ABSTRACT

Title of Document: FATE AND TRANSPORT OF NITROGEN AT A DEEP ROW BIOSOLIDS APPLICATION HYBRID POPLAR TREE FARM.

Diana Maimone, Master of Sciences, 2012

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This study evaluates deep row applied biosolids as a nutrient source for hybrid poplar trees grown on a gravel mine reclamation site in Brandywine, Maryland from November 2003 to April 2009. The study included biosolids application rates of 386, 773, and 1,159 dry Mg/ha (172, 345, and 517 dry ton/ac.) and hybrid poplar tree densities of 0, 716, and 1,074 trees/ha (0, 290, and 435 trees/ac.). Soil water samples taken from suction lysimeters located 15 - 120 cm (6 - 48 in.) vertically below the biosolids were analyzed for total ammoniacal-nitrogen (TAN) and nitrate-nitrogen (NO_3-N). The majority (96.3%) of NO_3-N values were less than EPA drinking water MCL of 10 mg/L. No NO_3-N values within the tree plots exceeded 2 mg/L. The TAN concentrations increased with application rates, but decreased with distance from the biosolids, except there was no difference between 60 cm (24 in.) and 120 cm (48 in.).

FATE AND TRANSPORT OF NITROGEN AT A DEEP ROW BIOSOLIDS APPLICATION HYBRID POPLAR TREE FARM

By

Diana Maimone

Thesis submitted to the Faculty of the Graduate School of the
University of Maryland, College Park, in partial fulfillment
of the requirements for the degree of
Master of Sciences
2012

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Acknowledgements

The road to completion was a long and arduous one for me. I'd like to thank those who have paved the way for this project, namely Carrie Buswell and Thomas Griffeth whose research at ERCO preceded my own. I am also grateful for the talent and resources provided by ERCO's Flamino brothers, Gary Seibel, and the Project Development Center staff. I appreciate the help and support of my family and friends, particularly EMPK and LJVM. Finally, I would like to acknowledge my patient committee for hanging in there while I pursued a career outside of the university.

Table of Contents

List of Tables

List of Figures

List of Equations

Chapter 1: Introduction

Biosolids

Definition

The United States Environmental Protection Agency (EPA) defines biosolids as, "…a solid, semi-solid, or liquid residue generated during the treatment of domestic sewage in a treatment works." (EPA, 1994). Biosolids are collected from the primary settling tanks, secondary settling tanks, nitrification/denitrification tanks, and other sedimentation tanks at wastewater treatment plants (WWTPs).

Biosolids Process

Biosolids treatment is complex due to the nature of the biosolids' constituents, which depend on the source of the wastewater as well as the efficiency of the wastewater processes. Many of the particles in biosolids contain compounds that are known to degrade water quality; therefore biosolids must be disposed of properly. The majority of the biosolids volume is composed of water (Metcalf and Eddy, 2003).

Because the biosolids are composed of mostly water, further concentration is necessary to decrease biosolids volume and their resulting disposal costs. Concentration of biosolids is achieved through thickening, digestion, and/or dewatering processes. Initially sludge leaves the individual wastewater treatment processes via pipes and pumps to the mixing tank. The mixing tank equalizes the flows from the treatment tanks and ensures a consistent mixture goes through the biosolids treatment process to prevent system overloads and failures.

Once the mixing tank equalizes the flow the sludge moves to the thickening process. The thickening process reduces the content of liquid in the mixture through physical processes such as gravity thickeners, centrifugation, and co-settling thickeners. Blue Plains Advanced Wastewater Treatment Plant in Washington, DC utilizes the gravity thickeners to accomplish liquid reduction (DC Water[2], 2011). Gravity thickeners are similar to sedimentation tanks. A rake arm distributes the sludge evenly across the top of the tank. The solids settle to the conical bottom of the tank. Any supernatant flow separated from the sludge settling returns to the head of the plant and joins the influent for wastewater treatment (Metcalf and Eddy, 2003). The sludge from the bottom of the tank is collected and pumped to the next stage in biosolids treatment.

After thickening, the sludge moves to the digesters where microbes are encouraged to grow and feast on the sludge in air-tight tanks. These tanks are specially designed to maintain optimum growth conditions for the microbes. Because the microbes use the sludge as a food source, the amount of sludge is reduced and many pathogens are destroyed. In addition, the microbes produce methane gas as a waste product. This methane gas is captured and used to heat other tanks and even facilities (DC Water, 2011).

Once the sludge has undergone digestion and pathogens are removed, it moves to the dewatering stage. Dewatering can be achieved through centrifuges, belt-filter presses, drying beds, and lagoons. In centrifugation, the dewatering process preferred by Blue Plains, the sludge spins at high speeds in a horizontal cylinder. As the cylinder spins, the water separates from the solids.

The sludge from the centrifuge moves to a tank where lime is added to further remove pathogens, increase solids content, and reduce odor by increasing the pH above 11. At this point, the sludge has been stabilized and is now referred to as biosolids. Despite all of the processes focused on concentrating the mixture, the biosolids can contain 0.25 to 25 percent solids by weight, depending on the composition of the influent and the treatment processes used for sludge treatment (Viessman and Hammer, 2005).

Biosolids Disposal

The final step of the sludge process is disposal. Non-use methods of sludge disposal include incineration and landfill storage (Viessman, and Hammer, 2005). Biosolids with a Class A or Class B designation, based on the concentrations of remaining pathogens may be land applied as fertilizer (EPA, 2000). The biosolids from Blue Plains in 2002 were lime stabilized to meet EPA Class B criteria (DC Water[1], 2011) (DC Water[2], 2011).

To decide which disposal method is appropriate for the facility's sludge, it is important to fully evaluate cost and environmental impact. Incineration is the most expensive of the disposal methods. In addition to cost, incinerating sludge may transform the environmental problem from a land-water pollutant to an air pollutant, depending on its composition.

Landfill Storage of Sludge

For landfill storage, costs include transporting, storing, and monitoring the sludge. Urban areas lack the space required to store or use the sludge and will need to transport it to farther locations. In transportation, there may be restrictions on trucking sludge through particular areas of a community, such as residential districts. Landfill capacity may also be a limiting factor. Opening new landfills lack aesthetic appeal and lower the property value of the surrounding land.

Beneficial Reuse of Biosolids

Biosolids may be land applied, field injected, or deep row applied as fertilizer for crops and vegetation. Again, there will be transportation issues associated with these methods. Whenever the biosolids application rates are greater than the nutrient need or agronomic rate of the area the surface disposal rules of biosolids in Part 503 Biosolids Rule apply (EPA, 1999).

Land Application of Biosolids

For land applied biosolids, there is an increased risk of runoff that could lead to non-point source pollution since the biosolids are applied to the ground's surface via spreaders (Figure 1). Once the biosolids have dried and hardened, crusted biosolids layer impedes infiltration, soil gas exchange with the atmosphere, and seedling emergence (Barrington and Madramootoo, 1989; Mathers and Stewart, 1984). Unpleasant odors may upset nearby residents and attract unwanted vectors to the area. Vectors such as flies, mosquitoes, rodents, or birds could, "…transmit diseases directly to humans or play a specific role in the life cycle of a pathogen as a host." (EPA[2], 2000). The climate of the receiving land also dictates timing of biosolids application, since biosolids should not be applied to frozen land. Application should be avoided when heavy rains are expected to decrease the potential for nutrient runoff (EPA[2], 2000). Depending on the nutrient needs of the crops and environmental conditions, such as weather, several cycles of biosolids application can take place within a year, as shown in Table 1. Individual states may enforce stricter application limits than EPA application limits.

Table 1. Biosolids Application Schedule for Different Land Uses (EPA[2], 2000)

Site/Vegetation	Schedule	Application Frequency	Application Rate Mg/ha (dry tons/ac.)
Agricultural Land			
Corn	Apr., May, after harvest	Annually	11-22 (5-10)
Small grains	Mar.-June, Aug., fall	Up to 3 times per year	4.5-11 (2-5)
Soybeans	Apr.-June, fall	Annually	11-45 (5-20)
Hay	After cuttings	Up to 3 times per year	4.5-11 (2-5)
Forest Land	Year round	Once every 2-5 years	11-224 (5-100)
Range Land	Year round	Once every 1-2 years	4.5-135 (2-60)
Reclamation Sites	Year round	Once	135-224 (60-100)

Figure 1. The equipment used for land and forest surface application of liquid biosolids (EPA[2], 2000).

Field Injection of Biosolids

One of the barrier methods to mitigate odors and vector attraction discussed in Part 503 Biosolids Rule is field injection (EPA[2], 1994). Field injected biosolids reduce the odors associated with application by positioning the biosolids below the surface of the land with injection shanks (shown in Figure 2). According to the regulations, no biosolids residue should be left on the surface of the land after one hour of the injection. This limitation often leads to several injection times, which require organization and procurement of resources, both personnel and equipment. Another disadvantage of the field injection method is spacing. The field layout and spacing must accommodate the maneuverability of the equipment.

Figure 2. The injection shanks of the biosolids field injecting tank (Wright Tech Systems Inc., 2006).

Deep Row Application of Biosolids

An alternative reuse method is deep row application of biosolids. In deep row application, biosolids are pushed into a trench and encapsulated with soil (Figure 3). The encapsulation reduces nitrogen volatilization rates and odor. Since the odor is less potent, vectors are less attracted to the site. With the biosolids encapsulated, nutrient runoff will be reduced and will not contribute as much to non-point source pollution, resulting in higher application rates than biosolids that are land applied. Unlike field injection, deep row application does not require multiple treatments. Once the biosolids are placed in the rows and encapsulated, there is no further maintenance required other than routine monitoring for regulatory purposes.

Figure 3. Installation process of deep row biosolids.
In deep row application of biosolids, the operator pushes the biosolids into the previously dug deep row and then covers the biosolids with the overburden material that originated from the hole.

Biosolids Production in the Washington, DC Metropolitan Area

The Blue Plains Advanced Wastewater Treatment Plant (Blue Plains) located in the Anacostia area of Washington, D.C. treats about 1.4 billion liters (370 million gallons) of water per day. The wastewater originates from more than 2 million residents of the Washington D.C. Metropolitan Area including Washington D.C., Virginia, and Maryland; an average of 17.9 million annual visitors; 60 combined sewer overflows; and industrial usage (DC Water, 2011[1]; Destination DC, 2012). Along with the treated water, the plant also produces about 454,000 wet Mg (500,000 wet tons) of Class B lime stabilized biosolids per year (almost 1,270 Mg or 1,400 wet tons of biosolids per day) (DC Water, 2011[1]).

Biosolids Utilization in the Washington, DC Metropolitan Area

The majority of Blue Plains biosolids provides fertilizer for farming in Maryland, Virginia, and Pennsylvania (about 90%), while the remainder is converted to energy at a Fairfax County, VA waste-to-energy plant (DC Water, 2011[1]). Since 1974, Maryland

Department of Environment (MDE) has issued over 4,900 permits for biosolids use without any related health or environment problems reported (MDE, 2008). Despite the number of biosolids use permits, MDE reports that about 41% of biosolids are still hauled out of state and about 6% of biosolids are discarded in landfills (MDE, 2006). Figure 4 shows where the remaining biosolids are used.

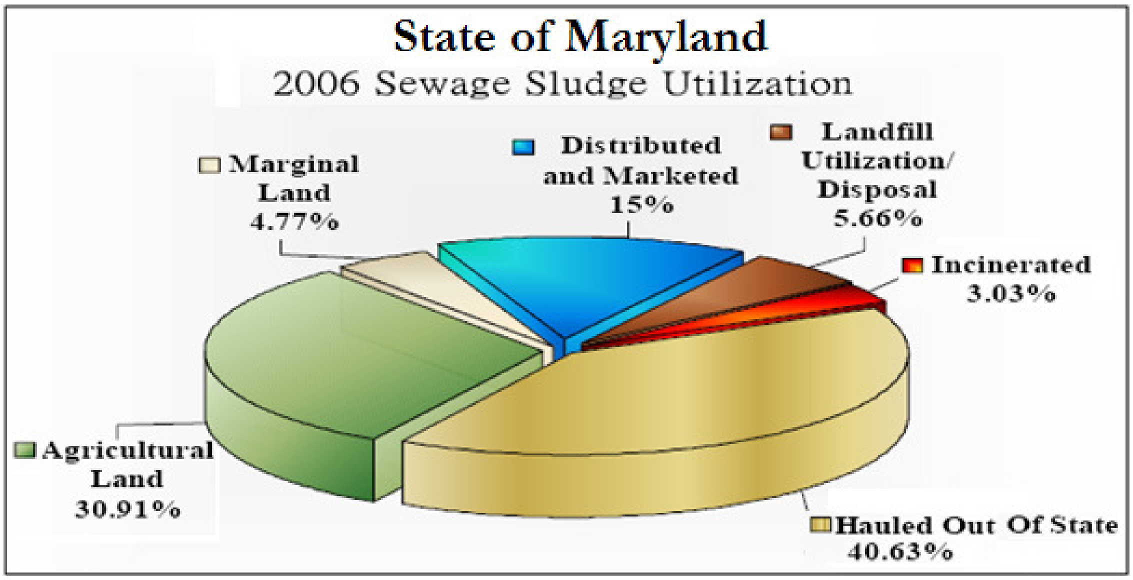

Figure 4. MDE's reported use of biosolids in 2006 (MDE, 2006).

Biosolids Properties

Positive Effects of Biosolids Properties on the Soil and Plants

Biosolids contain 16 elements that are necessary for plant growth, including nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), sulfur (S), zinc (Zn), and copper (Cu) (Currie, 2001). Nitrogen in biosolids is mainly in the form of ammonium (NH_4^+) and organic N, with a lower concentration of nitrate-nitrogen (NO_3-N) (Currie, 2001). Crops will use the NH_4^+ first, and then utilize organic N once it is mineralized by soil microbes (Shelton et al., 1970). In addition to containing essential elements, biosolids contain mostly organic matter, which can improve the soil's ability to adsorb nutrients (WSSC, 2008). Besides organic matter and essential elements, biosolids also consist of amino acids, amino sugars, and proteins. Lime stabilized biosolids usually have increased cation exchange capacity (CEC), or the ability of the soil to attract cations. According to the DC Water and Sewer Authority, mixing biosolids into the soil improves the soil's porosity and water holding capacity (DC Water, 2011[1]).

Negative Effects of Biosolids on the Soil, Plants, and Water Quality

Although copper and zinc were previously listed as essential nutrients for plant growth, high concentrations of these elements in addition to other metals commonly found in biosolids, such as cadmium (Cd), nickel (Ni), and lead (Pb) could lead to phytotoxicity, and be hazardous to plant growth (McGrath, 1994; Chaney, 1983). Metal accumulation in plants may continue accumulating in animal species that consume the plants, resulting in larger problems (Chaney, 1983). Even though NO_3-N is at lower concentrations initially within the biosolids, native soil microorganisms may convert other species of nitrogen into NO_3^- via mineralization and nitrification. High levels of NO_3^- (concentrations greater than 10 mg/L NO_3^- measured as nitrogen, NO_3-N) in drinking water have been a known cause of methemoglobinemia, also known as blue baby syndrome. Methemoglobinemia is caused by high levels of NO_3^- in the circulatory system that reduces oxygen delivery throughout the body, resulting in impaired breathing, vomiting, and diarrhea (CDC, 2003).

Deep Row Application of Biosolids at ERCO

ERCO Overview

Under permits from the Maryland Department of Environment (MDE), biosolids were trucked to the Environmental Reclamation Company, Incorporated (ERCO) site located in Brandywine, Maryland (MD). Hybrid poplar trees grow on the nutrients in the biosolids that are located beneath the roots. Not only is this procedure cost effective, but it is also beneficial. Without the nutrients the old sand and gravel quarry was barren. With the nutrients from the biosolids, the barren land is now home to a variety of vegetation and animals (Figures 5-7). The poplar trees are also valuable since they reduce erosion, shelter and feed wildlife, and can be harvested for wood or paper products. In fact, according to the Food and Agriculture Organization, international wood harvest has increased about 100 million m^3/year (131 million yd^3/year) for the last 60 years, but land areas designated for forests have decreased at a yearly rate of 0.2% (Lteif et al 2007). Therefore, there is an inherent need for forests to provide materials.

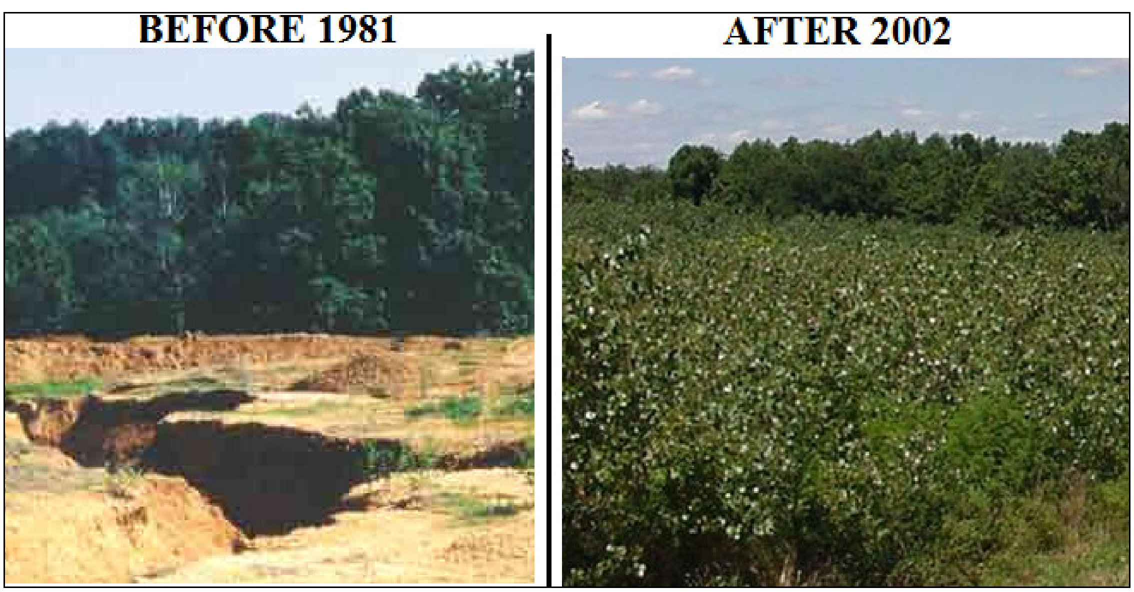

Figure 5. Contrasting images of ERCO before and after biosolids amendments.

Figure 6. ERCO’s diverse wildlife; insect, spider, bird, and bald eagles.

Figure 7. Photographs of a snail, beetle and grasshopper at ERCO.

Environmental Concerns

As mentioned previously, although biosolids contain vital nutrients for hybrid poplar growth, they also may contain high levels of metals, nitrogen, and phosphorus which may threaten water quality. Nutrients in the biosolids may leach into the groundwater or surface water (via runoff). The permits require that ERCO monitor the site for potential pollutants. Almost 20 years of data collected from seven groundwater monitoring wells ranging in depth from 11 to 36.5 m (35-120 ft.) installed around the biosolids disposal area have shown negligible concentrations of nutrients (primarily P and N), metals, and biological parameters (Buswell, 2006).

ERCO Study

Despite the availability of nutrients from the biosolids, the hybrid poplar trees at ERCO are below average in size and have an above average mortality rate from year to year. High tree densities and low nitrogen concentrations may contribute to the poor growth conditions. The on-going study at ERCO evaluates the effects of lower tree densities and different biosolids application rates than the ERCO standard procedure on hybrid poplar growth.

The main focus of this study is to investigate the fate and transport of nitrogen occurring within and near the biosolids rows. To study the effects of biosolids on the soil, soil water, and trees, monitoring equipment (pan and suction lysimeters) were installed below and around the biosolids rows at 1-3 m (3-10 ft.) depths below the surface. Data collected from these sampling lysimeters lead to an estimate of the optimal rate for biosolids application and poplar growth, without threatening the environment, an application of deep row biosolids for other gravel mine reclamation sites, and an alternative for biosolids disposal.

Chapter 2: Review of Literature

The Nitrogen Cycle

About 98% of the nitrogen found on earth is contained within rocks, sediments, and soils, while 78% of the earth's atmosphere comprises of nitrogen gas (N_2). The soils accumulate nitrogen through atmospheric deposition and biological conversion of nitrogen gas to elemental nitrogen. Organic nitrogen in the soil stems from the decomposition of organic material, such as plant matter and animal waste. According to Ferguson of the University of Nebraska's Cooperative Extension, the soil's organic matter composition correlates to the "long-term moisture and temperature trends" (Ferguson, 2008). As the temperatures increase, the soil organic matter decreases, because higher temperatures increase decomposition rates. Further decomposition produces soluble compounds which leach out of the soil profile. On the other hand, as the soil moisture increases, the soil organic matter also increases, because moisture encourages plant growth (Ferguson, 2008).

A main component in protein synthesis, nitrogen is an important element for plants. A closer look at how nitrogen transforms in the nitrogen cycle will help determine appropriate application rates for biosolids disposal (Figure 8). The nitrogen cycle starts with the simplest form of nitrogen, nitrogen gas (N_2) the nitrogen cycle proceeds through fixation, mineralization, nitrification, leaching, plant uptake, ammonia volatilization, denitrification, and finally, immobilization. Plants can only uptake nitrogen in water-soluble, inorganic forms, such as ammonium (NH_4^+)/ammonia (NH_3) and nitrate (NO_3^-), with a preference for ammonium because of an oxidation-reduction state equal to that of amino acids (valence = -3) (Pepper et al., 2006). In order for NO_3^- to be used, reductase enzymes need to reduce NO_3^- to nitrite (NO_2^-) and then undergo ammonification to form NH_4^+ or NH_3. Because NH_4^+ and NH_3 occur simultaneously in water, for the purposes of this paper NH_4^+ and NH_3 shall be referred to as the combined form, total ammoniacal-nitrogen (TAN) (Jeong and Kim, 2001).

Biosolids composition depends on the treatment processes forming it. Biosolids that have undergone anaerobic digestion typically possess most of the nitrogen in the form of ammonium, followed by organic nitrogen and trace amounts of nitrate (EPA, 1994). Most of the nitrogen in lime-stabilized biosolids is organic nitrogen (Shepherd, 1996; Gshwind and Pietz, 1992). In order for the plants to use the nitrogen in lime-stabilized biosolids, biochemical processes, such as mineralization, or decomposition of organic N to inorganic N, must occur.

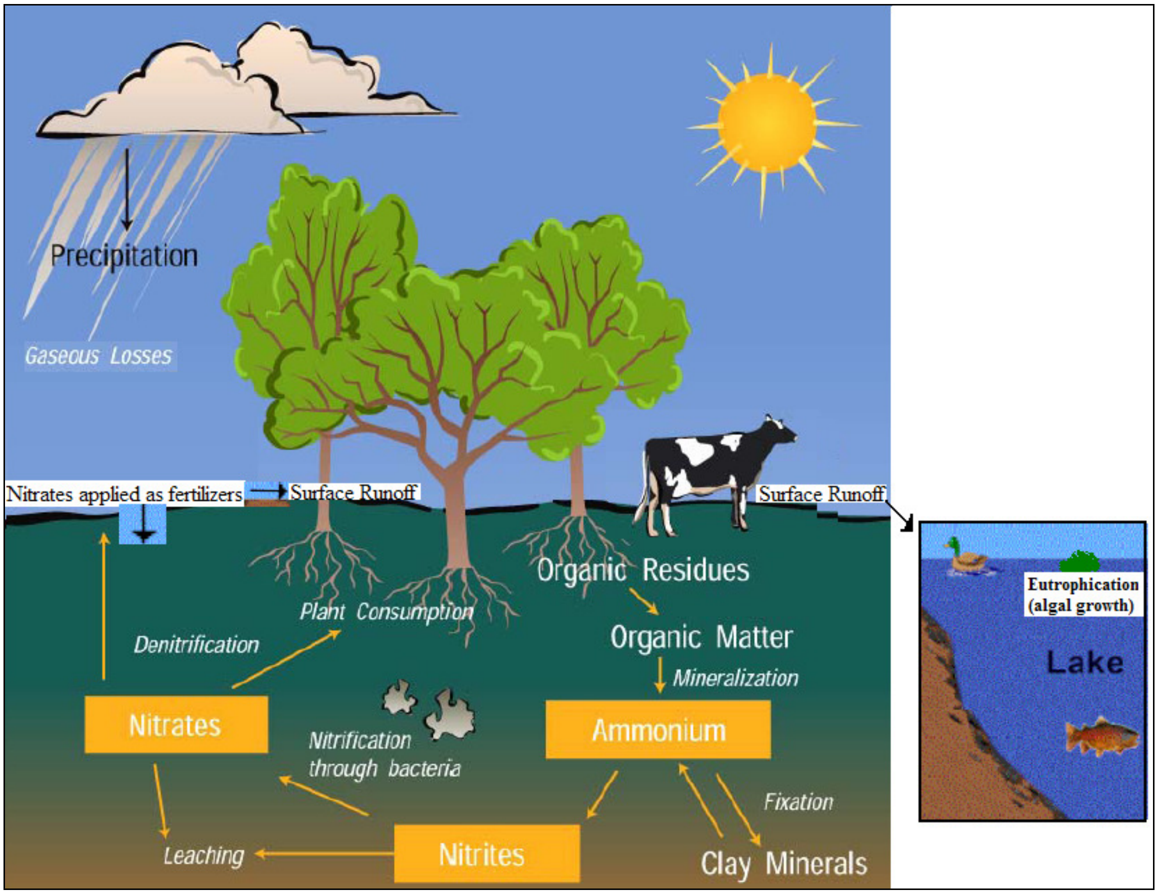

Figure 8. Modified diagram displaying the nitrogen cycle (Weismiller, 2008).

