG	2	2	2	RSFE	.	0.136	7.135	1.383	0.086	0.199	299
CG	2	3	1	RSFE	0.063	0.703	28.887	6.124	0.180	0.209	299
CG	2	4	2	RSFE	0.032	0.076	7.817	1.484	0.088	0.224	299
CG	2	5	1	RSFE	0.039	0.050	13.925	1.468	0.055	0.209	299
CG	2	6	2	RSFE	.	2.952	26.324	5.801	0.128	0.264	299
CG	2	7	1	RSFE	0.296	0.099	11.685	1.339	0.059	0.185	299
CG	2	8	2	RSFE	10.896	1.840	7.046	1.998	0.046	0.223	299
CG	2	9	1	RSFE	0.062	0.200	14.755	1.418	0.049	0.190	299
CG	2	10	2	RSFE	0.070	0.445	7.455	1.370	0.037	0.203	299
CG	2	11	1	RSFE	0.058	0.235	6.822	1.211	0.022	0.181	299
CG	2	12	2	RSFE	30.011	0.221	7.199	1.392	0.017	0.198	299
CG	2	13	1	CTRL	11.904	0.600	7.617	1.385	0.030	0.187	299
CG	2	14	2	CTRL	13.991	0.111	8.789	1.304	0.018	0.191	299
JB	3	1	1	STEE	0.039	3.918	8.261	2.296	0.055	0.174	308
JB	3	2	2	STEE	0.824	4.916	5.272	2.608	0.019	0.190	308
JB	3	3	1	STEE	0.041	11.384	9.229	4.552	0.002	0.179	308
JB	3	4	2	STEE	0.041	7.847	8.102	3.416	0.009	0.200	308
JB	3	5	1	STEE	0.038	11.712	7.827	4.840	0.010	0.185	308
JB	3	6	2	STEE	16.866	6.099	8.680	3.181	0.018	0.190	308
JB	3	7	1	STEE	0.042	2.735	7.410	2.003	.	0.177	308
JB	3	8	2	STEE	0.042	1.039	8.155	1.527	0.010	0.198	308
JB	3	9	1	STEE	0.040	2.454	10.894	1.954	.	0.173	308
JB	3	10	2	STEE	0.041	1.476	9.549	1.675	0.021	0.191	308
JB	3	11	1	STEE	0.042	7.615	8.525	3.471	.	0.197	308
JB	3	12	2	STEE	1.463	6.421	9.414	3.002	.	0.196	308
JB	3	13	1	CTRL	38.942	5.619	15.293	3.827	1.191	0.164	308
JB	3	14	2	CTRL	0.294	1.043	7.933	1.617	.	0.200	308
JB	3	1	1	RSFE	0.032	2.153	17.491	2.117	0.515	0.191	335
JB	3	2	2	RSFE	0.010	0.494	8.590	0.744	0.471	0.179	335
JB	3	3	1	RSFE	0.042	0.899	15.586	1.211	0.486	0.182	335
JB	3	4	2	RSFE	0.021	0.454	10.812	0.867	0.424	0.176	335
JB	3	5	1	RSFE	0.579	0.538	12.185	0.806	0.441	0.189	335
JB	3	6	2	RSFE	0.063	0.639	7.486	0.661	0.418	0.173	335
JB	3	7	1	RSFE	0.021	1.088	45.856	9.263	0.430	0.188	335
JB	3	8	2	RSFE	0.813	0.759	40.886	8.798	0.423	0.178	335
JB	3	9	1	RSFE	1.215	0.864	14.877	1.087	0.411	0.182	335
JB	3	10	2	RSFE	.	0.644	9.337	0.708	0.507	0.188	335
JB	3	11	1	RSFE	0.021	0.471	41.158	7.657	0.472	0.193	335
JB	3	12	2	RSFE	0.021	0.729	9.380	1.295	0.428	0.173	335
JB	3	13	1	CTRL	1.674	3.182	34.782	7.739	0.462	0.164	335
JB	3	14	2	CTRL	.	0.679	26.996	4.678	0.432	0.185	335
CG	3	1	1	STEE	0.249	14.080	9.699	4.069	0.342	0.191	014
CG	3	2	2	STEE	0.011	8.991	12.082	2.815	0.503	0.214	014
CG	3	3	1	STEE	0.189	29.623	15.691	7.649	0.217	0.194	014
CG	3	4	2	STEE	.	21.852	8.330	5.490	0.295	0.193	014
CG	3	5	1	STEE	0.013	25.519	10.040	6.787	0.253	0.192	014
CG	3	6	2	STEE	0.022	20.664	9.855	5.665	0.469	0.244	014
CG	3	7	1	STEE	0.297	18.700	9.071	5.107	0.323	0.215	014
CG	3	8	2	STEE	0.798	18.425	10.675	5.165	0.323	0.229	014
CG	3	9	1	STEE	0.039	26.473	17.657	6.913	0.269	0.193	014

CG	3	10	2	STEE	0.020	26.764	8.788	6.980	0.319	0.208	014
CG	3	11	1	STEE	0.040	25.365	9.325	7.269	0.288	0.191	014
CG	3	12	2	STEE	0.010	53.234	11.252	15.064	0.476	0.307	014
CG	3	13	1	CTRL	0.393	1.210	8.179	0.994	0.241	0.179	014
CG	3	14	2	CTRL	3.535	0.391	8.865	0.978	0.491	0.188	014
CG	3	1	1	RSFE	1.479	0.179	9.302	0.955	0.017	0.204	019
CG	3	2	2	RSFE	0.145	0.156	8.826	0.945	.	0.206	019
CG	3	3	1	RSFE	0.074	0.023	21.375	0.954	.	0.203	019
CG	3	4	2	RSFE	0.010	0.020	9.395	0.949	.	0.218	019
CG	3	5	1	RSFE	0.239	0.120	8.935	0.946	.	0.206	019
CG	3	6	2	RSFE	0.011	0.176	9.015	1.050	.	0.194	019
CG	3	7	1	RSFE	0.019	0.059	7.869	0.854	.	0.193	019
CG	3	8	2	RSFE	0.079	0.144	10.064	1.200	.	0.223	019
CG	3	9	1	RSFE	0.000	0.128	20.557	1.011	.	0.204	019
CG	3	10	2	RSFE	0.425	0.082	7.508	0.889	.	0.202	019
CG	3	11	1	RSFE	0.010	0.083	7.998	0.914	.	0.202	019
CG	3	12	2	RSFE	0.052	0.091	8.584	0.926	.	0.203	019
CG	3	13	1	CTRL	.	.	.	.	.	.	019
CG	3	14	2	CTRL	.	.	.	.	.	.	019
JB	4	1	1	STEE	1.585	28.798	8.476	7.303	.	0.223	028
JB	4	2	2	STEE	0.105	36.589	10.813	9.273	.	0.229	028
JB	4	3	1	STEE	9.457	20.372	7.319	5.260	.	0.225	028
JB	4	4	2	STEE	0.084	26.030	10.235	6.763	.	0.232	028
JB	4	5	1	STEE	0.899	20.014	8.873	5.172	.	0.213	028
JB	4	6	2	STEE	0.084	22.547	8.356	5.679	.	0.232	028
JB	4	7	1	STEE	0.084	33.895	12.006	8.400	.	0.220	028
JB	4	8	2	STEE	0.041	43.072	10.815	10.415	.	0.241	028
JB	4	9	1	STEE	0.513	24.381	10.680	5.950	.	0.226	028
JB	4	10	2	STEE	0.125	32.249	9.543	7.743	.	0.233	028
JB	4	11	1	STEE	0.168	22.312	10.192	5.470	.	0.212	028
JB	4	12	2	STEE	95.112	28.179	9.491	6.814	.	0.229	028
JB	4	13	1	CTRL	0.259	3.566	10.402	1.167	.	0.175	028
JB	4	14	2	CTRL	0.997	0.764	9.440	0.300	.	0.212	028
JB	4	1	1	RSFE	0.070	2.738	14.170	12.687	2.774	0.182	048
JB	4	2	2	RSFE	27.562	1.809	14.188	13.032	2.948	0.218	048
JB	4	3	1	RSFE	0.042	1.713	17.947	10.545	2.534	0.177	048
JB	4	4	2	RSFE	1.303	0.948	13.918	9.512	2.783	0.210	048
JB	4	5	1	RSFE	0.082	2.219	11.939	10.970	2.457	0.178	048
JB	4	6	2	RSFE	4.013	0.737	12.926	9.084	2.630	0.202	048
JB	4	7	1	RSFE	.	.	.	.	.	.	048
JB	4	8	2	RSFE	.	.	.	.	.	.	048
JB	4	9	1	RSFE	.	.	.	.	.	.	048
JB	4	10	2	RSFE	.	.	.	.	.	.	048
JB	4	11	1	RSFE	.	.	.	.	.	.	048
JB	4	12	2	RSFE	.	.	.	.	.	.	048
JB	4	13	1	CTRL	.	.	.	.	.	.	048
JB	4	14	2	CTRL	.	.	.	.	.	.	048
CG	4	1	1	STEE	2.182	7.673	9.067	2.712	0.399	0.200	054
CG	4	2	2	STEE	0.039	22.841	8.746	5.771	0.378	0.219	054
CG	4	3	1	STEE	0.042	21.924	13.333	5.575	0.341	0.205	054
CG	4	4	2	STEE	0.060	32.998	8.665	7.377	0.309	0.212	054

CG	4	5	1	STEE	2.219	13.063	8.864	3.800	0.344	0.203	054
CG	4	6	2	STEE	1.195	31.034	8.277	7.186	0.280	0.216	054
CG	4	7	1	STEE	.	.	.	.	.	.	054
CG	4	8	2	STEE	.	.	.	.	.	.	054
CG	4	9	1	STEE	.	.	.	.	.	.	054
CG	4	10	2	STEE	.	.	.	.	.	.	054
CG	4	11	1	STEE	.	.	.	.	.	.	054
CG	4	12	2	STEE	.	.	.	.	.	.	054
CG	4	13	1	STEE	1.126	1.656	16.892	1.287	0.466	0.191	054
CG	4	14	2	STEE	0.431	0.115	9.646	0.912	0.422	0.201	054
CG	4	1	1	RSFE	0.374	0.459	14.457	0.828	0.071	0.196	096
CG	4	2	2	RSFE	0.040	0.351	17.646	0.752	0.040	0.201	096
CG	4	3	1	RSFE	0.040	0.227	24.263	0.412	0.059	0.200	096
CG	4	4	2	RSFE	0.040	0.329	32.705	0.650	0.057	0.227	096
CG	4	5	1	RSFE	0.160	0.157	13.811	0.357	0.038	0.199	096
CG	4	6	2	RSFE	0.040	0.405	48.148	0.609	0.049	0.236	096
CG	4	7	1	RSFE	.	0.145	8.950	0.227	0.021	0.000	096
CG	4	8	2	RSFE	.	0.110	7.720	0.189	0.026	0.000	096
CG	4	9	1	RSFE	.	.	.	.	.	0.000	096
CG	4	10	2	RSFE	.	.	.	.	.	0.000	096
CG	4	11	1	RSFE	.	.	.	.	.	0.000	096
CG	4	12	2	RSFE	.	.	.	.	.	0.000	096
CG	4	13	1	RSFE	0.080	0.241	14.872	0.377	0.035	0.181	096
CG	4	14	2	RSFE	1.167	0.195	13.686	0.335	0.045	0.205	096

Appendix B: SAS Code – Jackson Bend

```
*Location     Round Position     Depth Treatment     Ksat     NO3     TC     TN
      TP;
*                   ft          cm/day      ppm_soil      ppm_soil
      ppm_soil      ppm_soil;
data Hill1;
input loc $ rnd pos depth trt $ Ksat NO3 TC TN TP;

datalines;
JB    1     1     1     STEE .     4.79  15.052      .     0.340
JB    1     2     2     STEE .     4.58  12.358      .     0.150
JB    1     3     1     STEE .     4.79  13.723      .     0.160
JB    1     4     2     STEE .     3.91  6.213 .     0.138
JB    1     5     1     STEE 0.02  4.94  10.287      .     0.198
JB    1     6     2     STEE .     4.32  12.363      .     0.120
JB    1     7     1     STEE .     4.09  12.793      .     0.087
JB    1     8     2     STEE .     4.62  8.108 .     0.298
JB    1     9     1     STEE .     4.02  11.680      .     0.250
JB    1     10    2     STEE .     4.40  14.380      .     0.257
JB    1     11    1     STEE .     4.67  16.648      .     0.212
JB    1     12    2     STEE .     4.39  7.280 .     0.112
JB    1     13    1     CTRL .     3.96  .     13.43 0.213
JB    1     14    2     CTRL .     3.83  86.267      10.60 0.143
JB    1     1     1     RSFE .     3.01  86.880      10.58 0.645
JB    1     2     2     RSFE 0.02  2.81  39.867      6.08  0.424
JB    1     3     1     RSFE 0.02  3.03  69.600      7.61  0.402
JB    1     4     2     RSFE .     3.12  53.805      10.41 0.307
JB    1     5     1     RSFE 0.02  3.09  .     12.51 0.462
JB    1     6     2     RSFE 0.01  4.71  88.587      11.29 0.418
JB    1     7     1     RSFE .     3.14  .     15.98 0.440
JB    1     8     2     RSFE 0.08  3.51  69.867      10.90 0.471
JB    1     9     1     RSFE .     4.23  .     13.71 0.642
JB    1     10    2     RSFE 0.01  3.75  65.147      14.51 0.554
JB    1     11    1     RSFE 0.02  3.32  .     9.02  0.662
JB    1     12    2     RSFE 0.01  3.87  51.208      7.36  0.476
JB    1     13    1     CTRL .     8.68  .     28.46 1.012
JB    1     14    2     CTRL .     3.29  .     14.57 0.689
JB    2     1     1     STEE 0.04  1.32  .     21.85 0.165
JB    2     2     2     STEE 0.08  1.41  .     8.64  0.143
JB    2     3     1     STEE .     3.24  .     16.92 0.179
JB    2     4     2     STEE 0.02  1.35  .     9.86  0.125
JB    2     5     1     STEE 0.02  1.87  .     36.40 0.213
JB    2     6     2     STEE 0.00  1.68  .     11.63 0.168
JB    2     7     1     STEE .     2.28  .     17.83 0.237
JB    2     8     2     STEE 0.01  1.60  .     11.65 0.138
JB    2     9     1     STEE .     5.06  .     13.93 0.292
```

JB	2	10	2	STEE	0.01	3.76	.	9.58	0.183	
JB	2	11	1	STEE	.	.	.	17.84	0.189	
JB	2	12	2	STEE	.	2.35	.	7.77	0.219	
JB	2	13	1	CTRL	.	1.20	.	18.16	0.429	
JB	2	14	2	CTRL	0.07	0.92	.	5.71	0.176	
JB	2	1	1	RSFE	.	0.00	.	0.00	0.000	
JB	2	2	2	RSFE	.	6.34	84.635		11.62	.
JB	2	3	1	RSFE	0.08	9.39	53.579		7.82	.
JB	2	4	2	RSFE	.	5.54	57.926		7.48	.
JB	2	5	1	RSFE	0.04	5.19	49.528		6.59	.
JB	2	6	2	RSFE	.	6.65	58.594		7.76	.
JB	2	7	1	RSFE	0.00	6.58	51.144		6.46	.
JB	2	8	2	RSFE	.	5.50	2.445	7.06	.	
JB	2	9	1	RSFE	.	1.32	.	12.50	.	
JB	2	10	2	RSFE	.	1.25	60.643		6.45	.
JB	2	11	1	RSFE	.	2.62	68.357		7.34	.
JB	2	12	2	RSFE	.	1.75	60.073		7.52	.
JB	2	13	1	CTRL	0.06	19.72	57.489		10.85	.
JB	2	14	2	CTRL	.	3.79	58.046		6.10	.
JB	3	1	1	STEE	0.04	3.92	8.261	2.30	0.055	
JB	3	2	2	STEE	.	4.92	5.272	2.61	0.019	
JB	3	3	1	STEE	0.04	11.38	9.229	4.55	0.002	
JB	3	4	2	STEE	0.04	7.85	8.102	3.42	0.009	
JB	3	5	1	STEE	0.04	11.71	7.827	4.84	0.010	
JB	3	6	2	STEE	.	6.10	8.680	3.18	0.018	
JB	3	7	1	STEE	0.04	2.73	7.410	2.00	.	
JB	3	8	2	STEE	0.04	1.04	8.155	1.53	0.010	
JB	3	9	1	STEE	0.04	2.45	10.894		1.95	.
JB	3	10	2	STEE	0.04	1.48	9.549	1.67	0.021	
JB	3	11	1	STEE	0.04	7.61	8.525	3.47	.	
JB	3	12	2	STEE	.	6.42	9.414	3.00	.	
JB	3	13	1	CTRL	.	5.62	15.293		3.83	1.191
JB	3	14	2	CTRL	.	1.04	7.933	1.62	.	
JB	3	1	1	RSFE	0.03	2.15	17.491		2.12	0.515
JB	3	2	2	RSFE	0.01	0.49	8.590	0.74	0.471	
JB	3	3	1	RSFE	0.04	0.90	15.586		1.21	0.486
JB	3	4	2	RSFE	0.02	0.45	10.812		0.87	0.424
JB	3	5	1	RSFE	.	0.54	12.185		0.81	0.441
JB	3	6	2	RSFE	0.06	0.64	7.486	0.66	0.418	
JB	3	7	1	RSFE	0.02	1.09	45.856		9.26	0.430
JB	3	8	2	RSFE	.	0.76	40.886		8.80	0.423
JB	3	9	1	RSFE	.	0.86	14.877		1.09	0.411
JB	3	10	2	RSFE	.	0.64	9.337	0.71	0.507	
JB	3	11	1	RSFE	0.02	0.47	41.158		7.66	0.472
JB	3	12	2	RSFE	0.02	0.73	9.380	1.29	0.428	

```
JB    3    13    1    CTRL .     3.18  34.782       7.74   0.462
JB    3    14    2    CTRL .     0.68  26.996       4.68   0.432
JB    4    1     1    STEE .     28.80 8.476  7.30  .
JB    4    2     2    STEE .     .     10.813       9.27   .
JB    4    3     1    STEE .     20.37 7.319  5.26  .
JB    4    4     2    STEE 0.08  26.03 10.235       6.76   .
JB    4    5     1    STEE .     20.01 8.873  5.17  .
JB    4    6     2    STEE 0.08  22.55 8.356  5.68  .
JB    4    7     1    STEE 0.08  .     12.006       8.40   .
JB    4    8     2    STEE 0.04  .     10.815       10.41  .
JB    4    9     1    STEE .     24.38 10.680       5.95   .
JB    4    10    2    STEE .     .     9.543  7.74  .
JB    4    11    1    STEE .     22.31 10.192       5.47   .
JB    4    12    2    STEE .     28.18 9.491  6.81  .
JB    4    13    1    CTRL .     3.57  10.402       1.17   .
JB    4    14    2    CTRL .     0.76  9.440  0.30  .
JB    4    1     1    RSFE 0.07  2.74  14.170       12.69  .
JB    4    2     2    RSFE .     1.81  14.188       13.03  .
JB    4    3     1    RSFE 0.04  1.71  17.947       10.54  .
JB    4    4     2    RSFE .     0.95  13.918       9.51   .
JB    4    5     1    RSFE 0.08  2.22  11.939       10.97  .
JB    4    6     2    RSFE .     0.74  12.926       9.08   .
JB    4    7     1    RSFE .     .     .      .      .
JB    4    8     2    RSFE .     .     .      .      .
JB    4    9     1    RSFE .     .     .      .      .
JB    4    10    2    RSFE .     .     .      .      .
JB    4    11    1    RSFE .     .     .      .      .
JB    4    12    2    RSFE .     .     .      .      .
JB    4    13    1    CTRL .     .     .      .      .
JB    4    14    2    CTRL .     .     .      .      .
;
%include 'c:\danda.sas';
*Block on rnd

*Saturated Conductivity
*no transform;
%mmaov(Hill1, Ksat, class=trt loc depth pos rnd, fixed=trt|depth,
random=rnd*loc rnd*loc*trt rnd*loc*depth*trt pos(rnd*loc*depth*trt),
diagnostics=noinf);

*Natrate-Nitrogen
*log transform;
%mmaov(Hill1, NO3, class=trt loc depth pos rnd, fixed=trt|depth,
random=rnd*loc rnd*loc*trt rnd*loc*depth*trt pos(rnd*loc*depth*trt),
diagnostics=noinf, transtype=log, transvalue=.5);
```

```
*Total Carbon-Organic Matter
*no transformations needed with outliers removed;
%mmaov(Hill1, TC, class=trt loc depth pos rnd, fixed=trt|depth,
random=rnd*loc rnd*loc*trt rnd*loc*depth*trt pos(rnd*loc*depth*trt),
diagnostics=noinf);

*Total Nitrogen
*sqrt transform;
%mmaov(Hill1, TN, class=trt loc depth pos rnd, fixed=trt|depth,
random=rnd*loc rnd*loc*trt rnd*loc*depth*trt pos(rnd*loc*depth*trt),
diagnostics=noinf, transtype=sqrt);

*Total Phosphorus
*log transform;
%mmaov(Hill1, TP, class=trt loc depth pos rnd, fixed=trt|depth,
random=rnd*loc rnd*loc*trt rnd*loc*depth*trt pos(rnd*loc*depth*trt),
diagnostics=noinf, transtype=log, transvalue=.2);
run;
```

Appendix C: SAS Output – Jackson Bend

Mixed ANOVA for Ksat

The Mixed Procedure

Model Information

Data Set	WORK.DSETZZ
Dependent Variable	Ksat
Covariance Structure	Variance Components
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Kenward-Roger
Degrees of Freedom Method	Kenward-Roger

Class Level Information

Class	Levels	Values
trt	3	CTRL RSFE STEE
loc	1	JB
depth	2	1 2
pos	14	1 2 3 4 5 6 7 8 9 10 11 12 13 14
rnd	4	1 2 3 4

Dimensions

Covariance Parameters	5
Columns in X	12
Columns in Z	144
Subjects	1
Max Obs Per Subject	112

Number of Observations

Number of Observations Read	112
Number of Observations Used	45
Number of Observations Not Used	67

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	-168.39791539	
1	4	-168.45260956	.
2	1	-171.56841971	.
3	1	-173.37467766	.
4	1	-174.30846488	.
5	1	-174.70464657	0.00078602

Mixed ANOVA for Ksat

The Mixed Procedure

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
6	1	-174.82043284	0.00011701
7	1	-174.83634404	0.00000368
8	1	-174.83680799	0.00000000

Convergence criteria met.

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr > Z
loc*rnd	0.000302	0.000302	1.00	0.1588
trt*loc*rnd	0	.	.	.
trt*loc*depth*rnd	0	.	.	.
pos(trt*loc*dep*rnd)	0	.	.	.
Residual	0.000448	0.000106	4.23	<.0001

Fit Statistics

-2 Res Log Likelihood	-174.8
AIC (smaller is better)	-170.8
AICC (smaller is better)	-170.5
BIC (smaller is better)	-172.1

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trt	2	37.6	2.16	0.1288
depth	1	35.8	0.01	0.9269
trt*depth	2	37.1	0.11	0.8961

Mean separation for Ksat

---------- Effect=trt Method=LSD(P<.05) Set=1 ----------

Obs	trt	depth	Estimate	Standard Error	Letter Group
1	CTRL	_	0.07277	0.01851	A
2	RSFE	_	0.03612	0.01010	B
3	STEE	_	0.04065	0.01006	AB

---------- Effect=depth Method=LSD(P<.05) Set=2 ----------

Obs	trt	depth	Estimate	Standard Error	Letter Group
4		1	0.04934	0.01182	A
5		2	0.05035	0.01184	A

---------- Effect=trt*depth Method=LSD(P<.05) Set=3 ----------

Obs	trt	depth	Estimate	Standard Error	Letter Group
6	CTRL	1	0.06777	0.02380	A
7	CTRL	2	0.07777	0.02380	A
8	RSFE	1	0.03726	0.01049	A
9	RSFE	2	0.03497	0.01205	A

10	STEE	1	0.04299	0.01127	A
11	STEE	2	0.03830	0.01114	A

Check on normality for Ksat

The UNIVARIATE Procedure
Variable: Resid (Residual)

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.905435	Pr < W	0.0014
Kolmogorov-Smirnov	D	0.136971	Pr > D	0.0334
Cramer-von Mises	W-Sq	0.166837	Pr > W-Sq	0.0147
Anderson-Darling	A-Sq	1.18444	Pr > A-Sq	<0.0050

Extreme Observations

-------Lowest------		------Highest------	
Value	Obs	Value	Obs
-0.0305261	34	0.0191222	103
-0.0294890	49	0.0294507	76
-0.0219149	92	0.0494739	30
-0.0208778	101	0.0505110	45
-0.0205493	72	0.0564395	22

Missing Values

Missing Value	Count	-----Percent Of----- All Obs	Missing Obs
.	67	59.82	100.00

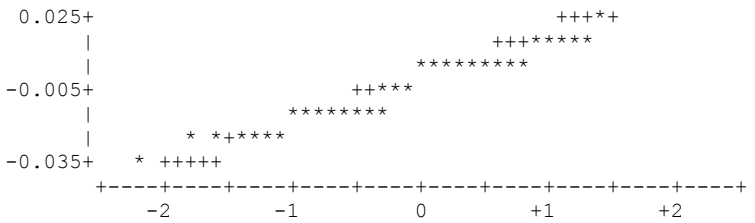
Stem	Leaf	#	Boxplot
5	16	2	0
4	9	1	0
3			
2	9	1	|
1	13889	5	|
0	00111111566679	14	+--+--+
-0	66643	5	| |
-1	5444332111	10	+-----+
-2	921111	6	|
-3	1	1	|

Multiply Stem.Leaf by 10**-2

Check on normality for Ksat

The UNIVARIATE Procedure
Variable: Resid (Residual)

Normal Probability Plot



Check equality of stddev for y= Ksat

Obs	trt	depth	nobs	rawmean_ y	stddev_y	stderr_y	Levene LeveneF_df	P
1	CTRL	1	1	0.060000	.	.	1.024(3,39)	0.3930
3	RSFE	1	13	0.036923	0.025293	.007015058		
4	RSFE	2	9	0.026667	0.025495	.008498366		
5	STEE	1	10	0.040000	0.016330	.005163978		
6	STEE	2	11	0.040000	0.029326	.008842048		

Mixed ANOVA for log NO3

The Mixed Procedure

Model Information

Data Set	WORK.DSETZZ
Dependent Variable	tzzNO3
Covariance Structure	Variance Components
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Kenward-Roger
Degrees of Freedom Method	Kenward-Roger

Class Level Information

Class	Levels	Values
trt	3	CTRL RSFE STEE
loc	1	JB
depth	2	1 2
pos	14	1 2 3 4 5 6 7 8 9 10 11 12 13 14
rnd	4	1 2 3 4

Dimensions

Covariance Parameters	5
Columns in X	12
Columns in Z	144
Subjects	1
Max Obs Per Subject	112

Number of Observations

Number of Observations Read	112
Number of Observations Used	99
Number of Observations Not Used	13

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	231.54206138	
1	4	176.84815858	.
2	1	174.19860462	.
3	1	173.09397880	0.24104133
4	1	172.78245113	0.03898045
5	1	172.74270598	0.00107167

Mixed ANOVA for log NO3

The Mixed Procedure

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
6	1	172.74171220	0.00000091
7	1	172.74171137	0.00000000

Convergence criteria met.

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr > Z
loc*rnd	0	.	.	.
trt*loc*rnd	0.4119	0.2090	1.97	0.0244
trt*loc*depth*rnd	0	.	.	.
pos(trt*loc*dep*rnd)	0	.	.	.
Residual	0.2462	0.03791	6.49	<.0001

Fit Statistics

-2 Res Log Likelihood	172.7
AIC (smaller is better)	176.7
AICC (smaller is better)	176.9
BIC (smaller is better)	175.5

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trt	2	9.36	2.07	0.1803
depth	1	84.4	10.27	0.0019
trt*depth	2	84.4	4.15	0.0191

Back-transformed (bt) Mean Separation for log NO3

---------- Effect=trt Method=LSD(P<.05) Set=1 ----------

Obs	trt	depth	Estimate	Standard Error	Letter Group	btestimate	btstderr
1	CTRL	_	1.1879	0.3493	A	2.78013	1.14566
2	RSFE	_	0.9151	0.3307	A	1.99692	0.82574
3	STEE	_	1.8413	0.3299	A	5.80449	2.08016

---------- Effect=depth Method=LSD(P<.05) Set=2 ----------

Obs	trt	depth	Estimate	Standard Error	Letter Group	btestimate	btstderr
4		1	1.4975	0.2025	A	3.97036	0.90520
5		2	1.1320	0.2027	B	2.60186	0.62887

---------- Effect=trt*depth Method=LSD(P<.05) Set=3 ----------

Obs	trt	depth	Estimate	Standard Error	Letter Group	btestimate	btstderr
6	CTRL	1	1.6403	0.3736	A	4.65690	1.92663
7	CTRL	2	0.7354	0.3736	B	1.58639	0.77948
8	RSFE	1	0.9321	0.3394	AB	2.03977	0.86213
9	RSFE	2	0.8980	0.3394	AB	1.95480	0.83328
10	STEE	1	1.9200	0.3380	A	6.32095	2.30518
11	STEE	2	1.7625	0.3393	AB	5.32713	1.97715

Check on normality for log NO3

The UNIVARIATE Procedure
Variable: Resid (Residual)

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.945599	Pr < W	0.0005
Kolmogorov-Smirnov	D	0.099783	Pr > D	0.0165
Cramer-von Mises	W-Sq	0.212296	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	1.215935	Pr > A-Sq	<0.0050

Extreme Observations

------Lowest----- ------Highest-----

Value	Obs	Value	Obs
-2.01425	43	0.697431	71
-1.23862	41	0.756146	59
-1.12945	64	0.783545	61
-0.87814	66	0.970419	45
-0.72746	52	1.237426	55

Missing Values

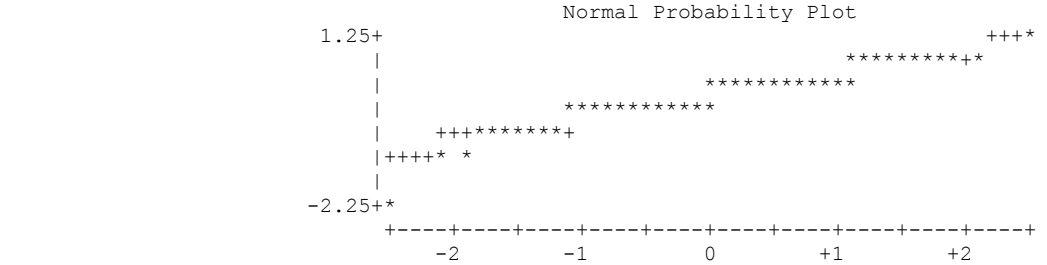
Missing Value	Count	Percent Of All Obs	Percent Of Missing Obs
.	13	11.61	100.00

```
                     Stem Leaf                                        #
Boxplot
                        1 02                                          2                0
                        0 555666667788                               12                |
                        0 000001111111111111222222233334444444      35             +--+-
-+
                       -0 433333322222222211111111111000000000      37             *----
-*
                       -0 9776555555                                10                |
                       -1 21                                         2                0
                       -1
                       -2 0                                          1                *
                          ----+----+----+----+----+----+----+--
```


Check on normality for log NO3

The UNIVARIATE Procedure
Variable: Resid (Residual)

Normal Probability Plot



Check equality of stddev for y=log NO3

Obs	trt	depth	nobs	rawmean_ y	stddev_y	stderr_y	Levene LeveneF_df	P
1	CTRL	1	7	1.68108	0.77884	0.29437	0.545(5,93)	0.7420
2	CTRL	2	7	0.77618	0.60784	0.22974	.	
3	RSFE	1	21	0.95583	0.71138	0.15524		

.

4	RSFE	2	21	0.92180	0.71295	0.15558

.

5	STEE	1	22	1.90038	0.83072	0.17711

.

6	STEE	2	21	1.58536	0.85362	0.18628

.

Mixed ANOVA for TC

The Mixed Procedure

Model Information

Data Set	WORK.DSETZZ
Dependent Variable	TC
Covariance Structure	Variance Components
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Kenward-Roger
Degrees of Freedom Method	Kenward-Roger

Class Level Information

Class	Levels	Values
trt	3	CTRL RSFE STEE
loc	1	JB
depth	2	1 2
pos	14	1 2 3 4 5 6 7 8 9 10 11 12 13 14
rnd	4	1 2 3 4

Dimensions

Covariance Parameters	5
Columns in X	12
Columns in Z	144
Subjects	1
Max Obs Per Subject	112

Number of Observations

Number of Observations Read	112
Number of Observations Used	81
Number of Observations Not Used	31

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	678.69243871	
1	4	616.54539437	0.00504077
2	1	615.00259624	0.00197138
3	1	614.42307697	0.00046153
4	1	614.29615937	0.00003736
5	1	614.28675223	0.00000032

Mixed ANOVA for TC

The Mixed Procedure

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
6	1	614.28667659	0.00000000

Convergence criteria met.

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr > Z
loc*rnd	338.96	372.41	0.91	0.1814
trt*loc*rnd	277.12	197.79	1.40	0.0806
trt*loc*depth*rnd	0	.	.	.
pos(trt*loc*dep*rnd)	0	.	.	.
Residual	125.33	21.7673	5.76	<.0001

Fit Statistics

-2 Res Log Likelihood	614.3
AIC (smaller is better)	620.3
AICC (smaller is better)	620.6
BIC (smaller is better)	618.4

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trt	2	4.94	2.47	0.1809
depth	1	68.1	1.08	0.3025
trt*depth	2	67.6	0.65	0.5273

Mean separation for TC

---------- Effect=trt Method=LSD(P<.05) Set=1 ----------

Obs	trt	depth	Estimate	Standard Error	Letter Group
1	CTRL	_	42.6735	13.1302	A
2	RSFE	_	39.1319	12.5640	A
3	STEE	_	13.5599	14.0155	A

---------- Effect=depth Method=LSD(P<.05) Set=2 ----------

Obs	trt	depth	Estimate	Standard Error	Letter Group
4		1	33.4416	10.8759	A
5		2	30.1353	10.7972	A

---------- Effect=trt*depth Method=LSD(P<.05) Set=3 ----------

				Standard	Letter

Obs	trt	depth	Estimate	Error	Group
6	CTRL	1	43.5208	13.9815	A
7	CTRL	2	41.8261	13.4326	A
8	RSFE	1	42.6676	12.7629	A
9	RSFE	2	35.5961	12.6601	A
10	STEE	1	14.1362	14.1391	A
11	STEE	2	12.9835	14.1391	A

Check on normality for TC

The UNIVARIATE Procedure
Variable: Resid (Residual)

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.848487	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.193072	Pr > D	<0.0100
Cramer-von Mises	W-Sq	0.637957	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	3.559217	Pr > A-Sq	<0.0050

Extreme Observations

------Lowest-----		-----Highest-----	
Value	Obs	Value	Obs
-49.1806	50	17.8677	81
-23.3440	16	22.5657	77
-13.4444	70	24.6672	78
-12.0030	26	25.3760	20
-11.1053	75	33.0094	44

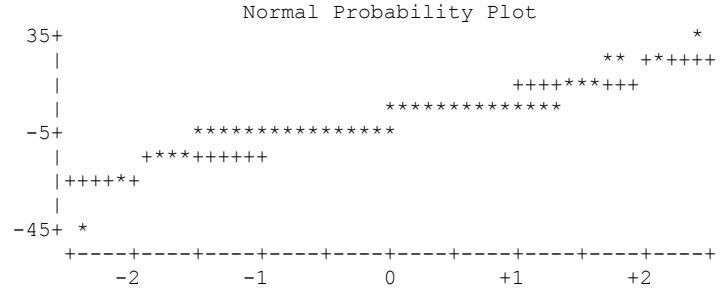
Missing Values

Missing Value	Count	-----Percent Of----- All Obs	Missing Obs
.	31	27.68	100.00

```
Stem Leaf                                    #             Boxplot
   3 3                                       1                *
   2 355                                     3                *
   1 0278                                    4                0
   0 00011111111122222222233346677899       33             +--+--+
  -0 99988888776665554443332111111100000    35             +-----+
  -1 321                                     3                |
  -2 3                                       1                0
  -3
  -4 9                                       1                *
     ----+----+----+----+----+----+----+
 Multiply Stem.Leaf by 10**+1
```


Check on normality for TC

The UNIVARIATE Procedure
Variable: Resid (Residual)



Check equality of stddev for y= TC

Obs	trt	depth	nobs	rawmean_ y	stddev_y	stderr_y	Levene LeveneF_df	P
1	CTRL	1	4	29.4915	21.4309	10.7155	9.79(5,75)	0.0000
2	CTRL	2	5	37.7364	33.8082	15.1195		.
3	RSFE	1	15	38.0198	24.9323	6.4375		.
4	RSFE	2	21	39.0629	28.2272	6.1597		.
5	STEE	1	18	10.5486	2.6810	0.6319		.
6	STEE	2	18	9.3959	2.2398	0.5279		.