Fixation

Fixation occurs when the inert nitrogen gas (N_2) is converted to other more reactive forms of nitrogen, which may include compounds with other elements, such as oxygen (O), hydrogen (H), and/or carbon (C). In the atmosphere, lightning converts nitrogen to nitrogen oxides. The results of the lightning reactions fall to the earth as precipitation or dry deposition. Factories and power plants that rely on fossil fuel for energy also involve nitrogen fixation. In the soil, microorganisms fix inorganic N gas to organic N forms, usually through several intermediate steps.

Mineralization and Aminization

Initially in biosolids mineralization heterotrophic microbes produce NH_3 from the organic nitrogen either anaerobically or aerobically. Next, microbes break down the complex proteins for energy, leaving simpler amino acids, amides, and amines, in a process called aminization (Equation 1).

Equation 1. Aminization (Furgeson, 2008)
Proteins → R*-NH_2 + CO_2 (*R designates a carbon chain of indefinite length.)

Ammonification

Microbes convert the amino groups (NH_2) and water into NH_3 and an alcohol (R-OH). The ammonia quickly dissolves in water, attaches to a free hydrogen atom (H^+), and forms NH_4^+. This process is commonly referred to as ammonification shown in Equation 2 (Furgeson, 2008).

Equation 2. Ammonification (Furgeson, 2008)
R-NH_2 + H_2O → NH_3 + R-OH (*R designates a carbon chain of indefinite length.)

Nitrification

In nitrification NH_4^+ is oxidized to NO_2^- by bacteria, such as *Nitrosomanas*, in aerobic conditions. Another type of aerobic bacteria, *Nitrobacter*, further oxidizes NO_2 to NO_3^-. Nitrous oxide (N_2O) may be produced as a by-product of nitrification (Equation 3). This formation is shown in Equation 4. Nitrate is not readily adsorbed to the soil and it typically dissolves in the groundwater, threatening subsurface water quality.

Equation 3. By-product of Nitrification (Stumm and Morgan, 1996)

$$NH_4^+ + O_2 \rightarrow 0.5\ N_2O(g) + 1.5\ H_2O + H^+$$

$$\Delta G^{o'}(\text{pH}=7, 25^{o}\text{C}, 77^{o}\text{F}) = -260.2\ \text{kJ/mol}$$

Equation 4. Nitrite to Nitrate (Furgeson, 2008)

$$2NO_2^- + O_2 \rightarrow 2NO_3^-$$

Immobilization

When NH_4^+ and NO_3^- return to an organic N species it is called immobilization (Ferguson, 2008). While in the organic form, the N will not be taken up by plants. However, over time with favorable conditions, such as an increase in decomposition and microbe mortality, N will become available (Ferguson, 2008). These cyclic processes rely on the carbon to N ratio in the organic matter present and microbial activity (Figure 9).

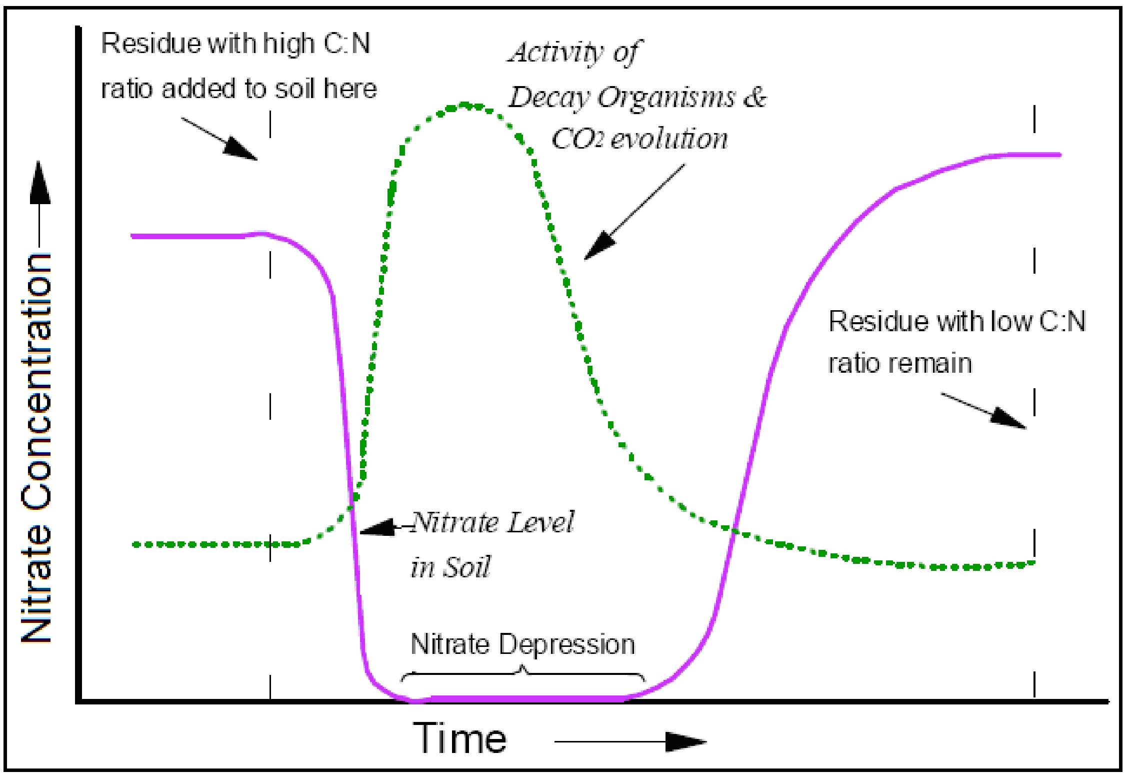

Figure 9. Available NO_3^- with respect to decomposition and microbial activity rates (Ferguson, 2008).

Denitrification

With organic material present facultative anaerobic microbes can reduce NO_3^- to nitrogen gas (N_2), nitric oxide gas (NO_2^+), or nitrous oxide gas (N_2O^+). An example of NO_3^- converting to nitrogen gas is shown in the free energy formation (Equation 5).

Equation 5. Denitrification (Stumm and Morgan, 1996)

$NO_3^- + 1.25\ CH_2O + H^+ \rightarrow 0.5\ N_2(g) + 1.75\ H_2O + 1.25\ CO_2(g)$

$\Delta G^{o'}(pH=7, 25^oC, 77^oF) = -594.6$ kJ/mol

Denitrification occurring via biological means is not considered reversible since the nitrogen gas does not undergo oxidation to become nitrate via microbial metabolic pathways. Sometimes nitrous oxide gas (N_2O) is produced as a by-product during denitrification and is released into the stratosphere following Equation 6. The nitrogen species produced sequentially during denitrification is shown in Equation 7.

Equation 6. By-product of Denitrification (Stumm and Morgan, 1996)

$NO_3^- + CH_2O + H^+ \rightarrow 0.5\ N_2O(g) + 1.5\ H_2O + CO_2(g)$

$\Delta G^{o'}(pH=7, 25^oC, 77^oF) = -417.1$ kJ/mol

Equation 7. Nitrogen species conversion during denitrification (Furgeson, 2008)

$NO_3^- \rightarrow NO_2^- \rightarrow NO \rightarrow N_2O \rightarrow N_2$

Roles of Microorganisms and Environmental Conditions in the Nitrogen Cycle

Because many of the necessary processes within the nitrogen cycle rely on biological interactions, the nitrogen cycle is also dependent on temperature, moisture concentrations, oxygen concentrations, available nutrient sources, duration, and pH. Figure 10 is a diagram depicting the stages within the nitrogen cycle that are heavily influenced by biological interactions.

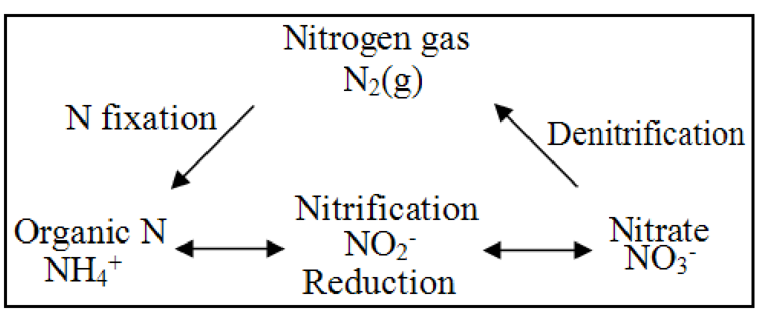

Figure 10. Nitrogen cycle processes that are affected by biological interactions (Stumm and Morgan, 1996).

Temperature

Microorganisms have optimal growth temperatures. Figure 11 shows the waxing and waning of microbial populations with respect to temperature. As temperatures increase, the specific growth rates of the microorganisms also increase at a steady pace until about 40^{o}C (104^{o}F). More specifically, the specific growth rate of microorganisms increases at least two times for each 10^{o}C (18^{o}F) interval increase between the minimum temperature for growth rate and the optimum temperature (Gaudy and Gaudy, 1980). On the other hand, if temperatures exceed 38^{o}C (100^{o}F) the microbial population dies rapidly. As expected, nitrification occurs more slowly at colder temperatures than at warmer temperatures due to the microbial activity. Nitrification rates are nonexistent at temperatures below freezing and decline around 35 ^{o}C to 38^{o}C (95 ^{o}F-100 ^{o}F). The effects of temperatures on nitrification rates are shown in Figure 12.

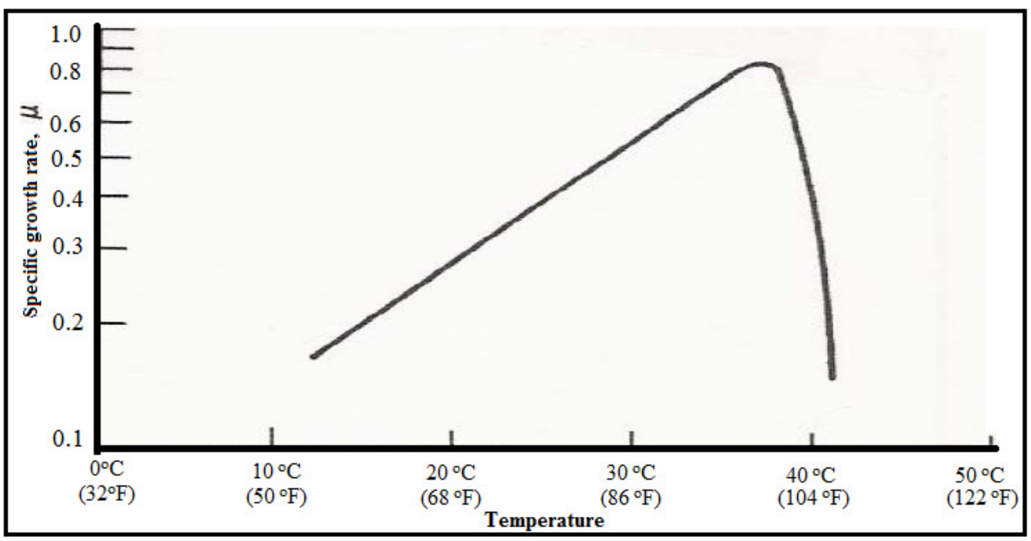

Figure 11. Temperature effects on microbial growth rates (Gaudy and Gaudy, 1980).

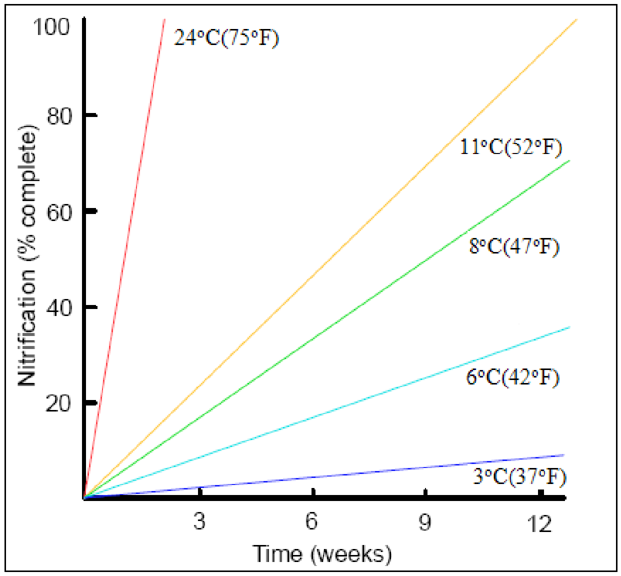

Figure 12. Temperature effects on nitrification rates (Furgeson, 2008).

Moisture Content and Oxygen Availability

The amount of moisture available in the microbial environment also plays a role in the nitrogen cycle. Oxygen availability is reduced when moisture levels increase (USDA, 2008). With decreased oxygen concentrations, both mineralization and nitrification rates decrease (Korom, 1992).

Nutrient Availability

The growth and development of bacteria generally involve two different reactions. The first reaction promotes energy production, while the second reaction promotes cellular synthesis. Energy production in microorganisms stem from oxidation-reduction (re-dox) reactions. In this case the nutrient needed is an electron donor. A commonly used generic formula for cells is $C_5H_7O_2N$ (Rittmann and McCarty, 2001). Using this formula microorganisms need to acquire nutrients in the form of carbon, hydrogen, oxygen, and nitrogen. Therefore, in the case of microbes, the nutrients needed to sustain life are in element form and electron form.

If the amount of nutrient available cannot support the current population of the microorganisms, the population will decrease. If, on the other hand, there is an adequate supply of nutrients available for microorganism consumption the population has the ability to increase exponentially, (Figure 13). The specific growth rate can be estimated using the Monod equation. At some point however, the population may overgrow the available substrate, in which case there will be a decline in population. The nutrient requirement of the population cannot exceed the amount of nutrient available.

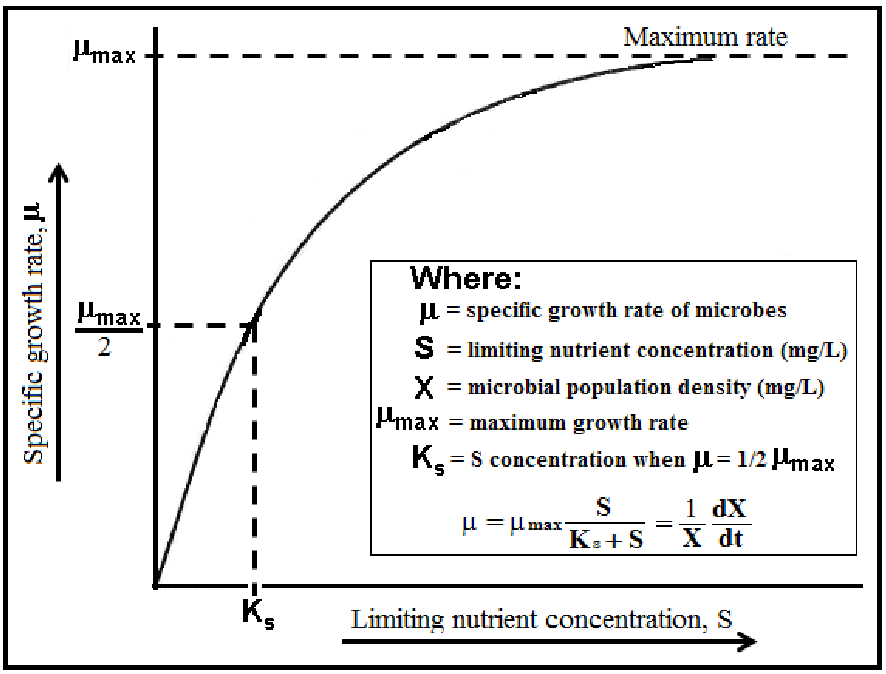

Figure 13. Nutrient availability effects on microbial growth rates (Rittmann and McCarty, 2001).

Duration

In areas of standing water from delayed infiltration denitrification may leave a deficit in nitrogen concentrations. Even at the same relative temperatures (13-16 ^{o}C or 55-60 ^{o}F), a duration of ten days instead of three days resulted in an additional 15% nitrogen loss (Table 2). Higher temperatures over a longer period of time generally result in a greater loss of nitrogen via denitrification (Ferguson, 2008).

Table 2. Denitrification effects of time and temperature on nitrogen loss (Ferguson, 2008).

Time	Temperature		Nitrogen Loss
days	°C	°F	Percent (%)
3	13-16	55-60	10
10	13-16	55-60	25
5	24-27	75-80	60

pH

Similar to the effects of temperature, microorganisms are in their prime when the pH of their environment is near neutral. Microbial activity decreases as the pH becomes more acidic or more alkaline. Therefore, denitrification rates are highest at or near neutral pH and lower in more acidic and alkaline conditions (EPA, 1993).

Ammonia (NH_3)/Ammonium (NH_4^+)

Ammonia (NH_3)/Ammonium (NH_4^+) Chemical Properties

Ammonia, a clear gas with a pungent odor, quickly dissolves in water, attaches to a free hydrogen atom (H^+), and forms NH_4^+. Because NH_3 forms NH_4^+ and hydroxide (OH-) in water, NH_3 is considered a weak base as shown in Equation 8 (Oram, 2009). Ammonium readily adheres to cation exchange sites of the soil matrix. These cation exchange sites occur most often in soils with high cation exchange capacity (CEC) of 30 or more meq per 100 g of soil. Average CEC values for soil ranges between 15 and 20 meq per 100 g soil (Pepper et al., 2006). Clay particles typically carry a negative charge that naturally attracts positively charged ions, such as NH_4^+. Clays and other soils with high CEC values limit percolation of NH_4^+ compared to soils with lower CEC values, like sand. Overall the rate of adsorption and types of ions absorbed depends on the soil water composition, plant uptake, microbial use, and oxidation rates of NH_4^+ (Pepper et al., 2006).

Equation 8. Ammonia and Ammonium Equilibrium in Water (Oram, 2009)

$$NH_3 + H_2O \leftrightarrow NH_4^+ + OH^-$$

Ammonia (NH_3)/Ammonium (NH_4^+) Health Hazards for Humans

Swallowing small amounts of NH_3, even levels lower than those that can be tasted at 35 ppm, may cause mouth and throat irritation. Direct contact with NH_3 can also lead to sores or burns to the area affected. Ammonia in contact with the eye may lead to blindness. (ATSDR, 2007)

Ammonia (NH_3)/Ammonium (NH_4^+) Health Hazards for Other Species

Ammonia levels as low as 0.53 mg/L are toxic to some fresh water organisms (Oram, 2009). Ammonia toxicity relies on both the pH and temperature of the water (Oram, 2009). As the water becomes more acidic, the toxicity level increases. Similarly, as the temperature decreases, the toxicity level increases. Fish are the most vulnerable species for NH_4^+ toxicity, followed by invertebrates, and plants (Oram, 2009). High levels of NH_3 may decrease fertility rates, cause swelling of the gill filaments, and damage internal organs. Ammonia poisoning is the result of the inability to excrete ammonia via the gills. In this case the concentration of NH_3 in the fish's blood increases and damages internal organs. During this time the fish becomes less active and may suffocate as a result of low oxygen concentrations in the gills (Oram, 2009).

Ammonia (NH_3)/Ammonium (NH_4^+) Regulations and Guidelines

Although there are not any regulations for drinking water regarding NH_3/ NH_4^+ concentrations, the United States Environmental Protection Agency (EPA) mandates that any NH_3 spill or discharge greater than 45 kg (99 lbs.) or NH_4^+ salts of 454-2,270 kg (1,000-5,000 lbs.) must be reported to EPA. The United States Food and Drug Administration (FDA) has set the maximum allowable levels of NH_4^+ in processed foods to 0.0003% for dibasic NH_4^+ phosphate in nonalcoholic beverages to 3.2% ammonium bicarbonate in baked goods, with varying levels in between depending on the food type and NH_4^+ compound . A workday (8 hour) exposure limit of 25 ppm and quarter hour (15 minute) exposure limit of 35 ppm for airborne NH_3 is set by the Occupational Safety and Health Administration (OSHA). (ATSDR, 2007)

Nitrite (NO_2^-)/Nitrate (NO_3^-)

Nitrite (NO_2^-)/Nitrate (NO_3^-) Chemical Properties

Nitrate is a water-soluble anion that under most circumstances does not interact with soil particles. Therefore, NO_3^- in the soil has a potential to enter the groundwater and stay there until plants or other organisms utilize and convert the compound or undergo denitrification.

Nitrite (NO_2^-)/Nitrate (NO_3^-) Health Hazards for Humans

If the NO_3^- enters the groundwater and does not get taken up by plants or microorganisms, the NO_3^- may threaten the health of aquatic species and humans. High concentrations of NO_3^- in drinking water may lead to methemoglobinemia, or Blue Baby Syndrome. Each red blood cell contains four hemoglobin chains for oxygen and other gas transport within the body. The hemoglobin molecules are composed of four polypeptide chains and four heme groups, as shown in Figure 14. Each heme group contains a ferrous iron atom (Fe^{2+}) that shares an electron with an oxygen atom to form oxyhemoglobin (Lee and Ferguson, 2004). Only with iron in the ferrous form can hemoglobin accept an oxygen atom. If the hemoglobin molecule is oxidized and Fe^{2+} becomes a ferric iron atom (Fe^{+3}), the electron is not available to bond with an oxygen atom. In this condition, the molecule is called methemoglobin (Mader, 1997). Methemoglobin can also form in the presence of NO_3^-, benzocaine, and local anesthetics. In a normal, healthy human, 0-3% of the body's blood is methemoglobin. Elevated levels of methemoglobin, however result in increasing health hazards, including death, as shown in Table 3, and thus, are the bases for regulations of NO_3^- and NO_2^- concentrations. Treatment for methemoglobinemia may include blood transfusions, oxygen breathing apparatus, or intravenously administered methylene blue to reduce the hemoglobin's iron to Fe^{+2} (Lee and Ferguson, 2004).

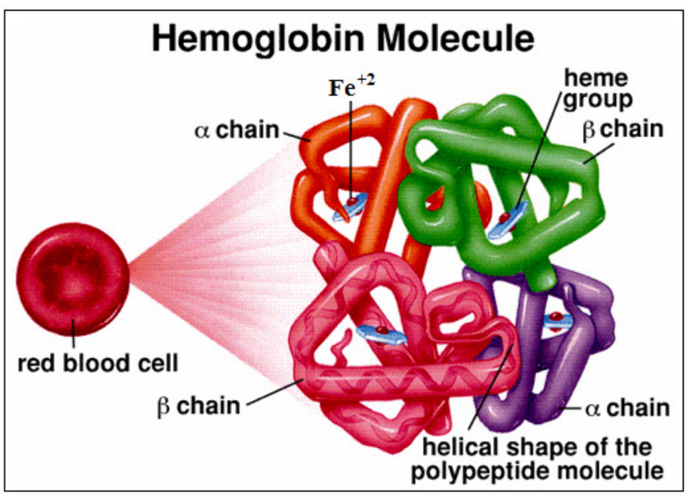

Figure 14. A hemoglobin molecule transporting oxygen throughout the body (Mader, 1997).

Table 3. Health problems associated with methemoglobin (%) in the bloodstream (Gomes, 2009).

fMetHb (%)	Signs and Symptoms	fMetHb (%)	Signs and Symptoms
< 3 (normal)	None	30 – 50	Dyspnea, Headache, Fatigue, Weakness, Dizziness, Syncope SpO_2 ~85%
3 – 15	Frequently none, Grayish skin	50 – 70	Tachypnea, Metabolic acidosis, Cardiac arrhythmias, Seizures, Central nervous system depression, Coma
15 – 30	Cyanosis, Chocolate-brown blood	>70	Death

Nitrite (NO_2^-)/Nitrate (NO_3^-) Health Hazards for Other Species

Nitrate concentrations of 100 ppm have been known to harm fish and limit reproduction (Sharpe, 2009). When nitrate concentrations are over 10 ppm, algal growth may occur (Sharpe, 2009). Oxygen-demanding bacteria promote the decay of algal blooms. As this process continues oxygen is depleted from the water source, resulting in toxically low levels of oxygen available for plants, fish, and other aquatic life, as shown in Figure 15 and Equations 9 and 10 (Sharpe, 2009). Algae have also been known to produce phenolic organics that can form pungent tasting and smelling chlorinated phenols with the wastewater disinfectant chlorine (Gaudy and Gaudy, 1980). Another byproduct of algae is toxins, such as domoic acid, which can act like a neurotoxin. The effects of a neurotoxin may lead to diarrhea, short-term memory loss, brain damage, or even death for humans and aquatic life (Gaudy and Gaudy, 1980).

Equation 9. Algae Photosynthesis (Viessman and Hammer, 2005)

$$CO_2 + 2H_2O + \text{Sunlight} \rightarrow (CH_2O) + O_2 + H_2O$$

Equation 10. Algae Respiration/Oxygen Depletion from Water (Viessman and Hammer, 2005)

$$(CH_2O) + O_2 \rightarrow CO_2 + H_2O$$

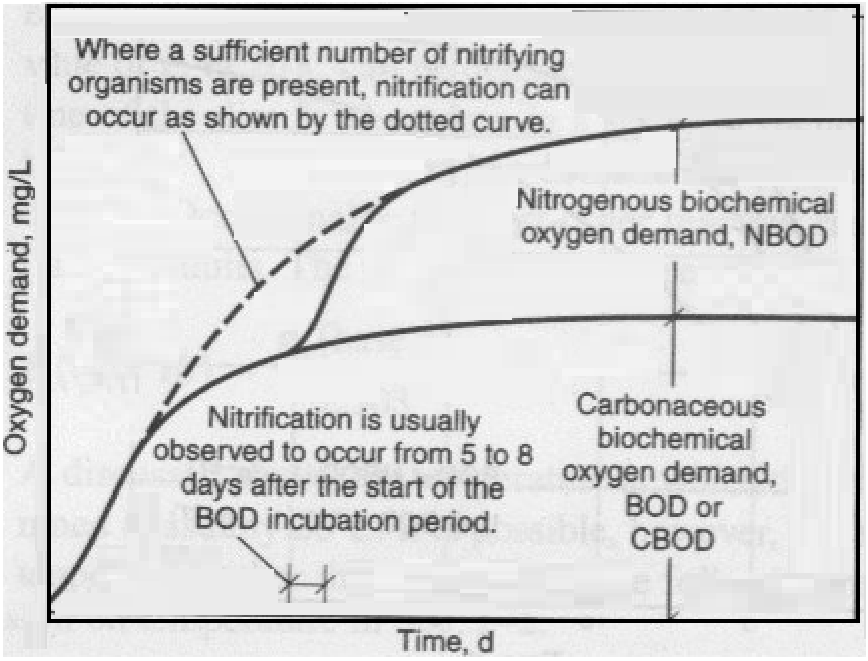

Figure 15. Oxygen demand throughout nitrification (Metcalf and Eddy, 2003). Oxygen demand increases as algae and other plant materials breakdown and nitrifying bacteria reproduce, requiring large amounts of oxygen (Metcalf and Eddy, 2003).

Nitrite (NO_2^-)/Nitrate (NO_3^-) Regulations and Guidelines

In accordance with the Safe Drinking Water Act EPA set the maximum contaminant level goals (MCLG) and maximum contaminant level (MCL) to 10 parts per million (10 ppm) for NO_3-N and 1 part per million (1 ppm) for NO_2-N in 1992. The EPA requires water suppliers to analyze yearly water samples for nitrates and nitrites. If the concentration of NO_3-N and/or NO_2-N exceed 50 percent of the MCL (5 ppm NO_3-N, 0.5 ppm NO_2-N) the supplier must continue sampling on a quarterly basis until the results are lower than 50 percent of the MCL (EPA, 2006).

Nutrient Losses from Corn for Comparison

The following section highlights nutrient losses and leaching from corn crops for comparison with the ongoing hybrid poplar trees grown on biosolids. In a Washington Post article, Tom Simpson and Daphne Pee (2007) discussed several implications of harvesting corn. They referred to corn as a “leaky crop”, meaning that corn loses “…more nitrogen per acre than most other crops.” (Simpson and Pee, 2007). Excess nutrient loss from a field could travel to a receiving area, in this case the Chesapeake Bay, and promote algal growth which would threaten the livelihood of the aquatic species.

Fertilizer Losses from Corn for Comparison

Between 1994 and 2000 Randall and Vetsch (2005) studied the effects of fertilizer application on corn and soybean growth and nutrient leaching were studied. Samples were taken from 36 individual subsurface tile drainage plots. Thirty-two different plots were used to test four different treatments; fall application of nitrogen, fall application of nitrapyrin, spring application of nitrogen, and spring application of nitrapyrin. The nitrogen treatments for corn included application of anhydrous ammonia rate of 135 kg N/ha (120 lbs. N/ac.). Nitrapyrin, chemically known as 2-chloro-6-(trichloromethyl) pyridine, is manufactured by Dow AgroSciences. The nitrapyrin was applied at Dow’s recommended rate of 0.56 kg/ha (0.51 lbs./ac.). Soybean plots did not receive nitrogen fertilizer applications. A control treatment of 0 kg N/ha (0 lbs. N/ac.) was not established for comparison.

Samples were taken during peak flows in addition to three days a week. The majority (71%) of the drainage tile peak flows occurred in the spring, from April to June, when evapo-transpiration is not as high as it is in July and August. These peak flow periods also represents 77% of NO_3-N lost from corn and 73% of NO_3-N lost from soybean per year. Nitrate-nitrogen concentrations among all treatments ranged from 5 to 22 mg/L throughout the seven year study. Greater losses occurred in treatments of fall applied nitrogen to corn crops as nitrification rates were higher than the effects of evapo-transpiration rates and plant uptake rates. More than half (54%) of the NO_3-N in the drainage tile samples originated from the corn phase.

Another study conducted by Randall et al. (1997), discovered that after fertilizer applications of 145 kg N/ha (130 lbs. N/ac.) to continuous corn and corn after soybean plots had peak residual soil N concentrations within the upper most 1.2 m (4 ft.) of the soil profile containing 177 kg NO_3-N/ha (158 lbs. NO_3-N/ac.) for continuous corn and 146 kg NO_3-N/ha (130 lbs. NO_3-N/ac.) for corn after soybean plots. Most of the NO_3-N concentration was found in the top 0.6 m (2 ft.) of soil, revealing the presence of unused fertilizer from previous applications (Randall et al., 1997). Figure 16 shows the residual soil NO_3-N concentrations recorded from 1988 to 1993. In 1989, the driest year in the study, had the highest amount of residual NO_3-N in the uppermost level of the soil. Rainfall also affected the average flow-weighted concentrations of NO_3-N in the water samples. In 1993 the plot experienced above average precipitation which resulted in decreased tile drainage NO_3-N concentrations compared to average rainfall in 1991 due to dilution. Average flow-weighted NO_3-N concentrations in the samples were 32 mg/L for corn, 24 mg/L for corn after soybean, 3 mg/L for alfalfa, and 2 mg/L for perennial crops shown in Figure 17 (Randall et al., 1997).

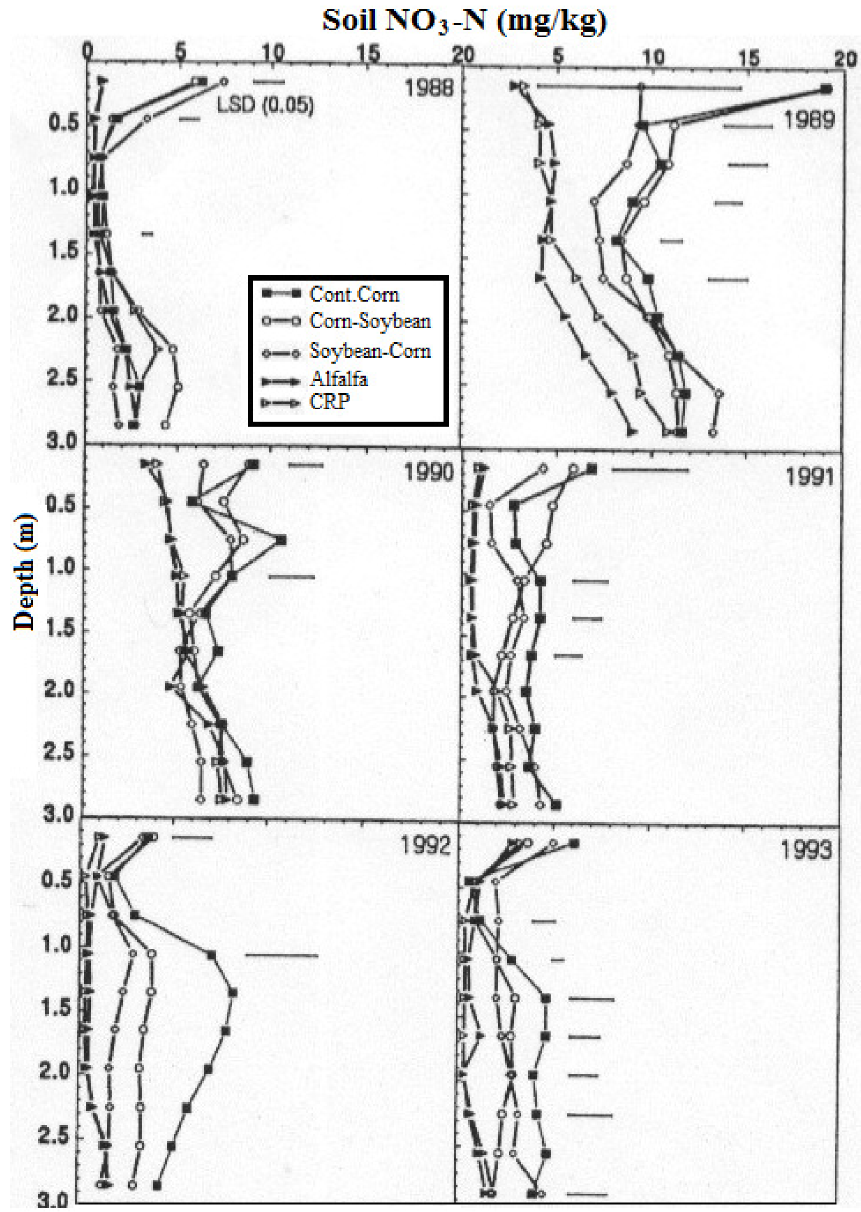

Figure 16. The effects of crop type on the residual soil NO_3-N distribution after fertilizer applications of 145 kg N/ha (130 lbs. N/ac.). CRP refers to perennial crops grown in the Conservation Reserve Program (Randall et al., 1997).

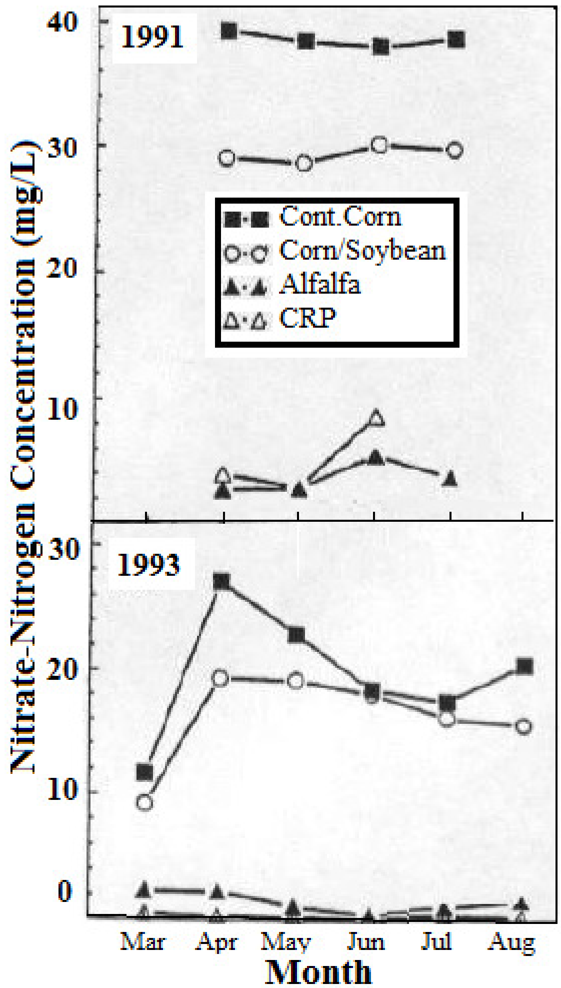

Figure 17. A comparison of the flow-weighted NO_3-N concentrations for the different crop systems during an average year of precipitation (1991) and an above average year of precipitation (1993). CRP refers to perennial crops grown in the Conservation Reserve Program. (Randall et al., 1997)

Land Application of Biosolids

For a study conducted by Stehouwer et al. (2006), a 6.2 ha (15.3 ac.) plot formerly mined for bituminous coal in Clinton County, Pennsylvania was reclaimed by backfilling with overburden, surface applying 152 dry Mg/ha (68 dry tons /ac.) of 50% anaerobically digested biosolids cake and 50% composted anaerobically digested biosolids, and planting cool-season grasses. This mixture of biosolids contained about 5,290 kg organic N/ha (4,719 lbs. N/ac.)The control area of 1.2 ha (3 ac.) did not receive biosolids, seeding, or tillage. Sampling methods included zero tension pan lysimeters, groundwater wells, and soil sampling. Zero tension pan lysimeters were placed 1 m (3.3 ft.) below the soil surface. The groundwater wells were positioned at varying depths between 5.2 and 9.4 m (17-31 ft.). Background soil samples were taken before biosolids were applied to the field. Soil samples were also taken for comparison after the biosolids were applied.

Soil analyses showed that despite efforts to apply biosolids at 134 Mg/ha (49 tons/ac.), the actual average biosolids application was 152 dry Mg/ha (68 dry tons/ac.) with a large variability in spreading throughout the plot (standard deviation = 72 Mg/ha or 29 tons/ac.). Soil samples taken before the biosolids were applied resulted in similar results between the control plot and treatment plots. Most of the variation in nutrient concentrations after application was due in part to the actual concentrations within the biosolids applied, as shown in the organic carbon and total N concentrations in Table 4. Table 4 also shows an increase in metal concentrations, specifically Zn and Cu that exceed the original loading.

Table 4. Soil analysis of study area with surface applied biosolids (152 dry Mg/ha or 68 dry tons /ac.) and control area without biosolids 2 months after application (Stehouwer et. al, 2006).

Parameter	Conc. in biosolids	Loading with 152 Mg ha^{-1} biosolids	Soil conc. 2 mo after biosolids application: Biosolids area	Control area
pH	8.09 ± 0.04	–	5.5 ± 0.4	5.6
Nutrients	g kg^{-1}	kg ha^{-1}	g kg^{-1}	
Organic C			64.6 ± 15.2	48.6
Total N	34.8 ± 3.3	5277 ± 1924	6.3 ± 2.5	3.0
			mg kg^{-1}	
NH_4–N	8.6 ± 1.3	1300 ± 412	404 ± 304	38.3
NO_3–N	NA	NA	415 ± 150	125
P	57.0 ± 3.4	3775 ± 1539	195 ± 37	16
K	3.2 ± 0.7	400 ± 178	124 ± 7	94
Ca	NA	NA	2564 ± 400	1874
Mg	NA	NA	407 ± 72	247
Trace elements	mg kg^{-1}	kg ha^{-1}	mg kg^{-1}	
Cd	4.67	0.72	0.86 ± 0.5	0.31
Cr	187	28.4	25.3 ± 9.1	10.1
Cu	529	80.2	101 ± 49	22.2
Pb	156	23.7	56.1 ± 37.2	20.8
Ni	47.7	7.23	17.9 ± 2.9	15.3
Zn	1086	165	287 ± 147	56.9

NA–Not analyzed.

Water samples were taken before surface application of biosolids and then every three months after biosolids application. Before the application of biosolids, the water sample from the control plot was similar to the water samples taken from the treatment plots. Samples from the control plot did not change significantly throughout the three year study however the samples from the treatment plots had much more variability throughout the study. Most of the changes in the biosolids area occurred within five months after application. For instance, as shown in Figure 18, NO_3-N concentrations peaked at or near 300 mg/L within three months after application. Due to reduced rain volume and high water demand by plants, no samples were available for analysis during the second summer (1 year mark) of the study. A noticeable decrease in the following winter's nitrate spike occurred. Within three years all treatment water samples had NO_3-N concentrations below 10 mg/L, but were not as low as the control NO_3-N values. The highest NO_3-N concentration of the four groundwater monitoring wells was 6.5 mg/L. Throughout the study the wells had low levels of NO_3-N and did not indicate a problem of nitrogen leaching.

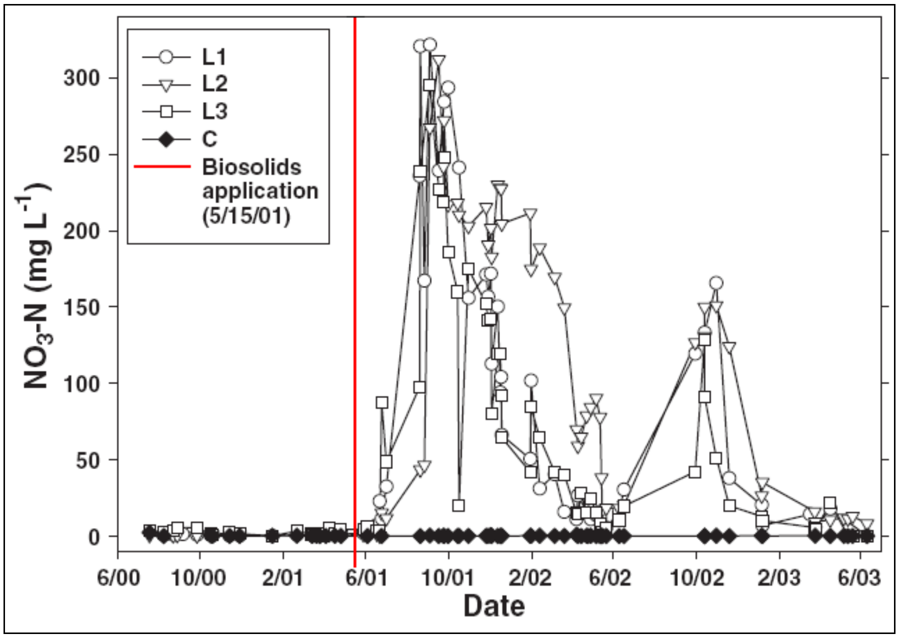

Figure 18. The NO_3-N concentrations from zero-tension pan lysimeters throughout the 3 year study of surface applied 152 dry Mg/ha (68 dry tons /ac.) anaerobically digested biosolids cake (L1-L3) and the control area without biosolids (C) (Stehouwer et. al, 2006).

Even before biosolids application, one lysimeter (L1) exhibited higher levels of P than any of the other lysimeters. This zero-tension pan lysimeter continued to have higher levels than leachate from the other lysimeters. The P concentrations peaked during the first three months after biosolids application, similar to that of NO_3-N concentrations. Despite the peaks that varied throughout the study, no P concentration exceeded 2 mg/L.

Because the biosolids were not amended with lime, the biosolids decreased the pH of the vadose zone. Acidity levels in the zero-tension pan lysimeters increased during the winter months, resulting in lower recorded pH for those time intervals. The change in pH is most likely due to the mineralization and oxidation reactions within the biosolids, since organic N converted to TAN and nitrification of TAN to NO_3^- generate acidity when NO_3^- is leached and not utilized by plants.

Overall, the leaching of NO_3-N at the site were about 30 times higher than the EPA drinking water MCL standard of 10 mg/L NO_3-N in the first two years after biosolids were applied. Stehouwer and his colleagues recommend reducing the application rate, ensuring a high C/N ratio in application, or adding lime to negate the effects of acid produced via nitrification within the biosolids. The researchers also noted that land application of biosolids could pose threats to the groundwater quality, especially during the initial months following application (Stehouwer et. al, 2006).

Deep Row Application of Sewage Sludge

Walker Study 1974

In 1974, Walker discussed the effects of trench applied Blue Plains sludge on surface drainage water, underground drainage water, and groundwater. The study incorporated dewatered raw-limed sludge in 0.6 m (2 ft.) wide by 0.6 – 1.2 m (2-4 ft.) deep trenches. On the surface fescue, alfalfa, rye, and trees were planted. The study monitored the water quality for about a year and a half and concluded that the deep-row sludge did not negatively impact the surface water, decreased ammonization rates, and discouraged pathogen growth. Nitrate-nitrogen concentrations increased in the subsurface drainage water and in the soil surrounding the sludge trenches. Nitrate-nitrogen is a water-soluble and under most circumstances does not interact with soil particles. Commonly found in sludge and similar to NO_3-N, chloride is a water-soluble anion that does not bond with soil particles. Tracing the chloride concentration indicates leaching from the sludge to the surrounding soil and water. Although metal movement was not found in the substrate, chloride concentrations increased in the groundwater samples.

In addition to the quantitative results, the study also noted that the sludge dewatered from the top down throughout the nineteen months. Dewatering occurred at a faster rate in the digested sludges compared to the raw-limed sludges. Faster dewatering also occurred in the sludges that contained higher root penetration and mass. Overall, Walker's study observed that deep row application of sewage sludge was a viable solution for the abundance of sludge, but also recommended that a more long-term study be conducted to fully investigate the effects of deep row applied sludge.

Sikora Studies 1978 and 1980

A four year study conducted by Sikora et al. (1978) investigated the water quality of deep row applied sludge. The site contained sandy soil with an underlying clay layer. Again, the 0.6 m x 0.6 m (2 ft. x 2 ft.) rows of sludge were under subsoil and fescue. Throughout the study water samples were taken from drainage tiles, a catchment basin, and monitoring wells located in and around the sludge plots. Eighteen months into the study the chloride concentrations from the water samples peaked. A peak in NO_3-N concentrations occurred after 30 months. Water samples taken from wells above and below the sludge plots had NO_3-N concentrations lower than 10 mg/L NO_3-N, the EPA's drinking water MCL. Similar to the Walker study (1974), metals did not move and pathogen populations decreased.

Sikora et al. conducted a more in-depth study that focused on the activity taking place in and under the sludge rows between 1974 and 1978. Within two years of the application of sludge, the upper most part of the sludge, about 5-20 cm (2-8 in.) from the top of the trench was significantly dry and contained dense root masses. Dewatering did not occur in the lower parts of the sludge rows until the fourth year (Sikora, 1982). These observations correlate well with Walker's (1974) findings that sludge dewatering proceeds from the top of the row to the bottom of the row.

Almost two years after sludge application (655 days) the chloride concentrations were highest at the bottom of the row and lowest at the top of the row, with a smooth transition in the middle of the row. Organic N and TAN leached downward throughout the sludge profile in a manner similar to the chloride concentrations, with the highest concentrations located at the bottom of the row and the lowest concentrations located at the top of the row (Sikora et al., 1982). However, the organic N and TAN concentrations below the rows were considered low or background concentrations towards the end of the four year study.

Unlike the chloride, organic N, and TAN concentration distribution, the NO_3-N concentrations were highest in the top of the sludge row and lowest in the bottom of the row at the 655 day mark (Sikora et al., 1982). After 998 days, the NO_3-N concentration in the middle of the sludge row surpassed the NO_3-N concentration at the top of the row. Nitrate-nitrogen concentrations in the soil under the rows reached 54 mg/kg (54 ppm), but decreased to 2-6 mg/kg (2-6 ppm) after four years (Sikora et al., 1982). The top of the sludge row has a more aerobic environment where TAN mineralizes and produces NO_3^-. Dewatering allows for TAN mineralization to occur deeper in the sludge rows.

Sikora et al. (1982) concluded that the likelihood of groundwater contamination from deep row applied sludge depends on the soil type, porosity, and depth to the water table. Nutrient dilution could occur via groundwater recharge. The uptake of nutrients for plant use could be optimized if the plot contained deep-rooted plants or higher plant densities.

Lasley Study 2010

From August 2006 until October 2007, Lasley et al. (2010) studied the pH, redox potential, dissolved oxygen (DO) concentration, and metal movement of deep row applied biosolids. Lasley and colleagues (2010) set up zero tension lysimeters 15 cm (6 in.) below anaerobically digested (213 and 426 dry Mg/ha or 78 and 156 dry tons/ac.) and lime-stabilized biosolids (329 and 657 dry Mg/ha or 121 and 241 dry tons/ac.) at a mineral sands mine in Dinwiddle County, Virginia.

From August to November 2006, the mean pH of the lime-stabilized biosolids leachate was 8.3. Anaerobically digested biosolids had a lower pH of 7.9 initially. After the first four months however, the pH of the lime-stabilized solids began to mirror the anaerobically digested biosolids pH. A little over a year later, in October 2007 the average pH had decreased to 6.0.

The average monthly redox potential for the control areas without biosolids was 483 mV indicating the presence of oxygen in the system (Lasley et al., 2010). On the other hand, the biosolids sites had an average monthly redox potential of -112 mV for anaerobically digested and -89 mV for lime-stabilized biosolids representing an anaerobic environment with in the biosolids system (Lasley et al., 2010). Although DO was not measured during the initial five months of the study which would have provided insight on microbial response to the system, the DO ranged from 3 to 7 mg/L and showed no difference between biosolids applications (Lasley et al., 2010).

While the metal concentrations leaching from the lime-stabilized biosolids were higher than the metals leaching from the anaerobically digested biosolids and control, only 5% of samples returned metal concentrations greater than EPA drinking water

MCLs (Lasley et al., 2010). Cadmium had the greatest leachate potential with 11% of the samples above EPA MCLs (Lasley et al., 2010). Lasley's group (2010) found that metals were more likely to leach during rain events assisted by colloidal fractions and macropores. Overall, Lasley and associates (2010) concluded that the movement of metals from deep row applied biosolids did not threaten groundwater quality.

Pollution Control with Hybrid Poplar Trees

Hybrid poplar trees are fast growing and reach maturity within 6 to 9 years, quickly stabilizing disturbed land. Poplars require higher volumes of water and have longer growing seasons, from April through October, than most agricultural crops (Table 5) (EPA[2], 1999). Furthermore, the hybrid poplar tree has a root system nearly as extensive as its above ground growth, capable of reaching depths of 4.6 m (15 feet) (Figure 19) (EPA[3], 2000).

Table 5. Crop Water Use Comparisons (EPA[2], 1999)

Estimated water use by agricultural crops and hybrid poplars in eastern Washington*.

Crop type	*Estimated Water Use (cm/ha-yr)*	*(in./ac-yr)*
Alfalfa	**176-282**[1]	**28-45**[1]
Apples w/ cover crop	**213-314**[1]	**34-50**[1]
Onions (dry)	**188-226**[1]	**30-36**[1]
Potatoes	**176-213**[1]	**28-34**[1]
Sweet corn	**151-176**[1]	**24-28**[1]
Winter wheat	**157-195**[1]	**25-31**[1]
Hybrid poplar (1st yr)	**63-88**[2]	**10-14**[2]
Hybrid poplar (2nd to 3rd yr)	**138-163**[2]	**22-26**[2]
Hybrid poplar (4th yr to harvest)	**201-226**[2/3]	**32-36**[2/3]

*Significantly lower water-use values would be expected in cooler, maritime climates

1) Values are derived from twenty-year water-use records (James et al. 1989).