Mixed ANOVA for sqrt TN

The Mixed Procedure

Model Information

Data Set	WORK.DSETZZ
Dependent Variable	tzzTN
Covariance Structure	Variance Components
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Kenward-Roger
Degrees of Freedom Method	Kenward-Roger

Class Level Information

Class	Levels	Values
trt	3	CTRL RSFE STEE
loc	1	JB
depth	2	1 2
pos	14	1 2 3 4 5 6 7 8 9 10 11 12 13 14
rnd	4	1 2 3 4

Dimensions

Covariance Parameters	5
Columns in X	12
Columns in Z	144
Subjects	1
Max Obs Per Subject	112

Number of Observations

Number of Observations Read	112
Number of Observations Used	92
Number of Observations Not Used	20

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	272.49395544	
1	2	205.24228414	0.02478109
2	1	204.50565168	0.00824395
3	1	204.27438832	0.00144815
4	1	204.23691103	0.00006445
5	1	204.23537601	0.00000016

Mixed ANOVA for sqrt TN

The Mixed Procedure

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
6	1	204.23537241	0.00000000

Convergence criteria met.

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr > Z
loc*rnd	0.4963	0.6792	0.73	0.2325
trt*loc*rnd	0.6120	0.4929	1.24	0.1072
trt*loc*depth*rnd	0.09806	0.08666	1.13	0.1289
pos(trt*loc*dep*rnd)	0	.	.	.
Residual	0.3720	0.06218	5.98	<.0001

Fit Statistics

-2 Res Log Likelihood	204.2
AIC (smaller is better)	212.2
AICC (smaller is better)	212.7
BIC (smaller is better)	209.8

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F

trt	2	4.47	0.15	0.8668
depth	1	11.3	5.73	0.0350
trt*depth	2	10.3	1.37	0.2959

Back-transformed (bt) Mean Separation for sqrt TN

Effect=trt Method=LSD(P<.05) Set=1

Obs	trt	depth	Estimate	Standard Error	Letter Group	btestimate	btstderr
1	CTRL	_	2.5354	0.5642	A	6.42816	2.86117
2	RSFE	_	2.6499	0.5468	A	7.02207	2.89817
3	STEE	_	2.9042	0.6300	A	8.43452	3.65924

Effect=depth Method=LSD(P<.05) Set=2

Obs	trt	depth	Estimate	Standard Error	Letter Group	btestimate	btstderr
4		1	2.9332	0.4527	A	8.60349	2.65549
5		2	2.4598	0.4527	B	6.05085	2.22697

Effect=trt*depth Method=LSD(P<.05) Set=3

Obs	trt	depth	Estimate	Standard Error	Letter Group	btestimate	btstderr
6	CTRL	1	2.9912	0.5983	A	8.94702	3.57917
7	CTRL	2	2.0796	0.5983	B	4.32477	2.48843
8	RSFE	1	2.6950	0.5663	AB	7.26327	3.05247
9	RSFE	2	2.6048	0.5663	AB	6.78495	2.95026
10	STEE	1	3.1133	0.6508	AB	9.69270	4.05238
11	STEE	2	2.6951	0.6508	AB	7.26377	3.50807

Check on normality for sqrt TN

The UNIVARIATE Procedure
Variable: Resid (Residual)

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.90665	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.090678	Pr > D	0.0619

Cramer-von Mises	W-Sq	0.242764	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	1.761348	Pr > A-Sq	<0.0050

Extreme Observations

------Lowest------		-----Highest-----	
Value	Obs	Value	Obs
-2.480685	43	1.05485	51
-0.769277	75	1.09839	81
-0.708634	13	1.37375	77
-0.706462	16	1.61402	78
-0.625247	79	1.74408	33

Missing Values

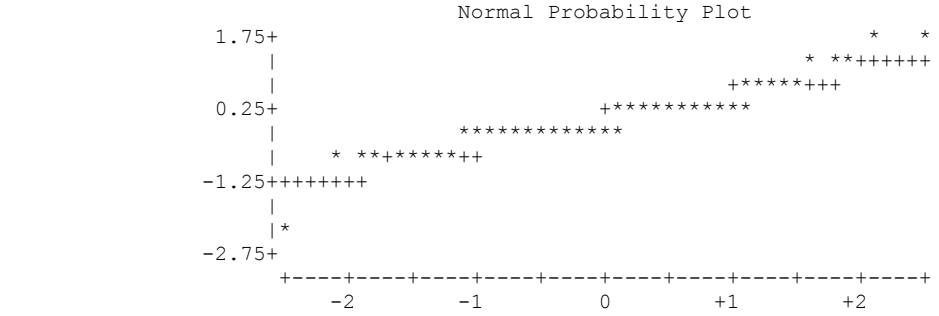
		-----Percent Of-----	
Missing Value	Count	All Obs	Missing Obs
.	20	17.86	100.00

```
Stem Leaf                                    #             Boxplot
   1 67                                      2                0
   1 0114                                    4                0
   0 666677                                  6                |
   0 000011111111112222233333444444         31             +--+--+
  -0 444433333333332222222221111111000      34             *-----*
  -0 87766665555555                         14                |
  -1
  -1
  -2
  -2 5                                       1                *
     ----+----+----+----+----+----+----
```


Check on normality for sqrt TN

The UNIVARIATE Procedure
Variable: Resid (Residual)

Normal Probability Plot



Check equality of stddev for y=sqrt TN

rawmean_

Levene

Obs	trt	depth	nobs	y	stddev_y	stderr_y	LeveneF_df	P
1	CTRL	1	7	3.19652	1.42101	0.53709	1.259(5,86)	0.2890
2	CTRL	2	7	2.27372	1.10990	0.41950	.	
3	RSFE	1	21	2.61112	1.07920	0.23550	.	
4	RSFE	2	21	2.52388	0.98389	0.21470	.	
5	STEE	1	18	2.91490	1.29458	0.30514	.	
6	STEE	2	18	2.49672	0.72779	0.17154	.	

Mixed ANOVA for log TP

The Mixed Procedure

Model Information

Data Set	WORK.DSETZZ
Dependent Variable	tzzTP
Covariance Structure	Variance Components
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Kenward-Roger
Degrees of Freedom Method	Kenward-Roger

Class Level Information

Class	Levels	Values
trt	3	CTRL RSFE STEE
loc	1	JB
depth	2	1 2
pos	14	1 2 3 4 5 6 7 8 9 10 11 12 13 14
rnd	4	1 2 3 4

Dimensions

Covariance Parameters	5
Columns in X	12
Columns in Z	144
Subjects	1
Max Obs Per Subject	112

Number of Observations

Number of Observations Read	112
Number of Observations Used	66
Number of Observations Not Used	46

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	43.45612722	
1	4	25.84492224	.
2	1	20.01932179	0.07392679

3	1	15.58386809	0.04350998
4	1	12.89374531	0.02169873
5	1	11.53859164	0.00888075

Mixed ANOVA for log TP

The Mixed Procedure

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
6	3	10.89334396	0.00094011
7	1	10.84082135	0.00004550
8	1	10.83848191	0.00000013
9	1	10.83847538	0.00000000

Convergence criteria met.

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr > Z
loc*rnd	0	.	.	.
trt*loc*rnd	0.1899	0.1236	1.54	0.0621
trt*loc*depth*rnd	0	.	.	.
pos(trt*loc*dep*rnd)	0	.	.	.
Residual	0.04066	0.007880	5.16	<.0001

Fit Statistics

-2 Res Log Likelihood	10.8
AIC (smaller is better)	14.8
AICC (smaller is better)	15.0
BIC (smaller is better)	13.6

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trt	2	5.28	1.67	0.2741
depth	1	53.5	8.71	0.0047
trt*depth	2	53.5	1.93	0.1558

Back-transformed (bt) Mean Separation for log TP

---------- Effect=trt Method=LSD(P<.05) Set=1 ----------

Obs	trt	depth	Estimate	Standard Error	Letter Group	btestimate	btstderr
1	CTRL	_	-0.4747	0.2612	A	0.42207	0.16251
2	RSFE	_	-0.7705	0.2619	A	0.26279	0.12122
3	STEE	_	-1.1390	0.2542	A	0.12013	0.08138

---------- Effect=depth Method=LSD(P<.05) Set=2 ----------

Obs	trt	depth	Estimate	Standard Error	Letter Group	btestimate	btstderr
4		1	-0.7086	0.1517	A	0.29234	0.074710
5		2	-0.8809	0.1531	B	0.21440	0.063463

---------- Effect=trt*depth Method=LSD(P<.05) Set=3 ----------

Obs	trt	depth	Estimate	Standard Error	Letter Group	btestimate	btstderr
6	CTRL	1	-0.2921	0.2681	A	0.54669	0.20021
7	CTRL	2	-0.6573	0.2720	B	0.31824	0.14096
8	RSFE	1	-0.7362	0.2631	AB	0.27894	0.12600
9	RSFE	2	-0.8048	0.2672	AB	0.24717	0.11948
10	STEE	1	-1.0975	0.2572	AB	0.13372	0.08582
11	STEE	2	-1.1806	0.2563	AB	0.10708	0.07871

Check on normality for log TP

The UNIVARIATE Procedure
Variable: Resid (Residual)

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.941333	Pr < W	0.0037
Kolmogorov-Smirnov	D	0.127486	Pr > D	<0.0100
Cramer-von Mises	W-Sq	0.259017	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	1.47177	Pr > A-Sq	<0.0050

Extreme Observations

------Lowest------		------Highest-----	
Value	Obs	Value	Obs
-0.596741	13	0.296487	1
-0.417247	14	0.298698	8
-0.338236	83	0.404277	69
-0.335600	7	0.479839	27
-0.258067	18	0.535120	28

Missing Values

Missing	-----Percent Of----- Missing

Value	Count	All Obs	Obs
.	46	41.07	100.00

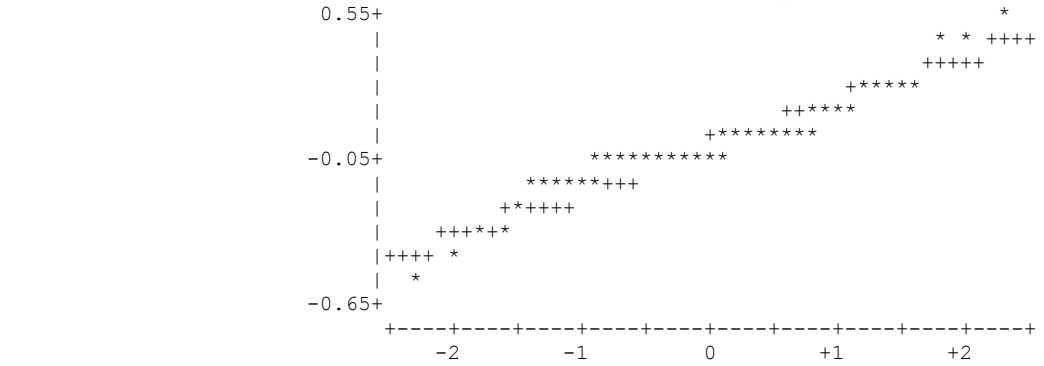
Stem	Leaf	#	Boxplot
5	4	1	0
4	08	2	0
3	00	2	|
2	011	3	|
1	0123488	7	|
0	002223333445779	15	+--+--+
-0	9999976665554322111000	22	*-----*
-1	755442100	9	|
-2	6	1	|
-3	44	2	0
-4	2	1	0
-5			
-6	0	1	*

Multiply Stem.Leaf by 10**-1

Check on normality for log TP

The UNIVARIATE Procedure
Variable: Resid (Residual)

Normal Probability Plot



Check equality of stddev for y=log TP

Obs	trt	depth	nobs	rawmean_ y	stddev_y	stderr_y	Levene LeveneF_df	P
1	CTRL	1	5	-0.24763	0.50159	0.22432	1.086(5,60)	0.3780
2	CTRL	2	4	-0.65618	0.44866	0.22433	.	
3	RSFE	1	13	-0.45953	0.36726	0.10186	.	
4	RSFE	2	12	-0.44517	0.09692	0.02798	.	
5	STEE	1	15	-1.02420	0.29276	0.07559	.	
6	STEE	2	17	-1.15909	0.27921	0.06772		

.

Appendix D: SAS Code – Crescent Glen

```
*Location     Round Position     Depth Treatment     Ksat     NO3     TC     TN
      TP;
*                   ft          cm/day      ppm_soil      ppm_soil
      ppm_soil      ppm_soil;
data Hill1;
input loc $ rnd pos depth trt $ Ksat NO3 TC TN TP;

datalines;
CG    1     1     1     STEE 0.06  .     .       23.73 0.605
CG    1     2     2     STEE 0.02  .     70.427        19.36 0.417
CG    1     3     1     STEE 0.01  .     .       27.54 0.362
CG    1     4     2     STEE .     .     75.200        21.71 0.395
CG    1     5     1     STEE 0.02  .     83.760        19.21 0.399
CG    1     6     2     STEE .     .     52.587        19.15 0.449
CG    1     7     1     STEE 0.07  .     .       22.71 0.471
CG    1     8     2     STEE .     17.37 67.733        15.66 0.468
CG    1     9     1     STEE 0.01  .     .       21.43 0.510
CG    1     10    2     STEE .     .     .       29.28 0.497
CG    1     11    1     STEE 0.03  .     .       28.12 0.572
CG    1     12    2     STEE .     .     59.573        19.46 0.461
CG    1     13    1     CTRL .     1.58  .       11.47 0.564
CG    1     14    2     CTRL .     1.58  .       15.82 0.503
CG    1     1     1     RSFE .     0.98  .       16.36 0.450
CG    1     2     2     RSFE .     1.07  82.213        11.67 0.387
CG    1     3     1     RSFE .     0.86  .       18.30 0.378
CG    1     4     2     RSFE .     1.44  .       17.98 0.381
CG    1     5     1     RSFE 0.01  0.96  .       17.47 0.393
CG    1     6     2     RSFE .     1.34  72.480        9.14  0.330
CG    1     7     1     RSFE 0.05  0.83  .       13.29 0.377
CG    1     8     2     RSFE 0.01  0.99  .       10.95 0.425
CG    1     9     1     RSFE .     0.90  .       13.64 0.454
CG    1     10    2     RSFE .     0.76  71.787        7.73  0.420
CG    1     11    1     RSFE .     0.74  83.200        12.42 0.371
CG    1     12    2     RSFE .     0.95  76.621        13.31 0.375
CG    1     13    1     CTRL 0.08  0.70  .       12.84 0.396
CG    1     14    2     CTRL .     0.69  74.613        11.25 0.328
CG    2     1     1     STEE .     .     13.562        11.10 0.133
CG    2     2     2     STEE .     .     11.911        10.50 0.005
CG    2     3     1     STEE .     .     13.714        15.67 .
CG    2     4     2     STEE .     .     10.043        14.25 0.016
CG    2     5     1     STEE .     22.77 9.238   8.74  .
CG    2     6     2     STEE .     14.43 9.650   6.86  .
CG    2     7     1     STEE 0.01  .     14.883        20.20 0.020
CG    2     8     2     STEE 0.01  .     10.035        19.17 .
CG    2     9     1     STEE 0.01  .     26.777        11.05 .
```

CG	2	10	2	STEE	.	.	18.497		10.88	0.037
CG	2	11	1	STEE	.	7.71	10.040		5.19	.
CG	2	12	2	STEE	.	1.93	16.585		4.24	.
CG	2	13	1	CTRL	.	0.39	8.848	3.13	.	
CG	2	14	2	CTRL	.	1.98	10.755		3.74	.
CG	2	1	1	RSFE	0.08	0.01	5.703	1.19	0.096	
CG	2	2	2	RSFE	.	0.14	7.135	1.38	0.086	
CG	2	3	1	RSFE	0.06	0.70	28.887		6.12	0.180
CG	2	4	2	RSFE	0.03	0.08	7.817	1.48	0.088	
CG	2	5	1	RSFE	0.04	0.05	13.925		1.47	0.055
CG	2	6	2	RSFE	.	2.95	26.324		5.80	0.128
CG	2	7	1	RSFE	.	0.10	11.685		1.34	0.059
CG	2	8	2	RSFE	.	1.84	7.046	2.00	0.046	
CG	2	9	1	RSFE	0.06	0.20	14.755		1.42	0.049
CG	2	10	2	RSFE	0.07	0.45	7.455	1.37	0.037	
CG	2	11	1	RSFE	0.06	0.24	6.822	1.21	0.022	
CG	2	12	2	RSFE	.	0.22	7.199	1.39	0.017	
CG	2	13	1	CTRL	.	0.60	7.617	1.39	0.030	
CG	2	14	2	CTRL	.	0.11	8.789	1.30	0.018	
CG	3	1	1	STEE	.	14.08	9.699	4.07	0.342	
CG	3	2	2	STEE	0.01	8.99	12.082		2.81	0.503
CG	3	3	1	STEE	.	.	15.691		7.65	0.217
CG	3	4	2	STEE	.	21.85	8.330	5.49	0.295	
CG	3	5	1	STEE	0.01	25.52	10.040		6.79	0.253
CG	3	6	2	STEE	0.02	20.66	9.855	5.67	0.469	
CG	3	7	1	STEE	.	18.70	9.071	5.11	0.323	
CG	3	8	2	STEE	.	18.43	10.675		5.17	0.323
CG	3	9	1	STEE	0.04	26.47	17.657		6.91	0.269
CG	3	10	2	STEE	0.02	26.76	8.788	6.98	0.319	
CG	3	11	1	STEE	0.04	25.37	9.325	7.27	0.288	
CG	3	12	2	STEE	0.01	.	11.252		15.06	0.476
CG	3	13	1	CTRL	.	1.21	8.179	0.99	0.241	
CG	3	14	2	CTRL	.	0.39	8.865	0.98	0.491	
CG	3	1	1	RSFE	.	0.18	9.302	0.95	0.017	
CG	3	2	2	RSFE	.	0.16	8.826	0.94	.	
CG	3	3	1	RSFE	0.07	0.02	21.375		0.95	.
CG	3	4	2	RSFE	0.01	0.02	9.395	0.95	.	
CG	3	5	1	RSFE	.	0.12	8.935	0.95	.	
CG	3	6	2	RSFE	0.01	0.18	9.015	1.05	.	
CG	3	7	1	RSFE	0.02	0.06	7.869	0.85	.	
CG	3	8	2	RSFE	0.08	0.14	10.064		1.20	.
CG	3	9	1	RSFE	.	0.13	20.557		1.01	.
CG	3	10	2	RSFE	.	0.08	7.508	0.89	.	
CG	3	11	1	RSFE	0.01	0.08	7.998	0.91	.	
CG	3	12	2	RSFE	0.05	0.09	8.584	0.93	.	

```
CG   3   13   1   CTRL .      .      .      .      .
CG   3   14   2   CTRL .      .      .      .      .
CG   4   1    1   STEE .      7.67   9.067  2.71   0.399
CG   4   2    2   STEE 0.04   22.84  8.746  5.77   0.378
CG   4   3    1   STEE 0.04   21.92  13.333        5.57   0.341
CG   4   4    2   STEE 0.06   .      8.665  7.38   0.309
CG   4   5    1   STEE .      13.06  8.864  3.80   0.344
CG   4   6    2   STEE .      .      8.277  7.19   0.280
CG   4   7    1   STEE .      .      .      .      .
CG   4   8    2   STEE .      .      .      .      .
CG   4   9    1   STEE .      .      .      .      .
CG   4   10   2   STEE .      .      .      .      .
CG   4   11   1   STEE .      .      .      .      .
CG   4   12   2   STEE .      .      .      .      .
CG   4   13   1   STEE .      1.66   16.892        1.29   0.466
CG   4   14   2   STEE .      0.11   9.646  0.91   0.422
CG   4   1    1   RSFE .      0.46   14.4568       0.83   0.0709
CG   4   2    2   RSFE 0.04   0.35   17.6456       0.75   0.0395
CG   4   3    1   RSFE 0.04   0.23   24.2632       0.41   0.0586
CG   4   4    2   RSFE 0.04   0.33   32.7051       0.65   0.0574
CG   4   5    1   RSFE .      0.16   13.8110       0.36   0.0375
CG   4   6    2   RSFE 0.04   0.40   48.1479       0.61   0.0491
CG   4   7    1   RSFE .      0.15   8.9500        0.23   0.0210
CG   4   8    2   RSFE .      0.11   7.7200        0.19   0.0255
CG   4   9    1   RSFE .      .      .      .      .
CG   4   10   2   RSFE .      .      .      .      .
CG   4   11   1   RSFE .      .      .      .      .
CG   4   12   2   RSFE .      .      .      .      .
CG   4   13   1   RSFE 0.08   0.24   14.8720       0.38   0.0349
CG   4   14   2   RSFE .      0.20   13.6863       0.34   0.0452
;
%include 'c:\danda.sas';
*Block on rnd

*Saturated Conductivity
*no transform;
%mmaov(Hill1, Ksat, class=trt loc depth pos rnd, fixed=trt|depth,
random=rnd*loc rnd*loc*trt rnd*loc*depth*trt pos(rnd*loc*depth*trt),
diagnostics=noinf);

*Natrate-Nitrogen
*log transform;
%mmaov(Hill1, NO3, class=trt loc depth pos rnd, fixed=trt|depth,
random=rnd*loc rnd*loc*trt rnd*loc*depth*trt pos(rnd*loc*depth*trt),
diagnostics=noinf, transtype=log, transvalue=.2);
```

```
*Total Carbon-Organic Matter
*no transformations needed with outliers removed;
%mmaov(Hill1, TC, class=trt loc depth pos rnd, fixed=trt|depth,
random=rnd*loc rnd*loc*trt rnd*loc*depth*trt pos(rnd*loc*depth*trt),
diagnostics=noinf);

*Total Nitrogen
*sqrt transform;
%mmaov(Hill1, TN, class=trt loc depth pos rnd, fixed=trt|depth,
random=rnd*loc rnd*loc*trt rnd*loc*depth*trt pos(rnd*loc*depth*trt),
diagnostics=noinf, transtype=sqrt);

*Total Phosphorus
*log transform;
%mmaov(Hill1, TP, class=trt loc depth pos rnd, fixed=trt|depth,
random=rnd*loc rnd*loc*trt rnd*loc*depth*trt pos(rnd*loc*depth*trt),
diagnostics=noinf, transtype=log);
run;
```

Appendix E: SAS Output – Crescent Glen

Mixed ANOVA for Ksat

The Mixed Procedure

Model Information

Data Set	WORK.DSETZZ
Dependent Variable	Ksat
Covariance Structure	Variance Components
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Kenward-Roger
Degrees of Freedom Method	Kenward-Roger

Class Level Information

Class	Levels	Values
trt	3	CTRL RSFE STEE
loc	1	CG
depth	2	1 2
pos	14	1 2 3 4 5 6 7 8 9 10 11 12 13 14
rnd	4	1 2 3 4

Dimensions

Covariance Parameters	5
Columns in X	11
Columns in Z	143
Subjects	1
Max Obs Per Subject	112

Number of Observations

Number of Observations Read	112
Number of Observations Used	43
Number of Observations Not Used	69

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	-171.23367222	
1	4	-171.24739839	.
2	1	-171.92443580	.
3	1	-172.17874208	0.00034735
4	1	-172.22623304	0.00001848
5	1	-172.22855178	0.00000006

Mixed ANOVA for Ksat

The Mixed Procedure

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
6	1	-172.22855928	0.00000000

Convergence criteria met.

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr > Z
loc*rnd	0	.	.	.
trt*loc*rnd	0.000090	0.000124	0.72	0.2350
trt*loc*depth*rnd	0	.	.	.
pos(trt*loc*dep*rnd)	0	.	.	.
Residual	0.000443	0.000113	3.92	<.0001

Fit Statistics

-2 Res Log Likelihood	-172.2
AIC (smaller is better)	-168.2
AICC (smaller is better)	-167.9
BIC (smaller is better)	-169.5

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trt	2	8.08	2.73	0.1246
depth	1	35.8	1.09	0.3041
trt*depth	1	35.8	0.06	0.8109

Mean separation for Ksat

---------- Effect=trt Method=LSD(P<.05) Set=1 ----------

Obs	trt	depth	Estimate	Standard Error	Letter Group
1	CTRL	_	.	.	
2	RSFE	_	0.04214	0.006712	A
3	STEE	_	0.02668	0.007014	A

---------- Effect=depth Method=LSD(P<.05) Set=2 ----------

Obs	trt	depth	Estimate	Standard Error	Letter Group
4		1	0.05208	0.008596	A
5		2	.	.	

---------- Effect=trt*depth Method=LSD(P<.05) Set=3 ----------

Obs	trt	depth	Estimate	Standard Error	Letter Group
6	CTRL	1	0.08000	0.02309	A
7	RSFE	1	0.04670	0.007940	AB
8	RSFE	2	0.03757	0.008463	AB
9	STEE	1	0.02953	0.008307	AB
10	STEE	2	0.02383	0.009281	B

Check on normality for Ksat

The UNIVARIATE Procedure
Variable: Resid (Residual)

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.964679	Pr < W	0.2051
Kolmogorov-Smirnov	D	0.104651	Pr > D	>0.1500
Cramer-von Mises	W-Sq	0.082044	Pr > W-Sq	0.1971
Anderson-Darling	A-Sq	0.520403	Pr > A-Sq	0.1839

Extreme Observations

-------Lowest------		------Highest------	
Value	Obs	Value	Obs
-0.0333255	81	0.0282751	88
-0.0290369	19	0.0288800	1
-0.0241896	76	0.0298909	111
-0.0241896	74	0.0388800	7
-0.0233255	77	0.0458104	78

Missing Values

Missing Value	Count	-----Percent Of----- All Obs	Missing Obs
.	69	61.61	100.00

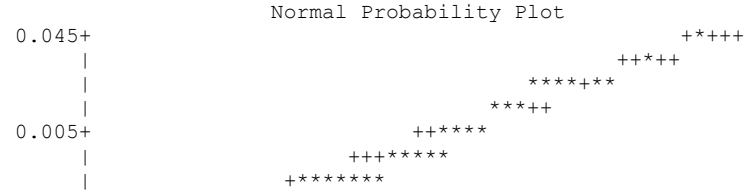
Stem	Leaf	#	Boxplot
4	6	1	
3	09	2	
2	56789	5	
1	1336	4	+-----+
0	036668	6	| + |
-0	75111111	8	*-----*
-1	754331110	9	+-----+
-2	9443110	7	
-3	3	1	

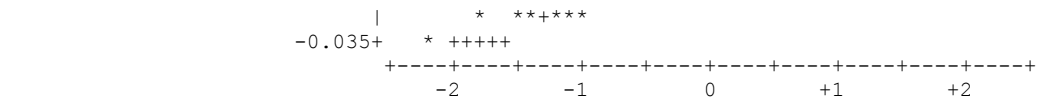
Multiply Stem.Leaf by 10**-2

Check on normality for Ksat

The UNIVARIATE Procedure
Variable: Resid (Residual)

Normal Probability Plot





Check equality of stddev for y= Ksat

Obs	trt	depth	nobs	rawmean_ y	stddev_y	stderr_y	Levene LeveneF_df	P
1	CTRL	1	1	0.080000	.	.	0.612(3,38)	0.6120
3	RSFE	1	12	0.048333	0.024802	.007159792	.	
4	RSFE	2	10	0.038000	0.024404	.007717225	.	
5	STEE	1	12	0.029167	0.021088	.006087535	.	
6	STEE	2	8	0.023750	0.017678	.006250000	.	

Mixed ANOVA for log NO3

The Mixed Procedure

Model Information

Data Set	WORK.DSETZZ
Dependent Variable	tzzNO3
Covariance Structure	Variance Components
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Kenward-Roger
Degrees of Freedom Method	Kenward-Roger

Class Level Information

Class	Levels	Values
trt	3	CTRL RSFE STEE
loc	1	CG
depth	2	1 2
pos	14	1 2 3 4 5 6 7 8 9 10 11 12 13 14
rnd	4	1 2 3 4

Dimensions

Covariance Parameters	5
Columns in X	12
Columns in Z	143
Subjects	1
Max Obs Per Subject	112

Number of Observations

Number of Observations Read	112
Number of Observations Used	77

Number of Observations Not Used 35

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	187.82066099	
1	2	169.54296047	0.00289232
2	1	169.47697439	0.00029318
3	1	169.47085241	0.00000401
4	1	169.47077352	0.00000000

Mixed ANOVA for log NO3

The Mixed Procedure

Convergence criteria met.

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr > Z
loc*rnd	0.08522	0.1899	0.45	0.3268
trt*loc*rnd	0.1929	0.1618	1.19	0.1167
trt*loc*depth*rnd	0	.	.	.
pos(trt*loc*dep*rnd)	0	.	.	.
Residual	0.4414	0.07778	5.67	<.0001

Fit Statistics

-2 Res Log Likelihood	169.5
AIC (smaller is better)	175.5
AICC (smaller is better)	175.8
BIC (smaller is better)	173.6

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trt	2	6.41	34.19	0.0004
depth	1	65.1	0.42	0.5168
trt*depth	2	65.3	2.29	0.1096

Back-transformed (bt) Mean Separation for log NO3

---------- Effect=trt Method=LSD(P<.05) Set=1 ----------

Obs	trt	depth	Estimate	Standard Error	Letter Group	btestimate	btstderr
1	CTRL	_	-0.1144	0.3896	B	0.6919	0.34752
2	RSFE	_	-0.6237	0.2814	B	0.3360	0.15081
3	STEE	_	2.4421	0.3248	A	11.2969	3.73461

---------- Effect=depth Method=LSD(P<.05) Set=2 ----------

Obs	trt	depth	Estimate	Standard Error	Letter Group	btestimate	btstderr
4		1	0.6279	0.2434	A	1.67375	0.45599
5		2	0.5081	0.2432	A	1.46206	0.40428

---------- Effect=trt*depth Method=LSD(P<.05) Set=3 ----------

Obs	trt	depth	Estimate	Standard Error	Letter Group	btestimate	btstderr
6	CTRL	1	-0.06202	0.4427	B	0.7399	0.41604
7	CTRL	2	-0.1667	0.4427	B	0.6464	0.37468
8	RSFE	1	-0.7495	0.2980	B	0.2726	0.14082
9	RSFE	2	-0.4980	0.2980	B	0.4078	0.18109
10	STEE	1	2.6953	0.3633	A	14.6102	5.37997
11	STEE	2	2.1888	0.3519	A	8.7248	3.14024

Check on normality for log NO3

The UNIVARIATE Procedure
Variable: Resid (Residual)

Tests for Normality

Test		--Statistic---	-----p Value------	
Shapiro-Wilk	W	0.90923	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.108119	Pr > D	0.0244
Cramer-von Mises	W-Sq	0.304458	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	1.795973	Pr > A-Sq	<0.0050

Extreme Observations

------Lowest------		-----Highest-----	
Value	Obs	Value	Obs
-2.724882	98	1.03631	87
-1.439597	97	1.08070	42
-1.227825	40	1.24312	50
-0.869805	56	1.58353	86
-0.778962	43	1.67758	48

Missing Values

Missing Value	Count	-----Percent Of----- All Obs	Missing Obs

```
                    .          35       31.25      100.00


                  Stem Leaf                             #             Boxplot
                     1 67                               2                0
                     1 012                              3                0
                     0 5556777                          7                |
                     0 00001111111111111222233333444    28            +--+--+
                    -0 444443333332221111111000000      26            +-----+
                    -0 98765555                         8                |
                    -1 42                               2                0
                    -1
                    -2
                    -2 7                                1                *
                       ----+----+----+----+----+---


                                        The SAS System          09:04 Thursday,
July 8, 2010 118
                                  Check on normality for log NO3

                                    The UNIVARIATE Procedure
                                   Variable:  Resid  (Residual)

                                        Normal Probability Plot
                     1.75+                                                  *   *+
                         |                                              ***+++++++
                         |                                        ++++++*+
                     0.25+                             ***********
                         |                  ************
                         |         *********++
                    -1.25+ ++++*+*+
                         |+
                         |
                    -2.75+ *
                           +----+----+----+----+----+----+----+----+----+----+----+
                               -2        -1         0        +1        +2


                                        The SAS System          09:04 Thursday,
July 8, 2010 119
                                 Check equality of stddev for y=log NO3

                                        rawmean_
Levene
            Obs    trt     depth    nobs        y       stddev_y    stderr_y    LeveneF_df
P

             1     CTRL      1        5      0.01281     0.44413     0.19862
1.757(5,71)    0.1330
             2     CTRL      2        5     -0.09188     0.80020     0.35786
.
             3     RSFE      1       23     -0.74175     0.58930     0.12288
.
             4     RSFE      2       23     -0.49023     0.75019     0.15643
.
             5     STEE      1       11      2.63068     0.80169     0.24172
.
             6     STEE      2       10      2.28398     1.42040     0.44917
.

                                        The SAS System          09:04 Thursday,
July 8, 2010 120
                                    Mixed ANOVA for  TC

                                    The Mixed Procedure
```

Model Information

Data Set	WORK.DSETZZ
Dependent Variable	TC
Covariance Structure	Variance Components
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Kenward-Roger
Degrees of Freedom Method	Kenward-Roger

Class Level Information

Class	Levels	Values
trt	3	CTRL RSFE STEE
loc	1	CG
depth	2	1 2
pos	14	1 2 3 4 5 6 7 8 9 10 11 12 13 14
rnd	4	1 2 3 4

Dimensions

Covariance Parameters	5
Columns in X	12
Columns in Z	143
Subjects	1
Max Obs Per Subject	112

Number of Observations

Number of Observations Read	112
Number of Observations Used	84
Number of Observations Not Used	28

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	721.85718584	
1	4	564.26748039	.
2	1	560.10786749	0.00780880
3	1	558.01363393	0.00351316
4	1	557.08854576	0.00134171
5	1	556.74344194	.

Mixed ANOVA for TC

The Mixed Procedure

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
6	1	555.02667376	0.00400972
7	1	553.90318902	0.00325292
8	1	553.00674387	0.00222729
9	1	552.40999975	0.00113090
10	1	552.11874666	0.00037356
11	1	552.02673977	0.00006836
12	1	552.01095112	0.00000380
13	1	552.01014383	0.00000001

14	1	552.01014078	0.00000000

Convergence criteria met.

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr > Z
loc*rnd	940.98	774.42	1.22	0.1122
trt*loc*rnd	3.1558	10.1180	0.31	0.3776
trt*loc*depth*rnd	7.1955	11.2345	0.64	0.2609
pos(trt*loc*dep*rnd)	44.5836	8.3351	5.35	<.0001
Residual	1.3536	1.3621	0.99	0.1602

Fit Statistics

-2 Res Log Likelihood	552.0
AIC (smaller is better)	562.0
AICC (smaller is better)	562.8
BIC (smaller is better)	558.9

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trt	2	7.02	0.96	0.4288
depth	1	18.3	0.13	0.7221
trt*depth	2	8.79	0.70	0.5237

Mean separation for TC

---------- Effect=trt Method=LSD(P<.05) Set=1 ----------

Obs	trt	depth	Estimate	Standard Error	Letter Group
1	CTRL	_	25.6903	15.7580	A
2	RSFE	_	29.8134	15.4396	A
3	STEE	_	26.7645	15.4406	A

---------- Effect=depth Method=LSD(P<.05) Set=2 ----------

Obs	trt	depth	Estimate	Standard Error	Letter Group
4		1	27.9141	15.4959	A
5		2	26.9313	15.4423	A

---------- Effect=trt*depth Method=LSD(P<.05) Set=3 ----------

Obs	trt	depth	Estimate	Standard Error	Letter Group
6	CTRL	1	24.6455	16.2891	A
7	CTRL	2	26.7351	15.9513	A
8	RSFE	1	29.9894	15.5341	A

9	RSFE	2	29.6374	15.4943	A
10	STEE	1	29.1075	15.5403	A
11	STEE	2	24.4215	15.4945	A

Check on normality for TC

The UNIVARIATE Procedure
Variable: Resid (Residual)

Tests for Normality

Test		--Statistic---	-----p Value------	
Shapiro-Wilk	W	0.863358	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.166909	Pr > D	<0.0100
Cramer-von Mises	W-Sq	0.70319	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	3.808372	Pr > A-Sq	<0.0050

Extreme Observations

------Lowest------		------Highest-----	
Value	Obs	Value	Obs
-1.000113	56	0.421379	48
-0.625516	55	0.446820	45
-0.447327	6	0.605484	41
-0.370392	106	0.820855	104
-0.241477	12	0.965887	42

Missing Values

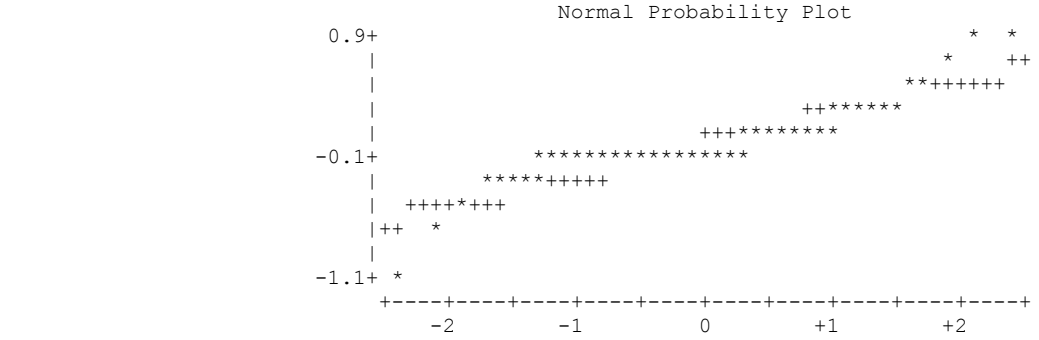
Missing Value	Count	-----Percent Of----- All Obs	Missing Obs
.	28	25.00	100.00

```
                Stem Leaf                                             #
Boxplot
                   8 27                                               2
*
                   6 1                                                1
0
                   4 25                                               2
0
                   2 22234667                                         8
0
                   0 112223355788016689                              18
+--+--+
                  -0 965554433332200999888766655554443333322221100    45
*-----*
                  -2 74430                                           5
|
                  -4 5                                               1
0
                  -6 3                                               1
0
                  -8
                 -10 0                                               1
*
                     ----+----+----+----+----+----+----+----+----+
                  Multiply Stem.Leaf by 10**-1
```

Check on normality for TC

The UNIVARIATE Procedure
Variable: Resid (Residual)

Normal Probability Plot



Check equality of stddev for y= TC

Obs	trt	depth	nobs	rawmean_ y	stddev_y	stderr_y	Levene LeveneF_df	P
1	CTRL	1	3	8.2147	0.6163	0.3558	0.773(5,78)	0.5720
2	CTRL	2	4	25.7555	32.5844	16.2922	.	
3	RSFE	1	18	17.6314	17.5730	4.1420	.	
4	RSFE	2	21	25.6845	26.9906	5.8898	.	
5	STEE	1	17	17.1537	17.7766	4.3115	.	
6	STEE	2	21	23.7408	24.1641	5.2730	.	