2) Calculated values based on maximum stand water losses of 0.188-0.194 in d^{-1} (Hinckley et al. 1994)

3) Kim Brown and Tom Hinckley, unpubl. data

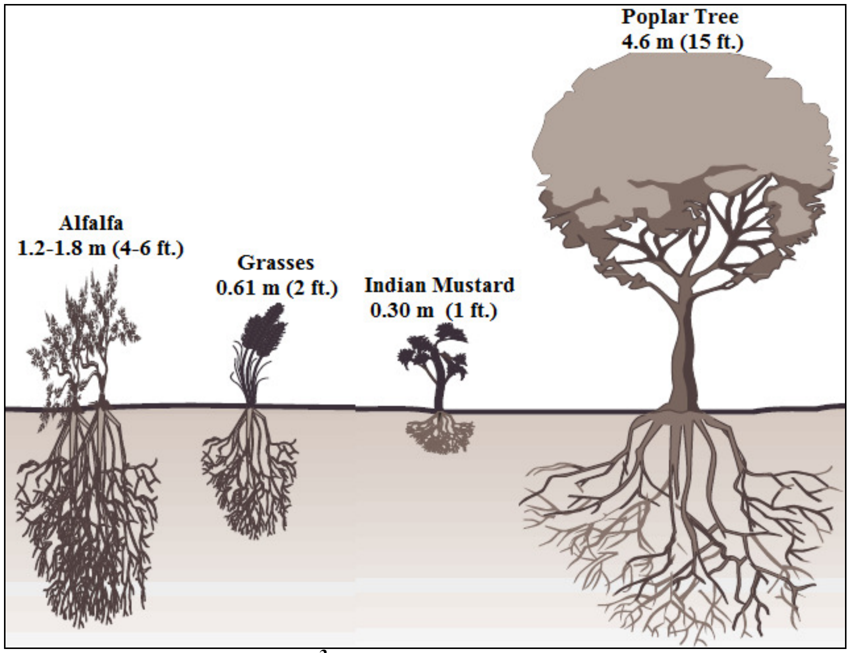

Figure 19. Crop root system depths (EPA[3], 2000)

Coupling the plant's thirst for water and deep root system, hybrid poplar trees have been used for phytoremediation for the following groundwater pollutants: nitrates, atrazine, metals, organics, chlorinated solvents, benzene, toluene, ethylbenzene, and xylene (BTEX) (EPA[3], 2000). In fact, a study by Jordahl and associates (1996) found that there were significantly higher concentrations of total heterotrophs, denitrifiers, pseudomonads, and BTEX degraders in the rhizosphere of poplar trees than in surrounding soil (Figure 20).

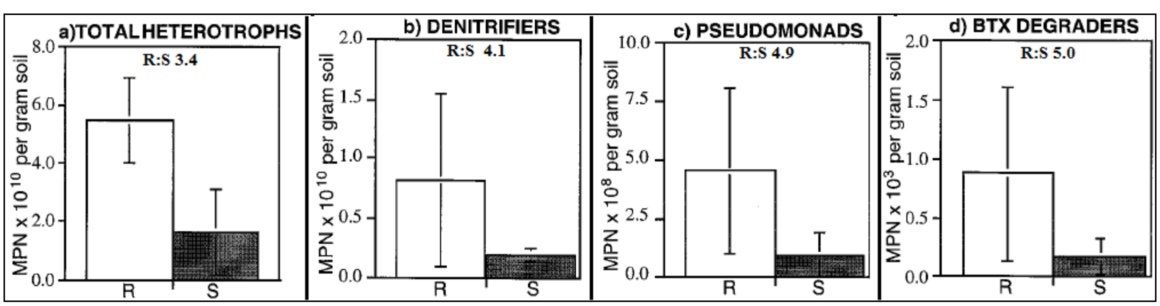

Figure 20. Microorganism populations in poplar rhizospheres (R) and soil (S) (Jordahl et al., 1996).
*One standard deviation shown with error bars.

Similar to the Pepper et al (2006) study, Stettler et al. (1996) reports that poplar trees have a larger NH_4^+ uptake rate than other deciduous trees based on net ion uptake calculations (Equation 11). In fact poplar trees can uptake about 10 times more NH_4^+ than phosphate (PO_4^{2-}) and NO_3^- (Stettler et al., 1996). Poplar trees have lower NO_3^- uptake rates than other deciduous trees. Table 6 shows the computed net ion influx rates for poplar tree species and various deciduous tree species (Stettler et al., 1996).

Table 6. Ion Uptake of *Populus* and Other Deciduous Trees (Stettler et al., 1996)

Species	Ion	C_1 (μM)	I_{net} (μmol/gdw-h)
P. balsamifera	PO_4^{-2}	20	4 - 7
	NH_4^+	4,000	30 - 40
	NO_3^-	600	1 - 3
P. tremuloides	PO_4^{-2}	20	2 - 3
	NH_4^+	4,000	40 - 60
	NO_3^-	600	3
Various eastern USA deciduous tree species (20°C or 68°F)	PO_4^{-2}	10	0.1 – 0.6
	NH_4^+	1,000	10 - 60
	NO_3^-	1,000	10 - 40

Note: Values were calculated using Equation 11.

Equation 11. Net Ion Uptake (Stettler et al., 1996)

$$I_{net} = I_{max} (C_1 - C_{min})/(K_m + C_1 - C_{min})$$

Where:

I_{net} – net ion influx rate;
I_{max} - maximum ion influx rate;
C_1 - solution concentration;
C_{min} - minimum solution concentration for positive I_{net}; and
K_m - solution concentration at which net ion influx is ½ I_{max}

Biosolids Conditions and Poplar Tree Root Zones

The biosolids pack may not be the most hospitable environment for the poplar tree roots. In fact, Taylor et al. (1978) reported that the methane in lime stabilized bisolids, such as those from Blue Plains, increased from 1 to 45% after 61 days. Oxygen decreased while carbon dioxide (CO_2) levels increased to 13% and nitrogen gas (N_2) approached atmospheric levels of 79.6% after 62 days (Taylor et al, 1978). Taylor et al. (1978) theorizes that the N_2 gas increase "…may result from rapid utilization of O_2 and the greater solubility of CO_2 than N_2 into water held by the soil and sludge." Harmful

NH_3 gas is also released from the biosolids. In the ERCO deep row biosolids poplar tree system, the trees are planted after the biosolids are applied. Tree roots must pass at least 30 to 60 cm (1-2 ft.) of top soil before penetrating the biosolids pack. The distance the roots must travel allows time for NH_3 gas to leave the system before the roots enter the biosolids. Although the NH_3 gas inhibits root proliferation, University of Maryland's Dr. Ray Weil is not concerned about the roots in the ERCO system (Ray Weil, PhD., University of Maryland- ENST Department, personal communication, 4 September 2012). Weil explained that as the roots approach a pocket of harmful ammonia gas, they will alter their path and navigate toward a more hospitable environment. Even if the gaseous environment changes and becomes more hostile, a section of the root system may die as a result, but the tree will survive. As the tree ages and becomes more established it is not as susceptible to the gaseous underground environment (Ray Weil, PhD., University of Maryland- ENST Department, personal communication, 4 September 2012).

Poplar Trees Utilized as Groundwater NO_3^- Buffers

In 1990 scientists monitored groundwater NO_3-N concentrations traveling from a corn field, through a four row poplar tree buffer, and entering a stream bank using suction lysimeters. The original NO_3-N value from the corn field was 33 mg/L, significantly higher than the EPA MCL of 10 mg/L (Licht and Schnoor, 1993). An average value of 2 mg/L NO_3-N was found within the group of three year old poplar trees. Additional NO_3^- was removed from the groundwater as it traveled from the tree buffer to the creek, resulting in concentrations of less than 1mg/L NO_3-N, indicating that grass uptake and/or infiltration through the soil profile further removed NO_3-N from the groundwater. Licht and Schnoor (1993) found that the poplar trees used soluble inorganic nitrogen (NO_3^- and TAN) through the rhizosphere. The tree system, including microbes and rhizosphere, transformed NO_3^- to protein and nitrogen gas. At the conclusion of the study, Licht and Schnoor (1993) calculated that poplar trees planted at a tree density of 11,000 trees/ha (4,452 trees/ac.) could take up 8.07 million liters (2.13 million gallons) of groundwater by their fifth year.

Poplar Trees Grown in Papermill Biosolids and Liquid Pig Slurry

After chisel plowing a former hayfield in Quebec, Canada to a 30 cm (2 ft.) depth, four blocks with ten plots and 16 trees per block were established to create 40 100m^2 (120 yd^2) plots with 160 trees total. Lteif and his colleagues (2007) recorded the height and diameter at breast height (DBH at 1.3 m high or 4.3 ft. high) after every growing season beginning three years prior to the addition of the papermill biosolids and liquid pig slurry. Different combinations of papermill biosolids and liquid pig slurry were used in addition to a plot with an inorganic fertilizer and a control group without any fertilizer, ranging in N application rates from 0 to 432 kg N/ha-yr (0- 385 lbs. N/ac.-yr). Soil samples were taken one month after the introduction of fertilizer and prior to leaf senescence.

Overall, the biomass of the poplar trees, not including the leaves, was greater in areas that received papermill biosolids, liquid pig slurry, or a combination of the two than in areas that received no fertilizers or inorganic fertilizers. Combinations of the papermill biosolids and liquid pig slurry produced more biomass than the papermill biosolids or liquid pig slurry alone. The organic fertilizers (papermill biosolids and liquid pig slurry) also had higher nitrification rates, microorganism populations, and ammonification rates than in the control plot or inorganic fertilizer plots. The soil analyses suggested that the increased biomass of trees grown in the organic fertilized plots over those grown in the inorganic fertilized plots may be affected by the higher concentrations of available calcium and magnesium. On the other hand, the inorganic fertilizer contained higher levels of phosphorus.

Calculating the nitrogen use efficiency (NUE) with Equation 12 shown below led to higher NUE values with the inorganic fertilizers, since the nutrients are more readily available for plant uptake. The combination of organic fertilizers had higher NUE values than the papermill biosolids or liquid pig slurry alone. Therefore it is assumed that there is an interaction between the two organic fertilizers that benefit the hybrid poplar trees. The most probable causes producing better results and increasing soil quality from the combination organic fertilizers are an increase in microbial and nutrient diversity from the different sources.

Equation 12. Nitrogen Use Efficiency (NUE) (Ltief et. al, 2007)

NUE = Biomass Increment/Cumulative N input

Existing Conditions at ERCO and Their Effects on the Nitrogen Cycle

Prior to the 2002 study conducted by faculty, staff, and graduate students of the Biological Resources Engineering Department of the University of Maryland, College Park, ERCO hired consultants to investigate groundwater quality, soil properties, nitrogen budgets of the biosolids-tree cycle, and hybrid poplar tree growth conditions. Overall, Pepperman (1995) found that the deep row applied biosolids have not threatened the groundwater quality and do not have adequate concentrations of N to support the amount of hybrid poplar trees growing in the area.

In 2002, Dr. Felton and his graduate students, Carrie Buswell and Thomas Griffeth, began researching the N cycle and potential nutrient leaching from the deep row applied biosolids throughout the longevity of the poplar tree life cycle at ERCO. The research plot was designed with four different biosolids application rates (0, 386, 773, and 1,159 dry Mg/ha or 0, 172, 345, and 517 dry tons/ac.) and three different tree densities (0, 716, and 1,074 trees/ha or 0, 290, and 435 trees/ac.). Sampling mechanisms included one zero-tension pan lysimeter and five suction lysimeters in each of the 30 plots, with varying treatment conditions. Further information regarding the experimental design at ERCO can be found in Chapter 4 Materials and Methods under the heading "Site Properties".

Buswell (2006) summarized data collected from 2002 to 2005, concluding that most samples' nitrogen was in TAN at concentrations higher than 100 mg/L. No significant differences (α= 0.05) in soil water nutrients were found between application rates (Figures 21 and 22) or tree densities. Despite the lack of significant differences, TAN concentrations decreased as distance between the biosolids and lysimeter increased (Figure 23). The concentrations of NO_2-N and NO_3-N were very low; often less than 1 mg/L, signifying that nitrification was not taking place. The graphs for NO_3-N values by application rate and depth are shown in Figures 22 and 24, respectively.

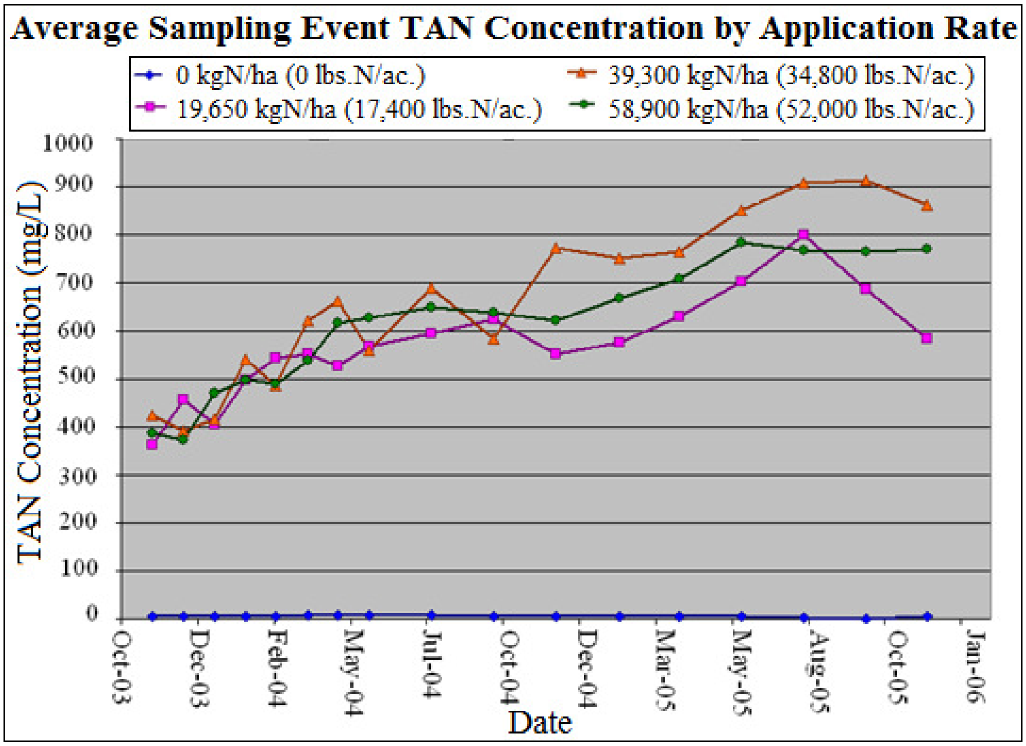

Figure 21. ERCO's average TAN concentrations of suction lysimeter samples (Buswell, 2006) from November 2003 to October 2005 sorted by application rates of 0, 19,650, 39,300, and 58,900 kgN/ha (0, 17,400, 34,800, and 52,000 lbs.N/ac.)

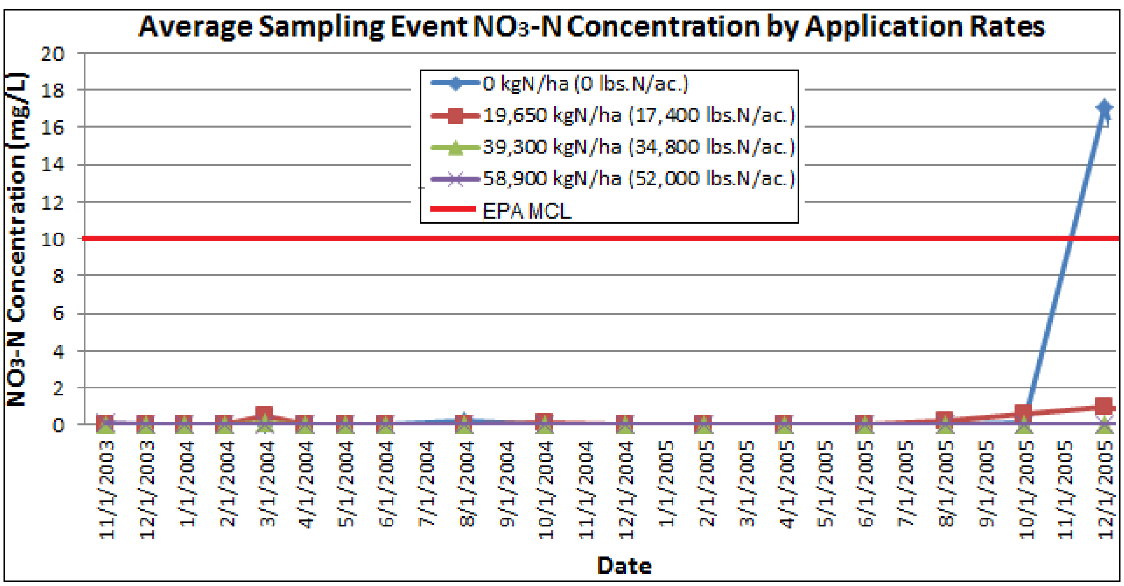

Figure 22. The average NO_3-N concentrations of the suction lysimeter samples (Buswell, 2006) from November 2003 to October 2005 sorted by application rates of 0, 19,650, 39,300, and 58,900 kgN/ha (0, 17,400, 34,800, and 52,000 lbs.N/ac.)

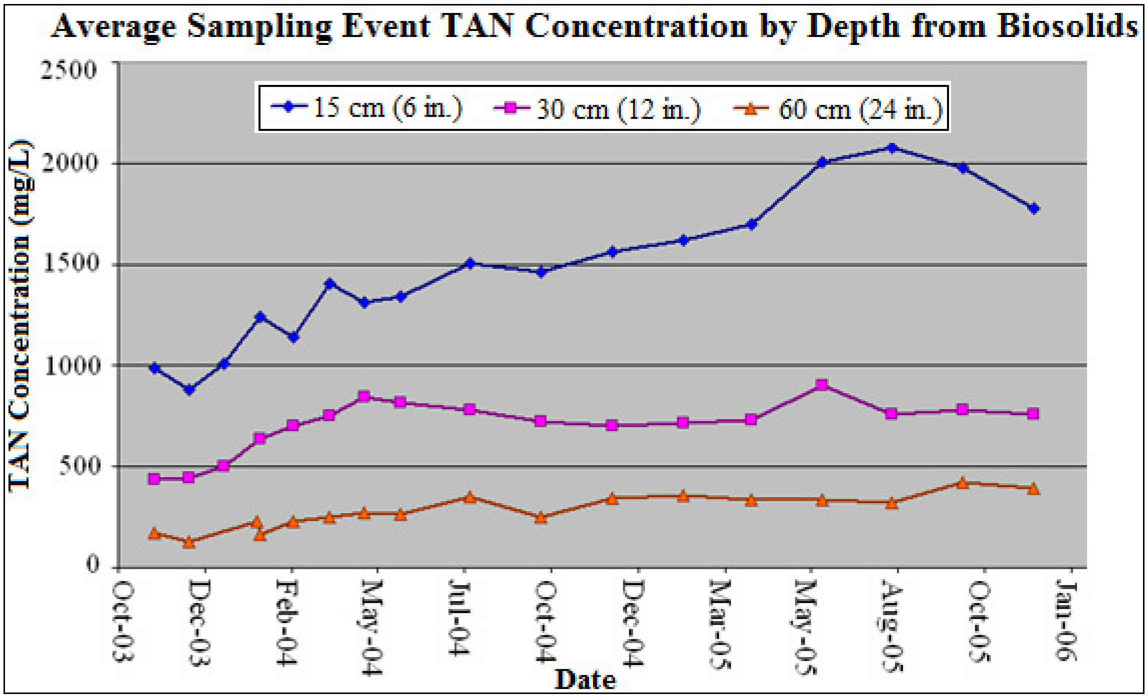

Figure 23. ERCO's average TAN concentrations of the suction lysimeter samples (Buswell, 2006) from November 2003 to December 2005 sorted by location to the bottom of the biosolids row (15, 30, and 60 cm or 6, 12, and 24 in.)

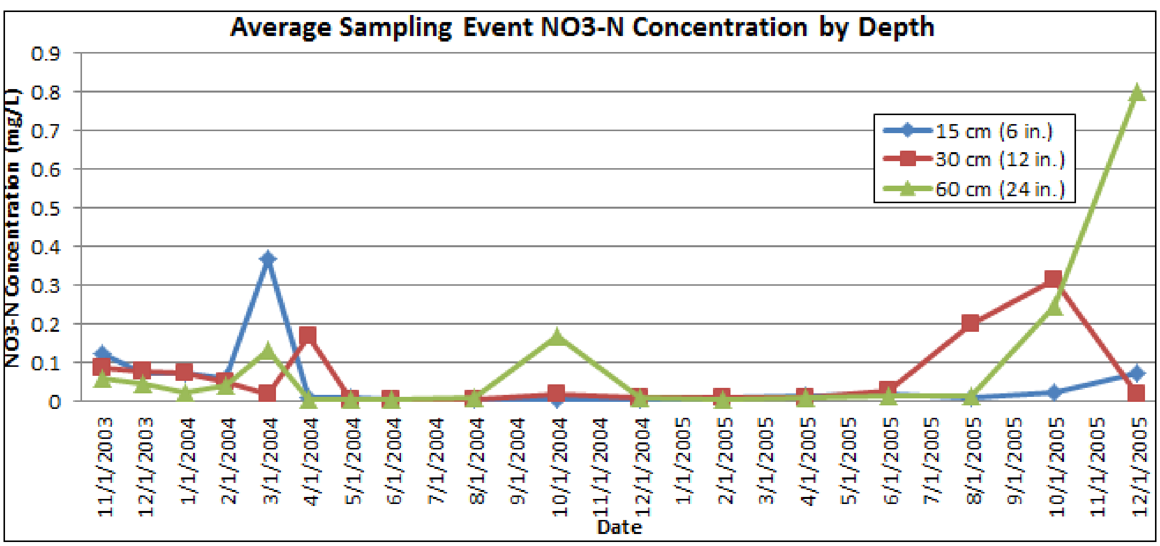

Figure 24. Average NO_3-N concentrations by depth (Buswell, 2006)

Background Nitrogen Concentration in ERCO Soil

Pepperman (1995) studied the nitrogen budget associated with ERCO techniques and conditions. Prior to biosolids application, the ERCO's soil contained total N concentrations of 100 mg/kg and TAN values of 1.2 mg/kg (Pepperman, 1995). With the subsoil bulk density of 1.6 to 1.9 g/cm^3; 1 kg of soil would have the equivalent volume of 625 to 526 cm^3. After Pepperman (1995) assumed water content between 25 and 50 percent, the resulting volume of water in 1 kg of soil is equivalent to 0.131- 0.312 L. Soluble total N was estimated to be 10 percent in solution based on soluble N content in plant matter (Haynes, 1986). From these assumptions, ERCO's soil water background levels of total N were estimated between 32 and 76 mg/L (Pepperman, 1995). The maximum TAN background concentration from the 1.2 mg/kg soil sample results in 4 to 9 mg/L TAN in ERCO's soil water background (Pepperman, 1995).

ERCO Nitrogen Budget

Sources of incoming N are the biosolids, atmospheric deposition, fallen leaves, and natural soil conditions. Outgoing N sources and/or nitrogen storage sources are the poplar trees and the soil profile. Other outgoing N sources include leachate, gaseous losses through volatilization, and gaseous losses through denitrification.

Native Microorganisms

Deep row application of biosolids decreases mineralization rates because surface temperatures for land application are higher than those temperatures below the surface for deep row application. Typically, microorganisms are more active in temperatures higher than those found within the soil profile. The biosolids, composed of mostly water, are constantly dewatering, resulting in decreased levels of oxygen available for nitrification (USDA, 2008). Another unfavorable condition for microorganisms is the lime-stabilized biosolids pH of about 11 and high salt concentrations. Pepperman reported that only 75%

of the trees' nutrient requirements are available at the ERCO's standard application rate of 383 dry Mg/ha (171 dry tons/ac.) and ERCO's experimental application rate of 658 dry Mg/ha (294 dry tons/ac.) (Pepperman, 1995). Limited nutrients are devastating for both the trees and the microorganisms. As mentioned previously, microorganisms are more active at near neutral pH, moderate temperature, aerobic concentrations, high substrate concentrations, and low salt concentrations. More information regarding the background site conditions before this research study are found in Chapter 4 Materials and Methods under the heading "Site Properties".

Chapter 3: Objectives

Nitrogen Objectives

- Evaluate the impact of deep row biosolids on nitrogen concentrations in leachate.

Water Quality Objectives

- Determine the effect of tree density and biosolids application rate on water (leachate) quality under the deep rows.

Chapter 4: Methods and Materials

Site Location and Properties

Site Location

This study takes place at the ERCO, Inc. Beneficial Reuse Tree Farm located at the end of Neale Drive in Brandywine, MD of Prince George's County (Figure 25). In all, the site contains 115 ha (284 ac.) divided into nine sections including seven detention ponds.

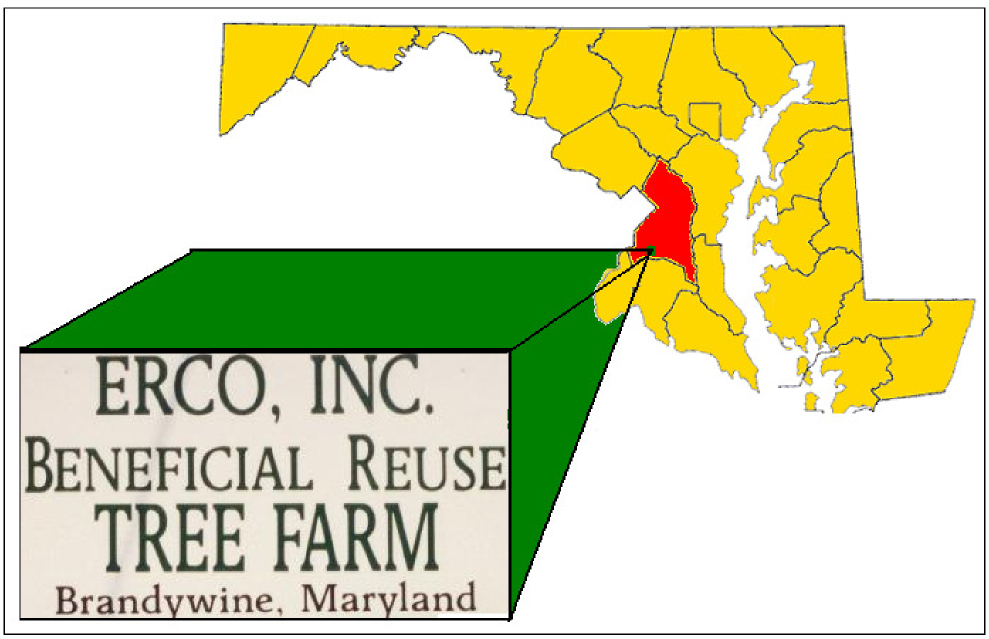

Figure 25. The location of ERCO, Inc. hybrid poplar tree farm in Brandywine, MD.

Site Use; Past, Present, and Future

Past Site Use

From 1968 until 1980, Prince George's Bank Run Gravel Corporation owned and operated the current ERCO site. During this time bank run material and gravel were mined and sold directly to construction companies for road base, without sorting or washing. Some materials were sold to concrete companies that would wash, size, and crush the bank run for aggregate in concrete mix.

Present Site Use

Since 1981, ERCO has managed the Brandywine, MD location. Biosolids were trucked in from the Blue Plains Advanced Wastewater Treatment Plant and applied to 37.8 ha (93.5 ac.) of the 115 ha (284 ac.). After the biosolids are placed into the deep rows (about 0.76 m deep x 1.0 m wide or 2.5 ft. deep x 3.3 ft. wide) at 383 dry Mg per hectare (171 dry tons per acre) and the mine spoilage enclosed the biosolids (about 0.3 to 0.6 m or 1.0 to 2.0 ft. deep), hybrid poplar tree steckings are planted at a density of 202 trees/ha (435 trees/ac.). Throughout their lifespan, the hybrid poplar trees draw upon the biosolids as a nutrient source (Kays et al., 1999). The poplars are harvested about 6 years after planting through standard whole tree harvesting procedures and in-field chipping operation. Every part of the tree, except the stump and roots, is chipped using in-field chipping operation and later stored in a chip pile until sold to local landscapers for mulch. In 2006 and 2007, District of Columbia Water and Sewer Authority, also known as DC Water, bought the wood chips to use as a bulking agent in their compost piles.

Future Site Use

The future of the site depends on the market for poplar products, biosolids disposal, and residential or commercial development. As long as ERCO, Inc. profits with biosolids disposal, that will remain the operation at the site. However, as the market continues to drive up transportation and disposal costs of biosolids, the site may sit inactively and undergo natural attenuation of the biosolids until the site is fully remediated and fit for development.

Site Properties

The first two sections located at the entrance of ERCO, Inc., are located on a plateau region with slopes between 0- and 2-percent. Runoff from the plateau region travels to a detention pond. The steep banks surrounding the upper two sections have permanent forest cover. An elevation drop between 1.5 and 3 m (5-10 ft.) resolves into a level area with a 0- to 2-percent slope in the rest of the sections. About 13 ha (32 ac.) of the site consists of forested steep slope, detention ponds, and buffer zones.

Geotechnical Site Data

In order to uncover the subsurface properties of the experimental plot, especially in relation to water movement in the deep-row applied biosolids, near-surface borings were taken between depths of 1.5 and 7.6 m (5-25 ft.). Information from the borings located perched water, measured hydraulic conductivity throughout the system's depths, and identified monitoring well locations.

Soil Data

A report by Wilson and Fleck (1990) investigating the soil borings in Prince George's County nearby the ERCO site shows that the mining industry destroyed the soil profile organization. Underneath the mining spoils are deep (1.5-21.3 m or 5-70 ft.) layers of clay. More detailed findings from the Wilson and Fleck report are as follows:

- Between the 1960s and 70s, most of the top layer was removed for mining purposes. According to the study the top layer consisted mostly of Pliocene Upland Deposits that are silty, fine to very coarse sand and gravel, some yellow-orange silty clays with a thickness of 6.1 to 15 m (20-50 ft.)

- The Lower Miocene Calvert Formation was at one point the second layer from the top, but is now mostly on the surface of the graded site. Miocene Calvert Formation was formed by marine shelf deposits of micaceous, clayey silt with an approximate depth of 27-30 m (90-100 ft.).
- The Lower Eocene Nanjemoy Formation sits below the Miocene Calvert Formation and contains fine to medium glauconite-bearing sands with 27-38 m thickness (90-125 ft.).
- A hydrologically confining layer with a depth of 4.6-9.1 m (15-30 ft.) named the Marlboro Clay Formation follows the Lower Eocene Nanjemoy Formation.
- Several aquifers lay beneath the confining layers.

In 1995 Pepperman reviewed data collected at the ERCO site and found similar soil properties as the Wilson and Fleck study in 1990. In addition to the Wilson and Fleck study, Pepperman concluded that a slow permeable layer exists underneath the mining spoils and biosolids and retards leachate flow, thus preserving groundwater quality.

Buswell evaluated the ERCO soil hydraulic conductivity from soil cores taken at and above the pan lysimeter depths. The hydraulic conductivity of ERCO soil cores were calculated by an adaptation of the constant head practice outlined in Methods of Soil Analysis and following Darcy's Law (Knute, A. 1986). The results indicated a range in saturated hydraulic conductivity from 1.40×10^{-7} to 1.84×10^{-2} cm/s (4.59×10^{-9} to 6.04×10^{-4}ft./s). Block 1 with higher average hydraulic conductivity values (10^{-2} to 10^{-4} cm/s or 3.28×10^{-4} to 3.28×10^{-6} ft./s) had more sand, gravel, and rock components in its soil matrix. Block 2 had hydraulic conductivity values ranging from 10^{-4} to 10^{-5} cm/s (3.28 x 10^{-6} to 3.28 x 10^{-7} ft./s) and more silt and clay deposits than Block 1. The lowest hydraulic conductivity values belonged to Block 3 with the range of 10^{-4} to 10^{-6} cm/s (3.28 x 10^{-6} to 3.28 x 10^{-8} ft./s). Block 3 was observed with higher clay components than Blocks 1 and 2. After using PROC Mixed to perform a factorial analysis of the ERCO soil hydraulic conductivity variance showed statistically significant differences ($\alpha = 0.05$) between blocks (Pr < 0.0001), but no significant difference between depths (Buswell, 2006). According to Buswell, "Least Squares Means evaluation showed all three blocks to be significantly different from one another (Pr <0.0031 for Blocks 1 and 2; Pr<0.0001 for Blocks 1 and 3; Pr<0.0038 for Blocks 2 and 3)." (Buswell, 2006). The average hydraulic conductivity for each subplot is shown in Figure 26.

Buswell used the hydraulic conductivity measurements to estimate travel time for leachate to reach the sampling ports. The travel time ranged from as little as 0.5 hours to as many as 13 months (Buswell, 2006). The estimated travel times do not take preferential flow patterns or voids into account and are based on data from 2003. Since then, compaction, voids, or channels may have developed and changed the travel times for water leaching through the soil matrix and biosolids. Figure 27 shows the 2003 estimated travel times for leachate. It is important to note that the travel times are significantly different between blocks, since the hydraulic conductivity values between the blocks were significantly different. Photographs of the soil conditions are shown in Figures 28 and 29.

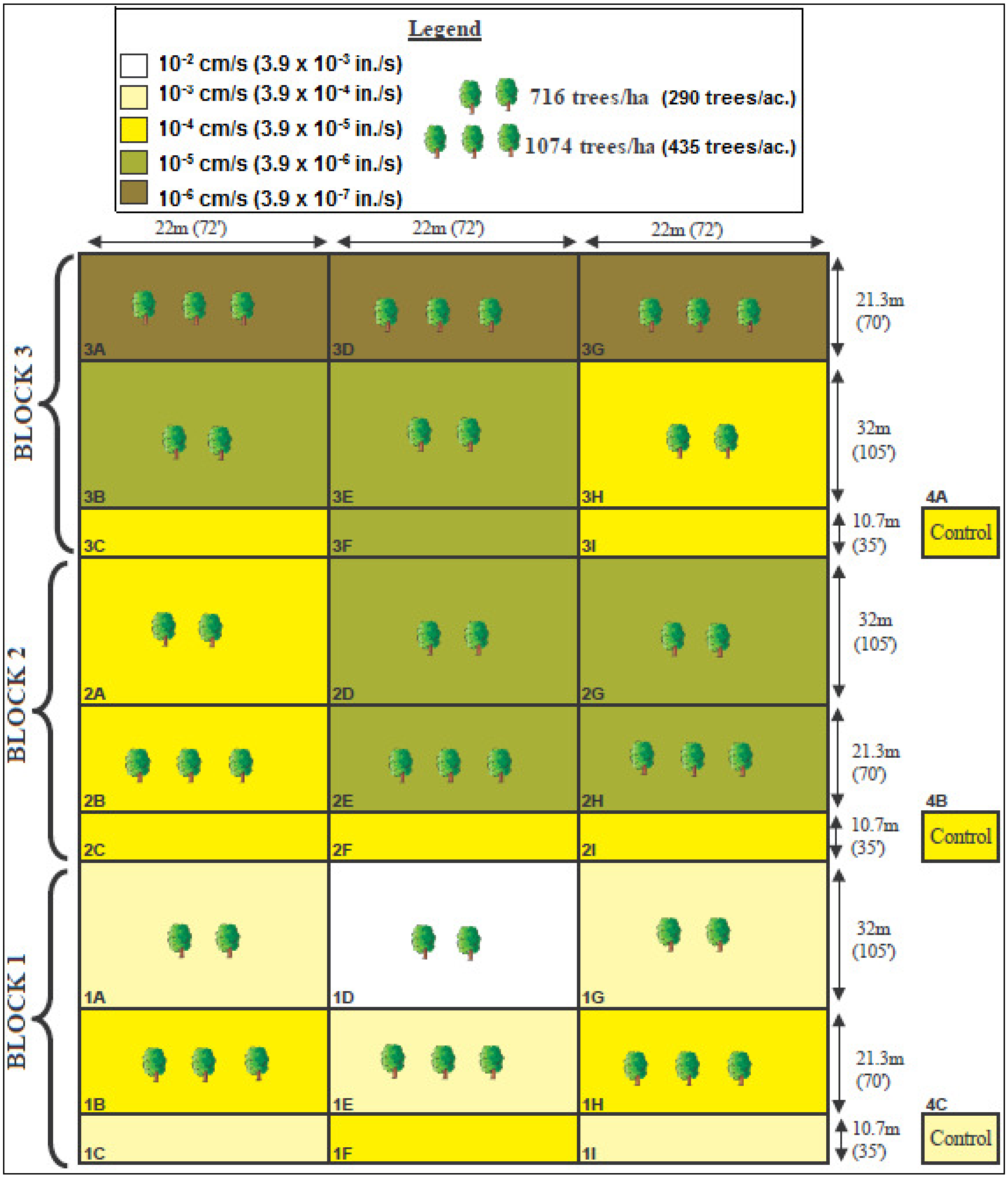

Figure 26. Average hydraulic conductivity values per subplot (Buswell, 2006).

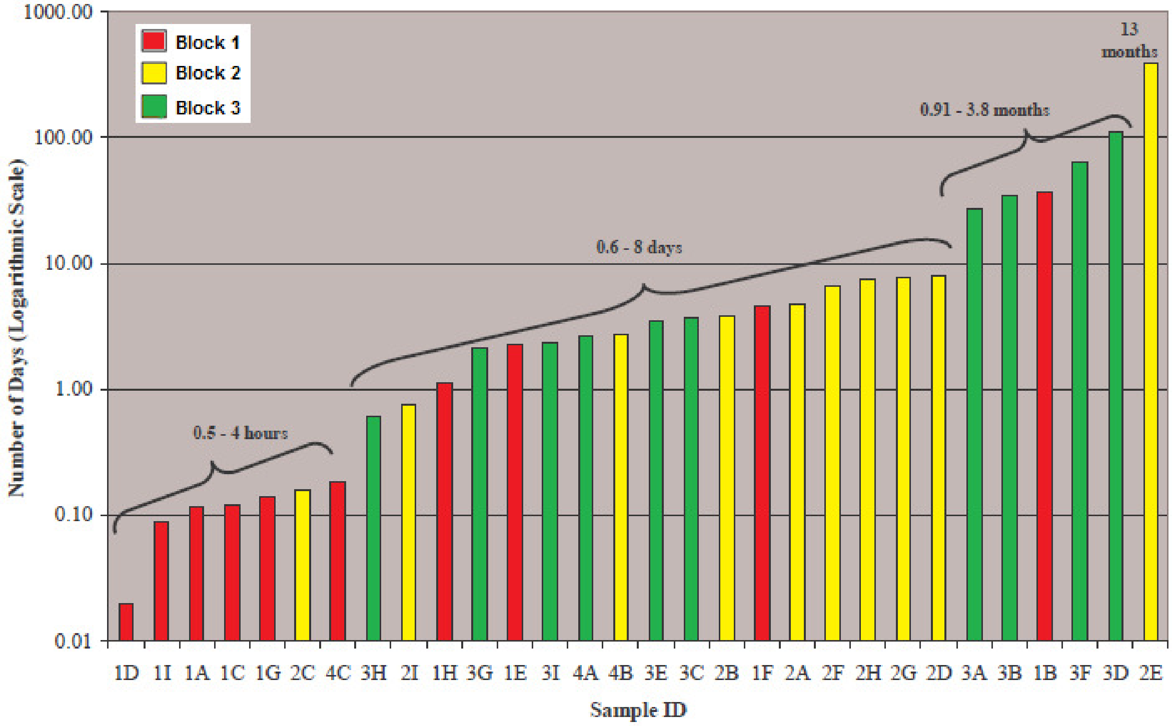

Figure 27. Estimated leachate travel time from bottom of biosolids row to sampling equipment (Buswell, 2006).

Figure 28. Pictures of the soil conditions at ERCO.

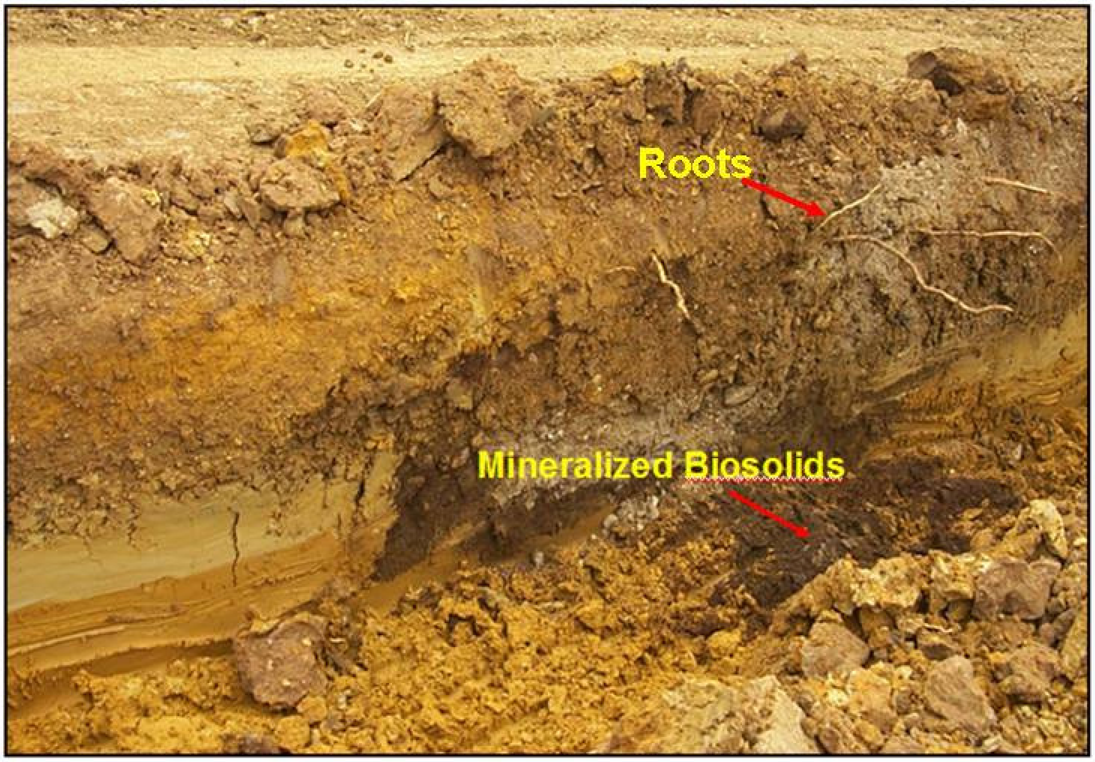

Figure 29. Picture of the soil profile with mineralized biosolids and root remains.

Water Data

Buswell (2006) reported that there were seven monitoring wells installed between depths of 6.1 and 30 m (20-100 ft.) collected samples since 1982 in order to perform baseline conditions in nutrients, metals, pH, and fecal Coliform. As of 2006, water quality monitoring produced the following results (Buswell, 2006).

- Very little changes in overall water quality.
- Chloride concentration remained fairly constant, indicating that water leaching from the biosolids has not percolated to the aquifer, where the groundwater samples are taken.
- Most NO_3-N concentrations were below detectable limits. One well produced the two highest levels of NO_3-N, 1.5 and 1.9 mg/L. The 1.5 mg NO_3-N /L

sample was taken before biosolids were applied to the site and represents a background concentration for NO_3-N.

- Metal concentrations did not exceed EPA drinking water MCLs, and were mostly below detectable limits.
- Concentrations of fecal coliform were low. The concentrations were more elevated in late summer and late fall.

Water samples from creeks located upstream and downstream of ERCO, Inc., were also analyzed before and after biosolids application (Buswell, 2006). Subsequently the analyses revealed that there was no threat of harming the water conditions at or downstream of the site {i.e., concentrations were either below the detectable limits, the EPA drinking water MCLs, and/or the Cumulative Pollutant Loading Rates specified in 40 CFR 503} with deep row biosolids application (Buswell, 2006).

Experimental Design

Biosolids Application Rates and Tree Densities

The 1.2-ha (3-ac) research plot exists within the 3.7-ha (9-ac) southeastern corner of the site. In 1989, this southeastern corner received 105 dry Mg of biosolids/ha (39 dry tons of biosolids/ac.). This site was divided into three lateral blocks based on the north-south slope and soil profile gradients. Within these three lateral blocks, there were three horizontal divisions made. There were also three biosolids application rates of 386, 773, and 1,159 dry Mg/ha (172, 345, and 517 dry tons/ac.) with approximately 19,650, 39,300, and 58,900 kg N/ha (17,400, 34,800, and 52,000 lbs. N/ac.), respectively and three tree densities of 0, 716, and 1,074 trees/ha (0, 290, and 435 trees/ac.) tested among the nine sections. Each biosolids application rate-tree density pairing had three replications. The biosolids application rates were assigned randomly, but tree densities were based on logistical considerations for ease of machinery and labor. Three control sections are located on the west end of each horizontal block. No biosolids or trees were installed in the control areas for the 2002 to 2009 study; however residual biosolids from the 1989 installation (105 dry Mg biosolids/ha or 39 dry tons biosolids/ac.) were not removed from the site.

In all there are 30 different subplots resulting from the setup in the split-block design layout. An individual subplot spans approximately 22 m (72 ft.) from east to west and either 32 m (105 ft.), 21.3 m (70 ft.), or 10.7 m (35 ft.) from north to south in order to contain the tree density of either 1,074, 716, or 0 trees/ha (435, 290, and 0 trees/ac.), respectively. A buffering perimeter of two tree rows (6.1 m or 20 ft.) isolates treatment subplots and reduces the influences of nearby treatments, especially since all sampling equipment resides within the inner area of the buffering perimeter. Figure 30 shows the labeled experimental layout with biosolids application rates and tree densities. Figures 30 through 33 show the locations of the sample lysimeters for each subplot.

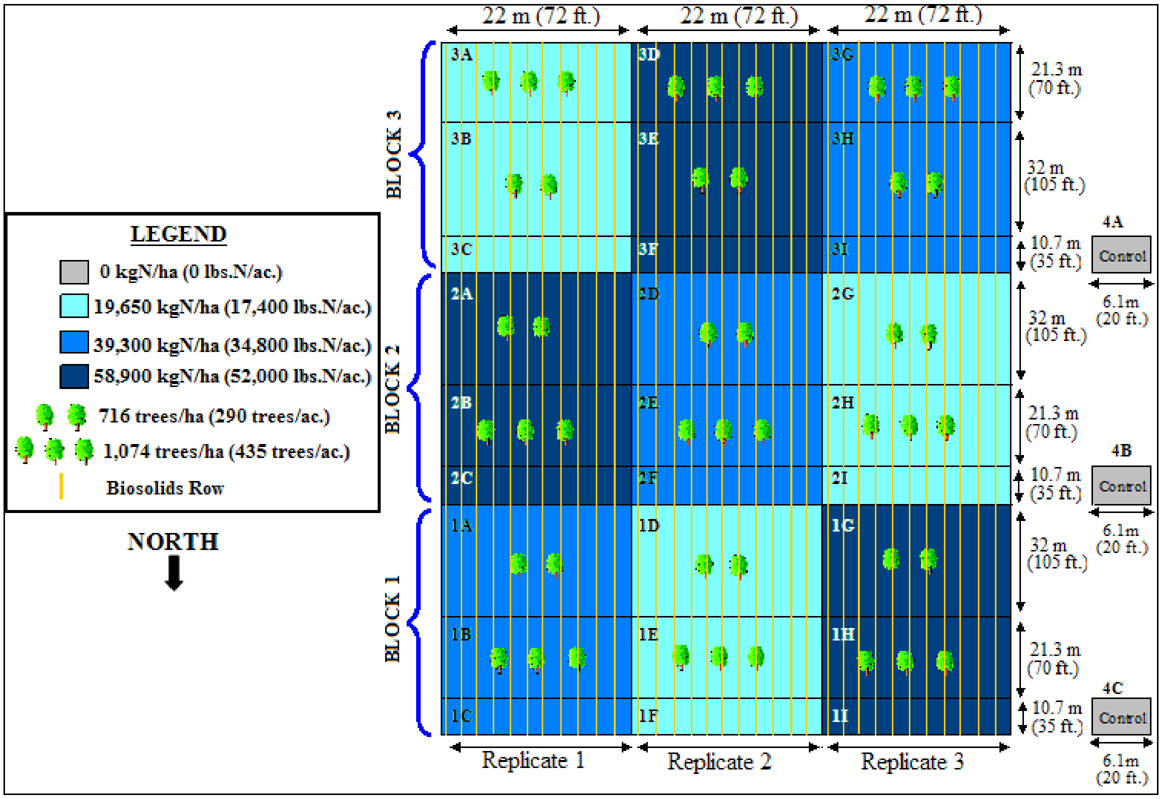

Figure 30. ERCO's comprehensive experimental layout (Buswell, 2006).

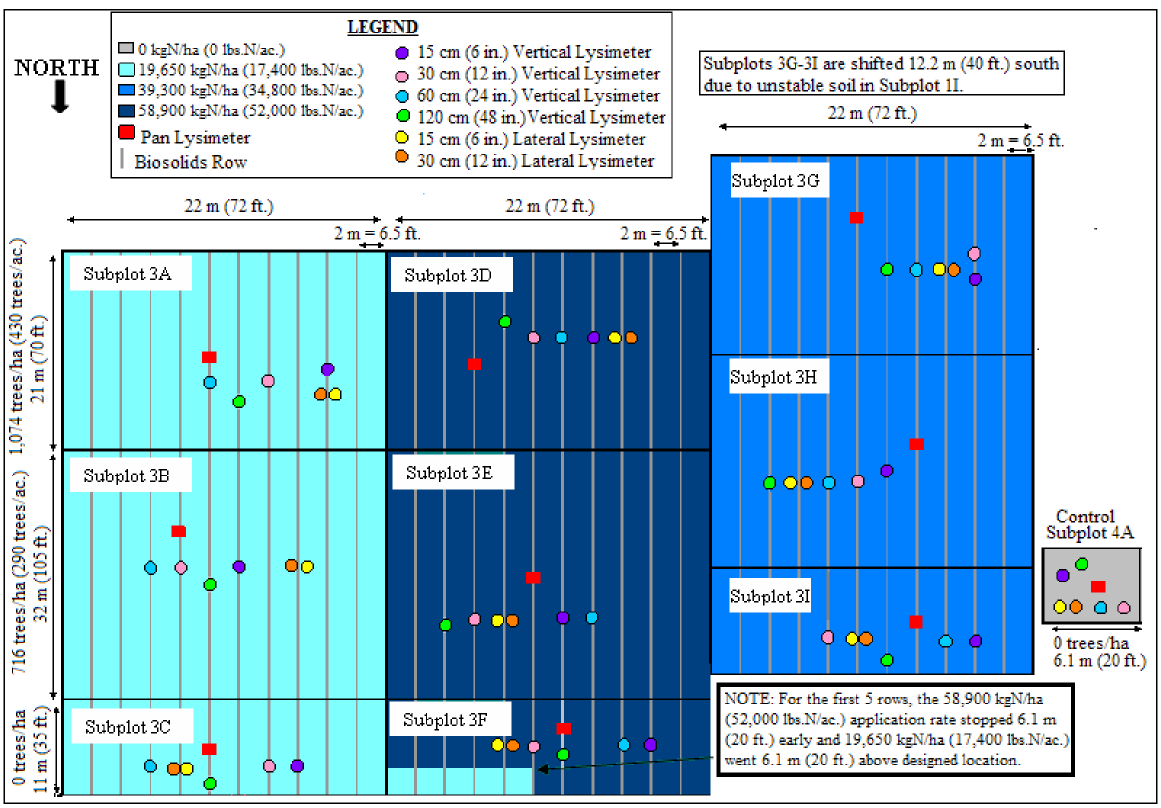

Figure 31. ERCO's Block 3experimental layout.