Mixed ANOVA for sqrt TN

The Mixed Procedure

Model Information

Data Set	WORK.DSETZZ
Dependent Variable	tzzTN
Covariance Structure	Variance Components
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Kenward-Roger
Degrees of Freedom Method	Kenward-Roger

Class Level Information

Class	Levels	Values

trt	3	CTRL RSFE STEE
loc	1	CG
depth	2	1 2
pos	14	1 2 3 4 5 6 7 8 9 10 11 12 13 14
rnd	4	1 2 3 4

Dimensions

Covariance Parameters	5
Columns in X	12
Columns in Z	143
Subjects	1
Max Obs Per Subject	112

Number of Observations

Number of Observations Read	112
Number of Observations Used	100
Number of Observations Not Used	12

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	320.83309984	
1	4	171.13358697	1.89042221
2	1	169.12877042	0.43674942
3	1	168.10590982	0.15086932
4	1	167.66367820	0.04426817
5	1	167.52790494	0.00711686

Mixed ANOVA for sqrt TN

The Mixed Procedure

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
6	1	167.50716650	0.00027897
7	1	167.50641333	0.00000052
8	1	167.50641196	0.00000000

Convergence criteria met.

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr > Z
loc*rnd	1.5883	1.3154	1.21	0.1136
trt*loc*rnd	0.03018	0.03377	0.89	0.1857
trt*loc*depth*rnd	0	.	.	.
pos(trt*loc*dep*rnd)	0	.	.	.
Residual	0.2413	0.03653	6.61	<.0001

Fit Statistics

-2 Res Log Likelihood	167.5
AIC (smaller is better)	173.5

AICC (smaller is better)	173.8
BIC (smaller is better)	171.7

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trt	2	6.93	46.37	<.0001
depth	1	87.3	0.02	0.8964
trt*depth	2	87.3	0.16	0.8518

Back-transformed (bt) Mean Separation for sqrt TN

---------- Effect=trt Method=LSD(P<.05) Set=1 ----------

Obs	trt	depth	Estimate	Standard Error	Letter Group	btestimate	btstderr
1	CTRL	_	1.6781	0.6595	B	2.81613	2.21349
2	RSFE	_	1.6743	0.6402	B	2.80337	2.14392
3	STEE	_	3.1304	0.6405	A	9.79969	4.01023

---------- Effect=depth Method=LSD(P<.05) Set=2 ----------

Obs	trt	depth	Estimate	Standard Error	Letter Group	btestimate	btstderr
4		1	2.1691	0.6389	A	4.70496	2.77151
5		2	2.1528	0.6389	A	4.63474	2.75075

---------- Effect=trt*depth Method=LSD(P<.05) Set=3 ----------

Obs	trt	depth	Estimate	Standard Error	Letter Group	btestimate	btstderr
6	CTRL	1	1.6299	0.6776	B	2.65655	2.20870
7	CTRL	2	1.7264	0.6776	B	2.98036	2.33943
8	RSFE	1	1.7226	0.6443	B	2.96723	2.21976
9	RSFE	2	1.6261	0.6443	B	2.64416	2.09543
10	STEE	1	3.1548	0.6448	A	9.95287	4.06837
11	STEE	2	3.1061	0.6448	A	9.64770	4.00552

Check on normality for sqrt TN

The UNIVARIATE Procedure
Variable: Resid (Residual)

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.966696	Pr < W	0.0124
Kolmogorov-Smirnov	D	0.09933	Pr > D	0.0164
Cramer-von Mises	W-Sq	0.233787	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	1.273235	Pr > A-Sq	<0.0050

Extreme Observations

------Lowest------		------Highest-----	
Value	Obs	Value	Obs
-1.124714	40	0.946131	45
-1.050627	98	0.977065	48
-0.954426	39	1.194515	36
-0.917527	97	1.261858	35
-0.802293	8	1.404392	68

Missing Values

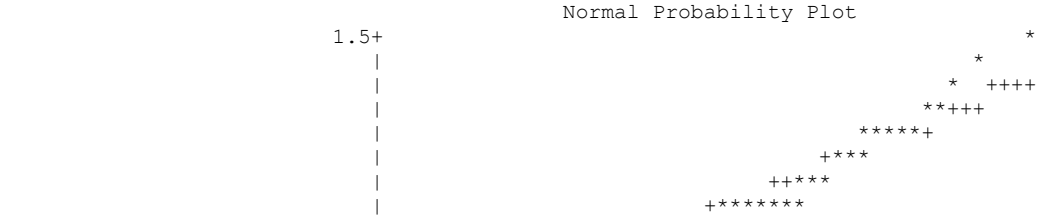
Missing Value	Count	-----Percent Of----- All Obs	Missing Obs
.	12	10.71	100.00

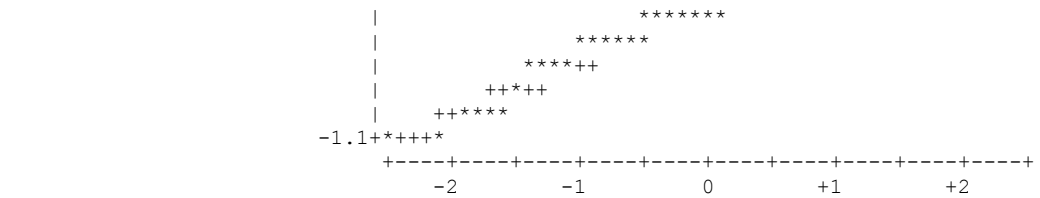
```
Stem Leaf                          #             Boxplot
  14 0                             1                0
  12 6                             1                0
  10 9                             1                0
   8 58                            2                0
   6 568123                        6                |
   4 0334969                       7                |
   2 1145611                       7                |
   0 12223667889001345778         20             +--+--+
  -0 98732100009987776644221      24             *-----*
  -2 8765442866652110             16             +-----+
  -4 61084331                      8                |
  -6 4                             1                |
  -8 5200                          4                0
 -10 25                            2                0
     ----+----+----+----+----
 Multiply Stem.Leaf by 10**-1
```


Check on normality for sqrt TN

The UNIVARIATE Procedure
Variable: Resid (Residual)

Normal Probability Plot





Check equality of stddev for y=sqrt TN

Obs	trt	depth	nobs	rawmean_ y	stddev_y	stderr_y	Levene LeveneF_df	P
1	CTRL	1	5	2.18264	1.22479	0.54774	0.393(5,94)	0.8520
2	CTRL	2	5	2.27911	1.33400	0.59658	.	
3	RSFE	1	23	1.76713	1.35238	0.28199	.	
4	RSFE	2	23	1.67065	1.13829	0.23735	.	
5	STEE	1	22	3.25495	1.24930	0.26635	.	
6	STEE	2	22	3.20621	1.12957	0.24082	.	

Mixed ANOVA for log TP

The Mixed Procedure

Model Information

Data Set	WORK.DSETZZ
Dependent Variable	tzzTP
Covariance Structure	Variance Components
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Kenward-Roger
Degrees of Freedom Method	Kenward-Roger

Class Level Information

Class	Levels	Values
trt	3	CTRL RSFE STEE
loc	1	CG
depth	2	1 2
pos	14	1 2 3 4 5 6 7 8 9 10 11 12 13 14
rnd	4	1 2 3 4

Dimensions

Covariance Parameters	5
Columns in X	12
Columns in Z	143
Subjects	1
Max Obs Per Subject	112

Number of Observations

Number of Observations Read	112
Number of Observations Used	80
Number of Observations Not Used	32

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	244.15667584	
1	4	161.21234245	.
2	3	148.34318585	.
3	2	145.13311750	0.15504668
4	2	144.15050261	0.01365553
5	1	143.08258135	0.00111489

Mixed ANOVA for log TP

The Mixed Procedure

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
6	2	141.13401737	0.00048767
7	2	139.77235587	0.00092832
8	2	138.87547082	8.07864025
9	2	138.42654062	0.14154525
10	2	138.31883652	0.01454140
11	1	138.29980226	0.00085247
12	1	138.29878030	0.00000420
13	1	138.29877546	0.00000000

Convergence criteria met.

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr > Z
loc*rnd	0.7848	0.9683	0.81	0.2088
trt*loc*rnd	1.0454	0.7175	1.46	0.0726
trt*loc*depth*rnd	0.05042	0.07207	0.70	0.2421
pos(trt*loc*dep*rnd)	0.1177	0.09563	1.23	0.1093
Residual	0.08186	0.08755	0.93	0.1749

Fit Statistics

-2 Res Log Likelihood	138.3
AIC (smaller is better)	148.3
AICC (smaller is better)	149.2
BIC (smaller is better)	145.2

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trt	2	5.15	1.08	0.4052

depth	1	8.15	0.15	0.7078
trt*depth	2	5.45	0.16	0.8559

Back-transformed (bt) Mean Separation for log TP

Effect=trt Method=LSD(P<.05) Set=1

Obs	trt	depth	Estimate	Standard Error	Letter Group	btestimate	btstderr
1	CTRL	_	-1.8700	0.8005	A	0.15413	0.12338
2	RSFE	_	-2.7022	0.6942	A	0.06706	0.04655
3	STEE	_	-1.6373	0.6856	A	0.19450	0.13335

Effect=depth Method=LSD(P<.05) Set=2

Obs	trt	depth	Estimate	Standard Error	Letter Group	btestimate	btstderr
4		1	-2.0364	0.5605	A	0.13050	0.073147
5		2	-2.1033	0.5616	A	0.12205	0.068539

Effect=trt*depth Method=LSD(P<.05) Set=3

Obs	trt	depth	Estimate	Standard Error	Letter Group	btestimate	btstderr
6	CTRL	1	-1.8731	0.8251	A	0.15365	0.12678
7	CTRL	2	-1.8669	0.8251	A	0.15460	0.12756
8	RSFE	1	-2.6920	0.6994	A	0.06774	0.04738
9	RSFE	2	-2.7124	0.7096	A	0.06638	0.04710
10	STEE	1	-1.5440	0.6954	A	0.21352	0.14847
11	STEE	2	-1.7306	0.6940	A	0.17718	0.12295

Check on normality for log TP

The UNIVARIATE Procedure
Variable: Resid (Residual)

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.93079	Pr < W	0.0003
Kolmogorov-Smirnov	D	0.147244	Pr > D	<0.0100
Cramer-von Mises	W-Sq	0.313455	Pr > W-Sq	<0.0050

Anderson-Darling A-Sq 1.829352 Pr > A-Sq <0.0050

Extreme Observations

------Lowest------		------Highest-----	
Value	Obs	Value	Obs
-0.559967	30	0.218003	99
-0.486502	54	0.261185	38
-0.415710	53	0.341763	48
-0.281195	105	0.446649	45
-0.239539	35	0.537770	29

Missing Values

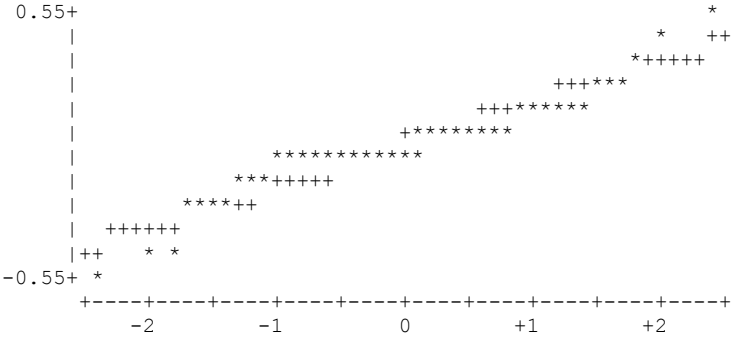
Missing Value	Count	-----Percent Of----- All Obs	Missing Obs
.	32	28.57	100.00

```
Stem Leaf                                #             Boxplot
   5 4                                   1                *
   4 5                                   1                0
   3 4                                   1                0
   2 0026                                4                |
   1 0233445899                          10               |
   0 11122233444555566789                20            +--+--+
  -0 99988887776555444433332222211 00    31            *-----*
  -1 76422                               5                |
  -2 8430                                4                0
  -3
  -4 92                                  2                0
  -5 6                                   1                *
     ----+----+----+----+----+----+-
 Multiply Stem.Leaf by 10**-1
```


Check on normality for log TP

The UNIVARIATE Procedure
Variable: Resid (Residual)

Normal Probability Plot



Check equality of stddev for y=log TP

Obs	trt	depth	nobs	rawmean_y	stddev_y	stderr_y	LeveneF_df	LeveneP
1	CTRL	1	4	-1.60714	1.31343	0.65671	0.559(5,74)	0.7310
2	CTRL	2	4	-1.63265	1.60187	0.80094	.	
3	RSFE	1	18	-2.34131	1.17522	0.27700	.	
4	RSFE	2	17	-2.29328	1.11666	0.27083	.	
5	STEE	1	18	-1.21334	0.76636	0.18063	.	
6	STEE	2	19	-1.44897	1.30051	0.29836	.	

Appendix F: SAS Code – Positional Analysis

Jackson bend - STE

```
*Location     Round Position     Depth Treatment     Ksat     NO3     TC     TN
      TP;
*                   ft           cm/day      ppm_soil      ppm_soil
      ppm_soil      ppm_soil;
data Hill1;
input loc $ rnd pos depth trt $ Ksat NO3 TC TN TP;

datalines;
JB    1     1     1     STEE  .     4.79  15.052      .     0.340
JB    1     2     2     STEE  .     4.58  12.358      .     0.150
JB    1     3     1     STEE  .     4.79  13.723      .     0.160
JB    1     4     2     STEE  .     3.91  6.213  .    0.138
JB    1     5     1     STEE  0.02  4.94  10.287      .     0.198
JB    1     6     2     STEE  .     4.32  12.363      .     0.120
JB    1     7     1     STEE  .     4.09  12.793      .     0.087
JB    1     8     2     STEE  .     4.62  8.108  .    0.298
JB    1     9     1     STEE  .     4.02  11.680      .     0.250
JB    1     10    2     STEE  .     4.40  14.380      .     0.257
JB    1     11    1     STEE  .     4.67  16.648      .     0.212
JB    1     12    2     STEE  .     4.39  7.280  .    0.112
JB    1     13    1     STEE  .     3.96  .      13.43 0.213
JB    1     14    2     STEE  .     3.83  86.267      10.60 0.143
JB    2     1     1     STEE  0.04  1.32  .      21.85 0.165
JB    2     2     2     STEE  0.08  1.41  .      8.64  0.143
JB    2     3     1     STEE  .     3.24  .      16.92 0.179
JB    2     4     2     STEE  0.02  1.35  .      9.86  0.125
JB    2     5     1     STEE  0.02  1.87  .      36.40 0.213
JB    2     6     2     STEE  .     1.68  .      11.63 0.168
JB    2     7     1     STEE  .     2.28  .      17.83 0.237
JB    2     8     2     STEE  0.01  1.60  .      11.65 0.138
JB    2     9     1     STEE  .     5.06  .      13.93 0.292
JB    2     10    2     STEE  0.01  3.76  .      9.58  0.183
JB    2     11    1     STEE  .     .     .      17.84 0.189
JB    2     12    2     STEE  .     2.35  .      7.77  0.219
JB    2     13    1     STEE  .     1.20  .      18.16 0.429
JB    2     14    2     STEE  0.07  0.92  .      5.71  0.176
JB    3     1     1     STEE  0.04  3.92  8.261  2.30  0.055
JB    3     2     2     STEE  .     4.92  5.272  2.61  0.019
JB    3     3     1     STEE  0.04  11.38 9.229  4.55  0.002
JB    3     4     2     STEE  0.04  7.85  8.102  3.42  0.009
JB    3     5     1     STEE  0.04  11.71 7.827  4.84  0.010
JB    3     6     2     STEE  .     6.10  8.680  3.18  0.018
JB    3     7     1     STEE  0.04  2.73  7.410  2.00  .
```

JB	3	8	2	STEE	0.04	1.04	8.155	1.53	0.010	
JB	3	9	1	STEE	0.04	2.45	10.894		1.95	.
JB	3	10	2	STEE	0.04	1.48	9.549	1.67	0.021	
JB	3	11	1	STEE	0.04	7.61	8.525	3.47	.	
JB	3	12	2	STEE	.	6.42	9.414	3.00	.	
JB	3	13	1	STEE	.	5.62	15.293		3.83	1.191
JB	3	14	2	STEE	.	1.04	7.933	1.62	.	
JB	4	1	1	STEE	.	28.80	8.476	7.30	.	
JB	4	2	2	STEE	.	.	10.813		9.27	.
JB	4	3	1	STEE	.	20.37	7.319	5.26	.	
JB	4	4	2	STEE	0.08	26.03	10.235		6.76	.
JB	4	5	1	STEE	.	20.01	8.873	5.17	.	
JB	4	6	2	STEE	0.08	22.55	8.356	5.68	.	
JB	4	7	1	STEE	0.08	.	12.006		8.40	.
JB	4	8	2	STEE	0.04	.	10.815		10.41	.
JB	4	9	1	STEE	.	24.38	10.680		5.95	.
JB	4	10	2	STEE	.	.	9.543	7.74	.	
JB	4	11	1	STEE	.	22.31	10.192		5.47	.
JB	4	12	2	STEE	.	28.18	9.491	6.81	.	
JB	4	13	1	STEE	.	3.57	10.402		1.17	.
JB	4	14	2	STEE	.	0.76	9.440	0.30	.	

;
*Saturated Conductivity
*no transforms;
%mmaov(Hill1, Ksat, class=trt loc depth pos rnd, fixed=trt|pos|loc,
random=rnd*loc rnd*loc*trt rnd*loc*depth*trt pos(rnd*loc*depth*trt),
diagnostics=noinf, sort=yes);

*Natrate-Nitrogen
*no transforms;
%mmaov(Hill1, NO3, class=trt loc depth pos rnd, fixed=trt|pos|loc,
random=rnd*loc rnd*loc*trt rnd*loc*depth*trt pos(rnd*loc*depth*trt),
diagnostics=noinf, sort=yes);

*Total Carbon-Organic Matter
*no transforms;
%mmaov(Hill1, TC, class=trt loc depth pos rnd, fixed=trt|pos|loc,
random=rnd*loc rnd*loc*trt rnd*loc*depth*trt pos(rnd*loc*depth*trt),
diagnostics=noinf, transtype=log, transvalue=0.05, sort=yes);

*Total Nitrogen
*log transforms;
%mmaov(Hill1, TN, class=trt loc depth pos rnd, fixed=trt|pos|loc,

```
random=rnd*loc rnd*loc*trt rnd*loc*depth*trt pos(rnd*loc*depth*trt),
diagnostics=noinf, transtype=log, sort=yes);

*Total Phosphorus
*log transform;
%mmaov(Hill1, TP, class=trt loc depth pos rnd, fixed=trt|pos|loc,
random=rnd*loc rnd*loc*trt rnd*loc*depth*trt pos(rnd*loc*depth*trt),
diagnostics=noinf, transtype=log, transvalue=0.5, sort=yes);

run;
```

Jackson Bend – RSFE

```
*Location     Round Position      Depth Treatment    Ksat    NO3    TC     TN
      TP;
*                   ft            cm/day       ppm_soil     ppm_soil
      ppm_soil      ppm_soil;
data Hill1;
input loc $ rnd pos depth trt $ Ksat NO3 TC TN TP;

datalines;

JB    1     1     1     RSFE .     3.01  86.880       10.58  0.645
JB    1     2     2     RSFE 0.02  2.81  39.867       6.08   0.424
JB    1     3     1     RSFE 0.02  3.03  69.600       7.61   0.402
JB    1     4     2     RSFE .     3.12  53.805       10.41  0.307
JB    1     5     1     RSFE 0.02  3.09  .      12.51 0.462
JB    1     6     2     RSFE 0.01  4.71  88.587       11.29  0.418
JB    1     7     1     RSFE 0.00  3.14  .      15.98 0.440
JB    1     8     2     RSFE 0.08  3.51  69.867       10.90  0.471
JB    1     9     1     RSFE 0.00  4.23  .      13.71 0.642
JB    1     10    2     RSFE 0.01  3.75  65.147       14.51  0.554
JB    1     11    1     RSFE 0.02  3.32  .      9.02  0.662
JB    1     12    2     RSFE 0.01  3.87  51.208       7.36   0.476
JB    1     13    1     RSFE .     8.68  .      28.46 1.012
JB    1     14    2     RSFE .     3.29  .      14.57 0.689
JB    2     1     1     RSFE .     0.00  .      0.00  0.000
JB    2     2     2     RSFE .     6.34  84.635       11.62  .
JB    2     3     1     RSFE 0.08  9.39  53.579       7.82   .
JB    2     4     2     RSFE .     5.54  57.926       7.48   .
JB    2     5     1     RSFE 0.04  5.19  49.528       6.59   .
JB    2     6     2     RSFE .     6.65  58.594       7.76   .
JB    2     7     1     RSFE .     6.58  51.144       6.46   .
JB    2     8     2     RSFE .     5.50  2.445  7.06  .
JB    2     9     1     RSFE .     1.32  .      12.50 .
JB    2     10    2     RSFE .     1.25  60.643       6.45   .
```

```
JB    2    11   1    RSFE .     2.62  68.357       7.34   .
JB    2    12   2    RSFE .     1.75  60.073       7.52   .
JB    2    13   1    RSFE 0.06  19.72 57.489       10.85  .
JB    2    14   2    RSFE .     3.79  58.046       6.10   .
JB    3    1    1    RSFE 0.03  2.15  17.491       2.12   0.515
JB    3    2    2    RSFE 0.01  0.49  8.590  0.74  0.471
JB    3    3    1    RSFE 0.04  0.90  15.586       1.21   0.486
JB    3    4    2    RSFE 0.02  0.45  10.812       0.87   0.424
JB    3    5    1    RSFE .     0.54  12.185       0.81   0.441
JB    3    6    2    RSFE 0.06  0.64  7.486  0.66  0.418
JB    3    7    1    RSFE 0.02  1.09  45.856       9.26   0.430
JB    3    8    2    RSFE .     0.76  40.886       8.80   0.423
JB    3    9    1    RSFE .     0.86  14.877       1.09   0.411
JB    3    10   2    RSFE .     0.64  9.337  0.71  0.507
JB    3    11   1    RSFE 0.02  0.47  41.158       7.66   0.472
JB    3    12   2    RSFE 0.02  0.73  9.380  1.29  0.428
JB    3    13   1    RSFE .     3.18  34.782       7.74   0.462
JB    3    14   2    RSFE .     0.68  26.996       4.68   0.432
JB    4    1    1    RSFE 0.07  2.74  14.170       12.69  .
JB    4    2    2    RSFE .     1.81  14.188       13.03  .
JB    4    3    1    RSFE 0.04  1.71  17.947       10.54  .
JB    4    4    2    RSFE .     0.95  13.918       9.51   .
JB    4    5    1    RSFE 0.08  2.22  11.939       10.97  .
JB    4    6    2    RSFE .     0.74  12.926       9.08   .
JB    4    7    1    RSFE .     .     .       .     .
JB    4    8    2    RSFE .     .     .       .     .
JB    4    9    1    RSFE .     .     .       .     .
JB    4    10   2    RSFE .     .     .       .     .
JB    4    11   1    RSFE .     .     .       .     .
JB    4    12   2    RSFE .     .     .       .     .
JB    4    13   1    RSFE .     .     .       .     .
JB    4    14   2    RSFE .     .     .       .     .

;
%include 'c:\danda.sas';
*Block on rnd

*Saturated Conductivity
*log transform;
%mmaov(Hill1, Ksat, class=trt loc depth pos rnd, fixed=trt|pos|loc,
random=rnd*loc rnd*loc*trt rnd*loc*depth*trt pos(rnd*loc*depth*trt),
diagnostics=noinf, sort=yes);

*Natrate-Nitrogen
*log transform;
```

```
%mmaov(Hill1, NO3, class=trt loc depth pos rnd, fixed=trt|pos|loc,
random=rnd*loc rnd*loc*trt rnd*loc*depth*trt pos(rnd*loc*depth*trt),
diagnostics=noinf, sort=yes);

*Total Carbon-Organic Matter
*no transformations needed with outliers removed;
%mmaov(Hill1, TC, class=trt loc depth pos rnd, fixed=trt|pos|loc,
random=rnd*loc rnd*loc*trt rnd*loc*depth*trt pos(rnd*loc*depth*trt),
diagnostics=noinf, sort=yes);

*Total Nitrogen
*no transforms needed;
%mmaov(Hill1, TN, class=trt loc depth pos rnd, fixed=trt|pos|loc,
random=rnd*loc rnd*loc*trt rnd*loc*depth*trt pos(rnd*loc*depth*trt),
diagnostics=noinf,  sort=yes);


*Total Phosphorus;
%mmaov(Hill1, TP, class=trt loc depth pos rnd, fixed=trt|pos|loc,
random=rnd*loc rnd*loc*trt rnd*loc*depth*trt pos(rnd*loc*depth*trt),
diagnostics=noinf,  sort=yes);

run;
```

Crescent Glen – STE

```
*Location     Round Position      Depth Treatment    Ksat   NO3   TC     TN
      TP;
*                   ft            cm/day      ppm_soil      ppm_soil
      ppm_soil      ppm_soil;
data Hill1;
input loc $ rnd pos depth trt $ Ksat NO3 TC TN TP;

datalines;

CG    1     1     1     STEE 0.06  .     .       23.73 0.605
CG    1     2     2     STEE 0.02  .     70.427        19.36 0.417
CG    1     3     1     STEE 0.01  .     .       27.54 0.362
CG    1     4     2     STEE .     .     75.200        21.71 0.395
CG    1     5     1     STEE 0.02  .     83.760        19.21 0.399
CG    1     6     2     STEE .     .     52.587        19.15 0.449
CG    1     7     1     STEE 0.07  .     .       22.71 0.471
CG    1     8     2     STEE .     17.37 67.733        15.66 0.468
CG    1     9     1     STEE 0.01  .     .       21.43 0.510
CG    1     10    2     STEE .     .     .       29.28 0.497
```

CG	1	11	1	STEE	0.03	.	.	28.12	0.572	
CG	1	12	2	STEE	.	.	59.573		19.46	0.461
CG	1	13	1	STEE	.	1.58	.	11.47	0.564	
CG	1	14	2	STEE	.	1.58	.	15.82	0.503	
CG	2	1	1	STEE	.	.	13.562		11.10	0.133
CG	2	2	2	STEE	.	.	11.911		10.50	0.005
CG	2	3	1	STEE	.	.	13.714		15.67	.
CG	2	4	2	STEE	.	.	10.043		14.25	0.016
CG	2	5	1	STEE	.	22.77	9.238	8.74	.	
CG	2	6	2	STEE	.	14.43	9.650	6.86	.	
CG	2	7	1	STEE	0.01	.	14.883		20.20	0.020
CG	2	8	2	STEE	0.01	.	10.035		19.17	.
CG	2	9	1	STEE	0.01	.	26.777		11.05	.
CG	2	10	2	STEE	.	.	18.497		10.88	0.037
CG	2	11	1	STEE	.	7.71	10.040		5.19	.
CG	2	12	2	STEE	.	1.93	16.585		4.24	.
CG	2	13	1	STEE	.	0.39	8.848	3.13	.	
CG	2	14	2	STEE	.	1.98	10.755		3.74	.
CG	3	1	1	STEE	.	14.08	9.699	4.07	0.342	
CG	3	2	2	STEE	0.01	8.99	12.082		2.81	0.503
CG	3	3	1	STEE	.	.	15.691		7.65	0.217
CG	3	4	2	STEE	.	21.85	8.330	5.49	0.295	
CG	3	5	1	STEE	0.01	25.52	10.040		6.79	0.253
CG	3	6	2	STEE	0.02	20.66	9.855	5.67	0.469	
CG	3	7	1	STEE	.	18.70	9.071	5.11	0.323	
CG	3	8	2	STEE	.	18.43	10.675		5.17	0.323
CG	3	9	1	STEE	0.04	26.47	17.657		6.91	0.269
CG	3	10	2	STEE	0.02	26.76	8.788	6.98	0.319	
CG	3	11	1	STEE	0.04	25.37	9.325	7.27	0.288	
CG	3	12	2	STEE	0.01	.	11.252		15.06	0.476
CG	3	13	1	STEE	.	1.21	8.179	0.99	0.241	
CG	3	14	2	STEE	.	0.39	8.865	0.98	0.491	
CG	4	1	1	STEE	.	7.67	9.067	2.71	0.399	
CG	4	2	2	STEE	0.04	22.84	8.746	5.77	0.378	
CG	4	3	1	STEE	0.04	21.92	13.333		5.57	0.341
CG	4	4	2	STEE	0.06	.	8.665	7.38	0.309	
CG	4	5	1	STEE	.	13.06	8.864	3.80	0.344	
CG	4	6	2	STEE	.	.	8.277	7.19	0.280	
CG	4	7	1	STEE	.	.	.	.	.	
CG	4	8	2	STEE	.	.	.	.	.	
CG	4	9	1	STEE	.	.	.	.	.	
CG	4	10	2	STEE	.	.	.	.	.	
CG	4	11	1	STEE	.	.	.	.	.	
CG	4	12	2	STEE	.	.	.	.	.	
CG	4	13	1	STEE	.	1.66	16.892		1.29	0.466

```
CG    4      14     2      STEE .      0.11   9.646  0.91   0.422

;
%include 'c:\danda.sas';
*Block on rnd

*Saturated Conductivity
*log transform;
%mmaov(Hill1, Ksat, class=trt loc depth pos rnd, fixed=trt|pos|loc,
random=rnd*loc rnd*loc*trt rnd*loc*depth*trt pos(rnd*loc*depth*trt),
diagnostics=noinf, sort=yes);

*Natrate-Nitrogen
*log transform;
%mmaov(Hill1, NO3, class=trt loc depth pos rnd, fixed=trt|pos|loc,
random=rnd*loc rnd*loc*trt rnd*loc*depth*trt pos(rnd*loc*depth*trt),
diagnostics=noinf, sort=yes);

*Total Carbon-Organic Matter
*no transformations needed with outliers removed;
%mmaov(Hill1, TC, class=trt loc depth pos rnd, fixed=trt|pos|loc,
random=rnd*loc rnd*loc*trt rnd*loc*depth*trt pos(rnd*loc*depth*trt),
diagnostics=noinf, sort=yes);

*Total Nitrogen
*no transforms needed;
%mmaov(Hill1, TN, class=trt loc depth pos rnd, fixed=trt|pos|loc,
random=rnd*loc rnd*loc*trt rnd*loc*depth*trt pos(rnd*loc*depth*trt),
diagnostics=noinf,  sort=yes);


*Total Phosphorus;
%mmaov(Hill1, TP, class=trt loc depth pos rnd, fixed=trt|pos|loc,
random=rnd*loc rnd*loc*trt rnd*loc*depth*trt pos(rnd*loc*depth*trt),
diagnostics=noinf,  sort=yes);

run;
```

Crescent Glen – RSFE

```
*Location     Round Position      Depth Treatment    Ksat   NO3   TC     TN
        TP;
*                   ft            cm/day       ppm_soil      ppm_soil
        ppm_soil      ppm_soil;
data Hill1;
```

```
input loc $ rnd pos depth trt $ Ksat NO3 TC TN TP;

datalines;

CG  1  1  1  RSFE .     0.98  .       16.36  0.450
CG  1  2  2  RSFE .     1.07  82.213         11.67  0.387
CG  1  3  1  RSFE .     0.86  .       18.30  0.378
CG  1  4  2  RSFE .     1.44  .       17.98  0.381
CG  1  5  1  RSFE 0.01  0.96  .       17.47  0.393
CG  1  6  2  RSFE .     1.34  72.480         9.14   0.330
CG  1  7  1  RSFE 0.05  0.83  .       13.29  0.377
CG  1  8  2  RSFE 0.01  0.99  .       10.95  0.425
CG  1  9  1  RSFE .     0.90  .       13.64  0.454
CG  1  10 2  RSFE .     0.76  71.787         7.73   0.420
CG  1  11 1  RSFE .     0.74  83.200         12.42  0.371
CG  1  12 2  RSFE .     0.95  76.621         13.31  0.375
CG  1  13 1  RSFE 0.08  0.70  .       12.84  0.396
CG  1  14 2  RSFE .     0.69  74.613         11.25  0.328
CG  2  1  1  RSFE 0.08  0.01  5.703   1.19   0.096
CG  2  2  2  RSFE .     0.14  7.135   1.38   0.086
CG  2  3  1  RSFE 0.06  0.70  28.887         6.12   0.180
CG  2  4  2  RSFE 0.03  0.08  7.817   1.48   0.088
CG  2  5  1  RSFE 0.04  0.05  13.925         1.47   0.055
CG  2  6  2  RSFE .     2.95  26.324         5.80   0.128
CG  2  7  1  RSFE .     0.10  11.685         1.34   0.059
CG  2  8  2  RSFE .     1.84  7.046   2.00   0.046
CG  2  9  1  RSFE 0.06  0.20  14.755         1.42   0.049
CG  2  10 2  RSFE 0.07  0.45  7.455   1.37   0.037
CG  2  11 1  RSFE 0.06  0.24  6.822   1.21   0.022
CG  2  12 2  RSFE .     0.22  7.199   1.39   0.017
CG  2  13 1  RSFE .     0.60  7.617   1.39   0.030
CG  2  14 2  RSFE .     0.11  8.789   1.30   0.018
CG  3  1  1  RSFE .     0.18  9.302   0.95   0.017
CG  3  2  2  RSFE .     0.16  8.826   0.94   .
CG  3  3  1  RSFE 0.07  0.02  21.375         0.95   .
CG  3  4  2  RSFE 0.01  0.02  9.395   0.95   .
CG  3  5  1  RSFE .     0.12  8.935   0.95   .
CG  3  6  2  RSFE 0.01  0.18  9.015   1.05   .
CG  3  7  1  RSFE 0.02  0.06  7.869   0.85   .
CG  3  8  2  RSFE 0.08  0.14  10.064         1.20   .
CG  3  9  1  RSFE 0.00  0.13  20.557         1.01   .
CG  3  10 2  RSFE .     0.08  7.508   0.89   .
CG  3  11 1  RSFE 0.01  0.08  7.998   0.91   .
CG  3  12 2  RSFE 0.05  0.09  8.584   0.93   .
CG  3  13 1  RSFE .     .     .       .      .
```

CG	3	14	2	RSFE	.	.	.	.	.
CG	4	1	1	RSFE	.	0.46	14.4568	0.83	0.0709
CG	4	2	2	RSFE	0.04	0.35	17.6456	0.75	0.0395
CG	4	3	1	RSFE	0.04	0.23	24.2632	0.41	0.0586
CG	4	4	2	RSFE	0.04	0.33	32.7051	0.65	0.0574
CG	4	5	1	RSFE	.	0.16	13.8110	0.36	0.0375
CG	4	6	2	RSFE	0.04	0.40	48.1479	0.61	0.0491
CG	4	7	1	RSFE	.	0.15	8.9500	0.23	0.0210
CG	4	8	2	RSFE	.	0.11	7.7200	0.19	0.0255
CG	4	9	1	RSFE	.	.	.	.	.
CG	4	10	2	RSFE	.	.	.	.	.
CG	4	11	1	RSFE	.	.	.	.	.
CG	4	12	2	RSFE	.	.	.	.	.
CG	4	13	1	RSFE	0.08	0.24	14.8720	0.38	0.0349
CG	4	14	2	RSFE	.	0.20	13.6863	0.34	0.0452

;

*Saturated Conductivity
*no transforms;
%mmaov(Hill1, Ksat, class=trt loc depth pos rnd, fixed=trt|pos|loc,
random=rnd*loc rnd*loc*trt rnd*loc*depth*trt pos(rnd*loc*depth*trt),
diagnostics=noinf, sort=yes);

*Natrate-Nitrogen
*no transforms;
%mmaov(Hill1, NO3, class=trt loc depth pos rnd, fixed=trt|pos|loc,
random=rnd*loc rnd*loc*trt rnd*loc*depth*trt pos(rnd*loc*depth*trt),
diagnostics=noinf, sort=yes);

*Total Carbon-Organic Matter
*no transforms;
%mmaov(Hill1, TC, class=trt loc depth pos rnd, fixed=trt|pos|loc,
random=rnd*loc rnd*loc*trt rnd*loc*depth*trt pos(rnd*loc*depth*trt),
diagnostics=noinf, sort=yes);

*Total Nitrogen
*no transforms;
%mmaov(Hill1, TN, class=trt loc depth pos rnd, fixed=trt|pos|loc,
random=rnd*loc rnd*loc*trt rnd*loc*depth*trt pos(rnd*loc*depth*trt),
diagnostics=noinf, sort=yes);

*Total Phosphorus
*log transform;
%mmaov(Hill1, TP, class=trt loc depth pos rnd, fixed=trt|pos|loc,
random=rnd*loc rnd*loc*trt rnd*loc*depth*trt pos(rnd*loc*depth*trt),

```
diagnostics=noinf,  transtype=log, sort=yes);

run;
```

Appendix G: SAS Output – Positional Analysis

Jackson Bend – STE

Mixed ANOVA for Ksat

The Mixed Procedure

Model Information

Data Set	WORK.DSETZZ
Dependent Variable	Ksat
Covariance Structure	Variance Components
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Kenward-Roger
Degrees of Freedom Method	Kenward-Roger

Class Level Information

Class	Levels	Values
trt	1	STEE
loc	1	JB
depth	2	1 2
pos	14	1 2 3 4 5 6 7 8 9 10 11 12 13 14
rnd	4	1 2 3 4

Dimensions

Covariance Parameters	5
Columns in X	52
Columns in Z	72
Subjects	1
Max Obs Per Subject	56

Number of Observations

Number of Observations Read	56
Number of Observations Used	21
Number of Observations Not Used	35

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	-38.58957579	
1	4	-38.59227620	5.00461406
2	3	-38.59765700	.
3	1	-40.19398690	.
4	1	-41.49819779	.
5	1	-42.32464861	0.03951836

Mixed ANOVA for Ksat

The Mixed Procedure

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion

6	1	-42.76376239	0.00568300
7	1	-42.93406948	0.00056665
8	1	-42.97099566	0.00002558
9	1	-42.97356018	0.00000016
10	1	-42.97357780	0.00000000

Convergence criteria met but final hessian is not positive definite.