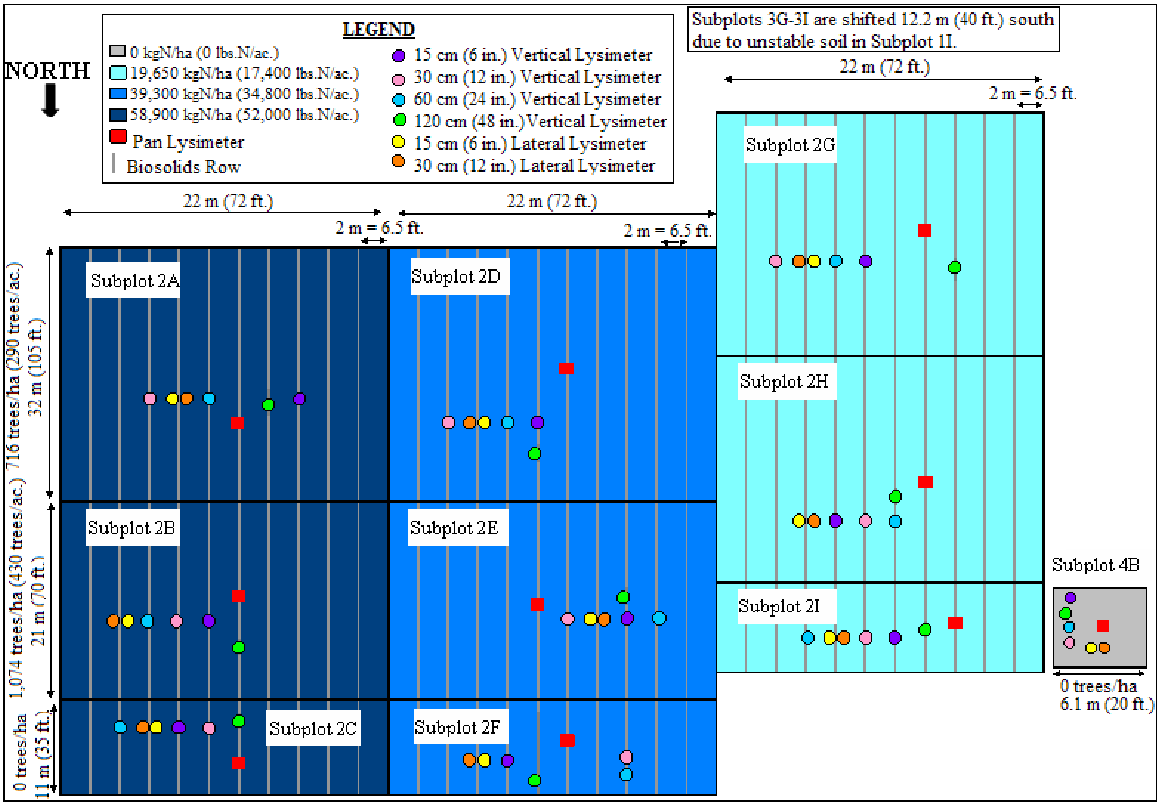

Figure 32. EROC's Block 2 experimental layout.

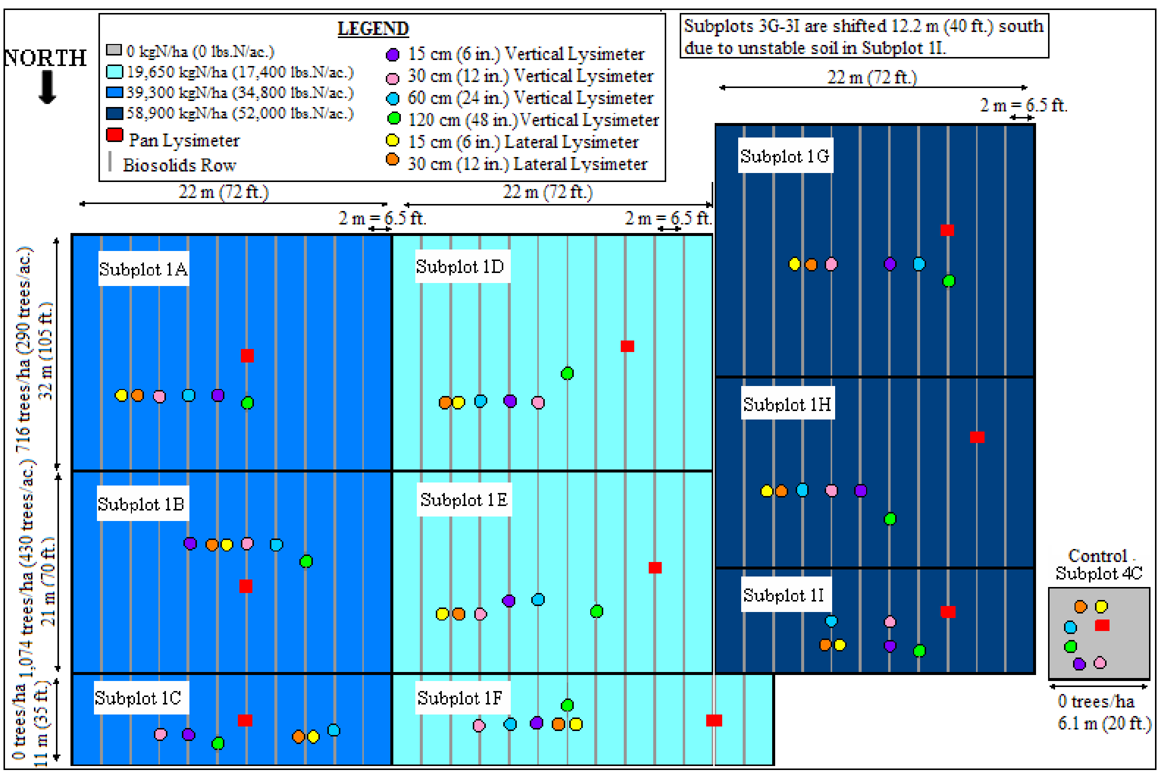

Figure 33. ERCO's Block 1 experimental layout.

Biosolids Characteristics

The biosolids buried at the ERCO site originate from the Blue Plains Wastewater Treatment Plant in Washington, D.C. (Blue Plains). Although they are categorized as Class B biosolids, the dewatered, lime-stabilized biosolids have notably low metal concentrations. Because the lime-stabilized biosolids have a high pH, around 12, the biosolids inhibit microbial growth. If quicklime (CaO) is used to stabilize the biosolids, then the temperature is raised via exothermic reactions, which further the destruction of pathogens (EPA, 2000).

Each delivery of biosolids from Blue Plains was tested for its composition. Results depicted an average organic N concentration of 1.16% (11,600 mg/kg), total phosphorus content of 0.38% (3,800 mg/kg), pH values between 11-12, and solids content of 20-25%, on a wet weight basis. Ammonium was also present, as evident from the gases released from the biosolids pile (Buswell, 2006). Samples were taken every month to characterize the physical and chemical nature of the biosolids throughout construction of the research plot.

In addition to the chemical properties of the biosolids, Buswell investigated the physical properties of the biosolids by evaluating the hydraulic conductivity. The biosolids' hydraulic conductivity was measured at 2.55 x 10-6 cm/s (8.37 x 10^{-8} ft./s), which is consistent with soils composed of silt and clay (Buswell, 2006). Buswell also noted that, "If the soil surrounding the biosolids row has a higher conductivity value than the biosolids, water entering the subsoil system via precipitation will likely travel around the biosolids row. Conversely, if the soil has a lower conductivity value, water will choose the path of least resistance and percolate through the biosolids row." (Buswell, 2006).

The hydraulic conductivity increases as the biosolids decompose. In general, the biosolids' instantaneous hydraulic conductivity is dependent on the dewatering and decomposition of the biosolids.

Biosolids Installation

As shown previously in Figures 32 to 35, the deep rows run in a north-south direction, which is perpendicular to the older deep rows constructed in 1989. The current deep rows are centered at 1.8-2.0 m (6-6.5 ft.) with widths of 1.07 m (3.5 ft.). Depths of 0.61 m (24 inches), 0.94 m (37 inches), or 1.24 m (49 inches) depend on the application rate of 5,982, 3,388, and 1,694 wet Mg/ha (2,277, 1,515, and 757wet tons/ac.), respectively. About 1 m of mining spoil divides one workday's biosolids from the next workday's biosolids. In other words, the rows are not continuous, with approximately 27.4 m (90 ft.) continuous rows interrupted by 1 m (3.28 ft.) daily cover. The application rates correspond to nitrogen concentrations of 58,900, 39,300, and 19,650 kg N/ha (52,000, 34,800, and 17,400 lbs. N/ac.) (Buswell, 2006).

After the biosolids were placed into the deep rows within 45 minutes of delivery, the initial layer of overburden was spread on top of the biosolids. Another layer, consisting of the excavated overburden from the next row, was spread on top. These two layers form a cap over the biosolids that is about 0.46 to 0.76 m (1.5-2.5 ft.) deep and seal in the biosolids. Pictures depicting the construction of the deep row applied biosolids are shown in Figures 34 through 35.

Figure 34. ERCO farm operator digs a deep row with a backhoe. On the right, the truck delivers biosolids.

Figure 35. The operator pushes the biosolids into the deep row and then covers the biosolids with the overburden material that originated from the hole.

<u>Biosolids Application Rates</u>

The application rates for the experimental site were based on ERCO's standard application rate of 383 dry Mg/ha (171 dry tons/ac.), ERCO's experimental application rate of 658 dry Mg/ha (294 dry tons/ac.), the trees' foliar nutrient content at ERCO, and the estimated nitrogen mass balance for the hybrid poplar tree cycle. Using past total nitrogen contents of 3.5% by dry weight, the standard application rate of 383 dry Mg/ha (171 dry tons/ac.) consists of about 58,900 kg N/ha (52,000 lbs. N/ac.), while the experimental application rate of 658 dry Mg/ha (294 dry tons/ac.) consists of about 23,070 kg N/ha (20,600 lbs. N/ac.). Application rates higher than 58,900 kg N/ha resulted in row collapses due to the instability created by the increased depths of the moisture-rich biosolids, and therefore were not used in this investigation.

Based on nitrogen evaluations and foliar nutrient analyses, Pepperman (1995) found that ERCO's trees did not receive adequate concentrations of nitrogen. In the fourth to sixth growing season, data shows that the foliar N concentrations of the trees declined below the optimal level of 3.5%.

Biosolids application rates of 19,650, 39,300, and 58,900 kg N/ha (17,400, 34,800, and 52,000 lbs. N/ac.) were used to test rates similar to those that have been executed by ERCO, Inc. The biosolids application rates were based on deep row dimensions and calculations. Table 7 shows the trench dimensions for each biosolids application rate.

Table 7. Approximate nitrogen treatment rates, depth of biosolids in the trench, total trench depth, and approximate biosolids application rate (Buswell, 2006).

Application Rate kg N/ha (lbs. N/ac.)	Depth of Biosolids cm (in.)	Total Trench Depth cm (in.)	Biosolids Rate Mg/ha (dry tons/ac)
19,650 (17,400)	31.8 (12.5)	61 (24)	386 (172)
39,300 (34,800)	63.5 (25.0)	94 (37)	773 (345)
58,900 (52,000)	95.3 (37.5)	124 (49)	1,159 (517)

Planting of Hybrid Poplar Clones

Obtaining and Caring for Hybrid Poplar Steckings

Steckings of the OP367 hybrid poplar clone (*Populus deltoides* x *Populus nigra*), ordered from Broadacres Nursery in Hubbard, Oregon were planted in June 2003. Typically, ERCO, Inc. plants the steckings in April, but the constant rain experienced in April and May delayed planting. Broadacres Nursery ships the trees in refrigerated conditions, where the trees remain dormant until planting. Before planting, the cuttings were removed from refrigeration and soaked in buckets of water for several hours, allowing the steckings to warm up and begin to absorb moisture. The planting procedures are shown in Figures 36 and 37.

Figure 36. The ERCO farm manager holds the dibble bar. On the right is the hole created by the dibble bar.

Figure 37. A stecking properly in place and secured with remnant soil. On the right is a stecking with its initial growth at approximately 15 days after planting.

Tree density of 716 trees/ha (290 trees/ac.), trees were planted on 3 m x 4.6 m (10 ft. x 15 ft.) centers, while the tree density of 1,074 trees/ha (435 trees/ac.) had trees planted on 3 m x 3 m (10 ft. x 10 ft.) centers. The experimental subplot extends 22 m (72 ft.) in an east-west direction and either 32 m (105 ft.), 21.3 m (70 ft.), or 10.7 m (35 ft.) in a north-south direction for the 1,074, 716, and 0 trees/ha (435, 290, and 0 trees/ac.).

Production Planting

A bulldozer with an attached subsoiling bar etches 0.3 m deep (1 ft.) lines that are 3 m (10 ft.) apart and parallel to each other. Another set of lines, equal in dimensions, are etched that are perpendicular to the first set of lines, creating a 3 m x 3 m (10 ft. x 10 ft.) square on the field, corresponding to the 1,074 trees/ha (435 trees/ac.) tree density. For the 716 trees/ha (290 trees/ac.) tree density, the same initial procedure was followed, but the perpendicular lines were etched at 4.6 m (15 ft.) apart, creating a 3 m x 4.6 m (10 ft. x 15 ft.) grid on the field. Although some tree rows coincide with biosolids rows, the plan did not call for intentional overlaps, because the tree densities do not line up with the biosolids row spacing necessary for the application rates.

Experimental Plots

At the appropriate spacings, a dibble bar was pushed into the ground about 0.3 m deep (1 ft.), as shown in Figure 36. Next, about 2/3 to 3/4 of the stecking is pushed into the ground by hand, and excess dirt is pushed around the stecking to secure its positioning and seal out air. This procedure was used to avoid having the weight of a bulldozer near the instrumentation that had already been installed.

Caring for the Trees: Herbicide Use and Re-planting

A pre-emergent and post-emergent combination herbicide, Goal* Herbicide, was applied in 1 m strips (3 ft.) along each side of the tree lines at 75 L/ha (8 pints/ac.) in March or April of each year. Goal* Herbicide, a Group G (protoporphyrinogen oxidase inhibitor) with oxyfluorfen as the active ingredient and 240 g/L emulsifiable concentrate, targets broad-leafed weeds and grasses without harm to brassicas, grapevines, onions, tree fruit, and other tree species (Dow AgroSciences LLC, 2008). According to Dow

AgroSciences LLC (2008) Goal* Herbicide's special formula adheres to soil particles and resists leaching into the groundwater. Any trees found dead were removed and replaced with new cuttings in the next growing season.

Lysimeter Sampling Equipment

Suction Lysimeters Layout

Four of the six suction lysimeters are located beneath the biosolids at depths of 15, 30, 60, and 120 cm (6, 12, 24, and 48 in.) below the biosolids. These four lysimeters collect soil water that flows due to gravimetric forces or that is held by soil profile matrix forces. The other two suction lysimeters are positioned at the same depth as the biosolids trench bottom to collect lateral flow soil water samples. One of the two lateral suction lysimeters is 15 cm (6 in.) away from the biosolids, and the other lateral suction lysimeter is 30 cm (12 in.) away from the biosolids. All suction lysimeters, except for the ones at a depth of 120 cm (48 in.), were installed as the biosolids rows were filled between July and August 2003. The 120 cm (48 in.) suction lysimeters were installed in July of 2007, approximately five years after the other lysimeters' installation. Due to field conditions, not all lysimeters in the same subplot were installed under the same biosolids row. A diagram of the six lysimeters and their positions to the biosolids row appears in Figure 38. Only the four suction lysimeters collecting flow due to gravimetric forces shall be evaluated in this project.

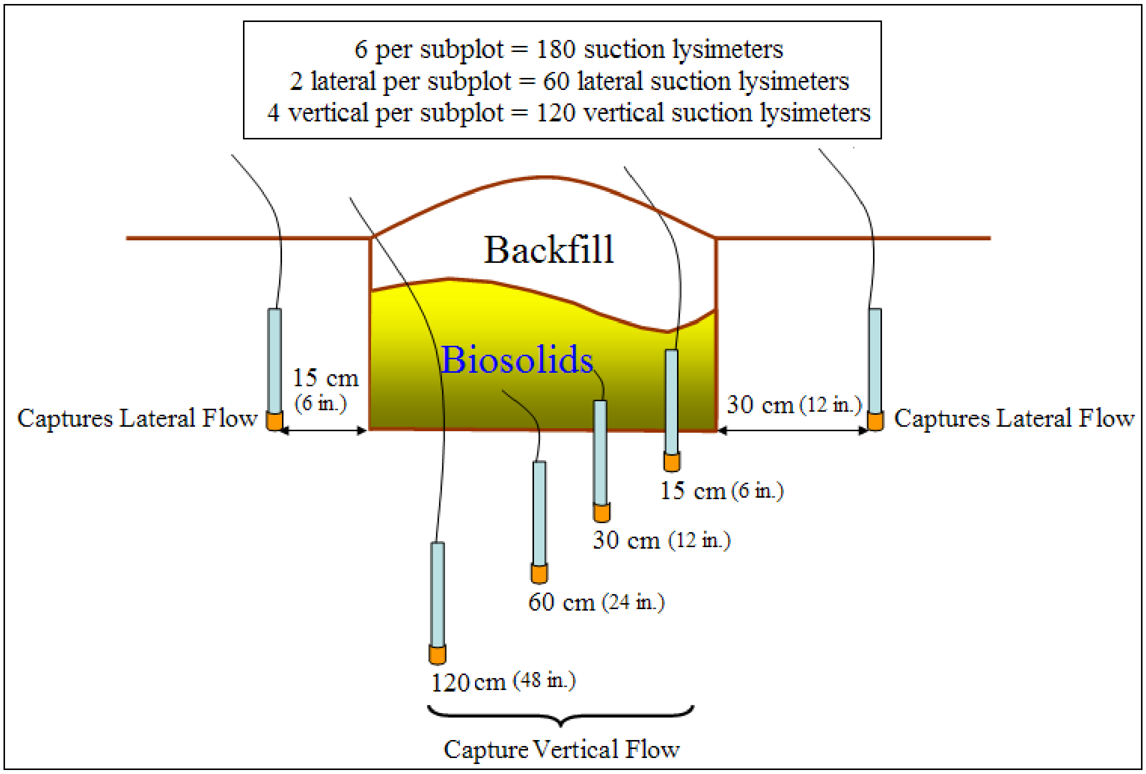

Figure 38. Suction lysimeter layout.

<u>Suction Lysimeter Design, Testing, and Installation</u>

Suction Lysimeter Design

All suction lysimeters, except for the ones at a depth of 120 cm (48 in.), were installed after the biosolids rows were filled, the field was leveled, and the trees were planted, between July and August 2003. The 120 cm (48 in.) suction lysimeters were installed in July of 2007, approximately five years after the other lysimeters' installation. Appendix 1 contains more information regarding the installation dates and conditions for the suction lysimeters. Suction lysimeters, also known as pressure/vacuum soil water samplers, were purchased pre-assembled from Soilmoisture Equipment Corporation. The samplers for the subplot's original five suction lysimeters installed in 2003 were 30 cm (12 in.) long, with a 4.83 cm (1.9 in.) outer diameter PVC body and an epoxy bonded 200 kPa (2 bar) porous ceramic cap with 1.1 *um* pore size on the bottom. The sixth suction lysimeters installed 120 cm (48 in.) below the biosolids were similar in dimensions and properties to the preceding samplers, except that the length was 60 cm (24 in.) instead of 30 cm (12 in.). On the top of each suction lysimeter was a cap with two threaded nylon compression fittings. One of the nylon fittings attaches to a plastic dip tube inside the sampler that runs down the length of the sampler to the ceramic cap.

Access tubes made of medium density polyethylene (MDPE) with 0.64 cm (0.25 in.) long enough to reach the top of the surface after the lysimeter hole is backfilled and attach to the vacuum/pressure pump and collection graduated cylinder (about 3.7 m or 12 ft.) were attached to the top of both nylon fittings. The black MDPE tube received the vacuum or pressure from the pump, while the green line provided the samples. The MDPE access tubes were closed by fitting a 10-15 cm (4-6 in.) long neoprene tube over the access tubes and folding the neoprene tubing in half. Then, an o-ring slid over the bent neoprene tube to keep it closed and seal in the applied tension and pressure. The suction lysimeters are used to collect soil water samples, as shown in Figures 39 and 40.

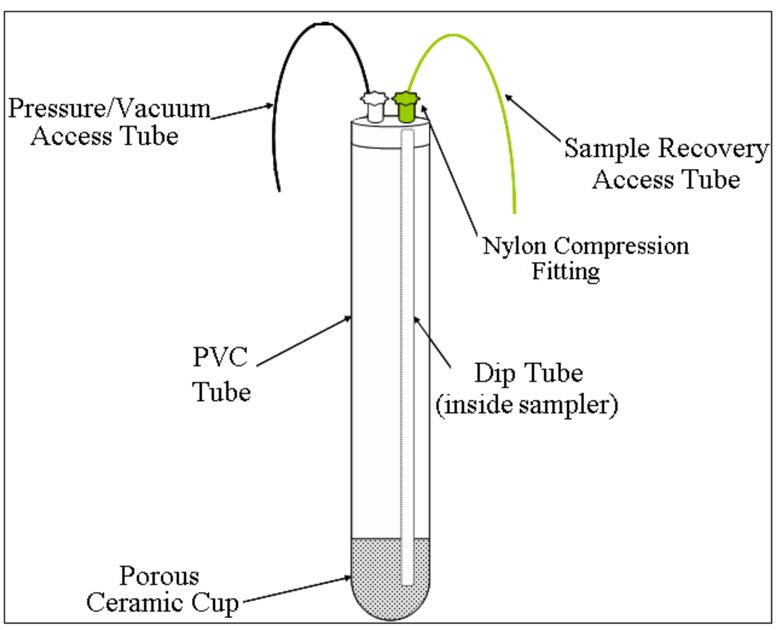

Figure 39. The suction lysimeter and its components.

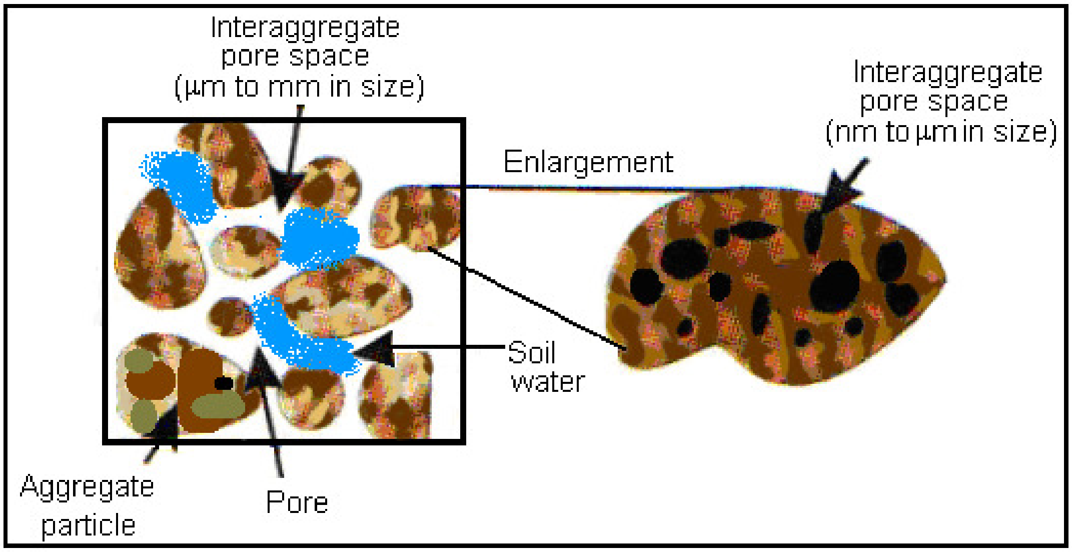

Figure 40. This modified diagram depicts the soil water sample originating in the pore spaces between aggregate soil particles. Different soil types have different aggregate particle and pore sizes. (Pepper et al., 2006).

Suction Lysimeter Testing

Before installing the lysimeters, they were subjected to pressure testing to ensure that the field samplers functioned properly. To test the suction lysimeters, they were first submerged in water for at least 5 hours. Once the ceramic cap was primed, pressure was applied with the hand pump through the pressure access tube (black tube), while the sampling tube (green tube) was still clamped. If bubbles formed near the lysimeter it indicated that there was a leak, and the lysimeter was discarded.

Suction Lysimeter Installation

To reduce interactions from equipment, suction lysimeters were positioned about 3 m (10 ft.) from the pan lysimeters and pan installation trenches. Each vertical flow lysimeter installed in 2003 (depths of 15, 30, and 60 cm or 6, 12, and 24 in.) were positioned in individual biosolids rows in random order. The two suction lysimeters collecting lateral flow data (15 and 30 cm or 6 and 12 in. away from the bottom of the biosolids) shared a biosolids row. The sixth lysimeter installed in 2007 was placed 3 m

(10 ft.) from the pan lysimeter, and not in the same row as the lateral suction lysimeters. Depending on spacing within each subplot, the sixth lysimeter was placed in its own biosolids row. However, if spacing was limited, the sixth lysimeter was placed up-gradient or down-gradient of an existing vertical flow suction lysimeter, at least 3 m (10 ft.) away from the existing lysimeter.

Since the Soilmoisture Equipment Corporation's 1900 Soil Water Samplers Operating Instructions Manual dated July 2007 does not indicate how far apart lysimeters should be installed, the distance was checked by calling the helpline. Greg Hart, Director of the Technical Department, stated that the suction lysimeter's sphere of influence is dependent on the soil's gradient, material, and texture (Greg Hart, Soilmoisture Equipment Corporation Technical Department, personal communication, 4 September 2012). Additionally, Hart did not foresee any issues or negative impacts on sample volumes from installing suction lysimeters at least 60 cm (2 ft.) apart at different depths with bentonite plugs (Greg Hart, Soilmoisture Equipment Corporation Technical Department, personal communication, 4 September 2012).

A second testing was performed before the suction lysimeters were installed. Again, the lysimeters were placed in buckets of water for several hours and tested for leaks. If any lysimeters failed the test or were found to be of questionable quality, they were discarded and not used for the study. Installations of the original 5 suction lysimeters per subplot were in accordance with the installation recommendations found in the 1920F1/1920F1K1 Pressure-Vacuum Soil Water Samplers Operating Instructions Manual (Soilmoisture Equipment Corporation, 1997) is outlined below.

- Put tree shelters (plastic tubes) over the trees for protection.

Drilling and Excavating Procedures:

- Remove 0.3–0.6 m (1-2 ft.) of overburden, including any volunteer growth (grasses and weeds) until the top of one or two biosolids rows are found with a point bar.
- Drop a T-handled steel point bar into the biosolids row to find the depth of the biosolids. Determine if an old biosolids row exists below the new row by taking a soil auger and inspecting the profile.
- If an old biosolids row exists below the new row, move to a new spot and drop the point bar again.
- Determine the depth to the bottom of the biosolids.
- Use the Little Beaver® 11 horsepower hydraulic earth drill with 2-man handle to excavate a hole close to the desired depth. Along the way, pull up and empty the auger. Set the contents aside for later use.
- Switch to hand auger once drilling is within 10 cm (4 in.) of the lysimeter depth. Clean out the hole with the hand auger.
    - For vertical flow lysimeters, drill through the biosolids row and then to the desired depth (15, 30, or 60 cm or 6, 12, or 24 in.).

Procedures for installing the lysimeter and packing the hole:

- Sift the bottom most layer of the excavated material using a 2mm (0.08 in.) sieve.
- Add water to the sifted material until it reaches a mud-like consistency.
- Form the mud around the ceramic cap of the suction lysimeter to create a hydraulic seal and draw soil water flow through the ceramic cap.

- Add 200 mL (0.85 cup) of distilled water to the hole to create mud at the bottom of the hole.
- Slowly drop the lysimeter to the bottom of the hole. Use the steel bar to push the lysimeter down snugly. The mud created at the bottom of the hole will push up and around the bottom of the ceramic cap.
- Continue filling the hole with the next layer of soil in the order opposite of when the layer came out of the hole.
- Once the hole has been filled to about one-third to one-half of the lysimeter length, pour about 200 mL (0.85 cup) of distilled water followed by about 500 mL (2.1 cup) of dry bentonite clay (drillers' clay) into the hole. Add another 300 mL (1.3 cup) of distilled water on top of the bentonite. The bentonite will expand and form an impermeable barrier around the lysimeter as it absorbs the moisture around it.
- Resume filling the hole with the next layer of soil or biosolids in the order opposite of when the layer came out of the hole until the backfill is at the same level as the lysimeter top.
- Pour about 200 mL (0.85 cup) of distilled water followed by about 500 mL (2.1 cup) of dry bentonite into the hole. Add another 300 mL (1.3 cup) of distilled water on top of the bentonite. The two bentonite barriers seal the area around the lysimeter and prevent water from flowing down the drilled hole through fissures or other preferential flow, ensuring that the soil water collected through the ceramic cap represents the leachate percolated through the biosolids and soil profile.

- Fill the hole with the remaining layers of soil, packing it firmly to prevent preferential flow pathways.

Procedures for cleaning up the installation site:

- Align the lysimeter access tubes to the side of the trench and fill the trench with the backhoe. Pause between filling and tamp the trench to reduce preferential flow.
- Hammer in wooden stakes into the ground near the access tubes. Use plastic cable ties to access tubes to the stakes.
- Remove residue from all equipment, including the Little Beaver®, sieve, hand auger, tamping tool, and buckets.
- Repeat the process for the remaining lysimeter installations.

Similar to the pan lysimeters in the control subplots, installation depth was equal to the design depth for the lowest application rate or 0.61 m (2 ft.). Therefore suction lysimeters in the control subplots were installed at their respective depths below 0.61 m (2 ft.). Pictures of the lysimeter installations are shown in Figures 41 to 48.

Figure 41. The backhoe removes overburden and the biosolids rows are located.

Figure 42. T-bar used to measure the depth to the bottom of the biosolids.

Figure 43. A photograph of the equipment used for installations, featuring the Little Beaver®.

Figure 44. The photograph on the left is the hole for a lysimeter in the control subplot. Moving toward the right, the next hole is for the vertically place lysimeter located under the biosolids. The photograph on the far right is the hole of a laterally placed lysimeter.

Figure 45. After the holes are dug the auger is emptied (shown on the left) and the depth of the hole is measured (shown on the right).

Figure 46. From left to right, pre-sifted material, sifting material, and post-sifted material.

Figure 47. On the left, a mudpack is created around the ceramic cap. On the right, bentonite is poured around the lysimeter to create an impermeable barrier.

Figure 48. The fill around the lysimeters is tamped and the lysimeter lines are set aside.

The biosolids rows and trenches were constructed prior to the installation of the sixth lysimeter at a depth of 120 cm (48 in.) in 2007. Therefore, the installation procedures for the 120 cm (48 in.) lysimeter differ from its predecessors. The procedure for the sixth lysimeter installed about 5 years after the original 5 lysimeters is summarized for your convenience.

- Locate the pan and lateral lysimeters in the subplot.

- Find a spot at least 3 m (10 ft.) away from the pan lysimeter.
- Go to a biosolids row or north or south of an existing vertical suction lysimeter.
- Remove vegetative growth (volunteer grasses and weeds) by hand or shovel.
- Use the Little Beaver® to dig as close as possible to the needed depth. If the dirt is too dry (as it was during July of 2007), add water to bring up soil from the hole.
- Empty auger flights and separate materials to use for backfill.
- Slow down digging when biosolids are reached. It is easy to tell when the drill reaches the biosolids, because the drill sinks. Continue to remove the biosolids until the bottom is reached. Record the bottom of biosolids depth.
- Add 120 cm (48 in.) to the bottom of biosolids depth.
- Continue drilling until the new depth is reached. Since the Little Beaver® can only reach depths of about 2.1 m (7 ft.), a 3 m (10 ft.) hand auger was used to reach depths (Figure 50).
- If the groundwater table is reached, record the depth. Use native soil and well gravel mixture to create a mudpack around the ceramic cap (shown in Figure 49). Pour an extra layer of bentonite down the hole to seal out groundwater influences.
- Keep the drill or hand auger in the hole to prevent collapses until the lysimeter is in place.
- Follow the previous procedures for the remainder of the process (from "Procedures for installing the lysimeter and packing the hole" to "Procedures for cleaning up the installation site".)

Figure 49. Well gravel material used to create a modified mudpack for suction lysimeters located within the groundwater table.

Figure 50. The hand auger used to reach design depths.

Again, a designed depth of 0.61 m (2 ft.) was used for the control subplots (those that did not contain biosolids rows). The sixth suction lysimeters were installed at 120 cm (48 in.) below this artificial biosolids row. More information about the 120 cm (48 in.) lysimeter installations is found in the appendix. Figure 51 shows a surface view of a completed plot.

Figure 51. Finished view of the six lysimeters (marked by orange painted stakes) and the pan lysimeter (marked by the tall, white PVC pipe). This particular plot is Control 4A.

Sample Collection

Soil Water Samples

During the initial stages of the project, monthly samples were taken. However, as the project progressed, samples were taken every other month. For instance samples were taken from the pan lysimeters monthly from April 2003 to June 2004. Monthly samples were taken from the suction lysimeters (laterals, 15, 30, and 60 cm or 6, 12, and 24 in.) from November 2004 to June 2004. This thesis addresses samples collected from November 2003 through October 2009.

Soil Water Samples from Suction Lysimeters

Between 4 and 7 days before the sampling date, 60-70 centibar (0.59-0.69 atm.) of vacuum was applied to the vacuum/pressure access tube (black tube) with the vacuum/pressure hand pump (Soilmoisture Equipment Corporation, 1997). The discharge tube (green tube) remained closed during vacuuming, and the vacuum access tube was closed rapidly to seal in the suction. Under the suction conditions the moisture is drawn from the soil surrounding the porous ceramic cap into the lysimeter. On sampling day, the vacuum/pressure access tube (black tube) is attached to the pressure side of the vacuum/pressure hand pump. The discharge tube (green tube) is open and held over a 500 mL graduated cylinder. As pressure is applied to the vacuum/pressure access tube, water discharges from the discharge tube into the graduated cylinder. The procedures for collecting the field samples are shown in Figure 52. Samples were poured into 125 mL HDPE plastic containers with lids and placed into coolers with other samples and ice packs to preserve current conditions and speciation within the water until the samples could be analyzed more thoroughly in the laboratory. Total volume collected was recorded along with any other field characteristics of notable interest, including color, smell, and equipment status. Since the graduated cylinder is only 500 mL, volumes greater than 500 mL are estimated. Figure 51 shows the field sampling methods for suction lysimeters.

Typically suction lysimeter samples in replicate 1 (samples A-C and control 4A) are done during the first week of the month with their respective pan lysimeters. Next, samples for the suction lysimeters in replicate 2 (samples D-F and control 4C) are taken during the second week of the month with their respective pan lysimeters. Finally, the suction lysimeters in replicate 3 (samples G-I and control 4B) are taken the third week of the month with their respective pan lysimeters.

Figure 52. Suction lysimeter sampling equipment

Cleaning the Suction Lysimeter Sampling Equipment

Once the sample has been transferred to the sample bottle, the remaining soil water in the graduated cylinder is emptied. Then, the graduated cylinder is filled to about 200 mL with distilled water and shaken vigorously. The graduated cylinder is emptied and rinsed with a streamline of deionized water around the top of the cylinder. Again, the graduate cylinder is shaken and emptied.

Error Samples

To test for any inconsistencies in cleaning techniques, laboratory procedures, or storage, two error samples were taken during each sampling period. For suction lysimeter error samples, distilled water was poured into the graduated cylinder to the 200 mL mark. Then, the distilled water was transferred into a 125 mL sample bottle and labeled appropriately. In all there are three suction lysimeter error samples each month (1 error sample per replicate).

Biosolids Samples

Biosolids samples were collected every month during biosolids row construction (March 2002 to April 2003) to analyze the nutrients over time. The initial biosolids sample was taken from the pile offloaded from the delivery truck. Five to seven aliquots were taken from different areas of the biosolids pile and mixed together in a HDPE sampling bottle. Next, the biosolids samples were frozen and delivered to the laboratory for analysis. Every month another five to seven aliquots were taken from the biosolids pile following the same procedures as the first sample.

Qualitative information and descriptions regarding the biosolids appearance were notated in the summer of 2007 when the sixth suction lysimeters were installed. Depths to the water table were also measured.

On October 31, 2008 biosolids samples were collected to analyze the remaining nutrients of the six year old biosolids. Using a hand auger soil, rocks, and other material residing above the biosolids were removed until the top of the biosolids profile was reached. None of the biosolids samples were taken within the poplar tree root mass. This was an effort to showcase worst case scenario results of no treatment or nutrient uptake from the trees. Then, an auger full of biosolids was removed to provide the sample. The samples were bagged, frozen, and delivered to the A&L Eastern Laboratories, Inc. in Richmond, VA for analysis. Between plots, the auger was dug into the ground to remove the remaining biosolids residue.

Weather Conditions

Precipitation and Ambient Temperature

On the highest trailer rooftop near the western edge of the research plot a tipping bucket rain gauge connected to an Onset Computer Corporation HOBO® Event data logger was installed to record rainfall events at the site. Every other week the data were downloaded with Boxcar® software supplied by the Onset Computer Corporation. The rain gauge records individual rainfall events of 0.025 cm (0.01 in.) and labels the events with a specific date and time. Then, the files from the data logger were transferred to spreadsheets in Microsoft Excel®, where the events were added to find daily totals and monthly totals.

During the second data logger download of each month, the rain gauge was inspected to maintain proper function. Any insects, spider webs, leaves, or other debris were removed from the tipping bucket. To prevent ice formation and inaccurate data collection, the rain gauge heating component was activated when freezing temperatures threatened.

Data from the Maryland State Climatologist's Office were used in conjunction with the U.S. National Weather Service's Inverse Square Distance Weighting Method to estimate precipitation volumes when ERCO the rain gauge did not record the data properly. Rain data from the National Arboretum in Washington, DC; Oxon Hill, MD; Upper Marlboro, MD; Mechanicsville, MD; Baltimore Washington International Airport in Glen Burnie, MD; Dulles International Airport in Dulles, VA; Reagan National Airport in Arlington, VA; and Beltsville, MD were used to substitute the missing data (MSCO, 2012). Equation 13 shows the U.S. National Weather Service's Inverse Square Distance Weighting Method for precipitation estimates (HydroViz, 2011).

Equation 13. U.S. National Weather Service's Inverse Square Distance Weighting Method (HydroViz, 2011)

$$P_x = \frac{\{(1/d_{ax})^2 * P_a + (1/d_{bx})^2 * P_b + (1/d_{cx})^2 * P_c + \ldots\}}{\{(1/d_{ax})^2 + (1/d_{bx})^2 + (1/d_{cx})^2 \ldots\}}$$

where:

P_x = estimated precipitation at gauge x,

$P_{a, b \text{ or } c}$ = known precipitation at gauge a, b, or c, and

$d_{ax, bx, \text{ or } cx}$ = distance between rain gauge x and rain gauge a, b, or c.

According to Buswell (2006), the U.S. National Weather Service's Inverse Square Distance Weighting Method to estimate precipitation volumes was used between May 12-30 2003 and June 20-23, 2003 due to HOBO® equipment failures. Additionally, rain gauge data were estimated between January and March 2005. The final rain gauge data estimates occurred between June and December 2009, because the data were not originally collected or recorded.

Soil Temperature

Since temperature has an effect on microorganism activity as well as denitrification rates, the temperature of the soil will be estimated from the United States Department of Agriculture's (USDA) Soil Temperature Regimes of the Contiguous United States map and soil surveys.

Laboratory Analysis

Soil Water Samples

Samples were brought in a cooler with ice packs to the Biological Resources Engineering Department's Water Quality Laboratory in College Park, MD. Using a Fisher Scientific Accumet Basic AB15 pH meter the pH of each sample was measured and recorded (Figure 53).

Next, about 25 to 50 mL of sample was vacuum filtered through a 0.45 micron pore size, 47 mm (1.85 in.) diameter nylon membrane filter (Whatman No. 7404-004) (shown in Figure 54). If samples were particularly viscous or turbid, a pre-filter with 47 mm (1.85 in.) diameter made of borosilicate microfiber glass with acrylic binder resin, grade AP 15 (Millipore Corporation No. AP1504700) was placed on top of the 0.45 micron pore size nylon membrane filter. Vacuum filtered soil water samples were transferred to 60 mL HDPE sampling bottles. The bottles were put into plastic, zipper-closed, freezer bags and stored in the freezer until they were delivered to the Appalachian Laboratory at the University of Maryland Center for Environmental Studies in Frostburg, MD, where further analyses were run (Figures 55 and 56). Deliveries were made three to six months after samples were filtered. Procedures for the Appalachian Laboratory analyses are in the appendix.

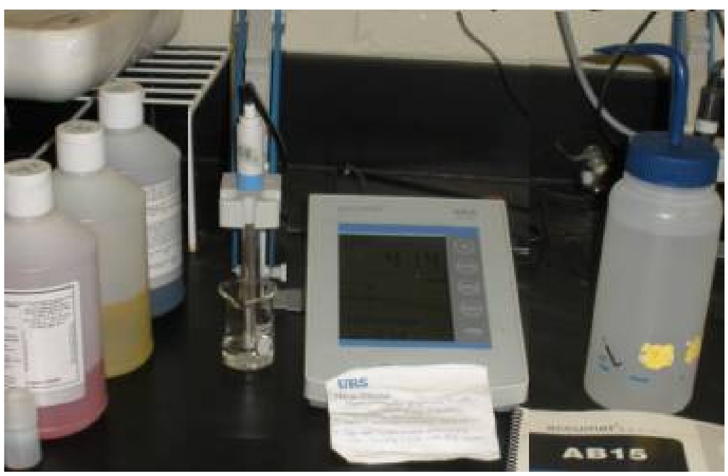

Figure 53. Measuring pH of a sample with a Fisher Scientific Accumet Basic AB15 pH meter.

Figure 54. Filtering sample through a 0.45 micron size pore filter.

Figure 55. Packing and delivering frozen filtered samples to Appalachian Laboratory

Figure 56. An Appalachian Laboratory technician determines the nitrogen content of the samples by Automated Colorimetry with a Lachet Quick Chem 8000 Flow Injection Analyzer.

Biosolids Samples

Recall that biosolids samples were collected every month during the development of the research plot between March 2002 and April 2003. These samples were brought to the University of Maryland's Cooperative Extension Soils Laboratory in College Park, MD. The procedures used to analyze the biosolids samples are found in Appendix 8.

Biosolids samples were collected on October 31, 2008 to assess the site's vegetation nutrient uptake and utilization. Biosolids samples were taken at least 1 m (3 ft.) from suction lysimeters and 3 m (10 ft.) from pan lysimeters in order to not disturb the soil surrounding sampling points. The biosolids samples were extracted at least 1 m (3 ft.) from trees as well in order to represent a worst case scenario situation in which there were no trees to uptake nitrogen. Biosolids samples were delivered to the A&L Eastern Laboratories, Inc. in Richmond, VA. Biosolids analyses procedures are found in Appendix 9.

- Locate the pan and lysimeters in the subplot.
- Find a spot at least 3 m (10 ft.) away from the pan lysimeter and 1 m (3 ft.) away from trees and lysimeters.
- Go to a biosolids row or north or south of an existing vertical suction lysimeter to avoid disturbing lateral suction lysimeter system.
- Remove vegetative growth (volunteer grasses and weeds) by hand or shovel.
- Use the Little Beaver® to dig. Clean auger flights once biosolids material is reached.
- Slow down digging when biosolids are reached. It is easy to tell when the drill reaches the biosolids, because the drill sinks.

- Continue to remove the biosolids until the bottom is reached. Record the depth.
- Remove biosolids from auger flights. Place into labeled sampling bags. Put the samples in a cooler with ice.
- Before moving to the next location, backfill hole and tamp the area.

Cleaning Procedures

Sample Bottle Cleaning Techniques for Reuse

In January of 2007 a trial run for cleaning previously used sample bottles was conducted. The bottles were emptied of their previous contents, rinsed with water, and soaked for at least 24 hours in a bleach-water solution of 158 mL (5.34 oz.) bleach for every 3.79 L (1 gal) water, as directed by the product's instructions and guidelines (The Clorox Company, 2009). After soaking in the bleach-water solution, the bottles were rinsed with distilled water and placed in a LABCONCO® Flaskscrubber™ shown in Figure 57. The dishwasher was set to the short cycle (for plastic ware). In the dishwasher the bottles were rinsed with deionized water, as shown in Figure 58, and dried with hot air. The steam option was not used since it causes excess ware on the bottle's material, according to the instructions on the machine.

Figure 57. The LABCONCO® Flaskscrubber™ display panel used to wash sample bottles for reuse.


Figure 58. Dishwater setup for sample bottle cleaning, including the deionized water for rinsing.

For the trial, twenty bottles were washed. Five bottles were randomly selected for analysis by the Appalachian Laboratory at the University of Maryland Center for Environmental Studies in Frostburg, MD. These five bottles were filled with deionized water and sent to the lab for nitrogen and phosphorus analysis, similar to the analyses run on the ERCO samples.

Cleaning Techniques for Field and Laboratory Materials

All equipment used in the field and in the laboratory that made contact with the water extracted from the research plots, other than the pH probe, were cleaned in the following manner. Figures 59 to 61 depict the cleaning process.

- Thoroughly rinse equipment with water.
- Soak equipment in a 5% solution of 50 mL (1.7 oz.) Alconox Detergent 8® and 1 L (0.26 gal) water, as directed by the product's instructions and guidelines. Alconox Detergent 8® is an ion-free, low-foaming detergent that does not contain phosphate, sulfur, chlorine, metal cations, halide, borate, silicate, carbonate, chlorocarbon, fluorocarbon, and chelating ingredients (Alconox, Inc., 2006).
- Scrub the equipment with a clean brush or sponge.
- Rinse with water.
- Soak equipment in a solution of 158 mL (5.34 oz.) bleach for every 3.79 L (1 gal) water, as directed by the product's instructions and guidelines. The bleach used for disinfection and deodorant contained 6.15% sodium hypochlorite (The Clorox Company, 2009).
- Rinse with water.
- Rinse with deionized water from the Barnstead Nanopure Ultra Water System with 0.2 μ final filter.
- To dry and further disinfect, place equipment in the Fisher Scientific Isotemp® Oven Model 655F at temperatures above 100^{o}C (212^{o}F) until dry.

Figure 59. The basin in the sink contains Alconox Detergent 8® and water. The basin on the left contains the bleach-water solution where the equipment soaks before being rinsed with tap water and then distilled water.

Figure 60. The Barnstead Nanopure Ultra Water System with 0.2 µ final filter for organic material removal. The carboy on the right dispenses distilled water. The nozzle on the sink's faucet dispenses deionized water.

Figure 61. On the left is the Fisher Scientific Isotemp® Oven Model 655F set to temperatures of at least 100°C (212°F). The photograph on the right displays the oven interior with filter apparatuses.

Freezing Procedures

Samples were sent to the Appalachian Laboratory at the University of Maryland Center for Environmental Studies in Frostburg, MD within 3 to 6 months after collection. To test the effects of freezing on the samples, one sample from Pan 3B (19,650 kg N/ha or 17,400 lbs. N/ac. treatment with 0 trees/ha or 0 trees/ac.) was subdivided into five samples in November 2007. The first sample was sent to the laboratory within 24 hours of collection to record the initial NO_2-N, NO_2+NO_3, NO_3-N, TAN, inorganic N, and total N concentrations. The subsamples were sent to the laboratory for analysis after 1, 6, 9, and 12 months of sample collection.

Data Analysis

Reused Bottle and Frozen Sample Results

Paired t-tests were used to determine the effects of freezing on samples. Unpaired t-tests were used to determine the effects of reusing cleaned sample bottles. If the nitrogen analyses means of the frozen distilled water and the distilled water contained in the reused sample bottles were not equal to zero, then freezing and/or reused bottles would affect the samples and would no longer be used in the experiment.

The null and alternative hypotheses for the purity of sampling events were:

H_o: $\mu_{reuse\ bottle} = 0$ (The nitrogen mean is not significantly different than 0.)

H_a: $\mu_{reuse\ bottle} \neq 0$ (The nitrogen mean is significantly different than 0.)

Null hypotheses were tested with a probability level (α) of 0.05.

Error Sample Results

Initially, outliers were determined by running an unpaired t-test on the equipment blank samples. If the nitrogen analyses means of the equipment blank samples consisting of distilled water run through the cleaned sampling equipment were not equal to zero, the samples from that event were removed.

The null and alternative hypotheses for the purity of sampling events were:

H_o: $\mu_{error\ sample} = 0$ (The equipment blank samples nitrogen mean is not significantly different than 0.)

H_a: $\mu_{error\ sample} \neq 0$ (The equipment blank samples nitrogen mean is significantly different than 0.)

Null hypotheses were tested with a probability level (α) of 0.05.

Outliers

In addition to the outliers found during preliminary investigations of the error samples, any outliers previously reported by Buswell or Dr. Gary Felton were removed prior to analyses in order to keep comparisons consistent. Removing these similar outliers also kept the baseline of previously reviewed data constant. After updating the nitrogen concentration charts for each condition (application rate, tree density, and depth), any suction lysimeter with noticeably different results than suction lysimeters of with similar conditions would be removed from the data set prior further analyses. Finally, any suction lysimeter that did not produce at least one-quarter of the total possible samples shall be removed since the sample quantity is not a full representation of nutrient transport throughout the biosolids. Therefore suction lysimeters installed prior to 2007 with less than 10 samples from the 38 total sampling events and any 120 cm (48 in.) suction lysimeter that did not produce at least 3 of the possible 12 samples shall be removed.

Soil Water Analysis

Buswell analyzed water quality data through analysis of variance (ANOVA) techniques with SAS 9.1 © 2002-2003 (SAS Institute, Inc., Cary, North Carolina). To use ANOVA, the data must meet three assumptions: data is normally distributed; data is independent; and data has homogeneity of variances. Based on Carrie Buswell's personal conversation with L. Douglass (2005) of the University of Maryland Biometrics Department, non-detect results were set to 2/3 of the detection limit (Buswell, 2006).