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr > Z
loc*rnd	0.000195	0.000393	0.50	0.3103
trt*loc*rnd	0.000195	0	.	.
trt*loc*depth*rnd	0.000018	0.000075	0.25	0.4024
pos(trt*loc*dep*rnd)	0	.	.	.
Residual	0.000125	0.000082	1.53	0.0634

Fit Statistics

-2 Res Log Likelihood	-43.0
AIC (smaller is better)	-35.0
AICC (smaller is better)	-25.0
BIC (smaller is better)	-37.4

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trt	0	.	.	.
pos	11	3.95	3.49	0.1213
trt*pos	0	.	.	.
loc	0	.	.	.
trt*loc	0	.	.	.
loc*pos	0	.	.	.
trt*loc*pos	0	.	.	.

Mean separation for Ksat

---------- Effect=trt Method=' ' Set=1 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
1	STEE	_		0.04907	0.01118	

---------- Effect=pos Method=LSD(P<.05) Set=2 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
2			2	0.09673	0.01685	A
3			14	0.08673	0.01685	A
4			6	0.05505	0.01720	AB
5			1	0.04708	0.01389	B
6			7	0.04704	0.01434	B
7			4	0.04294	0.01272	B
8			3	0.03994	0.01725	B

9		9	0.03994	0.01725	B
10		11	0.03994	0.01725	B
11		5	0.03529	0.01256	B
12		10	0.03189	0.01388	B
13		8	0.02628	0.01272	B

---------- Effect=trt*pos Method=LSD(P<.05) Set=3 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
14	STEE		2	0.09673	0.01685	A
15	STEE		14	0.08673	0.01685	A
16	STEE		6	0.05505	0.01720	AB
17	STEE		1	0.04708	0.01389	B
18	STEE		7	0.04704	0.01434	B
19	STEE		4	0.04294	0.01272	B
20	STEE		3	0.03994	0.01725	B
21	STEE		9	0.03994	0.01725	B
22	STEE		11	0.03994	0.01725	B
23	STEE		5	0.03529	0.01256	B
24	STEE		10	0.03189	0.01388	B
25	STEE		8	0.02628	0.01272	B

---------- Effect=loc Method=' ' Set=4 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
26		JB	_	0.04907	0.01118	

Mean separation for Ksat

---------- Effect=trt*loc Method=' ' Set=5 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
27	STEE	JB	_	0.04907	0.01118	

---------- Effect=loc*pos Method=LSD(P<.05) Set=6 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
28		JB	2	0.09673	0.01685	A
29		JB	14	0.08673	0.01685	A
30		JB	6	0.05505	0.01720	AB
31		JB	1	0.04708	0.01389	B
32		JB	7	0.04704	0.01434	B
33		JB	4	0.04294	0.01272	B
34		JB	3	0.03994	0.01725	B
35		JB	9	0.03994	0.01725	B
36		JB	11	0.03994	0.01725	B
37		JB	5	0.03529	0.01256	B
38		JB	10	0.03189	0.01388	B
39		JB	8	0.02628	0.01272	B

---------- Effect=trt*loc*pos Method=LSD(P<.05) Set=7 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
40	STEE	JB	2	0.09673	0.01685	A
41	STEE	JB	14	0.08673	0.01685	A
42	STEE	JB	6	0.05505	0.01720	AB
43	STEE	JB	1	0.04708	0.01389	B
44	STEE	JB	7	0.04704	0.01434	B
45	STEE	JB	4	0.04294	0.01272	B
46	STEE	JB	3	0.03994	0.01725	B
47	STEE	JB	9	0.03994	0.01725	B
48	STEE	JB	11	0.03994	0.01725	B
49	STEE	JB	5	0.03529	0.01256	B
50	STEE	JB	10	0.03189	0.01388	B
51	STEE	JB	8	0.02628	0.01272	B

Check on normality for Ksat

The UNIVARIATE Procedure
Variable: Resid (Residual)

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.95574	Pr < W	0.4348
Kolmogorov-Smirnov	D	0.18519	Pr > D	0.0591
Cramer-von Mises	W-Sq	0.092705	Pr > W-Sq	0.1350
Anderson-Darling	A-Sq	0.466295	Pr > A-Sq	0.2332

Extreme Observations

-------Lowest-------		-------Highest------	
Value	Obs	Value	Obs
-0.01122486	50	0.00516423	38
-0.00713898	29	0.00709700	49
-0.00709700	35	0.00713898	15
-0.00621846	18	0.01077666	36
-0.00589001	32	0.01210847	46

Missing Values

Missing Value	Count	-----Percent Of----- All Obs	Missing Obs
.	35	62.50	100.00

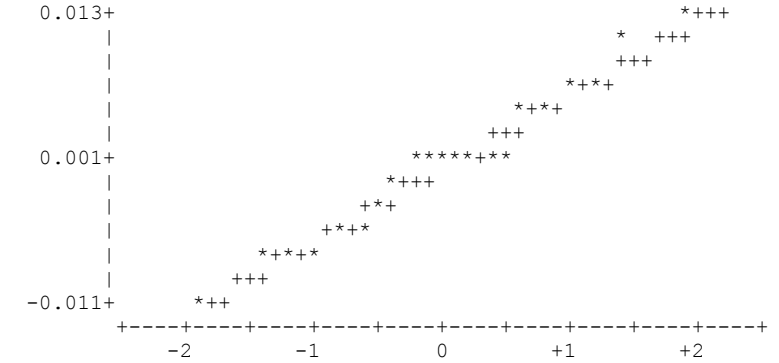
Stem	Leaf	#	Boxplot
12	1	1	
10	8	1	
8			
6	11	2	
4	72	2	+-----+
2			| |
0	0000004	7	*--+--*
-0	1	1	| |
-2	6	1	| |
-4	92	2	+-----+

```
 -6 112                     3               |
 -8                                         |
-10 2                       1               |
    ----+----+----+----+
Multiply Stem.Leaf by 10**-3
```


Check on normality for Ksat

The UNIVARIATE Procedure
Variable: Resid (Residual)

Normal Probability Plot



Check equality of stddev for y= Ksat

Obs	trt	loc	pos	nobs	rawmean_ y	stddev_y	stderr_y	LeveneF_df	Levene P
1	STEE	JB	1	2	0.040000	0.000000	0.000000	2.184(2,6)	0.1940
4	STEE	JB	4	3	0.046667	0.030551	0.017638	.	
5	STEE	JB	5	3	0.026667	0.011547	0.006667	.	
7	STEE	JB	7	2	0.060000	0.028284	0.020000	.	
8	STEE	JB	8	3	0.030000	0.017321	0.010000	.	
10	STEE	JB	10	2	0.025000	0.021213	0.015000	.	

Mixed ANOVA for NO3

The Mixed Procedure

Model Information

Data Set	WORK.DSETZZ
Dependent Variable	NO3
Covariance Structure	Variance Components
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Kenward-Roger
Degrees of Freedom Method	Kenward-Roger

Class Level Information

Class	Levels	Values
trt	1	STEE
loc	1	JB
depth	2	1 2
pos	14	1 2 3 4 5 6 7 8 9 10 11 12 13 14
rnd	4	1 2 3 4

Dimensions

Covariance Parameters	5
Columns in X	60
Columns in Z	72
Subjects	1
Max Obs Per Subject	56

Number of Observations

Number of Observations Read	56
Number of Observations Used	51
Number of Observations Not Used	5

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	278.53811608	
1	3	245.22772929	.
2	2	245.12530395	0.00001288
3	2	245.09105045	.
4	2	245.08887705	0.00000304
5	2	245.08824388	.

Mixed ANOVA for NO3

The Mixed Procedure

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
6	2	245.08665975	0.00000100
7	2	245.08654420	.
8	2	245.08653888	0.00000000

Convergence criteria met but final hessian is not positive definite.

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr > Z
loc*rnd	57.9398	48.9988	1.18	0.1185
trt*loc*rnd	0	.	.	.
trt*loc*depth*rnd	0	.	.	.
pos(trt*loc*dep*rnd)	8.5145	4.9242	1.73	0.0419
Residual	11.7777	0	.	.

Fit Statistics

-2 Res Log Likelihood	245.1
AIC (smaller is better)	251.1
AICC (smaller is better)	251.8
BIC (smaller is better)	249.2

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trt	0	.	.	.
pos	13	34	1.30	0.2592
trt*pos	0	.	.	.
loc	0	.	.	.
trt*loc	0	.	.	.
loc*pos	0	.	.	.
trt*loc*pos	0	.	.	.

Mean separation for NO3

---------- Effect=trt Method=' ' Set=1 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
1	STEE		_	7.7949	3.8604	

---------- Effect=pos Method=LSD(P<.05) Set=2 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
2			12	10.3350	4.4224	A
3			3	9.9450	4.4224	AB
4			4	9.7850	4.4224	AB
5			11	9.7488	4.6246	AB
6			1	9.7075	4.4224	AB
7			5	9.6325	4.4224	AB
8			9	8.9775	4.4224	AB
9			6	8.6625	4.4224	AB
10			2	7.3384	4.6285	ABC
11			10	6.9151	4.6285	ABC
12			7	6.7351	4.6285	ABC
13			8	6.1217	4.6285	ABC
14			13	3.5875	4.4224	BC
15			14	1.6375	4.4224	C

---------- Effect=trt*pos Method=LSD(P<.05) Set=3 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
16	STEE		12	10.3350	4.4224	A
17	STEE		3	9.9450	4.4224	AB
18	STEE		4	9.7850	4.4224	AB
19	STEE		11	9.7488	4.6246	AB
20	STEE		1	9.7075	4.4224	AB
21	STEE		5	9.6325	4.4224	AB
22	STEE		9	8.9775	4.4224	AB

23	STEE	6	8.6625	4.4224	AB
24	STEE	2	7.3384	4.6285	ABC
25	STEE	10	6.9151	4.6285	ABC
26	STEE	7	6.7351	4.6285	ABC
27	STEE	8	6.1217	4.6285	ABC
28	STEE	13	3.5875	4.4224	BC
29	STEE	14	1.6375	4.4224	C

Mean separation for NO3

---------- Effect=loc Method=' ' Set=4 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
30		JB	_	7.7949	3.8604	

---------- Effect=trt*loc Method=' ' Set=5 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
31	STEE	JB	_	7.7949	3.8604	

---------- Effect=loc*pos Method=LSD(P<.05) Set=6 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
32		JB	12	10.3350	4.4224	A
33		JB	3	9.9450	4.4224	AB
34		JB	4	9.7850	4.4224	AB
35		JB	11	9.7488	4.6246	AB
36		JB	1	9.7075	4.4224	AB
37		JB	5	9.6325	4.4224	AB
38		JB	9	8.9775	4.4224	AB
39		JB	6	8.6625	4.4224	AB
40		JB	2	7.3384	4.6285	ABC
41		JB	10	6.9151	4.6285	ABC
42		JB	7	6.7351	4.6285	ABC
43		JB	8	6.1217	4.6285	ABC
44		JB	13	3.5875	4.4224	BC
45		JB	14	1.6375	4.4224	C

---------- Effect=trt*loc*pos Method=LSD(P<.05) Set=7 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
46	STEE	JB	12	10.3350	4.4224	A
47	STEE	JB	3	9.9450	4.4224	AB
48	STEE	JB	4	9.7850	4.4224	AB
49	STEE	JB	11	9.7488	4.6246	AB
50	STEE	JB	1	9.7075	4.4224	AB
51	STEE	JB	5	9.6325	4.4224	AB
52	STEE	JB	9	8.9775	4.4224	AB
53	STEE	JB	6	8.6625	4.4224	AB
54	STEE	JB	2	7.3384	4.6285	ABC
55	STEE	JB	10	6.9151	4.6285	ABC

Mean separation for NO3

---------- Effect=trt*loc*pos Method=LSD(P<.05) Set=7 ----------

(continued)

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
56	STEE	JB	7	6.7351	4.6285	ABC
57	STEE	JB	8	6.1217	4.6285	ABC
58	STEE	JB	13	3.5875	4.4224	BC
59	STEE	JB	14	1.6375	4.4224	C

Check on normality for NO3

The UNIVARIATE Procedure
Variable: Resid (Residual)

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.929954	Pr < W	0.0050
Kolmogorov-Smirnov	D	0.124517	Pr > D	0.0467
Cramer-von Mises	W-Sq	0.10775	Pr > W-Sq	0.0891
Anderson-Darling	A-Sq	0.877154	Pr > A-Sq	0.0234

Extreme Observations

------Lowest-----		-----Highest-----	
Value	Obs	Value	Obs
-6.95479	56	2.68509	28
-6.45565	55	2.98316	46
-2.37869	37	3.20660	14
-1.94919	29	3.91181	54
-1.79417	18	4.63586	43

Missing Values

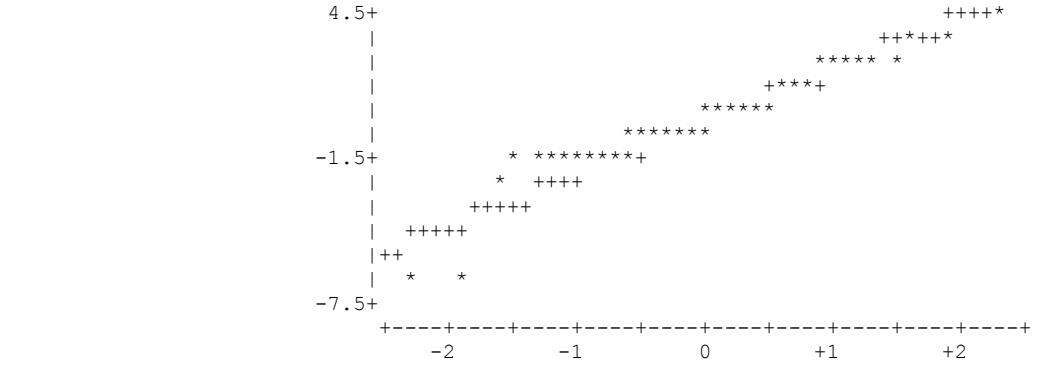
Missing Value	Count	-----Percent Of----- All Obs	Missing Obs
.	5	8.93	100.00

Stem	Leaf	#	Boxplot
4	6	1	
3	029	3	
2	225667	6	
1	11367	5	
0	0233455588	10	
-0	99998864431	11	
-1	988755554100	12	
-2	4	1	
-3			
-4			
-5			
-6	5	1	0
-7	0	1	0

Check on normality for NO3

The UNIVARIATE Procedure
Variable: Resid (Residual)

Normal Probability Plot



Check equality of stddev for y= NO3

Obs	trt	loc	pos	nobs	rawmean_ y	stddev_y	stderr_y	Levene LeveneF_df	P
1	STEE	JB	1	4	9.7075	12.8134	6.40671	1.052(13,37)	0.4270
2	STEE	JB	2	3	3.6367	1.9358	1.11765	.	
3	STEE	JB	3	4	9.9450	7.7947	3.89734	.	
4	STEE	JB	4	4	9.7850	11.1551	5.57755	.	
5	STEE	JB	5	4	9.6325	8.0475	4.02373	.	
6	STEE	JB	6	4	8.6625	9.4347	4.71736	.	
7	STEE	JB	7	3	3.0333	0.9424	0.54407	.	
8	STEE	JB	8	3	2.4200	1.9257	1.11182	.	
9	STEE	JB	9	4	8.9775	10.3242	5.16211	.	
10	STEE	JB	10	3	3.2133	1.5348	0.88614	.	
11	STEE	JB	11	3	11.5300	9.4508	5.45641	.	
12	STEE	JB	12	4	10.3350	12.0121	6.00607	.	
13	STEE	JB	13	4	3.5875	1.8230	0.91151	.	
14	STEE	JB	14	4	1.6375	1.4662	0.73308	.	

July 7, 2010 1911

Mixed ANOVA for log TC

The Mixed Procedure

Model Information

Data Set	WORK.DSETZZ
Dependent Variable	tzzTC
Covariance Structure	Variance Components
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Kenward-Roger
Degrees of Freedom Method	Kenward-Roger

Class Level Information

Class	Levels	Values
trt	1	STEE
loc	1	JB
depth	2	1 2
pos	14	1 2 3 4 5 6 7 8 9 10 11 12 13 14
rnd	4	1 2 3 4

Dimensions

Covariance Parameters	5
Columns in X	60
Columns in Z	72
Subjects	1
Max Obs Per Subject	56

Number of Observations

Number of Observations Read	56
Number of Observations Used	41
Number of Observations Not Used	15

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	47.74793859	
1	4	44.72157360	.
2	2	44.69485161	0.22054938
3	1	44.68293050	0.00584655
4	1	44.68251546	0.00000880
5	1	44.68251481	0.00000000

July 7, 2010 1912

Mixed ANOVA for log TC

The Mixed Procedure

Convergence criteria met but final hessian is not positive definite.

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr > Z

loc*rnd	0.02409	0.05290	0.46	0.3244
trt*loc*rnd	0.01663	0	.	.
trt*loc*depth*rnd	0	.	.	.
pos(trt*loc*dep*rnd)	0	.	.	.
Residual	0.1574	0.04455	3.53	0.0002

Fit Statistics

-2 Res Log Likelihood	44.7
AIC (smaller is better)	50.7
AICC (smaller is better)	51.7
BIC (smaller is better)	48.8

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trt	0	.	.	.
pos	13	25	0.86	0.6012
trt*pos	0	.	.	.
loc	0	.	.	.
trt*loc	0	.	.	.
loc*pos	0	.	.	.
trt*loc*pos	0	.	.	.

Back-transformed (bt) Mean Separation for log TC

Effect=trt Method=' ' Set=1

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group	btestimate	btstderr
1	STEE	_		2.3479	0.1322		10.4138	1.38300

Effect=pos Method=LSD(P<.05) Set=2

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group	btestimate	btstderr
2			14	2.9285	0.2570	A	18.6501	4.80582
3			13	2.6384	0.3080	AB	13.9403	4.30840
4			11	2.4302	0.2570	AB	11.3113	2.91979
5			9	2.4093	0.2570	AB	11.0765	2.85945
6			10	2.3973	0.2570	AB	10.9438	2.82536
7			7	2.3506	0.2570	AB	10.4423	2.69646
8			1	2.3252	0.2570	AB	10.1785	2.62866
9			3	2.2826	0.2570	AB	9.7520	2.51905
10			6	2.2715	0.2570	AB	9.6438	2.49125

11		8	2.1964	0.2570	B	8.9428	2.31111
12		5	2.1961	0.2570	B	8.9399	2.31036
13		2	2.1919	0.2570	B	8.9018	2.30056
14		12	2.1650	0.2570	B	8.6648	2.23966
15		4	2.0879	0.2570	B	8.0177	2.07336

---------- Effect=trt*pos Method=LSD(P<.05) Set=3 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group	btestimate	btstderr
16	STEE		14	2.9285	0.2570	A	18.6501	4.80582
17	STEE		13	2.6384	0.3080	AB	13.9403	4.30840
18	STEE		11	2.4302	0.2570	AB	11.3113	2.91979
19	STEE		9	2.4093	0.2570	AB	11.0765	2.85945
20	STEE		10	2.3973	0.2570	AB	10.9438	2.82536
21	STEE		7	2.3506	0.2570	AB	10.4423	2.69646
22	STEE		1	2.3252	0.2570	AB	10.1785	2.62866
23	STEE		3	2.2826	0.2570	AB	9.7520	2.51905
24	STEE		6	2.2715	0.2570	AB	9.6438	2.49125
25	STEE		8	2.1964	0.2570	B	8.9428	2.31111
26	STEE		5	2.1961	0.2570	B	8.9399	2.31036
27	STEE		2	2.1919	0.2570	B	8.9018	2.30056
28	STEE		12	2.1650	0.2570	B	8.6648	2.23966
29	STEE		4	2.0879	0.2570	B	8.0177	2.07336

Back-transformed (bt) Mean Separation for log TC

---------- Effect=loc Method=' ' Set=4 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group	btestimate	btstderr
30		JB	_	2.3479	0.1322		10.4138	1.38300

---------- Effect=trt*loc Method=' ' Set=5 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group	btestimate	btstderr

31	STEE	JB	_	2.3479	0.1322		10.4138	1.38300

---------- Effect=loc*pos Method=LSD(P<.05) Set=6 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group	btestimate	btstderr
32		JB	14	2.9285	0.2570	A	18.6501	4.80582
33		JB	13	2.6384	0.3080	AB	13.9403	4.30840
34		JB	11	2.4302	0.2570	AB	11.3113	2.91979
35		JB	9	2.4093	0.2570	AB	11.0765	2.85945
36		JB	10	2.3973	0.2570	AB	10.9438	2.82536
37		JB	7	2.3506	0.2570	AB	10.4423	2.69646
38		JB	1	2.3252	0.2570	AB	10.1785	2.62866
39		JB	3	2.2826	0.2570	AB	9.7520	2.51905
40		JB	6	2.2715	0.2570	AB	9.6438	2.49125
41		JB	8	2.1964	0.2570	B	8.9428	2.31111
42		JB	5	2.1961	0.2570	B	8.9399	2.31036
43		JB	2	2.1919	0.2570	B	8.9018	2.30056
44		JB	12	2.1650	0.2570	B	8.6648	2.23966
45		JB	4	2.0879	0.2570	B	8.0177	2.07336

---------- Effect=trt*loc*pos Method=LSD(P<.05) Set=7 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group	btestimate	btstderr
46	STEE	JB	14	2.9285	0.2570	A	18.6501	4.80582
47	STEE	JB	13	2.6384	0.3080	AB	13.9403	4.30840
48	STEE	JB	11	2.4302	0.2570	AB	11.3113	2.91979
49	STEE	JB	9	2.4093	0.2570	AB	11.0765	2.85945
50	STEE	JB	10	2.3973	0.2570	AB	10.9438	2.82536
51	STEE	JB	7	2.3506	0.2570	AB	10.4423	2.69646
52	STEE	JB	1	2.3252	0.2570	AB	10.1785	2.62866
53	STEE	JB	3	2.2826	0.2570	AB	9.7520	2.51905
54	STEE	JB	6	2.2715	0.2570	AB	9.6438	2.49125
55	STEE	JB	8	2.1964	0.2570	B	8.9428	2.31111

Back-transformed (bt) Mean Separation for log TC

Effect=trt*loc*pos Method=LSD(P<.05) Set=7

(continued)

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group	btestimate	btstderr
56	STEE	JB	5	2.1961	0.2570	B	8.93991	2.31036
57	STEE	JB	2	2.1919	0.2570	B	8.90177	2.30056
58	STEE	JB	12	2.1650	0.2570	B	8.66480	2.23966
59	STEE	JB	4	2.0879	0.2570	B	8.01771	2.07336

Check on normality for log TC

The UNIVARIATE Procedure
Variable: Resid (Residual)

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.850319	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.166009	Pr > D	<0.0100
Cramer-von Mises	W-Sq	0.1958	Pr > W-Sq	0.0056
Anderson-Darling	A-Sq	1.363296	Pr > A-Sq	<0.0050

Extreme Observations

------Lowest------		------Highest-----	
Value	Obs	Value	Obs
-0.708385	42	0.235120	41
-0.621834	56	0.245571	50
-0.452491	4	0.249965	44
-0.377175	30	0.299271	46
-0.372328	12	1.330219	14

Missing Values

Missing Value	Count	-----Percent Of----- All Obs	Missing Obs
.	15	26.79	100.00

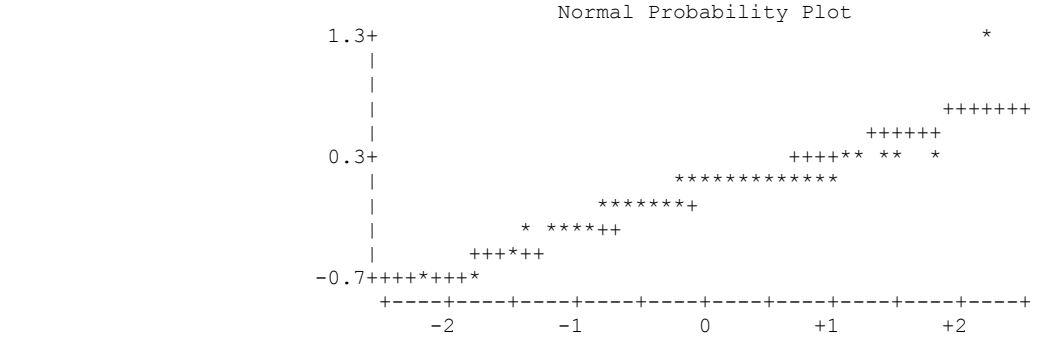
Stem	Leaf	#	Boxplot
12	3	1	*
10			
8			
6			
4			
2	034550	6	|
0	01124555793345599	17	+--+--+

```
  -0 54398665                 8             +-----+
  -2 870430                   6                |
  -4 5                        1                |
  -6 12                       2                0
     ----+----+----+----+
 Multiply Stem.Leaf by 10**-1
```


Check on normality for log TC

The UNIVARIATE Procedure
Variable: Resid (Residual)

Normal Probability Plot



Check equality of stddev for y=log TC

Obs	trt	loc	pos	nobs	rawmean_ y	stddev_y	stderr_y	Levene LeveneF_df	P
1	STEE	JB	1	3	2.32518	0.33769	0.19497	3.617(12,26)	0.0030
2	STEE	JB	2	3	2.19185	0.45522	0.26282	.	
3	STEE	JB	3	3	2.28258	0.31630	0.18261	.	
4	STEE	JB	4	3	2.08787	0.24818	0.14328	.	
5	STEE	JB	5	3	2.19610	0.13605	0.07855	.	
6	STEE	JB	6	3	2.27149	0.21497	0.12411	.	
7	STEE	JB	7	3	2.35064	0.29707	0.17152	.	
8	STEE	JB	8	3	2.19643	0.16381	0.09457	.	
9	STEE	JB	9	3	2.40933	0.04680	0.02702	.	
10	STEE	JB	10	3	2.39733	0.23554	0.13599	.	
11	STEE	JB	11	3	2.43021	0.34511	0.19925	.	
12	STEE	JB	12	3	2.16502	0.14992	0.08656	.	
13	STEE	JB	13	2	2.53873	0.27143	0.19193	.	
14	STEE	JB	14	3	2.92853	1.32740	0.76638		

.

Mixed ANOVA for log TN

The Mixed Procedure

Model Information

Data Set	WORK.DSETZZ
Dependent Variable	tzzTN
Covariance Structure	Variance Components
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Kenward-Roger
Degrees of Freedom Method	Kenward-Roger

Class Level Information

Class	Levels	Values
trt	1	STEE
loc	1	JB
depth	2	1 2
pos	14	1 2 3 4 5 6 7 8 9 10 11 12 13 14
rnd	4	1 2 3 4

Dimensions

Covariance Parameters	5
Columns in X	60
Columns in Z	72
Subjects	1
Max Obs Per Subject	56

Number of Observations

Number of Observations Read	56
Number of Observations Used	44
Number of Observations Not Used	12

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	102.65549854	
1	4	81.13023069	.
2	1	79.81188580	0.56291712
3	1	79.02365490	0.09189790
4	1	78.67956715	0.01131150
5	1	78.58141486	0.00080924

Mixed ANOVA for log TN

The Mixed Procedure

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
6	1	78.56900850	0.00001556

7	1	78.56870804	0.00000001
8	1	78.56870781	0.00000000

Convergence criteria met but final hessian is not positive definite.

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr > Z
loc*rnd	0.5641	0.8345	0.68	0.2495
trt*loc*rnd	0.3482	0	.	.
trt*loc*depth*rnd	0.02448	0.07242	0.34	0.3677
pos(trt*loc*dep*rnd)	0	.	.	.
Residual	0.3370	0.09624	3.50	0.0002

Fit Statistics

-2 Res Log Likelihood	78.6
AIC (smaller is better)	86.6
AICC (smaller is better)	88.2
BIC (smaller is better)	84.1

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trt	0	.	.	.
pos	13	18.6	1.37	0.2599
trt*pos	0	.	.	.
loc	0	.	.	.
trt*loc	0	.	.	.
loc*pos	0	.	.	.
trt*loc*pos	0	.	.	.

Back-transformed (bt) Mean Separation for log TN

---------- Effect=trt Method=' ' Set=1 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group	btestimate	btstderr
1	STEE	_		2.0558	0.4997		7.81322	3.90401

---------- Effect=pos Method=LSD(P<.05) Set=2 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group	btestimate	btstderr
2			5	2.5972	0.6027	A	13.4256	8.09183
3			3	2.3270	0.6027	A	10.2468	6.17590
4			1	2.2940	0.6027	A	9.9149	5.97588

5		11	2.2673	0.6027	A	9.6536	5.81842
6		7	2.2265	0.6027	A	9.2670	5.58541
7		4	2.1505	0.6027	A	8.5890	5.17676
8		6	2.1232	0.6027	A	8.3582	5.03763
9		2	2.1216	0.6027	A	8.3446	5.02944
10		8	2.0819	0.6027	A	8.0196	4.83353
11		12	2.0299	0.6027	A	7.6130	4.58851
12		9	2.0208	0.6027	A	7.5443	4.54711
13		10	1.9471	0.6027	A	7.0081	4.22392
14		13	1.7491	0.5643	A	5.7497	3.24447
15		14	0.8454	0.5643	B	2.3289	1.31415

---------- Effect=trt*pos Method=LSD(P<.05) Set=3 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group	btestimate	btstderr
16	STEE		5	2.5972	0.6027	A	13.4256	8.09183
17	STEE		3	2.3270	0.6027	A	10.2468	6.17590
18	STEE		1	2.2940	0.6027	A	9.9149	5.97588
19	STEE		11	2.2673	0.6027	A	9.6536	5.81842
20	STEE		7	2.2265	0.6027	A	9.2670	5.58541
21	STEE		4	2.1505	0.6027	A	8.5890	5.17676
22	STEE		6	2.1232	0.6027	A	8.3582	5.03763
23	STEE		2	2.1216	0.6027	A	8.3446	5.02944
24	STEE		8	2.0819	0.6027	A	8.0196	4.83353
25	STEE		12	2.0299	0.6027	A	7.6130	4.58851
26	STEE		9	2.0208	0.6027	A	7.5443	4.54711
27	STEE		10	1.9471	0.6027	A	7.0081	4.22392
28	STEE		13	1.7491	0.5643	A	5.7497	3.24447
29	STEE		14	0.8454	0.5643	B	2.3289	1.31415

Back-transformed (bt) Mean Separation for log TN

---------- Effect=loc Method=' ' Set=4 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group	btestimate

btstderr

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group	btestimate	btstderr
30	JB	_	2.0558	0.4997			7.81322	3.90401

---------- Effect=trt*loc Method=' ' Set=5 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group	btestimate	btstderr
31	STEE	JB	_	2.0558	0.4997		7.81322	3.90401

---------- Effect=loc*pos Method=LSD(P<.05) Set=6 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group	btestimate	btstderr
32		JB	5	2.5972	0.6027	A	13.4256	8.09183
33		JB	3	2.3270	0.6027	A	10.2468	6.17590
34		JB	1	2.2940	0.6027	A	9.9149	5.97588
35		JB	11	2.2673	0.6027	A	9.6536	5.81842
36		JB	7	2.2265	0.6027	A	9.2670	5.58541
37		JB	4	2.1505	0.6027	A	8.5890	5.17676
38		JB	6	2.1232	0.6027	A	8.3582	5.03763
39		JB	2	2.1216	0.6027	A	8.3446	5.02944
40		JB	8	2.0819	0.6027	A	8.0196	4.83353
41		JB	12	2.0299	0.6027	A	7.6130	4.58851
42		JB	9	2.0208	0.6027	A	7.5443	4.54711
43		JB	10	1.9471	0.6027	A	7.0081	4.22392
44		JB	13	1.7491	0.5643	A	5.7497	3.24447
45		JB	14	0.8454	0.5643	B	2.3289	1.31415

---------- Effect=trt*loc*pos Method=LSD(P<.05) Set=7 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group	btestimate	btstderr
46	STEE	JB	5	2.5972	0.6027	A	13.4256	8.09183
47	STEE	JB	3	2.3270	0.6027	A	10.2468	6.17590
48	STEE	JB	1	2.2940	0.6027	A	9.9149	5.97588
49	STEE	JB	11	2.2673	0.6027	A	9.6536	5.81842

50	STEE	JB	7	2.2265	0.6027	A	9.2670	5.58541
51	STEE	JB	4	2.1505	0.6027	A	8.5890	5.17676
52	STEE	JB	6	2.1232	0.6027	A	8.3582	5.03763
53	STEE	JB	2	2.1216	0.6027	A	8.3446	5.02944
54	STEE	JB	8	2.0819	0.6027	A	8.0196	4.83353
55	STEE	JB	12	2.0299	0.6027	A	7.6130	4.58851

Back-transformed (bt) Mean Separation for log TN

---------- Effect=trt*loc*pos Method=LSD(P<.05) Set=7 ----------

(continued)

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group	btestimate	btstderr
56	STEE	JB	9	2.0208	0.6027	A	7.54434	4.54711
57	STEE	JB	10	1.9471	0.6027	A	7.00812	4.22392
58	STEE	JB	13	1.7491	0.5643	A	5.74969	3.24447
59	STEE	JB	14	0.8454	0.5643	B	2.32887	1.31415

Check on normality for log TN

The UNIVARIATE Procedure
Variable: Resid (Residual)

Tests for Normality

Test		--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.922993	Pr < W	0.0060
Kolmogorov-Smirnov	D	0.123663	Pr > D	0.0895
Cramer-von Mises	W-Sq	0.080162	Pr > W-Sq	0.2084
Anderson-Darling	A-Sq	0.629511	Pr > A-Sq	0.0959

Extreme Observations

------Lowest------		------Highest-----	
Value	Obs	Value	Obs
-1.630451	56	0.524073	44
-1.072020	55	0.555614	27
-0.613545	36	0.645188	41
-0.481847	35	0.679788	50
-0.434167	47	0.680114	42

Missing Values

Missing Value	Count	-----Percent Of----- All Obs	Missing Obs

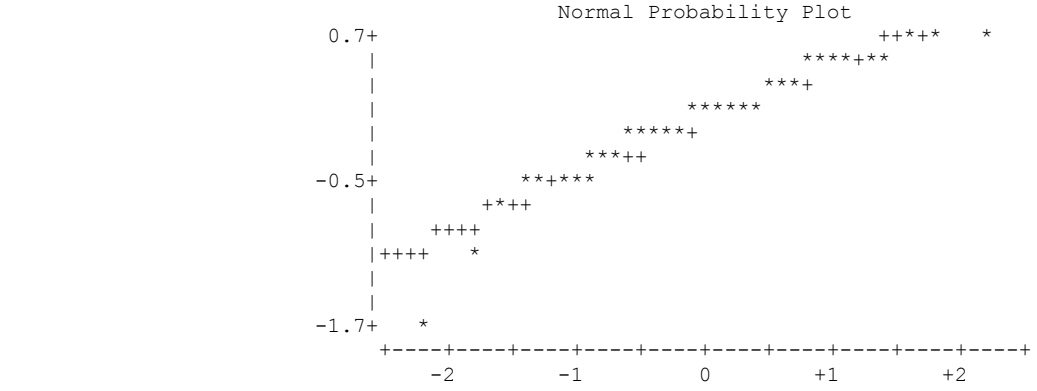
```
                .          12       21.43      100.00


 Stem Leaf                     #             Boxplot
    6 588                      3                |
    4 0269226                  7                |
    2 01481                    5             +------+
    0 2233368128              10             *--+--*
   -0 53321975                 8             |     |
   -2 900                      3             +------+
   -4 83210                    5                |
   -6 1                        1                |
   -8
  -10 7                        1                0
  -12
  -14
  -16 3                        1                0
      ----+----+----+----+
  Multiply Stem.Leaf by 10**-1
```


Check on normality for log TN

The UNIVARIATE Procedure
Variable: Resid (Residual)

Normal Probability Plot



Check equality of stddev for y=log TN

Obs	trt	loc	pos	nobs	rawmean_ y	stddev_y	stderr_y	Levene LeveneF_df	P
1	STEE	JB	1	3	1.96833	1.12577	0.64997	1.153(13,30)	0.3580
2	STEE	JB	2	3	1.78085	0.71231	0.41125	.	
3	STEE	JB	3	3	2.00125	0.72007	0.41574	.	
4	STEE	JB	4	3	1.80972	0.53664	0.30983	.	
5	STEE	JB	5	3	2.27145	1.14633	0.66183	.	
6	STEE	JB	6	3	1.78247	0.64955	0.37502	.	

7	STEE	JB	7	3	1.90075	1.11147	0.64171
8	STEE	JB	8	3	1.74111	1.14094	0.65872
9	STEE	JB	9	3	1.69509	0.98608	0.56931
10	STEE	JB	10	3	1.60630	0.95296	0.55019
11	STEE	JB	11	3	1.94163	0.84512	0.48793
12	STEE	JB	12	3	1.68909	0.51560	0.29768
13	STEE	JB	13	4	1.74915	1.25729	0.62865
14	STEE	JB	14	4	0.84538	1.57401	0.78701

Mixed ANOVA for log TP

The Mixed Procedure

Model Information

Data Set	WORK.DSETZZ
Dependent Variable	tzzTP
Covariance Structure	Variance Components
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Kenward-Roger
Degrees of Freedom Method	Kenward-Roger

Class Level Information

Class	Levels	Values
trt	1	STEE
loc	1	JB
depth	2	1 2
pos	14	1 2 3 4 5 6 7 8 9 10 11 12 13 14
rnd	4	1 2 3 4

Dimensions

Covariance Parameters	5
Columns in X	60
Columns in Z	72
Subjects	1
Max Obs Per Subject	56

Number of Observations

Number of Observations Read	56
Number of Observations Used	37
Number of Observations Not Used	19

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	4.54938340	
1	4	4.09199635	0.91913210
2	3	4.04869550	.

	3	1	3.99401390	.
	4	1	3.98569764	0.00076412
	5	1	3.98548271	0.00000063

Mixed ANOVA for log TP

The Mixed Procedure

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
6	1	3.98548252	0.00000000

Convergence criteria met but final hessian is not positive definite.

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr > Z
loc*rnd	0.002220	0.008590	0.26	0.3980
trt*loc*rnd	0.002144	0	.	.
trt*loc*depth*rnd	0	.	.	.
pos(trt*loc*dep*rnd)	0	.	.	.
Residual	0.03615	0.01128	3.20	0.0007

Fit Statistics

-2 Res Log Likelihood	4.0
AIC (smaller is better)	10.0
AICC (smaller is better)	11.2
BIC (smaller is better)	8.1

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trt	0	.	.	.
pos	13	20.7	1.66	0.1458
trt*pos	0	.	.	.
loc	0	.	.	.
trt*loc	0	.	.	.
loc*pos	0	.	.	.
trt*loc*pos	0	.	.	.

Back-transformed (bt) Mean Separation for log TP

---------- Effect=trt Method=' ' Set=1 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group	btestimate	btstderr
1	STEE		_	-0.4110	0.05106		0.16300	0.033849

---------- Effect=pos Method=LSD(P<.05) Set=2 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group	btestimate	btstderr
2			13	0.03780	0.1162	A	0.53852	0.12068
3			9	-0.2892	0.1435	AB	0.24890	0.10750
4			11	-0.3848	0.1435	B	0.18058	0.09770
5			1	-0.3904	0.1162	B	0.17681	0.07865
6			10	-0.4372	0.1162	B	0.14583	0.07505
7			12	-0.4392	0.1435	B	0.14457	0.09253
8			14	-0.4453	0.1435	B	0.14063	0.09196
9			7	-0.4477	0.1435	B	0.13912	0.09175
10			8	-0.4495	0.1162	B	0.13797	0.07413
11			5	-0.4571	0.1162	B	0.13315	0.07357
12			3	-0.4973	0.1162	B	0.10819	0.07067
13			2	-0.5094	0.1162	B	0.10085	0.06982
14			6	-0.5131	0.1162	B	0.09864	0.06956
15			4	-0.5316	0.1162	B	0.08768	0.06829

---------- Effect=trt*pos Method=LSD(P<.05) Set=3 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group	btestimate	btstderr
16	STEE		13	0.03780	0.1162	A	0.53852	0.12068
17	STEE		9	-0.2892	0.1435	AB	0.24890	0.10750
18	STEE		11	-0.3848	0.1435	B	0.18058	0.09770
19	STEE		1	-0.3904	0.1162	B	0.17681	0.07865
20	STEE		10	-0.4372	0.1162	B	0.14583	0.07505
21	STEE		12	-0.4392	0.1435	B	0.14457	0.09253
22	STEE		14	-0.4453	0.1435	B	0.14063	0.09196
23	STEE		7	-0.4477	0.1435	B	0.13912	0.09175
24	STEE		8	-0.4495	0.1162	B	0.13797	0.07413
25	STEE		5	-0.4571	0.1162	B	0.13315	0.07357
26	STEE		3	-0.4973	0.1162	B	0.10819	0.07067
27	STEE		2	-0.5094	0.1162	B	0.10085	0.06982
28	STEE		6	-0.5131	0.1162	B	0.09864	

0.06956
29 STEE 4 -0.5316 0.1162 B 0.08768
0.06829

The SAS System 14:02 Wednesday, July 7, 2010 1930

Back-transformed (bt) Mean Separation for log TP

---------- Effect=loc Method=' ' Set=4 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group	btestimate	btstderr
30		JB	_	-0.4110	0.05106		0.16300	0.033849

---------- Effect=trt*loc Method=' ' Set=5 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group	btestimate	btstderr
31	STEE	JB	_	-0.4110	0.05106		0.16300	0.033849

---------- Effect=loc*pos Method=LSD(P<.05) Set=6 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group	btestimate	btstderr
32		JB	13	0.03780	0.1162	A	0.53852	0.12068
33		JB	9	-0.2892	0.1435	AB	0.24890	0.10750
34		JB	11	-0.3848	0.1435	B	0.18058	0.09770
35		JB	1	-0.3904	0.1162	B	0.17681	0.07865
36		JB	10	-0.4372	0.1162	B	0.14583	0.07505
37		JB	12	-0.4392	0.1435	B	0.14457	0.09253
38		JB	14	-0.4453	0.1435	B	0.14063	0.09196
39		JB	7	-0.4477	0.1435	B	0.13912	0.09175
40		JB	8	-0.4495	0.1162	B	0.13797	0.07413
41		JB	5	-0.4571	0.1162	B	0.13315	0.07357
42		JB	3	-0.4973	0.1162	B	0.10819	0.07067
43		JB	2	-0.5094	0.1162	B	0.10085	0.06982
44		JB	6	-0.5131	0.1162	B	0.09864	0.06956
45		JB	4	-0.5316	0.1162	B	0.08768	0.06829

---------- Effect=trt*loc*pos Method=LSD(P<.05) Set=7 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group	btestimate	btstderr
46	STEE	JB	13	0.03780	0.1162	A	0.53852	0.12068
47	STEE	JB	9	-0.2892	0.1435	AB	0.24890	0.10750
48	STEE	JB	11	-0.3848	0.1435	B	0.18058	0.09770
49	STEE	JB	1	-0.3904	0.1162	B	0.17681	0.07865
50	STEE	JB	10	-0.4372	0.1162	B	0.14583	0.07505
51	STEE	JB	12	-0.4392	0.1435	B	0.14457	0.09253
52	STEE	JB	14	-0.4453	0.1435	B	0.14063	0.09196
53	STEE	JB	7	-0.4477	0.1435	B	0.13912	0.09175
54	STEE	JB	8	-0.4495	0.1162	B	0.13797	0.07413
55	STEE	JB	5	-0.4571	0.1162	B	0.13315	0.07357

Back-transformed (bt) Mean Separation for log TP

---------- Effect=trt*loc*pos Method=LSD(P<.05) Set=7 ----------

(continued)

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group	btestimate	btstderr
56	STEE	JB	3	-0.4973	0.1162	B	0.10819	0.070674
57	STEE	JB	2	-0.5094	0.1162	B	0.10085	0.069821
58	STEE	JB	6	-0.5131	0.1162	B	0.09864	0.069565
59	STEE	JB	4	-0.5316	0.1162	B	0.08768	0.068291

Check on normality for log TP

The UNIVARIATE Procedure
Variable: Resid (Residual)

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.899532	Pr < W	0.0029
Kolmogorov-Smirnov	D	0.149541	Pr > D	0.0358
Cramer-von Mises	W-Sq	0.12266	Pr > W-Sq	0.0538
Anderson-Darling	A-Sq	0.909239	Pr > A-Sq	0.0198

Extreme Observations

------Lowest------		------Highest-----	
Value	Obs	Value	Obs

-0.399011	13	0.108002	21
-0.166442	36	0.135890	10
-0.158860	33	0.193079	1
-0.157353	38	0.200885	8
-0.145943	27	0.544954	41

Missing Values

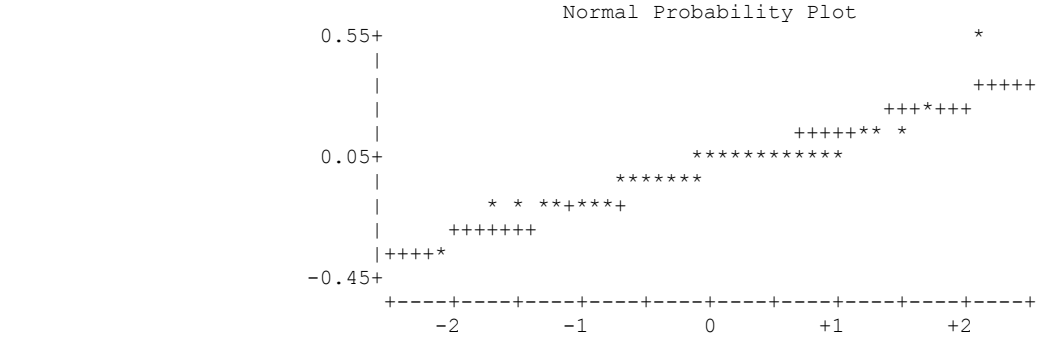
Missing Value	Count	Percent Of All Obs	Percent Of Missing Obs
.	19	33.93	100.00

```
Stem Leaf                    #             Boxplot
   5 4                       1                0
   4                                          
   3                                          
   2 0                       1                |
   1 149                     3                |
   0 122223366677888         15            +--+--+
  -0 999753222               9             +-----+
  -1 7665431                 7                |
  -2                                          
  -3                                          
  -4 0                       1                0
     ----+----+----+----+
 Multiply Stem.Leaf by 10**-1
```


Check on normality for log TP

The UNIVARIATE Procedure
Variable: Resid (Residual)

Normal Probability Plot



Check equality of stddev for y=log TP

Obs	trt	loc	pos	nobs	rawmean_ y	stddev_y	stderr_y	Levene LeveneF_df	P
1	STEE	JB	1	3	-0.39037	0.20778	0.11996	2.453(8,18)	0.0540

2	STEE	JB	2	3	-0.50941	0.12693	0.07328
3	STEE	JB	3	3	-0.49727	0.16678	0.09629
4	STEE	JB	4	3	-0.53158	0.12490	0.07211
5	STEE	JB	5	3	-0.45705	0.18762	0.10832
6	STEE	JB	6	3	-0.51309	0.13073	0.07548
7	STEE	JB	7	2	-0.41895	0.16091	0.11378
8	STEE	JB	8	3	-0.44947	0.22385	0.12924
9	STEE	JB	9	2	-0.26044	0.03853	0.02724
10	STEE	JB	10	3	-0.43722	0.19299	0.11142
11	STEE	JB	11	2	-0.35610	0.02322	0.01642
12	STEE	JB	12	2	-0.41046	0.11394	0.08056
13	STEE	JB	13	3	0.03780	0.44245	0.25545
14	STEE	JB	14	2	-0.41659	0.03539	0.02502

Jackson Bend – RSFE

Mixed ANOVA for Ksat

The Mixed Procedure

Model Information

Data Set	WORK.DSETZZ
Dependent Variable	Ksat
Covariance Structure	Variance Components
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Kenward-Roger
Degrees of Freedom Method	Kenward-Roger

Class Level Information

Class	Levels	Values
trt	1	RSFE
loc	1	JB
depth	2	1 2
pos	14	1 2 3 4 5 6 7 8 9 10 11 12 13 14
rnd	4	1 2 3 4

Dimensions

Covariance Parameters	5
Columns in X	52
Columns in Z	72
Subjects	1
Max Obs Per Subject	56

Number of Observations

Number of Observations Read	56
Number of Observations Used	22
Number of Observations Not Used	34

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	-39.99625823	
1	4	-39.99705088	.
2	3	-39.99870071	.
3	1	-40.42861436	.
4	1	-40.69411233	0.02673502
5	1	-40.77778209	0.00192797

Mixed ANOVA for Ksat

The Mixed Procedure

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
6	1	-40.78829706	0.00003479
7	1	-40.78853384	0.00000002
8	1	-40.78853399	0.00000000

Convergence criteria met but final hessian is not positive definite.

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr > Z
loc*rnd	0.000111	0.000339	0.33	0.3715
trt*loc*rnd	0.000111	0	.	.
trt*loc*depth*rnd	0	.	.	.
pos(trt*loc*dep*rnd)	0	.	.	.
Residual	0.000406	0.000225	1.80	0.0357

Fit Statistics

-2 Res Log Likelihood	-40.8
AIC (smaller is better)	-34.8
AICC (smaller is better)	-30.8
BIC (smaller is better)	-36.6

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trt	0	.	.	.
pos	11	6.76	1.02	0.5109
trt*pos	0	.	.	.
loc	0	.	.	.
trt*loc	0	.	.	.
loc*pos	0	.	.	.
trt*loc*pos	0	.	.	.

Mean separation for Ksat

Effect=trt Method=' ' Set=1

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
1	RSFE		_	0.03994	0.009925	

Effect=pos Method=LSD(P<.05) Set=2

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
2			8	0.09440	0.02416	A
3			13	0.05222	0.02598	AB
4			1	0.04669	0.01757	AB
5			5	0.04521	0.01433	AB
6			3	0.04500	0.01253	AB
7			6	0.04439	0.01802	AB
8			11	0.02939	0.01802	B
9			10	0.02440	0.02416	B
10			2	0.02439	0.01802	B
11			12	0.02439	0.01802	B
12			7	0.02437	0.02433	AB
13			4	0.02437	0.02433	AB

Effect=trt*pos Method=LSD(P<.05) Set=3

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
14	RSFE		8	0.09440	0.02416	A
15	RSFE		13	0.05222	0.02598	AB
16	RSFE		1	0.04669	0.01757	AB
17	RSFE		5	0.04521	0.01433	AB
18	RSFE		3	0.04500	0.01253	AB
19	RSFE		6	0.04439	0.01802	AB
20	RSFE		11	0.02939	0.01802	B
21	RSFE		10	0.02440	0.02416	B
22	RSFE		2	0.02439	0.01802	B
23	RSFE		12	0.02439	0.01802	B
24	RSFE		7	0.02437	0.02433	AB
25	RSFE		4	0.02437	0.02433	AB

Effect=loc Method=' ' Set=4

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
26		JB	_	0.03994	0.009925	

Mean separation for Ksat

Effect=trt*loc Method=' ' Set=5

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group

27	RSFE	JB	_	0.03994	0.009925	

---------- Effect=loc*pos Method=LSD(P<.05) Set=6 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
28		JB	8	0.09440	0.02416	A
29		JB	13	0.05222	0.02598	AB
30		JB	1	0.04669	0.01757	AB
31		JB	5	0.04521	0.01433	AB
32		JB	3	0.04500	0.01253	AB
33		JB	6	0.04439	0.01802	AB
34		JB	11	0.02939	0.01802	B
35		JB	10	0.02440	0.02416	B
36		JB	2	0.02439	0.01802	B
37		JB	12	0.02439	0.01802	B
38		JB	7	0.02437	0.02433	AB
39		JB	4	0.02437	0.02433	AB

---------- Effect=trt*loc*pos Method=LSD(P<.05) Set=7 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
40	RSFE	JB	8	0.09440	0.02416	A
41	RSFE	JB	13	0.05222	0.02598	AB
42	RSFE	JB	1	0.04669	0.01757	AB
43	RSFE	JB	5	0.04521	0.01433	AB
44	RSFE	JB	3	0.04500	0.01253	AB
45	RSFE	JB	6	0.04439	0.01802	AB
46	RSFE	JB	11	0.02939	0.01802	B
47	RSFE	JB	10	0.02440	0.02416	B
48	RSFE	JB	2	0.02439	0.01802	B
49	RSFE	JB	12	0.02439	0.01802	B
50	RSFE	JB	7	0.02437	0.02433	AB
51	RSFE	JB	4	0.02437	0.02433	AB

Check on normality for Ksat

The UNIVARIATE Procedure
Variable: Resid (Residual)

Tests for Normality

Test		--Statistic---		-----p Value------
Shapiro-Wilk	W	0.929838	Pr < W	0.1217
Kolmogorov-Smirnov	D	0.226812	Pr > D	<0.0100
Cramer-von Mises	W-Sq	0.129838	Pr > W-Sq	0.0423
Anderson-Darling	A-Sq	0.684497	Pr > A-Sq	0.0669

Extreme Observations

-------Lowest------		------Highest------	
Value	Obs	Value	Obs
-0.0199855	6	0.0100145	2
-0.0159959	45	0.0123154	43
-0.0129887	19	0.0199855	34
-0.0123154	29	0.0237952	47

-0.0108066	5	0.0272202	17

Missing Values

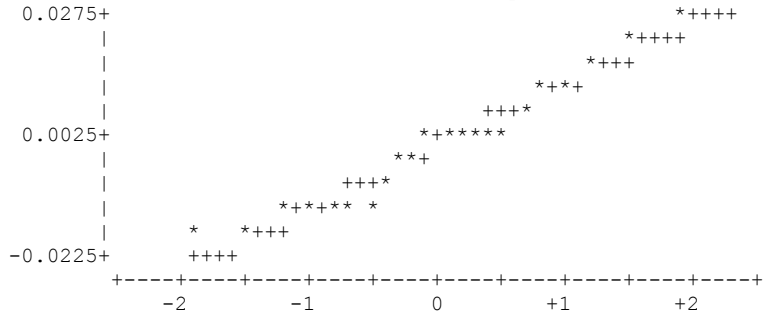
Missing Value	Count	Percent Of All Obs	Percent Of Missing Obs
.	34	60.71	100.00

```
Stem Leaf                    #             Boxplot
   2 7                       1                |
   2 04                      2                |
   1                                          |
   1 02                      2                |
   0 5                       1             +------+
   0 000000                  6             *--+--*
  -0 10                      2             |     |
  -0 5                       1             |     |
  -1 32110                   5             +------+
  -1 6                       1                |
  -2 0                       1                |
     ----+----+----+----+
 Multiply Stem.Leaf by 10**-2
```


Check on normality for Ksat

The UNIVARIATE Procedure
Variable: Resid (Residual)

Normal Probability Plot



Check equality of stddev for y= Ksat

Obs	trt	loc	pos	nobs	rawmean_ y	stddev_y	stderr_y	Levene LeveneF_df	P
1	RSFE	JB	1	2	0.050000	0.028284	0.020000	0.118(1,5)	0.7450
2	RSFE	JB	2	2	0.015000	0.007071	0.005000	.	
3	RSFE	JB	3	4	0.045000	0.025166	0.012583	.	
5	RSFE	JB	5	3	0.046667	0.030551	0.017638	.	
6	RSFE	JB	6	2	0.035000	0.035355	0.025000		

.

11	RSFE	JB	11	2	0.020000	0.000000	0.000000

.

12	RSFE	JB	12	2	0.015000	0.007071	0.005000

.

Mixed ANOVA for NO3

The Mixed Procedure

Model Information

Data Set	WORK.DSETZZ
Dependent Variable	NO3
Covariance Structure	Variance Components
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Kenward-Roger
Degrees of Freedom Method	Kenward-Roger

Class Level Information

Class	Levels	Values
trt	1	RSFE
loc	1	JB
depth	2	1 2
pos	14	1 2 3 4 5 6 7 8 9 10 11 12 13 14
rnd	4	1 2 3 4

Dimensions

Covariance Parameters	5
Columns in X	60
Columns in Z	72
Subjects	1
Max Obs Per Subject	56

Number of Observations

Number of Observations Read	56
Number of Observations Used	48
Number of Observations Not Used	8

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	189.72935687	
1	2	177.10553445	.
2	1	177.10553004	0.00000000

Mixed ANOVA for NO3

The Mixed Procedure

Convergence criteria met but final hessian is not positive definite.

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr > Z
loc*rnd	3.5892	3.2989	1.09	0.1383
trt*loc*rnd	0.002691	0	.	.
trt*loc*depth*rnd	0	.	.	.
pos(trt*loc*dep*rnd)	4.5312	1.3642	3.32	0.0004
Residual	0.8515	0	.	.

Fit Statistics

-2 Res Log Likelihood	177.1
AIC (smaller is better)	185.1
AICC (smaller is better)	186.5
BIC (smaller is better)	182.7

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trt	0	.	.	.
pos	13	31.2	2.63	0.0132
trt*pos	0	.	.	.
loc	0	.	.	.
trt*loc	0	.	.	.
loc*pos	0	.	.	.
trt*loc*pos	0	.	.	.

Mean separation for NO3

---------- Effect=trt Method=' ' Set=1 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
1	RSFE		_	3.0607	1.0187	

---------- Effect=pos Method=LSD(P<.05) Set=2 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
2			13	10.2206	1.6642	A
3			3	3.7575	1.4979	B
4			7	3.2973	1.6642	B
5			6	3.1850	1.4979	B
6			8	2.9506	1.6642	B
7			2	2.8625	1.4979	B
8			5	2.7600	1.4979	B
9			4	2.5150	1.4979	B
10			14	2.2806	1.6642	B
11			1	1.9750	1.4979	B
12			9	1.8306	1.6642	B
13			11	1.8306	1.6642	B
14			12	1.8106	1.6642	B
15			10	1.5739	1.6642	B

---------- Effect=trt*pos Method=LSD(P<.05) Set=3 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
16	RSFE		13	10.2206	1.6642	A
17	RSFE		3	3.7575	1.4979	B
18	RSFE		7	3.2973	1.6642	B
19	RSFE		6	3.1850	1.4979	B
20	RSFE		8	2.9506	1.6642	B
21	RSFE		2	2.8625	1.4979	B
22	RSFE		5	2.7600	1.4979	B
23	RSFE		4	2.5150	1.4979	B
24	RSFE		14	2.2806	1.6642	B
25	RSFE		1	1.9750	1.4979	B
26	RSFE		9	1.8306	1.6642	B
27	RSFE		11	1.8306	1.6642	B
28	RSFE		12	1.8106	1.6642	B
29	RSFE		10	1.5739	1.6642	B

Mean separation for NO3

---------- Effect=loc Method=' ' Set=4 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
30		JB	_	3.0607	1.0187	

---------- Effect=trt*loc Method=' ' Set=5 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
31	RSFE	JB	_	3.0607	1.0187	

---------- Effect=loc*pos Method=LSD(P<.05) Set=6 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
32		JB	13	10.2206	1.6642	A
33		JB	3	3.7575	1.4979	B
34		JB	7	3.2973	1.6642	B
35		JB	6	3.1850	1.4979	B
36		JB	8	2.9506	1.6642	B
37		JB	2	2.8625	1.4979	B
38		JB	5	2.7600	1.4979	B
39		JB	4	2.5150	1.4979	B
40		JB	14	2.2806	1.6642	B
41		JB	1	1.9750	1.4979	B
42		JB	9	1.8306	1.6642	B
43		JB	11	1.8306	1.6642	B
44		JB	12	1.8106	1.6642	B
45		JB	10	1.5739	1.6642	B

---------- Effect=trt*loc*pos Method=LSD(P<.05) Set=7 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group

46	RSFE	JB	13	10.2206	1.6642	A
47	RSFE	JB	3	3.7575	1.4979	B
48	RSFE	JB	7	3.2973	1.6642	B
49	RSFE	JB	6	3.1850	1.4979	B
50	RSFE	JB	8	2.9506	1.6642	B
51	RSFE	JB	2	2.8625	1.4979	B
52	RSFE	JB	5	2.7600	1.4979	B
53	RSFE	JB	4	2.5150	1.4979	B
54	RSFE	JB	14	2.2806	1.6642	B
55	RSFE	JB	1	1.9750	1.4979	B

Mean separation for NO3

---------- Effect=trt*loc*pos Method=LSD(P<.05) Set=7 ----------

(continued)

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
56	RSFE	JB	9	1.8306	1.6642	B
57	RSFE	JB	11	1.8306	1.6642	B
58	RSFE	JB	12	1.8106	1.6642	B
59	RSFE	JB	10	1.5739	1.6642	B

Check on normality for NO3

The UNIVARIATE Procedure
Variable: Resid (Residual)

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.909287	Pr < W	0.0013
Kolmogorov-Smirnov	D	0.121303	Pr > D	0.0769
Cramer-von Mises	W-Sq	0.164062	Pr > W-Sq	0.0161
Anderson-Darling	A-Sq	1.104187	Pr > A-Sq	0.0065

Extreme Observations

------Lowest------		------Highest-----	
Value	Obs	Value	Obs
-0.815003	41	0.266261	43
-0.647105	15	0.270244	9
-0.415453	23	0.326433	29
-0.385925	24	0.556324	17
-0.353024	13	1.168027	27

Missing Values

Missing Value	Count	-----Percent Of----- All Obs	Missing Obs
.	8	14.29	100.00

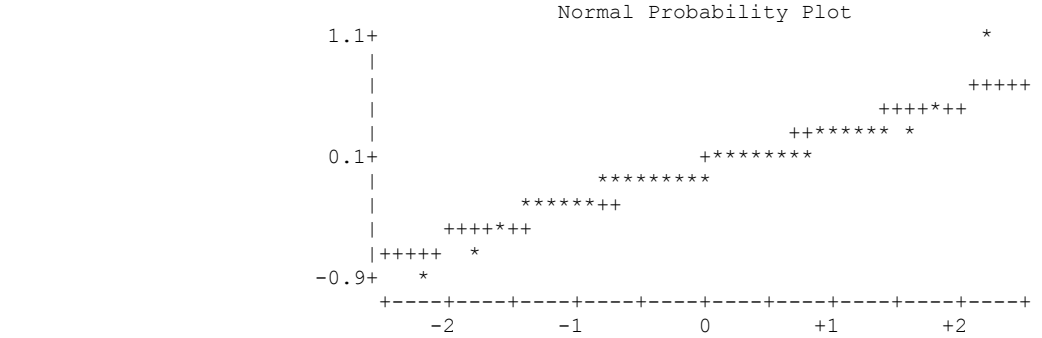
Stem	Leaf	#	Boxplot
10	7	1	*

```
   8
   6
   4 6                          1               0
   2 1223773                    7               |
   0 55556783334558            14             +--+--+
  -0 8532000865553221          16             *-----*
  -2 954421                    6               |
  -4 2                         1               |
  -6 5                         1               0
  -8 2                         1               0
     ----+----+----+----+
Multiply Stem.Leaf by 10**-1
```


Check on normality for NO3

The UNIVARIATE Procedure
Variable: Resid (Residual)

Normal Probability Plot



Check equality of stddev for y= NO3

Obs	trt	loc	pos	nobs	rawmean_ y	stddev_y	stderr_y	Levene LeveneF_df	P
1	RSFE	JB	1	4	1.9750	1.36476	0.68238	3.464(13,34)	0.0020
2	RSFE	JB	2	4	2.8625	2.50548	1.25274	.	
3	RSFE	JB	3	4	3.7575	3.85624	1.92812	.	
4	RSFE	JB	4	4	2.5150	2.32595	1.16297	.	
5	RSFE	JB	5	4	2.7600	1.93510	0.96755	.	
6	RSFE	JB	6	4	3.1850	2.98814	1.49407	.	
7	RSFE	JB	7	3	3.6033	2.77417	1.60167	.	
8	RSFE	JB	8	3	3.2567	2.38013	1.37417	.	
9	RSFE	JB	9	3	2.1367	1.82741	1.05506	.	
10	RSFE	JB	10	3	1.8800	1.64794	0.95144	.	
11	RSFE	JB	11	3	2.1367	1.48520	0.85748		

.

12	RSFE	JB	12	3	2.1167	1.60179	0.92479

.

13	RSFE	JB	13	3	10.5267	8.42321	4.86314

.

14	RSFE	JB	14	3	2.5867	1.67004	0.96420

.

Mixed ANOVA for TC

The Mixed Procedure

Model Information

Data Set	WORK.DSETZZ
Dependent Variable	TC
Covariance Structure	Variance Components
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Kenward-Roger
Degrees of Freedom Method	Kenward-Roger

Class Level Information

Class	Levels	Values
trt	1	RSFE
loc	1	JB
depth	2	1 2
pos	14	1 2 3 4 5 6 7 8 9 10 11 12 13 14
rnd	4	1 2 3 4

Dimensions

Covariance Parameters	5
Columns in X	60
Columns in Z	72
Subjects	1
Max Obs Per Subject	56

Number of Observations

Number of Observations Read	56
Number of Observations Used	40
Number of Observations Not Used	16

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	264.27878386	
1	3	243.90530779	0.00000000

Convergence criteria met but final hessian is not positive definite.

Mixed ANOVA for TC

The Mixed Procedure

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr > Z
loc*rnd	645.15	575.13	1.12	0.1310
trt*loc*rnd	0	.	.	.
trt*loc*depth*rnd	0	.	.	.
pos(trt*loc*dep*rnd)	288.92	85.2209	3.39	0.0003
Residual	1.0617	0	.	.

Fit Statistics

-2 Res Log Likelihood	243.9
AIC (smaller is better)	249.9
AICC (smaller is better)	251.0
BIC (smaller is better)	248.1

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trt	0	.	.	.
pos	13	23.2	0.47	0.9183
trt*pos	0	.	.	.
loc	0	.	.	.
trt*loc	0	.	.	.
loc*pos	0	.	.	.
trt*loc*pos	0	.	.	.

Mean separation for TC

---------- Effect=trt Method=' ' Set=1 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
1	RSFE		_	40.3513	13.1073	

---------- Effect=pos Method=LSD(P<.05) Set=2 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
2			11	57.0435	17.7970	A
3			7	50.7860	17.7970	A
4			13	48.4215	17.7970	A
5			14	44.8070	17.7970	A
6			1	44.2066	16.1425	A
7			6	41.8983	15.2900	A
8			3	39.1780	15.2900	A
9			10	37.5646	16.1957	A
10			2	36.8200	15.2900	A
11			4	34.1153	15.2900	A
12			5	33.5524	16.1649	A
13			9	33.5280	21.7403	A
14			12	32.7426	16.1957	A
15			8	30.2549	16.1957	A

---------- Effect=trt*pos Method=LSD(P<.05) Set=3 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
16	RSFE		11	57.0435	17.7970	A
17	RSFE		7	50.7860	17.7970	A
18	RSFE		13	48.4215	17.7970	A
19	RSFE		14	44.8070	17.7970	A
20	RSFE		1	44.2066	16.1425	A
21	RSFE		6	41.8983	15.2900	A
22	RSFE		3	39.1780	15.2900	A
23	RSFE		10	37.5646	16.1957	A
24	RSFE		2	36.8200	15.2900	A
25	RSFE		4	34.1153	15.2900	A
26	RSFE		5	33.5524	16.1649	A
27	RSFE		9	33.5280	21.7403	A
28	RSFE		12	32.7426	16.1957	A
29	RSFE		8	30.2549	16.1957	A

Mean separation for TC

---------- Effect=loc Method=' ' Set=4 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
30		JB	_	40.3513	13.1073	

---------- Effect=trt*loc Method=' ' Set=5 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
31	RSFE	JB	_	40.3513	13.1073	

---------- Effect=loc*pos Method=LSD(P<.05) Set=6 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
32		JB	11	57.0435	17.7970	A
33		JB	7	50.7860	17.7970	A
34		JB	13	48.4215	17.7970	A
35		JB	14	44.8070	17.7970	A
36		JB	1	44.2066	16.1425	A
37		JB	6	41.8983	15.2900	A
38		JB	3	39.1780	15.2900	A
39		JB	10	37.5646	16.1957	A
40		JB	2	36.8200	15.2900	A
41		JB	4	34.1153	15.2900	A
42		JB	5	33.5524	16.1649	A
43		JB	9	33.5280	21.7403	A
44		JB	12	32.7426	16.1957	A
45		JB	8	30.2549	16.1957	A

---------- Effect=trt*loc*pos Method=LSD(P<.05) Set=7 ----------

Standard	Letter

Obs	trt	loc	pos	Estimate	Error	Group
46	RSFE	JB	11	57.0435	17.7970	A
47	RSFE	JB	7	50.7860	17.7970	A
48	RSFE	JB	13	48.4215	17.7970	A
49	RSFE	JB	14	44.8070	17.7970	A
50	RSFE	JB	1	44.2066	16.1425	A
51	RSFE	JB	6	41.8983	15.2900	A
52	RSFE	JB	3	39.1780	15.2900	A
53	RSFE	JB	10	37.5646	16.1957	A
54	RSFE	JB	2	36.8200	15.2900	A
55	RSFE	JB	4	34.1153	15.2900	A

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Mean separation for TC

---------- Effect=trt*loc*pos Method=LSD(P<.05) Set=7 ----------

(continued)

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
56	RSFE	JB	5	33.5524	16.1649	A
57	RSFE	JB	9	33.5280	21.7403	A
58	RSFE	JB	12	32.7426	16.1957	A
59	RSFE	JB	8	30.2549	16.1957	A

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Check on normality for TC

The UNIVARIATE Procedure
Variable: Resid (Residual)

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.938107	Pr < W	0.0299
Kolmogorov-Smirnov	D	0.147471	Pr > D	0.0267
Cramer-von Mises	W-Sq	0.160377	Pr > W-Sq	0.0178
Anderson-Darling	A-Sq	0.924859	Pr > A-Sq	0.0185

Extreme Observations

-------Lowest------		------Highest------	
Value	Obs	Value	Obs
-0.1533682	22	0.0502366	35
-0.0877189	2	0.0573658	1
-0.0577070	34	0.0720673	6
-0.0502366	21	0.1072108	36
-0.0350719	30	0.1235186	16

Missing Values

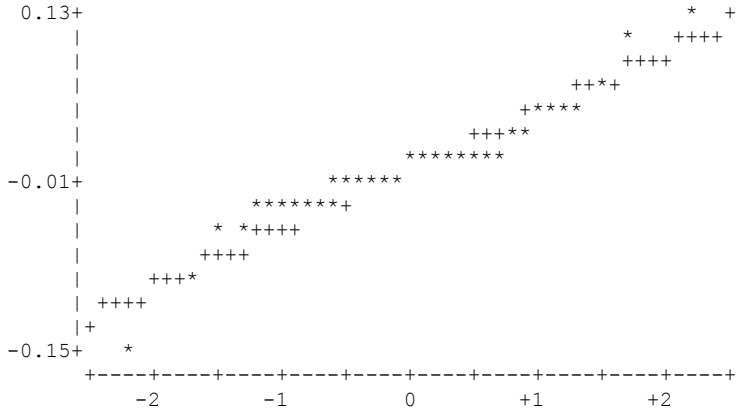
Missing Value	Count	-----Percent Of----- All Obs	Missing Obs
.	16	28.57	100.00

Check on normality for TC

The UNIVARIATE Procedure
Variable: Resid (Residual)

```
Stem Leaf                     #             Boxplot
  12 4                        1                0
  10 7                        1                0
   8
   6 2                        1                |
   4 6907                     4                |
   2 36                       2                |
   0 012334780038            12             +--+--+
  -0 88770031                 8             |     |
  -2 5510874                  7             +-----+
  -4 80                       2                |
  -6
  -8 8                        1                0
 -10
 -12
 -14 3                        1                *
     ----+----+----+----+
Multiply Stem.Leaf by 10**-2
```

Normal Probability Plot



Check equality of stddev for y= TC

Obs	trt	loc	pos	nobs	rawmean_ y	stddev_y	stderr_y	Levene LeveneF_df	P
1	RSFE	JB	1	3	39.5137	41.0540	23.7026	0.711(8,22)	0.6790
2	RSFE	JB	2	4	36.8200	34.6636	17.3318	.	
3	RSFE	JB	3	4	39.1780	26.7097	13.3549	.	
4	RSFE	JB	4	4	34.1153	25.2032	12.6016	.	
5	RSFE	JB	5	3	24.5507	21.6314	12.4889	.	
6	RSFE	JB	6	4	41.8983	38.6531	19.3265	.	

7	RSFE	JB	7	2	48.5000	3.7392	2.6440
8	RSFE	JB	8	3	37.7327	33.8214	19.5268
10	RSFE	JB	10	3	45.0423	31.0036	17.8999
11	RSFE	JB	11	2	54.7575	19.2326	13.5995
12	RSFE	JB	12	3	40.2203	27.0738	15.6311
13	RSFE	JB	13	2	46.1355	16.0563	11.3535
14	RSFE	JB	14	2	42.5210	21.9557	15.5250

Mixed ANOVA for TN

The Mixed Procedure

Model Information

Data Set	WORK.DSETZZ
Dependent Variable	TN
Covariance Structure	Variance Components
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Kenward-Roger
Degrees of Freedom Method	Kenward-Roger

Class Level Information

Class	Levels	Values
trt	1	RSFE
loc	1	JB
depth	2	1 2
pos	14	1 2 3 4 5 6 7 8 9 10 11 12 13 14
rnd	4	1 2 3 4

Dimensions

Covariance Parameters	5
Columns in X	60
Columns in Z	72
Subjects	1
Max Obs Per Subject	56

Number of Observations

Number of Observations Read	56
Number of Observations Used	48
Number of Observations Not Used	8

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	229.94870525	
1	2	205.95180168	0.00000000

Convergence criteria met but final hessian is not positive

definite.

Mixed ANOVA for TN

The Mixed Procedure

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr > Z
loc*rnd	18.5521	16.1529	1.15	0.1254
trt*loc*rnd	0.08160	0	.	.
trt*loc*depth*rnd	0	.	.	.
pos(trt*loc*dep*rnd)	10.7684	2.9791	3.61	0.0002
Residual	0.9609	0	.	.

Fit Statistics

-2 Res Log Likelihood	206.0
AIC (smaller is better)	214.0
AICC (smaller is better)	215.3
BIC (smaller is better)	211.5

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trt	0	.	.	.
pos	13	31.1	1.98	0.0594
trt*pos	0	.	.	.
loc	0	.	.	.
trt*loc	0	.	.	.
loc*pos	0	.	.	.
trt*loc*pos	0	.	.	.

Mean separation for TN

Effect=trt Method=' ' Set=1

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
1	RSFE		_	8.9654	2.2277	

Effect=pos Method=LSD(P<.05) Set=2

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
2			13	16.8310	2.9558	A
3			7	11.7143	2.9558	AB
4			9	10.2477	2.9558	B
5			8	10.0677	2.9558	B
6			14	9.5977	2.9558	B
7			11	9.1543	2.9558	B
8			10	8.3710	2.9558	B
9			2	7.8675	2.7551	B
10			5	7.7200	2.7551	B

11		6	7.1975	2.7551	B
12		4	7.0675	2.7551	B
13		3	6.7950	2.7551	B
14		12	6.5377	2.9558	B
15		1	6.3475	2.7551	B

---------- Effect=trt*pos Method=LSD(P<.05) Set=3 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
16	RSFE		13	16.8310	2.9558	A
17	RSFE		7	11.7143	2.9558	AB
18	RSFE		9	10.2477	2.9558	B
19	RSFE		8	10.0677	2.9558	B
20	RSFE		14	9.5977	2.9558	B
21	RSFE		11	9.1543	2.9558	B
22	RSFE		10	8.3710	2.9558	B
23	RSFE		2	7.8675	2.7551	B
24	RSFE		5	7.7200	2.7551	B
25	RSFE		6	7.1975	2.7551	B
26	RSFE		4	7.0675	2.7551	B
27	RSFE		3	6.7950	2.7551	B
28	RSFE		12	6.5377	2.9558	B
29	RSFE		1	6.3475	2.7551	B

Mean separation for TN

---------- Effect=loc Method=' ' Set=4 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
30		JB	_	8.9654	2.2277	

---------- Effect=trt*loc Method=' ' Set=5 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
31	RSFE	JB	_	8.9654	2.2277	

---------- Effect=loc*pos Method=LSD(P<.05) Set=6 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
32		JB	13	16.8310	2.9558	A
33		JB	7	11.7143	2.9558	AB
34		JB	9	10.2477	2.9558	B
35		JB	8	10.0677	2.9558	B
36		JB	14	9.5977	2.9558	B
37		JB	11	9.1543	2.9558	B
38		JB	10	8.3710	2.9558	B
39		JB	2	7.8675	2.7551	B
40		JB	5	7.7200	2.7551	B
41		JB	6	7.1975	2.7551	B
42		JB	4	7.0675	2.7551	B
43		JB	3	6.7950	2.7551	B
44		JB	12	6.5377	2.9558	B

45	JB	1	6.3475	2.7551	B	

---------- Effect=trt*loc*pos Method=LSD(P<.05) Set=7 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
46	RSFE	JB	13	16.8310	2.9558	A
47	RSFE	JB	7	11.7143	2.9558	AB
48	RSFE	JB	9	10.2477	2.9558	B
49	RSFE	JB	8	10.0677	2.9558	B
50	RSFE	JB	14	9.5977	2.9558	B
51	RSFE	JB	11	9.1543	2.9558	B
52	RSFE	JB	10	8.3710	2.9558	B
53	RSFE	JB	2	7.8675	2.7551	B
54	RSFE	JB	5	7.7200	2.7551	B
55	RSFE	JB	6	7.1975	2.7551	B

Mean separation for TN

---------- Effect=trt*loc*pos Method=LSD(P<.05) Set=7 ----------

(continued)

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
56	RSFE	JB	4	7.0675	2.7551	B
57	RSFE	JB	3	6.7950	2.7551	B
58	RSFE	JB	12	6.5377	2.9558	B
59	RSFE	JB	1	6.3475	2.7551	B

Check on normality for TN

The UNIVARIATE Procedure
Variable: Resid (Residual)

Tests for Normality

Test		--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.980574	Pr < W		0.6028
Kolmogorov-Smirnov	D	0.046363	Pr > D		>0.1500
Cramer-von Mises	W-Sq	0.016009	Pr > W-Sq		>0.2500
Anderson-Darling	A-Sq	0.159602	Pr > A-Sq		>0.2500

Extreme Observations

------Lowest------		------Highest-----	
Value	Obs	Value	Obs
-0.412301	2	0.296339	23
-0.408215	15	0.313690	39
-0.378188	27	0.332260	36
-0.318655	21	0.419241	16
-0.314139	37	0.686865	13

Missing Values

	-----Percent Of-----

Missing Value	Count	All Obs	Missing Obs
.	8	14.29	100.00

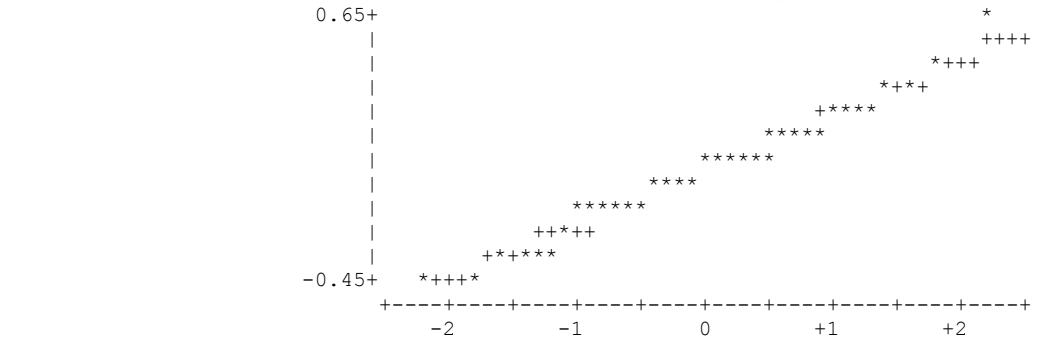
Stem	Leaf	#	Boxplot
6	9	1	0
5			
4	2	1	|
3	013	3	|
2	0444	4	|
1	344569	6	+-----+
0	1122237889	10	*--+--*
-0	875422	6	| |
-1	9753330	7	+-----+
-2	8000	4	|
-3	8211	4	|
-4	11	2	|

Multiply Stem.Leaf by 10**-1

Check on normality for TN

The UNIVARIATE Procedure
Variable: Resid (Residual)

Normal Probability Plot



Check equality of stddev for y= TN

Obs	trt	loc	pos	nobs	rawmean_ y	stddev_y	stderr_y	Levene LeveneF_df	P
1	RSFE	JB	1	4	6.3475	6.2264	3.11320	2.099(13,34)	0.0420
2	RSFE	JB	2	4	7.8675	5.6193	2.80964	.	
3	RSFE	JB	3	4	6.7950	3.9553	1.97763	.	
4	RSFE	JB	4	4	7.0675	4.3096	2.15479	.	
5	RSFE	JB	5	4	7.7200	5.2450	2.62252	.	
6	RSFE	JB	6	4	7.1975	4.5952	2.29760		

7	RSFE	JB	7	3	10.5667	4.8927	2.82478
8	RSFE	JB	8	3	8.9200	1.9228	1.11014
9	RSFE	JB	9	3	9.1000	6.9632	4.02020
10	RSFE	JB	10	3	7.2233	6.9324	4.00244
11	RSFE	JB	11	3	8.0067	0.8920	0.51502
12	RSFE	JB	12	3	5.3900	3.5516	2.05052
13	RSFE	JB	13	3	15.6833	11.1736	6.45111
14	RSFE	JB	14	3	8.4500	5.3474	3.08733

Mixed ANOVA for TP

The Mixed Procedure

Model Information

Data Set	WORK.DSETZZ
Dependent Variable	TP
Covariance Structure	Variance Components
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Kenward-Roger
Degrees of Freedom Method	Kenward-Roger

Class Level Information

Class	Levels	Values
trt	1	RSFE
loc	1	JB
depth	2	1 2
pos	14	1 2 3 4 5 6 7 8 9 10 11 12 13 14
rnd	4	1 2 3 4

Dimensions

Covariance Parameters	5
Columns in X	60
Columns in Z	72
Subjects	1
Max Obs Per Subject	56

Number of Observations

Number of Observations Read	56
Number of Observations Used	29
Number of Observations Not Used	27

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	0.94949934	
1	4	0.41382945	6.18409681

2	1	-0.07658322	1.81892458
3	1	-0.87530888	0.50625172
4	3	-1.19177715	.
5	1	-2.71320487	0.09606472

Mixed ANOVA for TP

The Mixed Procedure

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
6	1	-3.48639844	0.01257489
7	1	-3.83244278	0.00150304
8	1	-3.94766692	0.00012771
9	1	-3.96845758	0.00000446
10	1	-3.96951990	0.00000002
11	1	-3.96952386	0.00000000

Convergence criteria met but final hessian is not positive definite.

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr > Z
loc*rnd	0.04560	0.1076	0.42	0.3358
trt*loc*rnd	0.04556	0	.	.
trt*loc*depth*rnd	0.001377	0.005003	0.28	0.3916
pos(trt*loc*dep*rnd)	0	.	.	.
Residual	0.01433	0.005920	2.42	0.0077

Fit Statistics

-2 Res Log Likelihood	-4.0
AIC (smaller is better)	4.0
AICC (smaller is better)	8.0
BIC (smaller is better)	1.6

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trt	0	.	.	.
pos	13	6.51	1.09	0.4799
trt*pos	0	.	.	.
loc	0	.	.	.
trt*loc	0	.	.	.
loc*pos	0	.	.	.
trt*loc*pos	0	.	.	.

Mean separation for TP

---------- Effect=trt Method=' ' Set=1 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
1	RSFE		_	0.3293	0.1836	

---------- Effect=pos Method=LSD(P<.05) Set=2 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
2			13	0.5696	0.2021	A
3			11	0.3996	0.2021	AB
4			14	0.3956	0.2035	AB
5			1	0.3867	0.1887	AB
6			10	0.3656	0.2035	AB
7			9	0.3591	0.2021	AB
8			12	0.2871	0.2035	B
9			5	0.2841	0.2021	B
10			2	0.2826	0.2035	B
11			8	0.2821	0.2035	B
12			3	0.2766	0.2021	B
13			7	0.2676	0.2021	B
14			6	0.2531	0.2035	B
15			4	0.2006	0.2035	B

---------- Effect=trt*pos Method=LSD(P<.05) Set=3 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
16	RSFE		13	0.5696	0.2021	A
17	RSFE		11	0.3996	0.2021	AB
18	RSFE		14	0.3956	0.2035	AB
19	RSFE		1	0.3867	0.1887	AB
20	RSFE		10	0.3656	0.2035	AB
21	RSFE		9	0.3591	0.2021	AB
22	RSFE		12	0.2871	0.2035	B
23	RSFE		5	0.2841	0.2021	B
24	RSFE		2	0.2826	0.2035	B
25	RSFE		8	0.2821	0.2035	B
26	RSFE		3	0.2766	0.2021	B
27	RSFE		7	0.2676	0.2021	B
28	RSFE		6	0.2531	0.2035	B
29	RSFE		4	0.2006	0.2035	B

Mean separation for TP

---------- Effect=loc Method=' ' Set=4 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
30		JB	_	0.3293	0.1836	

---------- Effect=trt*loc Method=' ' Set=5 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
31	RSFE	JB	_	0.3293	0.1836	

---------- Effect=loc*pos Method=LSD(P<.05) Set=6 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
32		JB	13	0.5696	0.2021	A
33		JB	11	0.3996	0.2021	AB
34		JB	14	0.3956	0.2035	AB
35		JB	1	0.3867	0.1887	AB
36		JB	10	0.3656	0.2035	AB
37		JB	9	0.3591	0.2021	AB
38		JB	12	0.2871	0.2035	B
39		JB	5	0.2841	0.2021	B
40		JB	2	0.2826	0.2035	B
41		JB	8	0.2821	0.2035	B
42		JB	3	0.2766	0.2021	B
43		JB	7	0.2676	0.2021	B
44		JB	6	0.2531	0.2035	B
45		JB	4	0.2006	0.2035	B

---------- Effect=trt*loc*pos Method=LSD(P<.05) Set=7 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
46	RSFE	JB	13	0.5696	0.2021	A
47	RSFE	JB	11	0.3996	0.2021	AB
48	RSFE	JB	14	0.3956	0.2035	AB
49	RSFE	JB	1	0.3867	0.1887	AB
50	RSFE	JB	10	0.3656	0.2035	AB
51	RSFE	JB	9	0.3591	0.2021	AB
52	RSFE	JB	12	0.2871	0.2035	B
53	RSFE	JB	5	0.2841	0.2021	B
54	RSFE	JB	2	0.2826	0.2035	B
55	RSFE	JB	8	0.2821	0.2035	B

Mean separation for TP

---------- Effect=trt*loc*pos Method=LSD(P<.05) Set=7 ----------

(continued)

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
56	RSFE	JB	3	0.2766	0.2021	B
57	RSFE	JB	7	0.2676	0.2021	B
58	RSFE	JB	6	0.2531	0.2035	B
59	RSFE	JB	4	0.2006	0.2035	B

Check on normality for TP

The UNIVARIATE Procedure
Variable: Resid (Residual)

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.963101	Pr < W	0.3909
Kolmogorov-Smirnov	D	0.096545	Pr > D	>0.1500
Cramer-von Mises	W-Sq	0.041701	Pr > W-Sq	>0.2500

Anderson-Darling A-Sq 0.355579 Pr > A-Sq >0.2500

Extreme Observations

-------Lowest------		------Highest------	
Value	Obs	Value	Obs
-0.2179888	41	0.0584888	9
-0.0990112	3	0.0921921	32
-0.0948079	42	0.0948079	14
-0.0921921	4	0.0990112	31
-0.0584888	37	0.2179888	13

Missing Values

Missing Value	Count	-----Percent Of----- All Obs	Missing Obs
.	27	48.21	100.00

Stem	Leaf	#	Boxplot
2	2	1	0
1			
1	0	1	|
0	556699	6	+------+
0	1112334	7	*--+--*
-0	43111	5	| |
-0	9966555	7	+------+
-1	0	1	|
-1			
-2	2	1	0

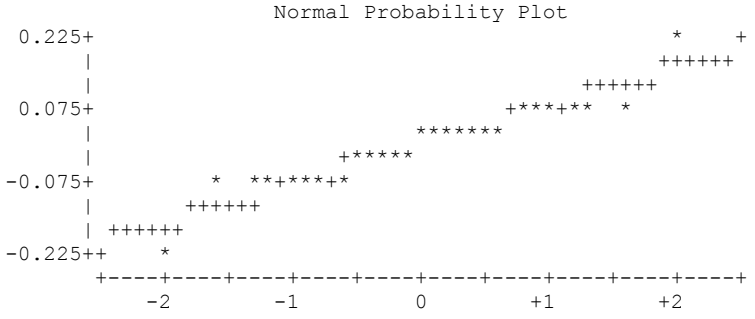
----+----+----+----+

Multiply Stem.Leaf by 10**-1

Check on normality for TP

The UNIVARIATE Procedure
Variable: Resid (Residual)

Normal Probability Plot



Check equality of stddev for y= TP

rawmean_

Obs	trt	loc	pos	nobs	y	stddev_y	stderr_y	Levene F_df	Levene P
1	RSFE	JB	1	3	0.38667	0.34111	0.19694	.(0,2)	.
2	RSFE	JB	2	2	0.44750	0.03323	0.02350	.	
3	RSFE	JB	3	2	0.44400	0.05940	0.04200	.	
4	RSFE	JB	4	2	0.36550	0.08273	0.05850	.	
5	RSFE	JB	5	2	0.45150	0.01485	0.01050	.	
6	RSFE	JB	6	2	0.41800	0.00000	0.00000	.	
7	RSFE	JB	7	2	0.43500	0.00707	0.00500	.	
8	RSFE	JB	8	2	0.44700	0.03394	0.02400	.	
9	RSFE	JB	9	2	0.52650	0.16334	0.11550	.	
10	RSFE	JB	10	2	0.53050	0.03323	0.02350	.	
11	RSFE	JB	11	2	0.56700	0.13435	0.09500	.	
12	RSFE	JB	12	2	0.45200	0.03394	0.02400	.	
13	RSFE	JB	13	2	0.73700	0.38891	0.27500	.	
14	RSFE	JB	14	2	0.56050	0.18173	0.12850		

Crescent Glen – STE

Mixed ANOVA for Ksat

The Mixed Procedure

Model Information

Data Set	WORK.DSETZZ
Dependent Variable	Ksat
Covariance Structure	Variance Components
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Kenward-Roger
Degrees of Freedom Method	Kenward-Roger

Class Level Information

Class	Levels	Values
trt	1	STEE
loc	1	CG
depth	2	1 2
pos	14	1 2 3 4 5 6 7 8 9 10 11 12 13 14
rnd	4	1 2 3 4

Dimensions

Covariance Parameters	5
Columns in X	52
Columns in Z	72
Subjects	1

Max Obs Per Subject 56

Number of Observations

Number of Observations Read	56
Number of Observations Used	20
Number of Observations Not Used	36

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	-34.39542140	
1	1	-34.39542140	0.00000000

Convergence criteria met.

Mixed ANOVA for Ksat

The Mixed Procedure

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr > Z
loc*rnd	0	.	.	.
trt*loc*rnd	0	.	.	.
trt*loc*depth*rnd	0	.	.	.
pos(trt*loc*dep*rnd)	2.091E-7	0.000214	0.00	0.4996
Residual	0.000427	0	.	.

Fit Statistics

-2 Res Log Likelihood	-34.4
AIC (smaller is better)	-30.4
AICC (smaller is better)	-28.0
BIC (smaller is better)	-31.6

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trt	0	.	.	.
pos	11	8	0.81	0.6367
trt*pos	0	.	.	.
loc	0	.	.	.
trt*loc	0	.	.	.
loc*pos	0	.	.	.
trt*loc*pos	0	.	.	.

Mean separation for Ksat

---------- Effect=trt Method=' ' Set=1 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
1	STEE		_	0.02819	0.005070	

---------- Effect=pos Method=LSD(P<.05) Set=2 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
2			4	0.06000	0.02067	A
3			1	0.06000	0.02067	A
4			7	0.04000	0.01461	A
5			11	0.03500	0.01461	A
6			3	0.02500	0.01461	A
7			2	0.02333	0.01193	A
8			10	0.02000	0.02067	A
9			9	0.02000	0.01193	A
10			6	0.02000	0.02067	A
11			5	0.01500	0.01461	A
12			8	0.01000	0.02067	A
13			12	0.01000	0.02067	A

---------- Effect=trt*pos Method=LSD(P<.05) Set=3 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
14	STEE		4	0.06000	0.02067	A
15	STEE		1	0.06000	0.02067	A
16	STEE		7	0.04000	0.01461	A
17	STEE		11	0.03500	0.01461	A
18	STEE		3	0.02500	0.01461	A
19	STEE		2	0.02333	0.01193	A
20	STEE		10	0.02000	0.02067	A
21	STEE		9	0.02000	0.01193	A
22	STEE		6	0.02000	0.02067	A
23	STEE		5	0.01500	0.01461	A
24	STEE		8	0.01000	0.02067	A
25	STEE		12	0.01000	0.02067	A

---------- Effect=loc Method=' ' Set=4 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
26		CG	_	0.02819	0.005070	

Mean separation for Ksat

---------- Effect=trt*loc Method=' ' Set=5 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
27	STEE	CG	_	0.02819	0.005070	

---------- Effect=loc*pos Method=LSD(P<.05) Set=6 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
28		CG	4	0.06000	0.02067	A
29		CG	1	0.06000	0.02067	A

30	CG	7	0.04000	0.01461	A
31	CG	11	0.03500	0.01461	A
32	CG	3	0.02500	0.01461	A
33	CG	2	0.02333	0.01193	A
34	CG	10	0.02000	0.02067	A
35	CG	9	0.02000	0.01193	A
36	CG	6	0.02000	0.02067	A
37	CG	5	0.01500	0.01461	A
38	CG	8	0.01000	0.02067	A
39	CG	12	0.01000	0.02067	A

---------- Effect=trt*loc*pos Method=LSD(P<.05) Set=7 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
40	STEE	CG	4	0.06000	0.02067	A
41	STEE	CG	1	0.06000	0.02067	A
42	STEE	CG	7	0.04000	0.01461	A
43	STEE	CG	11	0.03500	0.01461	A
44	STEE	CG	3	0.02500	0.01461	A
45	STEE	CG	2	0.02333	0.01193	A
46	STEE	CG	10	0.02000	0.02067	A
47	STEE	CG	9	0.02000	0.01193	A
48	STEE	CG	6	0.02000	0.02067	A
49	STEE	CG	5	0.01500	0.01461	A
50	STEE	CG	8	0.01000	0.02067	A
51	STEE	CG	12	0.01000	0.02067	A

Check on normality for Ksat

The UNIVARIATE Procedure
Variable: Resid (Residual)

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.95597	Pr < W	0.4668
Kolmogorov-Smirnov	D	0.2	Pr > D	0.0352
Cramer-von Mises	W-Sq	0.103805	Pr > W-Sq	0.0945
Anderson-Darling	A-Sq	0.523534	Pr > A-Sq	0.1664

Extreme Observations

-------Lowest------		-------Highest------	
Value	Obs	Value	Obs
-0.0299853	21	0.00499755	5
-0.0149927	3	0.01499266	45
-0.0133268	30	0.01665851	44
-0.0099951	23	0.01999021	37
-0.0099951	9	0.02998531	7

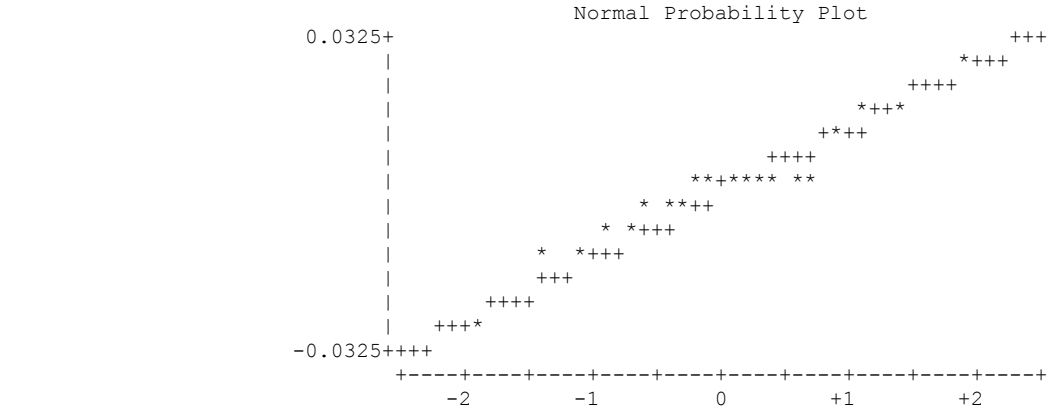
Missing Values

Missing Value	Count	-----Percent Of----- All Obs	Missing Obs
.	36	64.29	100.00

```
Stem Leaf                     #             Boxplot
   3 0                        1                0
   2
   2 0                        1                |
   1 57                       2                |
   1                                           |
   0 55                       2             +------+
   0 000000                   6             *--+--*
  -0 3                        1             |     |
  -0 55                       2             +------+
  -1 300                      3                |
  -1 5                        1                |
  -2
  -2
  -3 0                        1                0
     ----+----+----+----+
 Multiply Stem.Leaf by 10**-2
```


Check on normality for Ksat

The UNIVARIATE Procedure
Variable: Resid (Residual)



Check equality of stddev for y= Ksat

Obs	trt	loc	pos	nobs	rawmean_ y	stddev_y	stderr_y	Levene LeveneF_df	P
1	STEE	CG	1	1	0.060000	.	.	0.123(1,4)	0.7430
2	STEE	CG	2	3	0.023333	0.015275	0.008819	.	
3	STEE	CG	3	2	0.025000	0.021213	0.015000	.	
5	STEE	CG	5	2	0.015000	0.007071	0.005000	.	
7	STEE	CG	7	2	0.040000	0.042426	0.030000	.	
9	STEE	CG	9	3	0.020000	0.017321	0.010000	.	
11	STEE	CG	11	2	0.035000	0.007071	0.005000	.	

Mixed ANOVA for NO3

The Mixed Procedure

Model Information

Data Set	WORK.DSETZZ
Dependent Variable	NO3
Covariance Structure	Variance Components
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Kenward-Roger
Degrees of Freedom Method	Kenward-Roger

Class Level Information

Class	Levels	Values
trt	1	STEE
loc	1	CG
depth	2	1 2
pos	14	1 2 3 4 5 6 7 8 9 10 11 12 13 14
rnd	4	1 2 3 4

Dimensions

Covariance Parameters	5
Columns in X	60
Columns in Z	72
Subjects	1
Max Obs Per Subject	56

Number of Observations

Number of Observations Read	56
Number of Observations Used	27
Number of Observations Not Used	29

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	88.15955072	
1	4	88.15955072	.
2	1	87.97884739	0.00007880
3	2	87.95343877	0.00000178
4	2	87.95290869	0.00000005
5	1	87.95289641	0.00000000

Mixed ANOVA for NO3

The Mixed Procedure

Convergence criteria met but final hessian is not positive definite.

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr > Z

loc*rnd	0	.	.	.
trt*loc*rnd	0	.	.	.
trt*loc*depth*rnd	3.0837	7.4883	0.41	0.3402
pos(trt*loc*dep*rnd)	24.0168	11.9967	2.00	0.0226
Residual	2.0217	0	.	.

Fit Statistics

-2 Res Log Likelihood	88.0
AIC (smaller is better)	94.0
AICC (smaller is better)	96.6
BIC (smaller is better)	92.1

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trt	0	.	.	.
pos	13	8.73	5.39	0.0088
trt*pos	0	.	.	.
loc	0	.	.	.
trt*loc	0	.	.	.
loc*pos	0	.	.	.
trt*loc*pos	0	.	.	.

Mean separation for NO3

Effect=trt Method=' ' Set=1

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
1	STEE		_	15.5471	1.4535	

Effect=pos Method=LSD(P<.05) Set=2

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
2			10	27.1012	5.7542	A
3			9	25.0406	5.7434	AB
4			3	22.7829	5.7325	AB
5			4	22.1912	5.7542	AB
6			5	20.4631	3.1596	AB
7			8	18.0774	3.9629	AB
8			6	17.8323	3.9629	AB
9			7	17.2706	5.7434	ABC
10			11	16.1281	3.9626	ABC
11			2	15.7915	3.9629	ABC
12			1	10.5918	3.9626	BCD
13			12	2.1634	5.6893	CD
14			13	1.2100	2.6982	D
15			14	1.0150	2.6982	D

Effect=trt*pos Method=LSD(P<.05) Set=3

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group

16	STEE	10	27.1012	5.7542	A
17	STEE	9	25.0406	5.7434	AB
18	STEE	3	22.7829	5.7325	AB
19	STEE	4	22.1912	5.7542	AB
20	STEE	5	20.4631	3.1596	AB
21	STEE	8	18.0774	3.9629	AB
22	STEE	6	17.8323	3.9629	AB
23	STEE	7	17.2706	5.7434	ABC
24	STEE	11	16.1281	3.9626	ABC
25	STEE	2	15.7915	3.9629	ABC
26	STEE	1	10.5918	3.9626	BCD
27	STEE	12	2.1634	5.6893	CD
28	STEE	13	1.2100	2.6982	D
29	STEE	14	1.0150	2.6982	D

Mean separation for NO3

Effect=loc Method=' ' Set=4

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
30		CG	_	15.5471	1.4535	

Effect=trt*loc Method=' ' Set=5

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
31	STEE	CG	_	15.5471	1.4535	

Effect=loc*pos Method=LSD(P<.05) Set=6

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
32		CG	10	27.1012	5.7542	A
33		CG	9	25.0406	5.7434	AB
34		CG	3	22.7829	5.7325	AB
35		CG	4	22.1912	5.7542	AB
36		CG	5	20.4631	3.1596	AB
37		CG	8	18.0774	3.9629	AB
38		CG	6	17.8323	3.9629	AB
39		CG	7	17.2706	5.7434	ABC
40		CG	11	16.1281	3.9626	ABC
41		CG	2	15.7915	3.9629	ABC
42		CG	1	10.5918	3.9626	BCD
43		CG	12	2.1634	5.6893	CD
44		CG	13	1.2100	2.6982	D
45		CG	14	1.0150	2.6982	D

Effect=trt*loc*pos Method=LSD(P<.05) Set=7

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
46	STEE	CG	10	27.1012	5.7542	A
47	STEE	CG	9	25.0406	5.7434	AB
48	STEE	CG	3	22.7829	5.7325	AB
49	STEE	CG	4	22.1912	5.7542	AB

50	STEE	CG	5	20.4631	3.1596	AB
51	STEE	CG	8	18.0774	3.9629	AB
52	STEE	CG	6	17.8323	3.9629	AB
53	STEE	CG	7	17.2706	5.7434	ABC
54	STEE	CG	11	16.1281	3.9626	ABC
55	STEE	CG	2	15.7915	3.9629	ABC

Mean separation for NO3

---------- Effect=trt*loc*pos Method=LSD(P<.05) Set=7 ----------

(continued)

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
56	STEE	CG	1	10.5918	3.9626	BCD
57	STEE	CG	12	2.1634	5.6893	CD
58	STEE	CG	13	1.2100	2.6982	D
59	STEE	CG	14	1.0150	2.6982	D

Check on normality for NO3

The UNIVARIATE Procedure
Variable: Resid (Residual)

Tests for Normality

Test		--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.927087	Pr < W		0.0587
Kolmogorov-Smirnov	D	0.170822	Pr > D		0.0421
Cramer-von Mises	W-Sq	0.187171	Pr > W-Sq		0.0073
Anderson-Darling	A-Sq	0.988967	Pr > A-Sq		0.0114

Extreme Observations

------Lowest------		------Highest-----	
Value	Obs	Value	Obs
-0.606576	25	0.226141	19
-0.507792	47	0.246042	34
-0.501588	30	0.281650	33
-0.246042	20	0.501588	44
-0.159854	43	0.606576	39

Missing Values

Missing Value	Count	-----Percent Of----- All Obs	Missing Obs
.	29	51.79	100.00

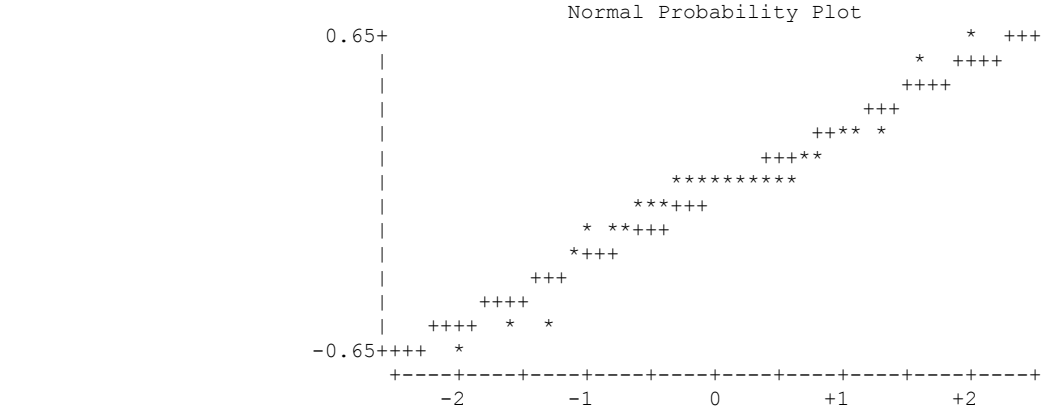
Stem	Leaf	#	Boxplot
6	1	1	0
5	0	1	0
4			
3			
2	358	3	|
1	06	2	+-----+

```
 0 0000003459              10             *--+--*
-0 522                      3             |     |
-1 621                      3             +-----+
-2 5                        1                |
-3
-4
-5 10                       2                0
-6 1                        1                0
   ----+----+----+----+
Multiply Stem.Leaf by 10**-1
```


Check on normality for NO3

The UNIVARIATE Procedure
Variable: Resid (Residual)

Normal Probability Plot



Check equality of stddev for y= NO3

Obs	trt	loc	pos	nobs	rawmean_ y	stddev_y	stderr_y	Levene LeveneF_df	P
1	STEE	CG	1	2	10.875	4.5326	3.20500	5.641(2,8)	0.0300
2	STEE	CG	2	2	15.915	9.7934	6.92500	.	
5	STEE	CG	5	3	20.450	6.5460	3.77932	.	
6	STEE	CG	6	2	17.545	4.4053	3.11500	.	
8	STEE	CG	8	2	17.900	0.7495	0.53000	.	
11	STEE	CG	11	2	16.540	12.4875	8.83000	.	
13	STEE	CG	13	4	1.210	0.5807	0.29037	.	
14	STEE	CG	14	4	1.015	0.9056	0.45278	.	

Mixed ANOVA for TC

The Mixed Procedure

Model Information

Data Set	WORK.DSETZZ
Dependent Variable	TC
Covariance Structure	Variance Components
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Kenward-Roger
Degrees of Freedom Method	Kenward-Roger

Class Level Information

Class	Levels	Values
trt	1	STEE
loc	1	CG
depth	2	1 2
pos	14	1 2 3 4 5 6 7 8 9 10 11 12 13 14
rnd	4	1 2 3 4

Dimensions

Covariance Parameters	5
Columns in X	60
Columns in Z	72
Subjects	1
Max Obs Per Subject	56

Number of Observations

Number of Observations Read	56
Number of Observations Used	42
Number of Observations Not Used	14

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	270.82600932	
1	4	210.69836843	.
2	1	207.84453612	0.03632644
3	3	203.36825080	.
4	2	201.75386464	.
5	2	201.30293580	.

Mixed ANOVA for TC

The Mixed Procedure

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
6	2	201.21447175	0.00007034
7	1	201.19658197	0.00000008
8	1	201.19656219	0.00000000

Convergence criteria met but final hessian is not positive definite.

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr > Z
loc*rnd	962.81	802.95	1.20	0.1152
trt*loc*rnd	0	.	.	.
trt*loc*depth*rnd	28.7605	34.1331	0.84	0.1997
pos(trt*loc*dep*rnd)	13.4961	6.0532	2.23	0.0129
Residual	5.8350	0	.	.

Fit Statistics

-2 Res Log Likelihood	201.2
AIC (smaller is better)	209.2
AICC (smaller is better)	210.9
BIC (smaller is better)	206.7

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trt	0	.	.	.
pos	13	15.8	1.39	0.2626
trt*pos	0	.	.	.
loc	0	.	.	.
trt*loc	0	.	.	.
loc*pos	0	.	.	.
trt*loc*pos	0	.	.	.

Mean separation for TC

---------- Effect=trt Method=' ' Set=1 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
1	STEE		_	27.3803	15.6586	

---------- Effect=pos Method=LSD(P<.05) Set=2 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
2			9	39.7526	16.1347	A
3			3	31.5437	16.0064	AB
4			7	29.5126	16.1347	B
5			13	28.6041	16.0064	B
6			1	28.0737	16.0064	B
7			5	27.9755	15.8973	B
8			11	27.2181	16.1347	B
9			10	26.9633	16.0813	AB
10			2	25.7915	15.8973	B
11			4	25.5595	15.8973	B
12			8	24.4644	15.9622	B
13			12	24.1200	15.9622	B
14			14	23.6525	15.9591	B
15			6	20.0922	15.8973	B

---------- Effect=trt*pos Method=LSD(P<.05) Set=3 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
16	STEE		9	39.7526	16.1347	A
17	STEE		3	31.5437	16.0064	AB
18	STEE		7	29.5126	16.1347	B
19	STEE		13	28.6041	16.0064	B
20	STEE		1	28.0737	16.0064	B
21	STEE		5	27.9755	15.8973	B
22	STEE		11	27.2181	16.1347	B
23	STEE		10	26.9633	16.0813	AB
24	STEE		2	25.7915	15.8973	B
25	STEE		4	25.5595	15.8973	B
26	STEE		8	24.4644	15.9622	B
27	STEE		12	24.1200	15.9622	B
28	STEE		14	23.6525	15.9591	B
29	STEE		6	20.0922	15.8973	B

Mean separation for TC

---------- Effect=loc Method=' ' Set=4 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
30		CG	_	27.3803	15.6586	

---------- Effect=trt*loc Method=' ' Set=5 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
31	STEE	CG	_	27.3803	15.6586	

---------- Effect=loc*pos Method=LSD(P<.05) Set=6 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
32		CG	9	39.7526	16.1347	A
33		CG	3	31.5437	16.0064	AB
34		CG	7	29.5126	16.1347	B
35		CG	13	28.6041	16.0064	B
36		CG	1	28.0737	16.0064	B
37		CG	5	27.9755	15.8973	B
38		CG	11	27.2181	16.1347	B
39		CG	10	26.9633	16.0813	AB
40		CG	2	25.7915	15.8973	B
41		CG	4	25.5595	15.8973	B
42		CG	8	24.4644	15.9622	B
43		CG	12	24.1200	15.9622	B
44		CG	14	23.6525	15.9591	B
45		CG	6	20.0922	15.8973	B

---------- Effect=trt*loc*pos Method=LSD(P<.05) Set=7 ----------

					Standard	Letter

Obs	trt	loc	pos	Estimate	Error	Group
46	STEE	CG	9	39.7526	16.1347	A
47	STEE	CG	3	31.5437	16.0064	AB
48	STEE	CG	7	29.5126	16.1347	B
49	STEE	CG	13	28.6041	16.0064	B
50	STEE	CG	1	28.0737	16.0064	B
51	STEE	CG	5	27.9755	15.8973	B
52	STEE	CG	11	27.2181	16.1347	B
53	STEE	CG	10	26.9633	16.0813	AB
54	STEE	CG	2	25.7915	15.8973	B
55	STEE	CG	4	25.5595	15.8973	B

Mean separation for TC

---------- Effect=trt*loc*pos Method=LSD(P<.05) Set=7 ----------

(continued)

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
56	STEE	CG	8	24.4644	15.9622	B
57	STEE	CG	12	24.1200	15.9622	B
58	STEE	CG	14	23.6525	15.9591	B
59	STEE	CG	6	20.0922	15.8973	B

Check on normality for TC

The UNIVARIATE Procedure
Variable: Resid (Residual)

Tests for Normality

Test		--Statistic---		-----p Value------
Shapiro-Wilk	W	0.976821	Pr < W	0.5419
Kolmogorov-Smirnov	D	0.093562	Pr > D	>0.1500
Cramer-von Mises	W-Sq	0.059962	Pr > W-Sq	>0.2500
Anderson-Darling	A-Sq	0.392948	Pr > A-Sq	>0.2500

Extreme Observations

------Lowest-----		-----Highest-----	
Value	Obs	Value	Obs
-2.77604	6	1.17457	5
-1.88311	12	1.31011	34
-1.08598	38	1.36709	26
-1.04507	27	1.54241	55
-1.04210	18	2.39935	4

Missing Values

Missing Value	Count	-----Percent Of----- All Obs	Missing Obs
.	14	25.00	100.00

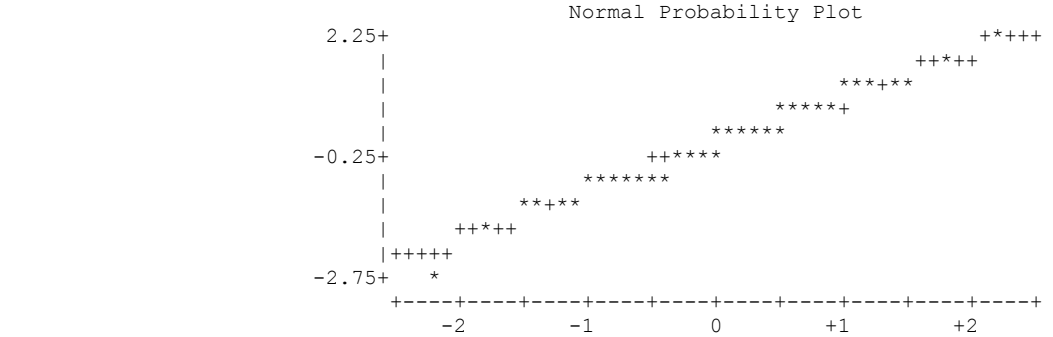
Stem	Leaf	#	Boxplot

```
      2 4                        1               0
      1 5                        1               |
      1 001234                   6               |
      0 5555599                  7           +------+
      0 123333                   6           *--+--*
     -0 4331                     4           |     |
     -0 87777665555             11           +------+
     -1 1000                     4               |
     -1 9                        1               |
     -2
     -2 8                        1               0
        ----+----+----+----+
```


Check on normality for TC

The UNIVARIATE Procedure
Variable: Resid (Residual)

Normal Probability Plot



Check equality of stddev for y= TC

Obs	trt	loc	pos	nobs	rawmean_ y	stddev_y	stderr_y	Levene LeveneF_df	P
1	STEE	CG	1	3	10.7760	2.4334	1.4049	0.943(9,24)	0.5070
2	STEE	CG	2	4	25.7915	29.7965	14.8983	.	
3	STEE	CG	3	3	14.2460	1.2658	0.7308	.	
4	STEE	CG	4	4	25.5595	33.1020	16.5510	.	
5	STEE	CG	5	4	27.9755	37.1929	18.5965	.	
6	STEE	CG	6	4	20.0923	21.6745	10.8372	.	
7	STEE	CG	7	2	11.9770	4.1097	2.9060	.	
8	STEE	CG	8	3	29.4810	33.1287	19.1269	.	
9	STEE	CG	9	2	22.2170	6.4488	4.5600	.	
10	STEE	CG	10	2	13.6425	6.8653	4.8545	.	
11	STEE	CG	11	2	9.6825	0.5056	0.3575		

.

12	STEE	CG	12	3	29.1367	26.4932	15.2958
.							
13	STEE	CG	13	3	11.3063	4.8489	2.7995
.							
14	STEE	CG	14	3	9.7553	0.9497	0.5483

.

Mixed ANOVA for TN

The Mixed Procedure

Model Information

Data Set	WORK.DSETZZ
Dependent Variable	TN
Covariance Structure	Variance Components
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Kenward-Roger
Degrees of Freedom Method	Kenward-Roger

Class Level Information

Class	Levels	Values
trt	1	STEE
loc	1	CG
depth	2	1 2
pos	14	1 2 3 4 5 6 7 8 9 10 11 12 13 14
rnd	4	1 2 3 4

Dimensions

Covariance Parameters	5
Columns in X	60
Columns in Z	72
Subjects	1
Max Obs Per Subject	56

Number of Observations

Number of Observations Read	56
Number of Observations Used	50
Number of Observations Not Used	6

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	272.50715717	
1	2	229.14635673	0.00000019
2	1	229.14491148	0.00000000

Mixed ANOVA for TN

The Mixed Procedure

Convergence criteria met but final hessian is not positive definite.

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr > Z
loc*rnd	51.2696	42.9289	1.19	0.1162
trt*loc*rnd	0	.	.	.
trt*loc*depth*rnd	0	.	.	.
pos(trt*loc*dep*rnd)	14.3873	3.7694	3.82	<.0001
Residual	0.9277	0	.	.

Fit Statistics

-2 Res Log Likelihood	229.1
AIC (smaller is better)	235.1
AICC (smaller is better)	235.9
BIC (smaller is better)	233.3

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trt	0	.	.	.
pos	13	33	2.12	0.0403
trt*pos	0	.	.	.
loc	0	.	.	.
trt*loc	0	.	.	.
loc*pos	0	.	.	.
trt*loc*pos	0	.	.	.

Mean separation for TN

---------- Effect=trt Method=' ' Set=1 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
1	STEE		_	10.7213	3.6276	

---------- Effect=pos Method=LSD(P<.05) Set=2 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
2			7	14.3742	4.2526	A
3			3	14.1075	4.0800	A
4			10	14.0809	4.2526	A
5			4	12.2075	4.0800	A
6			11	11.8942	4.2526	A
7			8	11.7009	4.2526	A
8			9	11.4975	4.2526	AB
9			12	11.2875	4.2526	AB
10			1	10.4025	4.0800	AB
11			6	9.7175	4.0800	ABC
12			5	9.6350	4.0800	ABC
13			2	9.6100	4.0800	ABC
14			14	5.3625	4.0800	BC
15			13	4.2200	4.0800	C

---------- Effect=trt*pos Method=LSD(P<.05) Set=3 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
16	STEE		7	14.3742	4.2526	A
17	STEE		3	14.1075	4.0800	A
18	STEE		10	14.0809	4.2526	A
19	STEE		4	12.2075	4.0800	A
20	STEE		11	11.8942	4.2526	A
21	STEE		8	11.7009	4.2526	A
22	STEE		9	11.4975	4.2526	AB
23	STEE		12	11.2875	4.2526	AB
24	STEE		1	10.4025	4.0800	AB
25	STEE		6	9.7175	4.0800	ABC
26	STEE		5	9.6350	4.0800	ABC
27	STEE		2	9.6100	4.0800	ABC
28	STEE		14	5.3625	4.0800	BC
29	STEE		13	4.2200	4.0800	C

Mean separation for TN

---------- Effect=loc Method=' ' Set=4 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
30		CG	_	10.7213	3.6276	

---------- Effect=trt*loc Method=' ' Set=5 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
31	STEE	CG	_	10.7213	3.6276	

---------- Effect=loc*pos Method=LSD(P<.05) Set=6 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
32		CG	7	14.3742	4.2526	A
33		CG	3	14.1075	4.0800	A
34		CG	10	14.0809	4.2526	A
35		CG	4	12.2075	4.0800	A
36		CG	11	11.8942	4.2526	A
37		CG	8	11.7009	4.2526	A
38		CG	9	11.4975	4.2526	AB
39		CG	12	11.2875	4.2526	AB
40		CG	1	10.4025	4.0800	AB
41		CG	6	9.7175	4.0800	ABC
42		CG	5	9.6350	4.0800	ABC
43		CG	2	9.6100	4.0800	ABC
44		CG	14	5.3625	4.0800	BC
45		CG	13	4.2200	4.0800	C

---------- Effect=trt*loc*pos Method=LSD(P<.05) Set=7 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
46	STEE	CG	7	14.3742	4.2526	A
47	STEE	CG	3	14.1075	4.0800	A
48	STEE	CG	10	14.0809	4.2526	A
49	STEE	CG	4	12.2075	4.0800	A
50	STEE	CG	11	11.8942	4.2526	A
51	STEE	CG	8	11.7009	4.2526	A
52	STEE	CG	9	11.4975	4.2526	AB
53	STEE	CG	12	11.2875	4.2526	AB
54	STEE	CG	1	10.4025	4.0800	AB
55	STEE	CG	6	9.7175	4.0800	ABC

Mean separation for TN

---------- Effect=trt*loc*pos Method=LSD(P<.05) Set=7 ----------

(continued)

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
56	STEE	CG	5	9.6350	4.0800	ABC
57	STEE	CG	2	9.6100	4.0800	ABC
58	STEE	CG	14	5.3625	4.0800	BC
59	STEE	CG	13	4.2200	4.0800	C

Check on normality for TN

The UNIVARIATE Procedure
Variable: Resid (Residual)

Tests for Normality

Test		--Statistic---		-----p Value------
Shapiro-Wilk	W	0.959742	Pr < W	0.0867
Kolmogorov-Smirnov	D	0.103929	Pr > D	>0.1500
Cramer-von Mises	W-Sq	0.111464	Pr > W-Sq	0.0805
Anderson-Darling	A-Sq	0.716865	Pr > A-Sq	0.0598

Extreme Observations

------Lowest------		------Highest-----	
Value	Obs	Value	Obs
-0.404134	26	0.308317	10
-0.383336	25	0.370509	11
-0.372567	8	0.375692	21
-0.268250	35	0.475240	22
-0.220503	45	0.521470	40

Missing Values

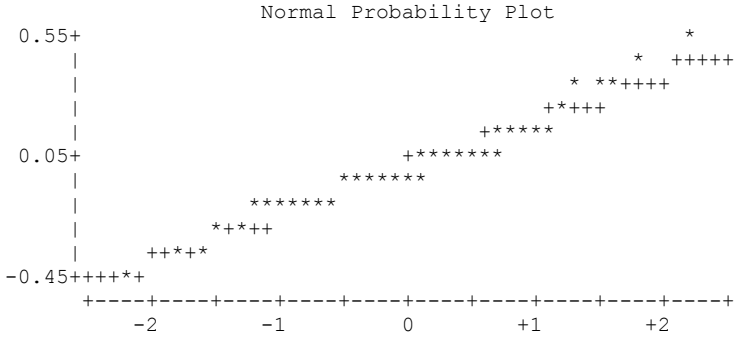
Missing Value	Count	-----Percent Of----- All Obs	Missing Obs
.	6	10.71	100.00

```
Stem Leaf                     #             Boxplot
   5 2                        1                0
   4 8                        1                0
   3 178                      3                |
   2 0                        1                |
   1 0222459                  7             +------+
   0 0122335678              10             |  +   |
  -0 98644433210             11             *------*
  -1 77754221100             11             +------+
  -2 72                       2                |
  -3 87                       2                |
  -4 0                        1                |
     ----+----+----+----+
 Multiply Stem.Leaf by 10**-1
```


Check on normality for TN

The UNIVARIATE Procedure
Variable: Resid (Residual)

Normal Probability Plot



Check equality of stddev for y= TN

Obs	trt	loc	pos	nobs	rawmean_ y	stddev_y	stderr_y	Levene LeveneF_df	P
1	STEE	CG	1	4	10.4025	9.6157	4.80784	0.775(13,36)	0.6800
2	STEE	CG	2	4	9.6100	7.2305	3.61525	.	
3	STEE	CG	3	4	14.1075	9.9576	4.97880	.	
4	STEE	CG	4	4	12.2075	7.3688	3.68441	.	
5	STEE	CG	5	4	9.6350	6.6988	3.34941	.	
6	STEE	CG	6	4	9.7175	6.3221	3.16106	.	
7	STEE	CG	7	3	16.0067	9.5199	5.49630	.	
8	STEE	CG	8	3	13.3333	7.2842	4.20555	.	
9	STEE	CG	9	3	13.1300	7.4801	4.31866	.	
10	STEE	CG	10	3	15.7133	11.9098	6.87613		

.

11	STEE	CG	11	3	13.5267	12.6809	7.32133
12	STEE	CG	12	3	12.9200	7.8324	4.52205
13	STEE	CG	13	4	4.2200	4.9251	2.46253
14	STEE	CG	14	4	5.3625	7.0951	3.54757

.

Mixed ANOVA for TP

The Mixed Procedure

Model Information

Data Set	WORK.DSETZZ
Dependent Variable	TP
Covariance Structure	Variance Components
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Kenward-Roger
Degrees of Freedom Method	Kenward-Roger

Class Level Information

Class	Levels	Values
trt	1	STEE
loc	1	CG
depth	2	1 2
pos	14	1 2 3 4 5 6 7 8 9 10 11 12 13 14
rnd	4	1 2 3 4

Dimensions

Covariance Parameters	5
Columns in X	60
Columns in Z	72
Subjects	1
Max Obs Per Subject	56

Number of Observations

Number of Observations Read	56
Number of Observations Used	41
Number of Observations Not Used	15

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	-6.00851319	
1	4	-8.31251032	417.11061656
2	1	-16.39112371	104.26837017
3	1	-25.46874170	21.40206849
4	1	-32.98237920	4.09161569
5	1	-38.32537942	0.75601669

The Mixed Procedure

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
6	1	-41.77535673	0.13476058
7	1	-43.82711729	0.02285679
8	1	-44.92650387	0.00355294
9	1	-45.42290512	0.00046249
10	1	-45.58628686	0.00004077
11	1	-45.61486103	0.00000138
12	1	-45.61622708	0.00000000

Convergence criteria met but final hessian is not positive definite.

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr > Z
loc*rnd	0.01607	0.02819	0.57	0.2843
trt*loc*rnd	0.01603	0	.	.
trt*loc*depth*rnd	0.003551	0.003357	1.06	0.1450
pos(trt*loc*dep*rnd)	0	.	.	.
Residual	0.003153	0.000965	3.27	0.0005

Fit Statistics

-2 Res Log Likelihood	-45.6
AIC (smaller is better)	-37.6
AICC (smaller is better)	-35.8
BIC (smaller is better)	-40.1

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trt	0	.	.	.
pos	13	17.4	2.06	0.0794
trt*pos	0	.	.	.
loc	0	.	.	.
trt*loc	0	.	.	.
loc*pos	0	.	.	.
trt*loc*pos	0	.	.	.

Mean separation for TP

---------- Effect=trt Method=' ' Set=1 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
1	STEE		_	0.3092	0.09262	

---------- Effect=pos Method=LSD(P<.05) Set=2 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
2			14	0.3831	0.1003	AB
3			1	0.3698	0.09849	AC
4			12	0.3522	0.1034	ABCD
5			11	0.3458	0.1036	ABC
6			13	0.3387	0.1005	ABC
7			2	0.3258	0.09849	ABCD
8			6	0.3105	0.1003	ABCD
9			9	0.3053	0.1036	ABCD
10			7	0.3002	0.1002	ABCD
11			10	0.2957	0.1002	ABCD
12			8	0.2792	0.1034	ABCD
13			4	0.2538	0.09849	CDE
14			5	0.2470	0.1005	BDE
15			3	0.2217	0.1005	D

---------- Effect=trt*pos Method=LSD(P<.05) Set=3 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
16	STEE		14	0.3831	0.1003	AB
17	STEE		1	0.3698	0.09849	AC
18	STEE		12	0.3522	0.1034	ABCD
19	STEE		11	0.3458	0.1036	ABC
20	STEE		13	0.3387	0.1005	ABC
21	STEE		2	0.3258	0.09849	ABCD
22	STEE		6	0.3105	0.1003	ABCD
23	STEE		9	0.3053	0.1036	ABCD
24	STEE		7	0.3002	0.1002	ABCD
25	STEE		10	0.2957	0.1002	ABCD
26	STEE		8	0.2792	0.1034	ABCD
27	STEE		4	0.2538	0.09849	CDE
28	STEE		5	0.2470	0.1005	BDE
29	STEE		3	0.2217	0.1005	D

Mean separation for TP

---------- Effect=loc Method=' ' Set=4 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
30		CG	_	0.3092	0.09262	

---------- Effect=trt*loc Method=' ' Set=5 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
31	STEE	CG	_	0.3092	0.09262	

---------- Effect=loc*pos Method=LSD(P<.05) Set=6 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
32		CG	14	0.3831	0.1003	AB

33	CG	1	0.3698	0.09849	AC
34	CG	12	0.3522	0.1034	ABCD
35	CG	11	0.3458	0.1036	ABC
36	CG	13	0.3387	0.1005	ABC
37	CG	2	0.3258	0.09849	ABCD
38	CG	6	0.3105	0.1003	ABCD
39	CG	9	0.3053	0.1036	ABCD
40	CG	7	0.3002	0.1002	ABCD
41	CG	10	0.2957	0.1002	ABCD
42	CG	8	0.2792	0.1034	ABCD
43	CG	4	0.2538	0.09849	CDE
44	CG	5	0.2470	0.1005	BDE
45	CG	3	0.2217	0.1005	D

---------- Effect=trt*loc*pos Method=LSD(P<.05) Set=7 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
46	STEE	CG	14	0.3831	0.1003	AB
47	STEE	CG	1	0.3698	0.09849	AC
48	STEE	CG	12	0.3522	0.1034	ABCD
49	STEE	CG	11	0.3458	0.1036	ABC
50	STEE	CG	13	0.3387	0.1005	ABC
51	STEE	CG	2	0.3258	0.09849	ABCD
52	STEE	CG	6	0.3105	0.1003	ABCD
53	STEE	CG	9	0.3053	0.1036	ABCD
54	STEE	CG	7	0.3002	0.1002	ABCD
55	STEE	CG	10	0.2957	0.1002	ABCD

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Mean separation for TP

---------- Effect=trt*loc*pos Method=LSD(P<.05) Set=7 ----------

(continued)

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
56	STEE	CG	8	0.2792	0.1034	ABCD
57	STEE	CG	4	0.2538	0.09849	CDE
58	STEE	CG	5	0.2470	0.1005	BDE
59	STEE	CG	3	0.2217	0.1005	D

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Check on normality for TP

The UNIVARIATE Procedure
Variable: Resid (Residual)

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.968477	Pr < W	0.3072
Kolmogorov-Smirnov	D	0.107038	Pr > D	>0.1500
Cramer-von Mises	W-Sq	0.086467	Pr > W-Sq	0.1705
Anderson-Darling	A-Sq	0.504284	Pr > A-Sq	0.2014

Extreme Observations

-------Lowest------ ------Highest------

Value	Obs	Value	Obs
-0.0765160	41	0.0455420	8
-0.0660066	38	0.0457890	1
-0.0645689	48	0.0580775	10
-0.0574412	43	0.0692424	34
-0.0541164	16	0.0879479	30

Missing Values

Missing Value	Count	Percent Of All Obs	Percent Of Missing Obs
.	15	26.79	100.00

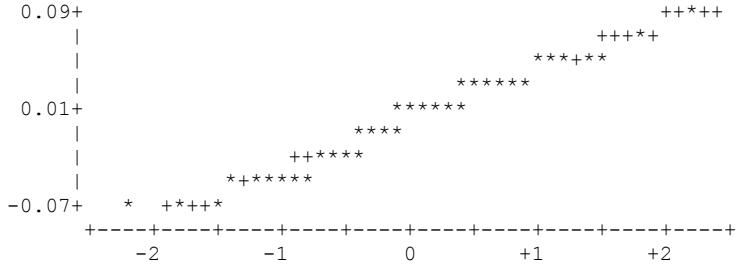
Stem	Leaf	#	Boxplot
8	8	1	
6	9	1	
4	14668	5	
2	1793467	7	+-----+
0	58056889	8	*--+--*
-0	95752	5	| |
-2	77453	5	+-----+
-4	742986	6	
-6	765	3	

Multiply Stem.Leaf by 10**-2

Check on normality for TP

The UNIVARIATE Procedure
Variable: Resid (Residual)

Normal Probability Plot



Check equality of stddev for y= TP

Obs	trt	loc	pos	nobs	rawmean_ y	stddev_y	stderr_y	Levene LeveneF_df	P
1	STEE	CG	1	4	0.36975	0.19410	0.09705	0.959(9,23)	0.4970
2	STEE	CG	2	4	0.32575	0.22012	0.11006	.	
3	STEE	CG	3	3	0.30667	0.07836	0.04524		

4	STEE	CG	4	4	0.25375	0.16455	0.08228
5	STEE	CG	5	3	0.33200	0.07374	0.04257
6	STEE	CG	6	3	0.39933	0.10383	0.05995
7	STEE	CG	7	3	0.27133	0.22990	0.13273
8	STEE	CG	8	2	0.39550	0.10253	0.07250
9	STEE	CG	9	2	0.38950	0.17041	0.12050
10	STEE	CG	10	3	0.28433	0.23195	0.13392
11	STEE	CG	11	2	0.43000	0.20082	0.14200
12	STEE	CG	12	2	0.46850	0.01061	0.00750
13	STEE	CG	13	3	0.42367	0.16561	0.09561
14	STEE	CG	14	3	0.47200	0.04371	0.02524

Crescent Glen – RSFE

The SAS System 14:02 Wednesday, July 7, 2010 1388

Mixed ANOVA for Ksat

The Mixed Procedure

Model Information

Data Set	WORK.DSETZZ
Dependent Variable	Ksat
Covariance Structure	Variance Components
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Kenward-Roger
Degrees of Freedom Method	Kenward-Roger

Class Level Information

Class	Levels	Values
trt	1	RSFE
loc	1	CG
depth	2	1 2
pos	14	1 2 3 4 5 6 7 8 9 10 11 12 13 14
rnd	4	1 2 3 4

Dimensions

Covariance Parameters	5
Columns in X	56
Columns in Z	72
Subjects	1
Max Obs Per Subject	56

Number of Observations

Number of Observations Read	56
Number of Observations Used	24
Number of Observations Not Used	32

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	-41.52442185	
1	4	-41.52773488	.
2	1	-41.82144864	.
3	1	-41.92621666	0.00062134
4	1	-41.94846473	0.00004912
5	1	-41.95007734	0.00000040

Mixed ANOVA for Ksat

The Mixed Procedure

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
6	1	-41.95008988	0.00000000

Convergence criteria met.

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr > Z
loc*rnd	0	.	.	.
trt*loc*rnd	0	.	.	.
trt*loc*depth*rnd	0.000168	0.000337	0.50	0.3090
pos(trt*loc*dep*rnd)	0	.	.	.
Residual	0.000537	0.000332	1.62	0.0531

Fit Statistics

-2 Res Log Likelihood	-42.0
AIC (smaller is better)	-38.0
AICC (smaller is better)	-36.5
BIC (smaller is better)	-39.2

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trt	0	.	.	.
pos	12	5.4	1.09	0.4938
trt*pos	0	.	.	.
loc	0	.	.	.
trt*loc	0	.	.	.
loc*pos	0	.	.	.
trt*loc*pos	0	.	.	.

Mean separation for Ksat

---------- Effect=trt Method=' ' Set=1 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
1	RSFE		_	0.04393	0.007469	

---------- Effect=pos Method=LSD(P<.05) Set=2 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
2			13	0.08177	0.02024	A
3			1	0.06852	0.02888	AB
4			10	0.06846	0.02938	AB
5			3	0.05667	0.01591	AB
6			8	0.04917	0.01996	AB
7			12	0.04900	0.02931	AB
8			7	0.03897	0.01996	AB
9			11	0.03323	0.02024	AB
10			2	0.03320	0.02943	AB
11			9	0.02823	0.02024	AB
12			4	0.02355	0.01581	B
13			6	0.02110	0.02023	AB
14			5	0.01926	0.01996	AB

---------- Effect=trt*pos Method=LSD(P<.05) Set=3 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
15	RSFE		13	0.08177	0.02024	A
16	RSFE		1	0.06852	0.02888	AB
17	RSFE		10	0.06846	0.02938	AB
18	RSFE		3	0.05667	0.01591	AB
19	RSFE		8	0.04917	0.01996	AB
20	RSFE		12	0.04900	0.02931	AB
21	RSFE		7	0.03897	0.01996	AB
22	RSFE		11	0.03323	0.02024	AB
23	RSFE		2	0.03320	0.02943	AB
24	RSFE		9	0.02823	0.02024	AB
25	RSFE		4	0.02355	0.01581	B
26	RSFE		6	0.02110	0.02023	AB
27	RSFE		5	0.01926	0.01996	AB

Mean separation for Ksat

---------- Effect=loc Method=' ' Set=4 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
28		CG	_	0.04393	0.007469	

---------- Effect=trt*loc Method=' ' Set=5 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group

29	RSFE	CG	_	0.04393	0.007469	

---------- Effect=loc*pos Method=LSD(P<.05) Set=6 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
30		CG	13	0.08177	0.02024	A
31		CG	1	0.06852	0.02888	AB
32		CG	10	0.06846	0.02938	AB
33		CG	3	0.05667	0.01591	AB
34		CG	8	0.04917	0.01996	AB
35		CG	12	0.04900	0.02931	AB
36		CG	7	0.03897	0.01996	AB
37		CG	11	0.03323	0.02024	AB
38		CG	2	0.03320	0.02943	AB
39		CG	9	0.02823	0.02024	AB
40		CG	4	0.02355	0.01581	B
41		CG	6	0.02110	0.02023	AB
42		CG	5	0.01926	0.01996	AB

---------- Effect=trt*loc*pos Method=LSD(P<.05) Set=7 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
43	RSFE	CG	13	0.08177	0.02024	A
44	RSFE	CG	1	0.06852	0.02888	AB
45	RSFE	CG	10	0.06846	0.02938	AB
46	RSFE	CG	3	0.05667	0.01591	AB
47	RSFE	CG	8	0.04917	0.01996	AB
48	RSFE	CG	12	0.04900	0.02931	AB
49	RSFE	CG	7	0.03897	0.01996	AB
50	RSFE	CG	11	0.03323	0.02024	AB
51	RSFE	CG	2	0.03320	0.02943	AB
52	RSFE	CG	9	0.02823	0.02024	AB
53	RSFE	CG	4	0.02355	0.01581	B

Mean separation for Ksat

---------- Effect=trt*loc*pos Method=LSD(P<.05) Set=7 ----------

(continued)

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
54	RSFE	CG	6	0.02110	0.02023	AB
55	RSFE	CG	5	0.01926	0.01996	AB

Check on normality for Ksat

The UNIVARIATE Procedure
Variable: Resid (Residual)

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.986287	Pr < W	0.9787

Kolmogorov-Smirnov	D	0.088594	Pr > D	>0.1500
Cramer-von Mises	W-Sq	0.034808	Pr > W-Sq	>0.2500
Anderson-Darling	A-Sq	0.196096	Pr > A-Sq	>0.2500

Extreme Observations

Lowest		Highest	
Value	Obs	Value	Obs
-0.0298329	8	0.0120965	48
-0.0202913	37	0.0152913	25
-0.0152913	39	0.0202913	23
-0.0145511	32	0.0212671	31
-0.0131168	45	0.0298329	36

Missing Values

Missing Value	Count	Percent Of All Obs	Percent Of Missing Obs
.	32	57.14	100.00

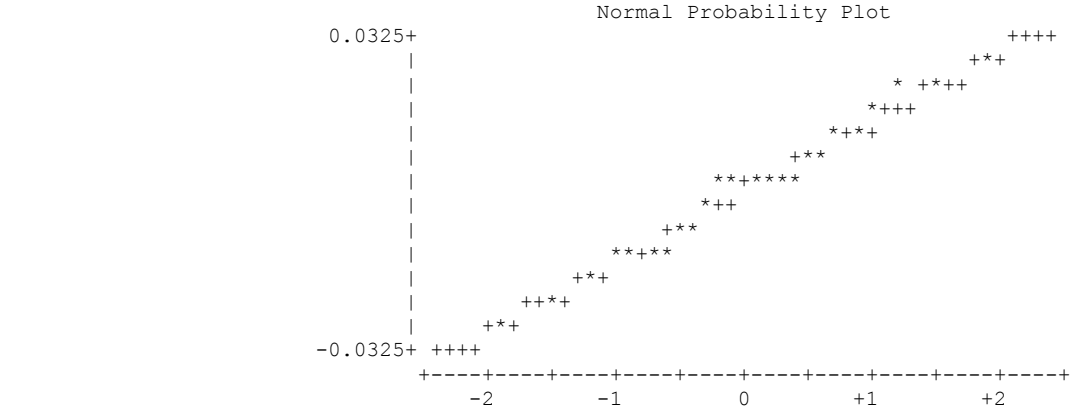
Stem	Leaf	#	Boxplot
3	0	1	
2			
2	01	2	
1	5	1	
1	012	3	+-----+
0	59	2	| |
0	00002	5	*--+--*
-0	2	1	| |
-0	98	2	| |
-1	321	3	+-----+
-1	55	2	
-2	0	1	
-2			
-3	0	1	

Multiply Stem.Leaf by 10**-2

Check on normality for Ksat

The UNIVARIATE Procedure
Variable: Resid (Residual)

Normal Probability Plot



Check equality of stddev for y= Ksat

Obs	trt	loc	pos	nobs	rawmean_ y	stddev_y	stderr_y	Levene F_df	Levene P
1	RSFE	CG	1	1	0.080000	.	.	0(1,4)	1.0000
3	RSFE	CG	3	3	0.056667	0.015275	0.008819	.	
4	RSFE	CG	4	3	0.026667	0.015275	0.008819	.	
5	RSFE	CG	5	2	0.025000	0.021213	0.015000	.	
6	RSFE	CG	6	2	0.025000	0.021213	0.015000	.	
7	RSFE	CG	7	2	0.035000	0.021213	0.015000	.	
8	RSFE	CG	8	2	0.045000	0.049497	0.035000	.	
9	RSFE	CG	9	2	0.030000	0.042426	0.030000	.	
11	RSFE	CG	11	2	0.035000	0.035355	0.025000	.	
13	RSFE	CG	13	2	0.080000	0.000000	0.000000	.	

Mixed ANOVA for NO3

The Mixed Procedure

Model Information

Data Set	WORK.DSETZZ
Dependent Variable	NO3
Covariance Structure	Variance Components
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Kenward-Roger
Degrees of Freedom Method	Kenward-Roger

Class Level Information

Class	Levels	Values
trt	1	RSFE
loc	1	CG
depth	2	1 2
pos	14	1 2 3 4 5 6 7 8 9 10 11 12 13 14
rnd	4	1 2 3 4

Dimensions

Covariance Parameters	5
Columns in X	60
Columns in Z	72
Subjects	1
Max Obs Per Subject	56

Number of Observations

Number of Observations Read	56
Number of Observations Used	50
Number of Observations Not Used	6

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	80.89260724	
1	4	69.75396239	76.61509399
2	1	68.88184578	16.59451769
3	1	68.49034297	2.43352558
4	1	68.37473853	0.19477703
5	1	68.35875664	0.00442983

Mixed ANOVA for NO3

The Mixed Procedure

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
6	1	68.35828644	0.00000493
7	1	68.35828589	0.00000000

Convergence criteria met but final hessian is not positive definite.

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr > Z
loc*rnd	0.07731	0.1232	0.63	0.2652
trt*loc*rnd	0.05071	0	.	.
trt*loc*depth*rnd	0.01175	0.03549	0.33	0.3703
pos(trt*loc*dep*rnd)	0	.	.	.
Residual	0.1938	0.04981	3.89	<.0001

Fit Statistics

-2 Res Log Likelihood	68.4
AIC (smaller is better)	76.4
AICC (smaller is better)	77.6
BIC (smaller is better)	73.9

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trt	0	.	.	.
pos	13	24.3	1.19	0.3413
trt*pos	0	.	.	.
loc	0	.	.	.
trt*loc	0	.	.	.
loc*pos	0	.	.	.

trt*loc*pos 0 . . .

Mean separation for NO3

Effect=trt Method=' ' Set=1

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
1	RSFE		_	0.4514	0.1938	

Effect=pos Method=LSD(P<.05) Set=2

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
2			6	1.2175	0.2888	A
3			8	0.7700	0.2888	AB
4			4	0.4675	0.2888	B
5			3	0.4525	0.2888	B
6			2	0.4300	0.2888	B
7			13	0.4138	0.3205	B
8			1	0.4075	0.2888	B
9			10	0.3533	0.3208	B
10			9	0.3499	0.3208	B
11			12	0.3433	0.3208	B
12			5	0.3225	0.2888	B
13			11	0.2932	0.3208	B
14			7	0.2850	0.2888	B
15			14	0.2132	0.3205	B

Effect=trt*pos Method=LSD(P<.05) Set=3

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
16	RSFE		6	1.2175	0.2888	A
17	RSFE		8	0.7700	0.2888	AB
18	RSFE		4	0.4675	0.2888	B
19	RSFE		3	0.4525	0.2888	B
20	RSFE		2	0.4300	0.2888	B
21	RSFE		13	0.4138	0.3205	B
22	RSFE		1	0.4075	0.2888	B
23	RSFE		10	0.3533	0.3208	B
24	RSFE		9	0.3499	0.3208	B
25	RSFE		12	0.3433	0.3208	B
26	RSFE		5	0.3225	0.2888	B
27	RSFE		11	0.2932	0.3208	B
28	RSFE		7	0.2850	0.2888	B
29	RSFE		14	0.2132	0.3205	B

Mean separation for NO3

Effect=loc Method=' ' Set=4

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
30		CG	_	0.4514	0.1938	

---------- Effect=trt*loc Method=' ' Set=5 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
31	RSFE	CG	_	0.4514	0.1938	

---------- Effect=loc*pos Method=LSD(P<.05) Set=6 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
32		CG	6	1.2175	0.2888	A
33		CG	8	0.7700	0.2888	AB
34		CG	4	0.4675	0.2888	B
35		CG	3	0.4525	0.2888	B
36		CG	2	0.4300	0.2888	B
37		CG	13	0.4138	0.3205	B
38		CG	1	0.4075	0.2888	B
39		CG	10	0.3533	0.3208	B
40		CG	9	0.3499	0.3208	B
41		CG	12	0.3433	0.3208	B
42		CG	5	0.3225	0.2888	B
43		CG	11	0.2932	0.3208	B
44		CG	7	0.2850	0.2888	B
45		CG	14	0.2132	0.3205	B

---------- Effect=trt*loc*pos Method=LSD(P<.05) Set=7 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
46	RSFE	CG	6	1.2175	0.2888	A
47	RSFE	CG	8	0.7700	0.2888	AB
48	RSFE	CG	4	0.4675	0.2888	B
49	RSFE	CG	3	0.4525	0.2888	B
50	RSFE	CG	2	0.4300	0.2888	B
51	RSFE	CG	13	0.4138	0.3205	B
52	RSFE	CG	1	0.4075	0.2888	B
53	RSFE	CG	10	0.3533	0.3208	B
54	RSFE	CG	9	0.3499	0.3208	B
55	RSFE	CG	12	0.3433	0.3208	B

Mean separation for NO3

---------- Effect=trt*loc*pos Method=LSD(P<.05) Set=7 ----------

(continued)

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
56	RSFE	CG	5	0.3225	0.2888	B
57	RSFE	CG	11	0.2932	0.3208	B
58	RSFE	CG	7	0.2850	0.2888	B
59	RSFE	CG	14	0.2132	0.3205	B

Check on normality for NO3

The UNIVARIATE Procedure
Variable: Resid (Residual)

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.834063	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.198058	Pr > D	<0.0100
Cramer-von Mises	W-Sq	0.332819	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	2.017832	Pr > A-Sq	<0.0050

Extreme Observations

------Lowest------		------Highest-----	
Value	Obs	Value	Obs
-0.676980	34	0.216900	56
-0.587440	48	0.232919	43
-0.532000	18	0.526420	4
-0.434500	16	0.925500	22
-0.430492	15	1.588000	20

Missing Values

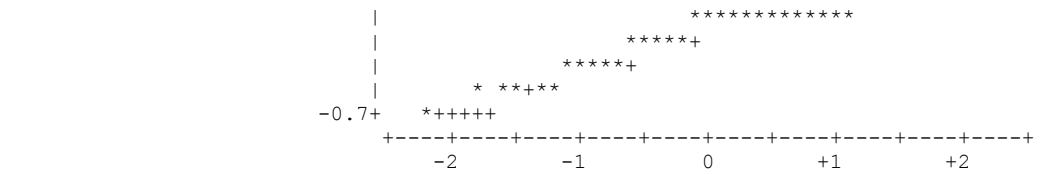
Missing Value	Count	-----Percent Of----- All Obs	Missing Obs
.	6	10.71	100.00

```
Stem Leaf                     #             Boxplot
  14 9                        1                *
  12
  10
   8 3                        1                0
   6
   4 3                        1                |
   2 123                      3                |
   0 012357789999000135569 9  22             +--+--+
  -0 863995444                9              |     |
  -2 2177532                  7              +-----+
  -4 93333                    5                 |
  -6 8                        1                 |
     ----+----+----+----+--
 Multiply Stem.Leaf by 10**-1
```


Check on normality for NO3

The UNIVARIATE Procedure
Variable: Resid (Residual)

Normal Probability Plot



Check equality of stddev for y= NO3

Obs	trt	loc	pos	nobs	rawmean_ y	stddev_y	stderr_y	Levene LeveneF_df	P
1	RSFE	CG	1	4	0.40750	0.42437	0.21219	1.97(13,36)	0.0540
2	RSFE	CG	2	4	0.43000	0.43704	0.21852	.	
3	RSFE	CG	3	4	0.45250	0.39322	0.19661	.	
4	RSFE	CG	4	4	0.46750	0.66209	0.33104	.	
5	RSFE	CG	5	4	0.32250	0.42742	0.21371	.	
6	RSFE	CG	6	4	1.21750	1.25980	0.62990	.	
7	RSFE	CG	7	4	0.28500	0.36519	0.18260	.	
8	RSFE	CG	8	4	0.77000	0.82175	0.41087	.	
9	RSFE	CG	9	3	0.41000	0.42579	0.24583	.	
10	RSFE	CG	10	3	0.43000	0.34044	0.19655	.	
11	RSFE	CG	11	3	0.35333	0.34429	0.19877	.	
12	RSFE	CG	12	3	0.42000	0.46357	0.26764	.	
13	RSFE	CG	13	3	0.51333	0.24194	0.13968	.	
14	RSFE	CG	14	3	0.33333	0.31214	0.18022	.	

Mixed ANOVA for TC

The Mixed Procedure

Model Information

Data Set	WORK.DSETZZ
Dependent Variable	TC
Covariance Structure	Variance Components
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Kenward-Roger
Degrees of Freedom Method	Kenward-Roger

Class Level Information

Class	Levels	Values

trt	1	RSFE
loc	1	CG
depth	2	1 2
pos	14	1 2 3 4 5 6 7 8 9 10 11 12 13 14
rnd	4	1 2 3 4

Dimensions

Covariance Parameters	5
Columns in X	60
Columns in Z	72
Subjects	1
Max Obs Per Subject	56

Number of Observations

Number of Observations Read	56
Number of Observations Used	42
Number of Observations Not Used	14

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	277.26034175	
1	3	230.09426731	0.00002148
2	2	226.19248493	0.00001714
3	2	224.73040102	0.00000166
4	3	220.57575139	.
5	2	220.07564632	0.00000277

Mixed ANOVA for TC

The Mixed Procedure

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
6	1	220.07011861	0.00000005
7	1	220.07000266	0.00000000

Convergence criteria met but final hessian is not positive definite.

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr > Z
loc*rnd	851.42	851.09	1.00	0.1586
trt*loc*rnd	175.31	0	.	.
trt*loc*depth*rnd	8.4872	19.7775	0.43	0.3339
pos(trt*loc*dep*rnd)	44.7613	14.6521	3.05	0.0011
Residual	2.6947	0	.	.

Fit Statistics

-2 Res Log Likelihood	220.1
AIC (smaller is better)	230.1

AICC (smaller is better)	232.8
BIC (smaller is better)	227.0

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trt	0	.	.	.
pos	13	15.5	1.73	0.1522
trt*pos	0	.	.	.
loc	0	.	.	.
trt*loc	0	.	.	.
loc*pos	0	.	.	.
trt*loc*pos	0	.	.	.

Mean separation for TC

Effect=trt Method=' ' Set=1

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
1	RSFE		_	29.6953	16.1072	

Effect=pos Method=LSD(P<.05) Set=2

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
2			3	41.0032	16.6638	A
3			6	38.9917	16.4520	AB
4			9	35.9275	16.9598	ABC
5			4	32.2130	16.5962	ABC
6			2	28.9549	16.4520	ABC
7			11	28.6929	16.6154	ABC
8			5	28.3851	16.6638	BC
9			12	28.1113	16.6061	ABC
10			10	26.2267	16.6061	C
11			13	26.0809	16.9701	BC
12			1	25.9821	16.6638	C
13			7	25.6628	16.6638	C
14			14	25.6512	16.6026	C
15			8	23.8507	16.5962	C

Effect=trt*pos Method=LSD(P<.05) Set=3

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
16	RSFE		3	41.0032	16.6638	A
17	RSFE		6	38.9917	16.4520	AB
18	RSFE		9	35.9275	16.9598	ABC
19	RSFE		4	32.2130	16.5962	ABC
20	RSFE		2	28.9549	16.4520	ABC
21	RSFE		11	28.6929	16.6154	ABC
22	RSFE		5	28.3851	16.6638	BC
23	RSFE		12	28.1113	16.6061	ABC
24	RSFE		10	26.2267	16.6061	C
25	RSFE		13	26.0809	16.9701	BC
26	RSFE		1	25.9821	16.6638	C

27	RSFE	7	25.6628	16.6638	C
28	RSFE	14	25.6512	16.6026	C
29	RSFE	8	23.8507	16.5962	C

Mean separation for TC

Effect=loc Method=' ' Set=4

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
30		CG	_	29.6953	16.1072	

Effect=trt*loc Method=' ' Set=5

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
31	RSFE	CG	_	29.6953	16.1072	

Effect=loc*pos Method=LSD(P<.05) Set=6

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
32		CG	3	41.0032	16.6638	A
33		CG	6	38.9917	16.4520	AB
34		CG	9	35.9275	16.9598	ABC
35		CG	4	32.2130	16.5962	ABC
36		CG	2	28.9549	16.4520	ABC
37		CG	11	28.6929	16.6154	ABC
38		CG	5	28.3851	16.6638	BC
39		CG	12	28.1113	16.6061	ABC
40		CG	10	26.2267	16.6061	C
41		CG	13	26.0809	16.9701	BC
42		CG	1	25.9821	16.6638	C
43		CG	7	25.6628	16.6638	C
44		CG	14	25.6512	16.6026	C
45		CG	8	23.8507	16.5962	C

Effect=trt*loc*pos Method=LSD(P<.05) Set=7

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
46	RSFE	CG	3	41.0032	16.6638	A
47	RSFE	CG	6	38.9917	16.4520	AB
48	RSFE	CG	9	35.9275	16.9598	ABC
49	RSFE	CG	4	32.2130	16.5962	ABC
50	RSFE	CG	2	28.9549	16.4520	ABC
51	RSFE	CG	11	28.6929	16.6154	ABC
52	RSFE	CG	5	28.3851	16.6638	BC
53	RSFE	CG	12	28.1113	16.6061	ABC
54	RSFE	CG	10	26.2267	16.6061	C
55	RSFE	CG	13	26.0809	16.9701	BC

Mean separation for TC

---------- Effect=trt*loc*pos Method=LSD(P<.05) Set=7 ----------

(continued)

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
56	RSFE	CG	1	25.9821	16.6638	C
57	RSFE	CG	7	25.6628	16.6638	C
58	RSFE	CG	14	25.6512	16.6026	C
59	RSFE	CG	8	23.8507	16.5962	C

Check on normality for TC

The UNIVARIATE Procedure
Variable: Resid (Residual)

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.962855	Pr < W	0.1867
Kolmogorov-Smirnov	D	0.096726	Pr > D	>0.1500
Cramer-von Mises	W-Sq	0.060743	Pr > W-Sq	>0.2500
Anderson-Darling	A-Sq	0.43618	Pr > A-Sq	>0.2500

Extreme Observations

------Lowest------		------Highest-----	
Value	Obs	Value	Obs
-0.751443	6	0.341990	11
-0.558852	34	0.360462	36
-0.457706	50	0.371139	2
-0.333813	18	0.486176	46
-0.272474	45	0.978145	48

Missing Values

Missing Value	Count	-----Percent Of----- All Obs	Missing Obs
.	14	25.00	100.00

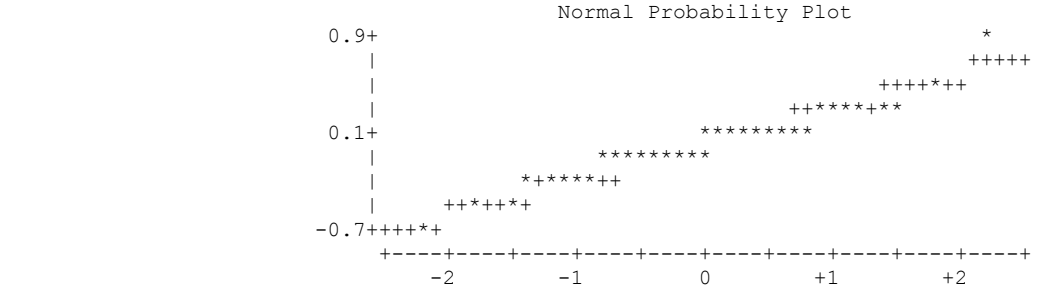
Stem	Leaf	#	Boxplot
8	8	1	0
6			
4	9	1	|
2	0123467	7	|
0	023468900239	12	+--+--+
-0	985544175441	12	*-----*
-2	377420	6	|
-4	66	2	|
-6	5	1	0

----+----+----+----+

Multiply Stem.Leaf by 10**-1

Check on normality for TC

The UNIVARIATE Procedure
Variable: Resid (Residual)



Check equality of stddev for y= TC

Obs	trt	loc	pos	nobs	rawmean_ y	stddev_y	stderr_y	Levene LeveneF_df	P
1	RSFE	CG	1	3	9.8206	4.3999	2.5403	1.68(11,26)	0.1340
2	RSFE	CG	2	4	28.9549	35.8032	17.9016	.	
3	RSFE	CG	3	3	24.8417	3.7893	2.1877	.	
4	RSFE	CG	4	3	16.6390	13.9360	8.0459	.	
5	RSFE	CG	5	3	12.2237	2.8486	1.6447	.	
6	RSFE	CG	6	4	38.9917	27.4735	13.7367	.	
7	RSFE	CG	7	3	9.5013	1.9668	1.1356	.	
8	RSFE	CG	8	3	8.2767	1.5841	0.9146	.	
9	RSFE	CG	9	2	17.6560	4.1026	2.9010	.	
10	RSFE	CG	10	3	28.9167	37.1268	21.4352	.	
11	RSFE	CG	11	3	32.6733	43.7613	25.2656	.	
12	RSFE	CG	12	3	30.8013	39.6870	22.9133	.	
13	RSFE	CG	13	2	11.2445	5.1301	3.6275	.	
14	RSFE	CG	14	3	32.3628	36.6716	21.1724	.	

Mixed ANOVA for TN

The Mixed Procedure

Model Information

Data Set	WORK.DSETZZ
Dependent Variable	TN
Covariance Structure	Variance Components
Estimation Method	REML

Residual Variance Method	Profile
Fixed Effects SE Method	Kenward-Roger
Degrees of Freedom Method	Kenward-Roger

Class Level Information

Class	Levels	Values
trt	1	RSFE
loc	1	CG
depth	2	1 2
pos	14	1 2 3 4 5 6 7 8 9 10 11 12 13 14
rnd	4	1 2 3 4

Dimensions

Covariance Parameters	5
Columns in X	60
Columns in Z	72
Subjects	1
Max Obs Per Subject	56

Number of Observations

Number of Observations Read	56
Number of Observations Used	50
Number of Observations Not Used	6

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	256.84733080	
1	3	180.12537017	0.04085917
2	2	179.65681339	0.00934297
3	1	179.07709518	0.00134142
4	2	178.87333740	0.00003613
5	1	178.86726452	.

Mixed ANOVA for TN

The Mixed Procedure

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
6	1	178.86718406	0.00000000

Convergence criteria met but final hessian is not positive definite.

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr > Z
loc*rnd	37.5854	31.2853	1.20	0.1148
trt*loc*rnd	0	.	.	.
trt*loc*depth*rnd	0.9433	1.1608	0.81	0.2082

pos(trt*loc*dep*rnd)	2.0094	0.8032	2.50	0.0062
Residual	1.1132	0	.	.

Fit Statistics

-2 Res Log Likelihood	178.9
AIC (smaller is better)	186.9
AICC (smaller is better)	188.2
BIC (smaller is better)	184.4

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trt	0	.	.	.
pos	13	24.4	1.06	0.4301
trt*pos	0	.	.	.
loc	0	.	.	.
trt*loc	0	.	.	.
loc*pos	0	.	.	.
trt*loc*pos	0	.	.	.

Mean separation for TN

---------- Effect=trt Method=' ' Set=1 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
1	RSFE		_	4.1091	3.0951	

---------- Effect=pos Method=LSD(P<.05) Set=2 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
2			3	6.4450	3.2269	A
3			4	5.2650	3.2269	AB
4			5	5.0625	3.2269	ABC
5			1	4.8325	3.2269	ABC
6			6	4.1500	3.2269	ABC
7			12	3.9995	3.2754	ABC
8			9	3.9737	3.2754	ABC
9			7	3.9275	3.2269	ABC
10			13	3.7022	3.2743	ABC
11			2	3.6850	3.2269	ABC
12			8	3.5850	3.2269	ABC
13			11	3.4637	3.2754	BC
14			14	3.3165	3.2743	ABC
15			10	2.1195	3.2754	C

---------- Effect=trt*pos Method=LSD(P<.05) Set=3 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
16	RSFE		3	6.4450	3.2269	A
17	RSFE		4	5.2650	3.2269	AB
18	RSFE		5	5.0625	3.2269	ABC

19	RSFE	1	4.8325	3.2269	ABC
20	RSFE	6	4.1500	3.2269	ABC
21	RSFE	12	3.9995	3.2754	ABC
22	RSFE	9	3.9737	3.2754	ABC
23	RSFE	7	3.9275	3.2269	ABC
24	RSFE	13	3.7022	3.2743	ABC
25	RSFE	2	3.6850	3.2269	ABC
26	RSFE	8	3.5850	3.2269	ABC
27	RSFE	11	3.4637	3.2754	BC
28	RSFE	14	3.3165	3.2743	ABC
29	RSFE	10	2.1195	3.2754	C

Mean separation for TN

---------- Effect=loc Method=' ' Set=4 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
30		CG	_	4.1091	3.0951	

---------- Effect=trt*loc Method=' ' Set=5 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
31	RSFE	CG	_	4.1091	3.0951	

---------- Effect=loc*pos Method=LSD(P<.05) Set=6 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
32		CG	3	6.4450	3.2269	A
33		CG	4	5.2650	3.2269	AB
34		CG	5	5.0625	3.2269	ABC
35		CG	1	4.8325	3.2269	ABC
36		CG	6	4.1500	3.2269	ABC
37		CG	12	3.9995	3.2754	ABC
38		CG	9	3.9737	3.2754	ABC
39		CG	7	3.9275	3.2269	ABC
40		CG	13	3.7022	3.2743	ABC
41		CG	2	3.6850	3.2269	ABC
42		CG	8	3.5850	3.2269	ABC
43		CG	11	3.4637	3.2754	BC
44		CG	14	3.3165	3.2743	ABC
45		CG	10	2.1195	3.2754	C

---------- Effect=trt*loc*pos Method=LSD(P<.05) Set=7 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
46	RSFE	CG	3	6.4450	3.2269	A
47	RSFE	CG	4	5.2650	3.2269	AB
48	RSFE	CG	5	5.0625	3.2269	ABC
49	RSFE	CG	1	4.8325	3.2269	ABC
50	RSFE	CG	6	4.1500	3.2269	ABC
51	RSFE	CG	12	3.9995	3.2754	ABC
52	RSFE	CG	9	3.9737	3.2754	ABC

53	RSFE	CG	7	3.9275	3.2269	ABC
54	RSFE	CG	13	3.7022	3.2743	ABC
55	RSFE	CG	2	3.6850	3.2269	ABC

Mean separation for TN

---------- Effect=trt*loc*pos Method=LSD(P<.05) Set=7 ----------

(continued)

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group
56	RSFE	CG	8	3.5850	3.2269	ABC
57	RSFE	CG	11	3.4637	3.2754	BC
58	RSFE	CG	14	3.3165	3.2743	ABC
59	RSFE	CG	10	2.1195	3.2754	C

Check on normality for TN

The UNIVARIATE Procedure
Variable: Resid (Residual)

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.965294	Pr < W	0.1481
Kolmogorov-Smirnov	D	0.098357	Pr > D	>0.1500
Cramer-von Mises	W-Sq	0.106576	Pr > W-Sq	0.0917
Anderson-Darling	A-Sq	0.619178	Pr > A-Sq	0.1014

Extreme Observations

------Lowest------		------Highest-----	
Value	Obs	Value	Obs
-1.188341	6	0.671076	3
-0.967126	10	0.711298	17
-0.725023	18	0.868039	5
-0.709955	31	1.212523	20
-0.672419	45	1.565576	4

Missing Values

Missing Value	Count	-----Percent Of----- All Obs	Missing Obs
.	6	10.71	100.00

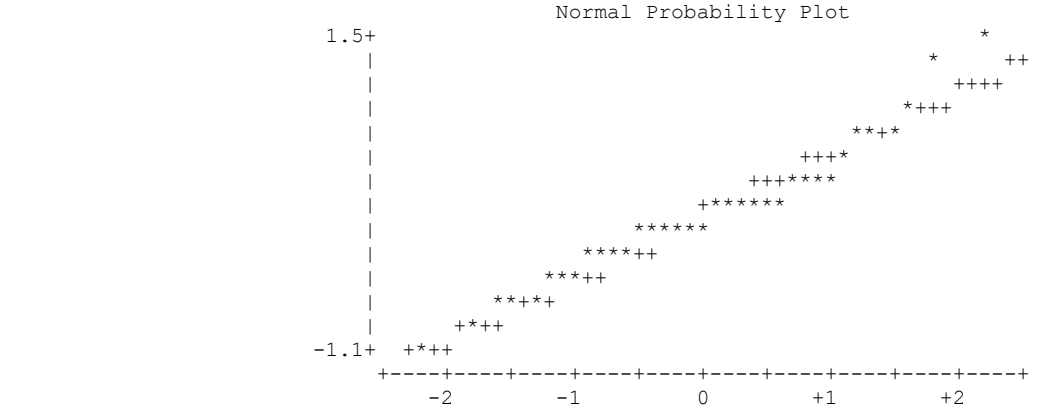
Stem	Leaf	#	Boxplot
14	7	1	0
12	1	1	0
10			
8	7	1	|
6	171	3	|
4	5	1	|
2	0359456	7	+-----+
0	0235678569	10	| + |
-0	442109865	9	*-----*

```
 -2 654102200                9             +-----+
 -4 975                      3                |
 -6 317                      3                |
 -8 7                        1                |
-10 9                        1                0
    ----+----+----+----+
Multiply Stem.Leaf by 10**-1
```


Check on normality for TN

The UNIVARIATE Procedure
Variable: Resid (Residual)

Normal Probability Plot



Check equality of stddev for y= TN

Obs	trt	loc	pos	nobs	rawmean_ y	stddev_y	stderr_y	Levene LeveneF_df	P
1	RSFE	CG	1	4	4.83250	7.68646	3.84323	0.414(13,36)	0.9550
2	RSFE	CG	2	4	3.68500	5.32987	2.66493	.	
3	RSFE	CG	3	4	6.44500	8.31190	4.15595	.	
4	RSFE	CG	4	4	5.26500	8.48361	4.24180	.	
5	RSFE	CG	5	4	5.06250	8.28409	4.14204	.	
6	RSFE	CG	6	4	4.15000	4.07285	2.03642	.	
7	RSFE	CG	7	4	3.92750	6.25817	3.12908	.	
8	RSFE	CG	8	4	3.58500	4.96554	2.48277	.	
9	RSFE	CG	9	3	5.35667	7.17651	4.14336	.	
10	RSFE	CG	10	3	3.33000	3.81806	2.20436	.	
11	RSFE	CG	11	3	4.84667	6.56041	3.78766	.	
12	RSFE	CG	12	3	5.21000	7.01858	4.05218	.	
13	RSFE	CG	13	3	4.87000	6.92067	3.99565		

.

14	RSFE	CG	14	3	4.29667	6.04086	3.48769

.

Mixed ANOVA for log TP

The Mixed Procedure

Model Information

Data Set	WORK.DSETZZ
Dependent Variable	tzzTP
Covariance Structure	Variance Components
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Kenward-Roger
Degrees of Freedom Method	Kenward-Roger

Class Level Information

Class	Levels	Values
trt	1	RSFE
loc	1	CG
depth	2	1 2
pos	14	1 2 3 4 5 6 7 8 9 10 11 12 13 14
rnd	4	1 2 3 4

Dimensions

Covariance Parameters	5
Columns in X	60
Columns in Z	72
Subjects	1
Max Obs Per Subject	56

Number of Observations

Number of Observations Read	56
Number of Observations Used	39
Number of Observations Not Used	17

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	101.46560855	
1	4	61.38524550	1.43074721
2	1	59.05839447	0.35385024
3	1	57.55998021	0.06932586
4	1	56.79084234	0.01112130
5	1	56.48184891	0.00131925

Mixed ANOVA for log TP

The Mixed Procedure

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion

6	1	56.40201060	0.00008430
7	1	56.39354547	0.00000119
8	1	56.39340132	0.00000000

Convergence criteria met but final hessian is not positive definite.

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr > Z
loc*rnd	1.2198	1.7926	0.68	0.2481
trt*loc*rnd	0.8760	0	.	.
trt*loc*depth*rnd	0	.	.	.
pos(trt*loc*dep*rnd)	0	.	.	.
Residual	0.1959	0.05916	3.31	0.0005

Fit Statistics

-2 Res Log Likelihood	56.4
AIC (smaller is better)	62.4
AICC (smaller is better)	63.5
BIC (smaller is better)	60.6

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trt	0	.	.	.
pos	13	22	1.49	0.1969
trt*pos	0	.	.	.
loc	0	.	.	.
trt*loc	0	.	.	.
loc*pos	0	.	.	.
trt*loc*pos	0	.	.	.

Back-transformed (bt) Mean Separation for log TP

Effect=trt Method=' ' Set=1

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group	btestimate	btstderr
1	RSFE		_	-2.8947	0.7376		0.055315	0.040799

Effect=pos Method=LSD(P<.05) Set=2

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group	btestimate	btstderr
2			3	-2.3320	0.7785	A	0.097102	0.075597
3			1	-2.4657	0.7569	AB	0.084946	0.064297

4		6	-2.5499	0.7785	ABC	0.078092
0.060798						
5		4	-2.5748	0.7785	ABC	0.076169
0.059301						
6		2	-2.7018	0.7785	ABCD	0.067083
0.052226						
7		9	-2.8354	0.8013	ABCD	0.058697
0.047032						
8		5	-2.8630	0.7785	ABCD	0.057096
0.044451						
9		10	-3.0147	0.8013	ABCD	0.049058
0.039309						
10		8	-3.0251	0.7785	ABCD	0.048555
0.037802						
11		7	-3.0468	0.7785	ABCD	0.047513
0.036991						
12		13	-3.0865	0.7785	BCD	0.045662
0.035549						
13		14	-3.2334	0.7785	CD	0.039425
0.030694						
14		11	-3.3367	0.8013	CD	0.035554
0.028488						
15		12	-3.4603	0.8013	D	0.031422
0.025177						

---------- Effect=trt*pos Method=LSD(P<.05) Set=3 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group	btestimate	btstderr
16	RSFE		3	-2.3320	0.7785	A	0.097102	0.075597
17	RSFE		1	-2.4657	0.7569	AB	0.084946	0.064297
18	RSFE		6	-2.5499	0.7785	ABC	0.078092	0.060798
19	RSFE		4	-2.5748	0.7785	ABC	0.076169	0.059301
20	RSFE		2	-2.7018	0.7785	ABCD	0.067083	0.052226
21	RSFE		9	-2.8354	0.8013	ABCD	0.058697	0.047032
22	RSFE		5	-2.8630	0.7785	ABCD	0.057096	0.044451
23	RSFE		10	-3.0147	0.8013	ABCD	0.049058	0.039309
24	RSFE		8	-3.0251	0.7785	ABCD	0.048555	0.037802
25	RSFE		7	-3.0468	0.7785	ABCD	0.047513	0.036991
26	RSFE		13	-3.0865	0.7785	BCD	0.045662	0.035549
27	RSFE		14	-3.2334	0.7785	CD	0.039425	0.030694
28	RSFE		11	-3.3367	0.8013	CD	0.035554	0.028488
29	RSFE		12	-3.4603	0.8013	D	0.031422	0.025177

Back-transformed (bt) Mean Separation for log TP

---------- Effect=loc Method=' ' Set=4 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group	btestimate	btstderr
30		CG	_	-2.8947	0.7376		0.055315	0.040799

---------- Effect=trt*loc Method=' ' Set=5 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group	btestimate	btstderr
31	RSFE	CG	_	-2.8947	0.7376		0.055315	0.040799

---------- Effect=loc*pos Method=LSD(P<.05) Set=6 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group	btestimate	btstderr
32		CG	3	-2.3320	0.7785	A	0.097102	0.075597
33		CG	1	-2.4657	0.7569	AB	0.084946	0.064297
34		CG	6	-2.5499	0.7785	ABC	0.078092	0.060798
35		CG	4	-2.5748	0.7785	ABC	0.076169	0.059301
36		CG	2	-2.7018	0.7785	ABCD	0.067083	0.052226
37		CG	9	-2.8354	0.8013	ABCD	0.058697	0.047032
38		CG	5	-2.8630	0.7785	ABCD	0.057096	0.044451
39		CG	10	-3.0147	0.8013	ABCD	0.049058	0.039309
40		CG	8	-3.0251	0.7785	ABCD	0.048555	0.037802
41		CG	7	-3.0468	0.7785	ABCD	0.047513	0.036991
42		CG	13	-3.0865	0.7785	BCD	0.045662	0.035549
43		CG	14	-3.2334	0.7785	CD	0.039425	0.030694
44		CG	11	-3.3367	0.8013	CD	0.035554	0.028488
45		CG	12	-3.4603	0.8013	D	0.031422	0.025177

---------- Effect=trt*loc*pos Method=LSD(P<.05) Set=7 ----------

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group	btestimate	btstderr
46	RSFE	CG	3	-2.3320	0.7785	A	0.097102	0.075597
47	RSFE	CG	1	-2.4657	0.7569	AB	0.084946	0.064297
48	RSFE	CG	6	-2.5499	0.7785	ABC	0.078092	0.060798

49	RSFE	CG	4	-2.5748	0.7785	ABC	0.076169
0.059301							
50	RSFE	CG	2	-2.7018	0.7785	ABCD	0.067083
0.052226							
51	RSFE	CG	9	-2.8354	0.8013	ABCD	0.058697
0.047032							
52	RSFE	CG	5	-2.8630	0.7785	ABCD	0.057096
0.044451							
53	RSFE	CG	10	-3.0147	0.8013	ABCD	0.049058
0.039309							
54	RSFE	CG	8	-3.0251	0.7785	ABCD	0.048555
0.037802							
55	RSFE	CG	7	-3.0468	0.7785	ABCD	0.047513
0.036991							

Back-transformed (bt) Mean Separation for log TP

---------- Effect=trt*loc*pos Method=LSD(P<.05) Set=7 ----------

(continued)

Obs	trt	loc	pos	Estimate	Standard Error	Letter Group	btestimate	btstderr
56	RSFE	CG	13	-3.0865	0.7785	BCD	0.045662	0.035549
57	RSFE	CG	14	-3.2334	0.7785	CD	0.039425	0.030694
58	RSFE	CG	11	-3.3367	0.8013	CD	0.035554	0.028488
59	RSFE	CG	12	-3.4603	0.8013	D	0.031422	0.025177

Check on normality for log TP

The UNIVARIATE Procedure
Variable: Resid (Residual)

Tests for Normality

Test		--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.986087	Pr < W		0.9027
Kolmogorov-Smirnov	D	0.088097	Pr > D		>0.1500
Cramer-von Mises	W-Sq	0.030275	Pr > W-Sq		>0.2500
Anderson-Darling	A-Sq	0.190017	Pr > A-Sq		>0.2500

Extreme Observations

------Lowest------		------Highest-----	
Value	Obs	Value	Obs
-0.712394	28	0.408376	11
-0.577647	3	0.530554	56
-0.542652	26	0.542652	12
-0.495581	6	0.565765	20
-0.422628	49	0.688824	17

Missing Values

-----Percent Of-----

Missing Value	Count	All Obs	Missing Obs
.	17	30.36	100.00

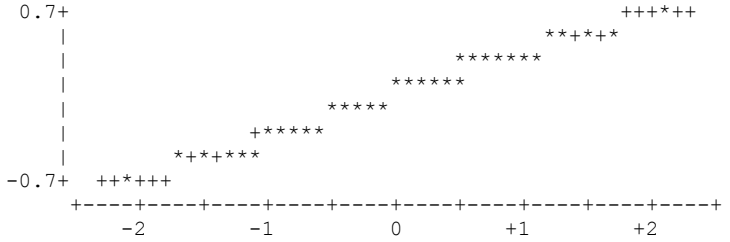
Stem	Leaf	#	Boxplot
6	9	1	
4	1347	4	
2	1122392	7	+------+
0	23113389	8	*--+--*
-0	84411731	8	| |
-2	53751	5	+------+
-4	84021	5	
-6	1	1	

Multiply Stem.Leaf by 10**-1

Check on normality for log TP

The UNIVARIATE Procedure
Variable: Resid (Residual)

Normal Probability Plot



Check equality of stddev for y=log TP

Obs	trt	loc	pos	nobs	rawmean_ y	stddev_y	stderr_y	Levene LeveneF_df	P
1	RSFE	CG	1	4	-2.46574	1.34357	0.67179	0.376(9,21)	0.9340
2	RSFE	CG	2	3	-2.21140	1.16015	0.66981	.	
3	RSFE	CG	3	3	-1.84156	0.93852	0.54186	.	
4	RSFE	CG	4	3	-2.08436	0.99270	0.57313	.	
5	RSFE	CG	5	3	-2.37259	1.26054	0.72777	.	
6	RSFE	CG	6	3	-2.05943	0.95262	0.55000	.	
7	RSFE	CG	7	3	-2.55632	1.46322	0.84479	.	
8	RSFE	CG	8	3	-2.53462	1.48364	0.85658	.	
9	RSFE	CG	9	2	-1.90280	1.57422	1.11314	.	
10	RSFE	CG	10	2	-2.08217	1.71780	1.21467		

.

11	RSFE	CG	11	2	-2.40413	1.99769	1.41258

.

12	RSFE	CG	12	2	-2.52769	2.18759	1.54686

.

13	RSFE	CG	13	3	-2.59606	1.44799	0.83600

.

14	RSFE	CG	14	3	-2.74293	1.48330	0.85638

.

VITA

Boone Hillenbrand was born on December 10, 1982 in Knoxville, TN, to the parent of Marilou and Steve Hillenbrand. He has an older sister, Laurel Hillenbrand. Boone attended South-Doyle High School in Knoxville, TN. After graduating in 2001 he attended Pellissippi State Technical Community College where he obtained an Associate's Degree in 2005. Boone then attended the University of Tennessee where he obtained his Bachelor's Degree in Biosystems Engineering and a Minor in Environmental Engineering. While an undergrad at UTK, Boone competed in a senior design competition where his team placed 2nd in the 2008 AGCO national student design competition. Boone attended the University of Tennessee for graduate school also and in 2010 he obtained his Master's Degree in Biosystems Engineering. While in graduate school; Boone mainly focused on wastewater and stormwater management and completed a thesis entitled, "An Investigation for the need for Secondary Treatment of Residential Wastewater when applied with a Subsurface Drip Irrigation System."