Data Distribution

In order to meet the first assumption of normal distribution, the distribution was tested using XLSTAT 2012© provided by Addinsoft SARL (New York, New York). Several different scenarios were run in an attempt to meet the normal distribution assumption. All normal distribution tests were run excluding the previously defined outliers. The null hypothesis and alternative hypothesis for normal distribution tests were:

H_o: The results follow a normal distribution

H_a: The results do not follow a normal distribution

Null hypotheses were tested with a probability level (α) of 0.05.

Normal distribution was not achieved for the data run by sampling event without averaging for NO_3-N, TAN, Log NO_3-N, and Log TAN. Since samples were dependent on rainfall accumulation, not all samples were present every sampling month. Therefore, the available monthly samples for each subplot were averaged on a quarterly basis following the protocol setup by Buswell (2006). The data was averaged by quarter and tested again for normal distribution for NO_3-N, TAN, Log NO_3-N, and Log TAN. Table 8 shows the months that represent the seasonal quarters.

Table 8. Quarterly assignments for Suction Lysimeter monthly samples.

Month-Year	Quarter	Month-Year	Quarter	Month-Year	Quarter
November 2003	4[1]				
December 2003	4[1]	August 2005	9	August 2007	15
January 2004	4[1]	October 2005	9	October 2007	15
February 2004	4[1]	December 2005	10	December 2007[2]	N/A
March 2004	5[1]	February 2006	10	February 2008	16
April 2004	5[1]	April 2006	11	April 2008	16
May 2004	5[1]	June 2006	11	June 2008	17
June 2004	6[1]	August 2006	12	August 2008	17
August 2004	6[1]	October 2006	12	October 2008	17
October 2004	7[1]	December 2006	13	January 2009	18
December 2004	7[1]	February 2007	13	April 2009	18
February 2005	7	April 2007	14	July 2009	19
April 2005	8	June 2007	14	October 2009	19
June 2005	8				

[1]Quarters 4 through 7 from November 2003 to December 2004 were set by Buswell (2006).

[2] December 2007 data met the outlier data and did not qualify for further analyses and was not included in a quarter.

Buswell's (2006) data from 2003 to 2004 met the normal distribution and homogeneity of variance assumptions for proper application of ANOVA after log transformation of the quarterly averaged data. The data from 2003 to 2009 did not meet these assumptions after log transformation of the quarterly averaged data with and without the control data. Furthermore, the data did not meet the assumptions required for ANOVA after annual averages were log transformed with and without the control data.

Wilcoxon Rank Sum Test for Nonparametric Data

The Wilcoxon rank sum test allows *t* tests to determine if there are statistical differences between the means of two groups, regardless of normal distribution as long as the sample size is large (Ott and Longnecker 2001). Since the sample size exceeds 2,333 data points, it is considered large. In addition to comparing the means of one subgroup to the next for biosolids application rate, suction lysimeter depth from the biosolids, tree density, and sample blocks, the controls for each subgroup were also compared to the non-controls. Table 9 shows the Wilcoxon rank sum tests that were performed using XLSTAT 2012©.

Table 9. Wilcoxon Rank Sum Tests (α=0.05) Performed for NO_3-N and TAN Variables

Application Rate Comparisons
Control 0 kgN/ha (0 lbs.N/ac.) vs. 19,650 kgN/ha (17,400 lbs.N/ac.)
Control 0 kgN/ha (0 lbs.N/ac.) vs. 39,300 kgN/ha (34,800 lbs.N/ac.)
Control 0 kgN/ha (0 lbs.N/ac.) vs. 58,900 kgN/ha (52,000 lbs.N/ac.)
19,650 kgN/ha (17,400 lbs.N/ac.) vs. 39,300 kgN/ha (34,800 lbs.N/ac.)
19,650 kgN/ha (17,400 lbs.N/ac.) vs. 58,900 kgN/ha (52,000 lbs.N/ac.)
39,300 kgN/ha (34,800 lbs.N/ac.) vs. 58,900 kgN/ha (52,000 lbs.N/ac.)
Depth Comparisons
15 cm (6 in.) vs. Control 15 cm (6 in.)
30 cm (12 in.) vs. Control 30 cm (12 in.)
60 cm (24 in.) vs. Control 60 cm (24 in.)
120 cm (48 in.) vs. Control 120 cm (48 in.)
15 cm (6 in.) vs. 30 cm (12 in.)
15 cm (6 in.) vs. 60 cm (24 in.)
15 cm (6 in.) vs. 120 cm (48 in.)
30 cm (12 in.) vs. 60 cm (24 in.)
30 cm (12 in.) vs. 120 cm (48 in.)
60 cm (24 in.) vs. 120 cm (48 in.)
Tree Density Comparisons
0 trees/ha (0 trees/ac.) vs. Control 0 trees/ha (0 trees/ac.)
0 trees/ha (0 trees/ac.) vs. 716 trees/ha (290 trees/ac.)
0 trees/ha (0 trees/ac.) vs. 1,074 trees/ha (435 trees/ac.)
716 trees/ha (290 trees/ac.) vs. 1,074 trees/ha (435 trees/ac.)
Block Comparisons
Block 1 vs. Control Block 1
Block 2 vs. Control Block 2
Block 3 vs. Control Block 3
Block 1 vs. Block 2
Block 1 vs. Block 3
Block 2 vs. Block 3
Replicate Comparisons
Replicate 1 vs. Replicate 2
Replicate 1 vs. Replicate 3
Replicate 2 vs. Replicate 3

Pearson Correlation

In addition to the Wilcoxon Rank Sum Tests, the Pearson product-moment correlation was run. In the Pearson correlation, the covariance of the two variables is divided by the product of the variables' standard deviations (Ott and Longnecker 2001). The Pearson Correlation Coefficient ranges from -1 to 1, with 1 being a direct relationship between the two variables and values less than 0.1 indicating no relationship between the two variables (Ott and Longnecker 2001). The Pearson Correlation Coefficients were presented in a table.

Visual interpretations of the Pearson Correlations were charted in scatter plots of the Pearson Correlations. Scatter plots are useful in identifying contributing factors to results, depicting linear relationships between variables, and highlighting nonlinear relationships between variables. For example in this study, the main contributing factors are application rate, lysimeter depth, tree density, and sample date. Most of the graphs involve using the data from the treatment and plotting NO_3-N and TAN as a function of time. Plotting NO_3-N and TAN as a function of application rate, lysimeter depth, and tree density shows a more direct relationship between the condition and nutrient value. If the strong correlation exists, then the dots will converge in the shape of a line (Ott and Longnecker 2001).

Following Buswell's methodology, soil water statistical analyses evaluated the following conditions for significance with respect to nitrogen concentrations (Buswell, 2006):

- Application rate
- Depth of lysimeter from biosolids
- Tree density

Soil Water NO_3-N Concentration Trends

Although deep row applied biosolids are not intended to reside over drinking water wells, comparing NO_3-N leachate concentrations to EPA drinking water MCL of

10 mg/L NO_3-N highlights contamination risks. Therefore the EPA drinking water MCL will be a benchmark on graphs when feasible for additional comparisons.

Soil Water TAN Concentration Trends

Since Pepperman (1995) calculated the TAN background concentration in ERCO's soil water as 4 to 9 mg/L, these values will serve as a benchmark for comparisons. When feasible, the graphs will include 9 mg/L TAN as the ERCO background.

Biosolids

Paired t-tests were used to determine the changes in biosolids composition from installation in 2003 and sample collection in 2008. Organic carbon, metals, and phosphorus oxide (P_2O_5) measured in 2003 were not measured in 2008, so direct comparisons were not made. However, for total N, TAN, and total moisture content comparisons were made based on the results of the following hypotheses:

H_o : $\mu_{2003\ biosolids} = \mu_{2008\ biosolids}$ (The 2008 sample mean is not significantly different than the 2003 sample mean.)

$H_{a:}$ $\mu_{2003\ biosolids} \neq \mu_{2008\ biosolids}$ (The 2008 sample mean is significantly different than the 2003 sample mean.)

Null hypotheses were tested with a probability level (α) of 0.05.

Weather Conditions

The average monthly rainfall volumes were estimated from the recorded monthly rainfall volumes of each month between 2003 and 2009. Monthly averages throughout the study compared to the calculated average were graphed for both rainfall volumes and temperature.

Chapter 5: Results and Discussion

The following subjects will be discussed according to the outline below:

- Reused Bottle Results
    - Results from cleaning and reusing the sample bottles indicated that reusing the sample bottles would not impact the results.
- Frozen Sample Results
    - Results from one divided sample throughout the course of a year indicated that freezing the samples for as long as 12 months before analysis would not impact the results.
- Error Sample Results
    - Results from the field blank samples assist in the decision to remove potentially unreliable data and increase confidence in the overall results and discussion.
- Outliers
    - Remove potentially unreliable data and increase confidence in overall results by removing outliers from error sample results and those previously reported by Buswell or Dr. Gary Felton in order to keep comparisons consistent.
    - Remove potentially unreliable data and increase confidence in overall results by removing suction lysimeters with results that are greater than 2 standard deviations from the mean of lysimeters under the same conditions.

    - Remove suction lysimeters that did not produce at least one-quarter of the possible samples throughout the experiment in order to increase data reliability and consistency.
- Soil Water Analysis and Results: Overview
    - Number of Samples Collected
    - Sample pH Values
    - Data Distribution
    - Wilcoxon Rank Sum Test for Nonparametric Data
        - Study Layout
        - Control
        - Application Rate
        - Depth
        - Tree Density
    - Pearson Correlation Coefficients and Scatter plots
- Soil Water Results: Nitrate-Nitrogen (NO_3-N) Data
- Soil Water Results: Total Ammoniacal-Nitrogen (TAN) Data
- Biosolids Analysis
    - The biosolids results depict the nutrient concentration applied in 2003 and changes as a result of biosolids mineralization, nutrient leaching, or plant nutrient uptake in 2008.
- Weather Conditions

- The rain gauge data in conjunction with the ambient temperature and soil temperature explain the effects of microbial activity and tree growth on denitrification rates.

Reused Bottle Results

Five bottles from the twenty washed bottles were randomly selected for analysis by the Appalachian Laboratory at the University of Maryland Center for Environmental Studies in Frostburg, MD. These five bottles were filled with deionized water and sent to the lab for nitrogen and phosphorus analysis, similar to the analyses run on the ERCO samples. All of the results showed no detectable limits of the nutrients and were therefore not significantly different than the assigned value of zero.

Between January 2007 and October 2008 about 30% of the sample bottles were reused from previous sample collections. No notes were included as to which samples were stored in reused bottles or which samples were stored in new bottles. The reused bottles were used in the same fashion as the new bottles whenever available, with no preference to the samples' characteristics. It was assumed from the trial that these bottles would not interfere with the integrity of the ERCO study and would not alter the data.

Frozen Sample Results

The original Pan 3B sample from November 1, 2007 was analyzed by the Appalachian Laboratory at the University of Maryland Center for Environmental Studies in Frostburg, MD within 48 hours of collection. The sample's nitrogen concentrations are shown in Table 10 along with the nitrogen concentrations of the subsamples. Furthermore a power outage at the University of Maryland's ENBE Soil-Water Laboratory occurred on or around June 9, 2008, which thawed the 9 and 12 month subsamples. Despite the thawed samples, a t-test confirmed that there were no significant effects of freezing on the samples. In fact, the coefficient of variation for NO_3-N, NO_2+NO_3, TAN, Inorganic

N, and Total N were less than 0.1, indicating a strong estimate of the mean and increasing the overall confidence that there are no significant impacts on the samples from freezing and prolonged storage.

Table 10. Effects of Freezing Samples on Nitrogen Analyses

Time to Analysis	NO_2+NO_3	NO_3-N	TAN	Inorganic N	Total N
48 hours (Original)	**32.303**	**31.574**	**302.05**	**334.35**	**320.07**
1 month	32.165	31.440	296.53	328.69	310.04
6 months	30.409	29.952	301.28	331.69	339.44
9 months	34.480	33.974	312.25	346.73	338.39
12 months	35.109	35.052	299.45	334.56	334.94
Mean	33.041	32.604	302.38	335.42	330.70
Standard Deviation	1.8736	2.0160	5.9481	6.8533	12.044
Coefficient of Variation	0.0567	0.0618	0.0197	0.0204	0.0364

Error Results

To test for any inconsistencies in cleaning techniques, laboratory procedures, or storage, two error samples consisting of distilled water were taken during each sampling period. In all there are three suction lysimeter error samples each month (1 error sample per replicate). For simplicity, results that were below the quantification level of 0.0020 mg/L were calculated as two-thirds of the detection limit, or 0.0007 mg/L. Sample collection in December 2007 occurred in temperatures at or below freezing (0 ^{o}C or 32^{o}F). Two error samples from December 2007 resulted in NO_3-N values that were significantly different than 0 mg NO_3-N/L. On December 7, 2007, the suction lysimeter sample SL-4E-1 had a NO_3-N value of 27.86 mg/L. Table 11 shows the December 2007 error sample results and the ambient temperature during the collection.

Table 11. Error Sample Outliers (NO_3-N Values Significantly Different from 0)

Sample	Collection Date	Temperature	NO_2-N (mg/L)	NO_3-N (mg/L)	TAN (mg/L)
SL-4E-1	12/7/2007	-6.1°C (21°F)	0.0049	27.86	0.0623
4E	12/7/2007	-6.1°C (21°F)	0.004	0.0353	0.0912
SL-4F-1	12/14/2007	0 °C (32°F)	0.0063	0.0415	0.0128
4F	12/14/2007	0 °C (32°F)	0.0039	0.0177	0.0154
SL-4D-1	12/19/2007	-1.7 °C (29°F)	0.0046	0.0000	0.0328

One explanation for the significant NO_3-N concentrations in the field blank error samples is that the field sampling technician wore winter gloves over her blue nitrile gloves to stay warm. Because the winter gloves were porous, residue from other samples may have remained on the gloves and been transferred to the field blank error bottles. The winter gloves were worn for all three sampling events in December 2007 and were not washed until February 2008. Another possibility is that laboratory equipment was contaminated and created a spike for all December 2007 samples run. Regardless, it is clear that contamination occurred in the December 2007 samples and the results from December 2007 will be removed from the results and discussion.

Outliers

Based on blank field results with nitrogen values significantly greater than 0 mg/L, all samples taken in December 2007 have been removed. Graphical depictions of the sample results from December 2007 concur with possible contamination since several of the graphs peak during that month. The graphical relationship featuring peaks in December 2007 is best seen in the NO_3-N concentrations of suction lysimeters at 120 cm (48in.) depth shown in Figure 62.

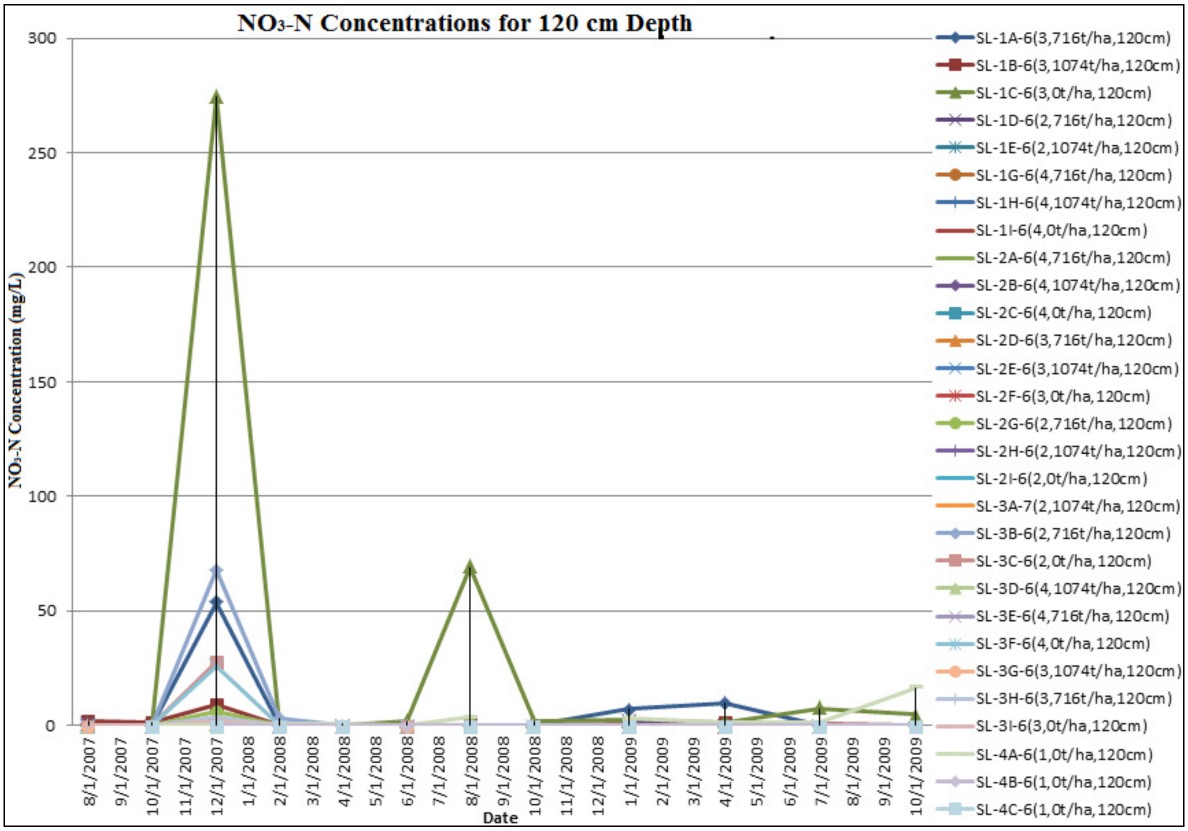

Figure 62. NO_3-N values for samples at 120 cm (48in.) depth with peaks in December 2007.
In the legend, the first number in parentheses represents the application rate in numerical order following 0, 19,650, 39,300, and 59,800 kgN/ha (0, 17,400, 34,800, and 52,000 lbs.N/ac.). The number preceding "t/ha" refers to the tree density (0, 716, and 1,074 trees/ha or 0, 290, and 435 trees/ac.), and the number before "cm" refers to the depth (120 cm or 48 in.). The 120 cm (48 in.) suction lysimeters were installed in July 2007; therefore no data prior to August 2007 exists. Note the peak for nearly all samples occurring in December 2007, the same month that had blank field results with significantly greater than 0 mg/L nitrate values.

Subplot 3A with 19,650 kg N/ha (17,400 lbs. N/ac.) application rate and tree density of 1,074 trees/ha (435 trees/ac.) contains 7 suction lysimeters. During the installation in 2003, there were questions about whether SL-3A-4 at 30 cm (12in.) depth would produce viable samples, so SL-3A-6 replicated the SL-3A-4 conditions. However, as the study progressed samples were produced from both SL-3A-4 and SL-3A-6. Results from SL-3A-6 were not used in Buswell's thesis or subsequent ERCO reports. Therefore, SL-3A-6 noted as “redo” in the sample logs is not included in the analyses or discussion. Buswell did not report any suction lysimeter outliers in her 2006 thesis (Buswell, 2006).

In a 2008 presentation for American Society of Agricultural and Biological Engineers (ASABE) Northeast Agricultural and Biological Engineering Conference (NABEC), Felton et al. (2008) identified suction lysimeter SL-1E-2 at 15 cm (6 in.) with application rate of 19,650 kg N/ha (17,400 lbs. N/ac.) and tree density of 1,074 trees/ha (435 trees/ac.) as an outlier due to an average study NO_3-N value that was greater than two standard deviations from the mean of suction lysimeters with the same application rate (Felton et al., 2008).

Table 12 shows the minimum, maximum, mean, standard deviation, and average NO_3-N and TAN values for all samples with 19,650 kg N/ha (17,400 lbs. N/ac.) application rate and SL-1E-2 throughout the study. The mean NO_3-N value for SL-1E-2 was 115.5 mg/L, which is greater than the mean plus two standard deviations (78.74 mg/L) for the NO_3-N and TAN values for all samples with the application rate of 19,650 kg N/ha (17,400 lbs. N/ac.). The mean TAN value for SL-1E-2 was 1,922 mg/L which is higher than the mean of all TAN values (851.6 mg/L) for the application rate, but less than the mean plus two standard deviations (2,552 mg/L).

Table 12. NO_3-N and TAN Comparisons for Averaged 19,650 kg N/ha Application Rate and Sample SL-1E-2

	NO_3-N 19,650 kg N/ha (17,400 lbs. N/ac.) application rate	**NO_3-N SL-1E-2**	**TAN 19,650 kg N/ha (17,400 lbs. N/ac.) application rate**	**TAN SL-1E-2**
Minimum	<0.002[2]	<0.002[2]	0.081	1,168
Maximum	557.7	557.7	3,609	2,752
Mean	4.993	115.5	851.6	1,922
Std Dev[1]	36.87	166.8	850.4	460.9
Mean + 2 Std Dev[1]	78.74	N/A[3]	2,552	N/A[3]

1- Standard Deviation
2- Below detection limit, 0.0007 used in calculations.
3- Not applicable

Figure 63 shows the NO_3-N concentrations for all suction lysimeters with 19,650 kg N/ha (17,400 lbs. N/ac.) application rate, including outlier SL-1E-2. It is important to note that SL-1E-2 is equally noticeable in a graph of NO_3-N for all lysimeters at 15 cm (6in.) depth and with tree density of 1,074 trees/ha (435 trees/ac.).

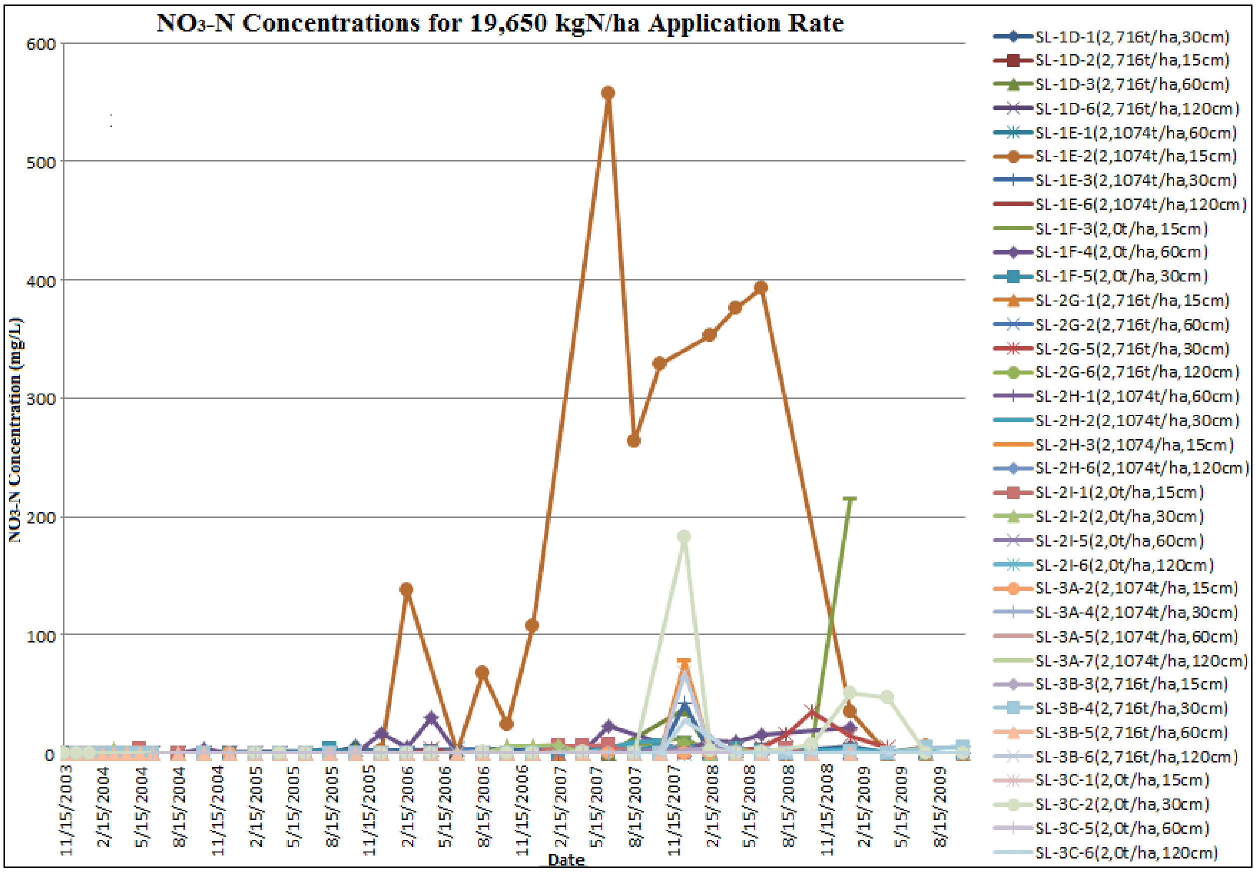

Figure 63. NO_3-N values for 19,650 kgN/ha (17,400 lbs.N/ac.) application rate with outlier SL-1E-2. In the legend, "2" represents the application rate, the number preceding "t/ha" refers to the tree density (0, 716, and 1,074 trees/ha or 0, 290, and 435 trees/ac.), and the number before "cm" refers to the depth (15, 30, 60, and 120 cm or 6, 12, 24, and 48 in.).

As indicated in Table 11, SL-1E-2 blends in with other suction lysimeters with the same application rate, tree density, or depth for TAN results. Figure 64 features the TAN results for all samples in the 19,650kgN/ha (17,400 lbs.N/ac.) application rate. Results in this study are frequently shown as averages per sampling event for samples with similar conditions and treatments in order to reduce noise and better show the effects of treatment.

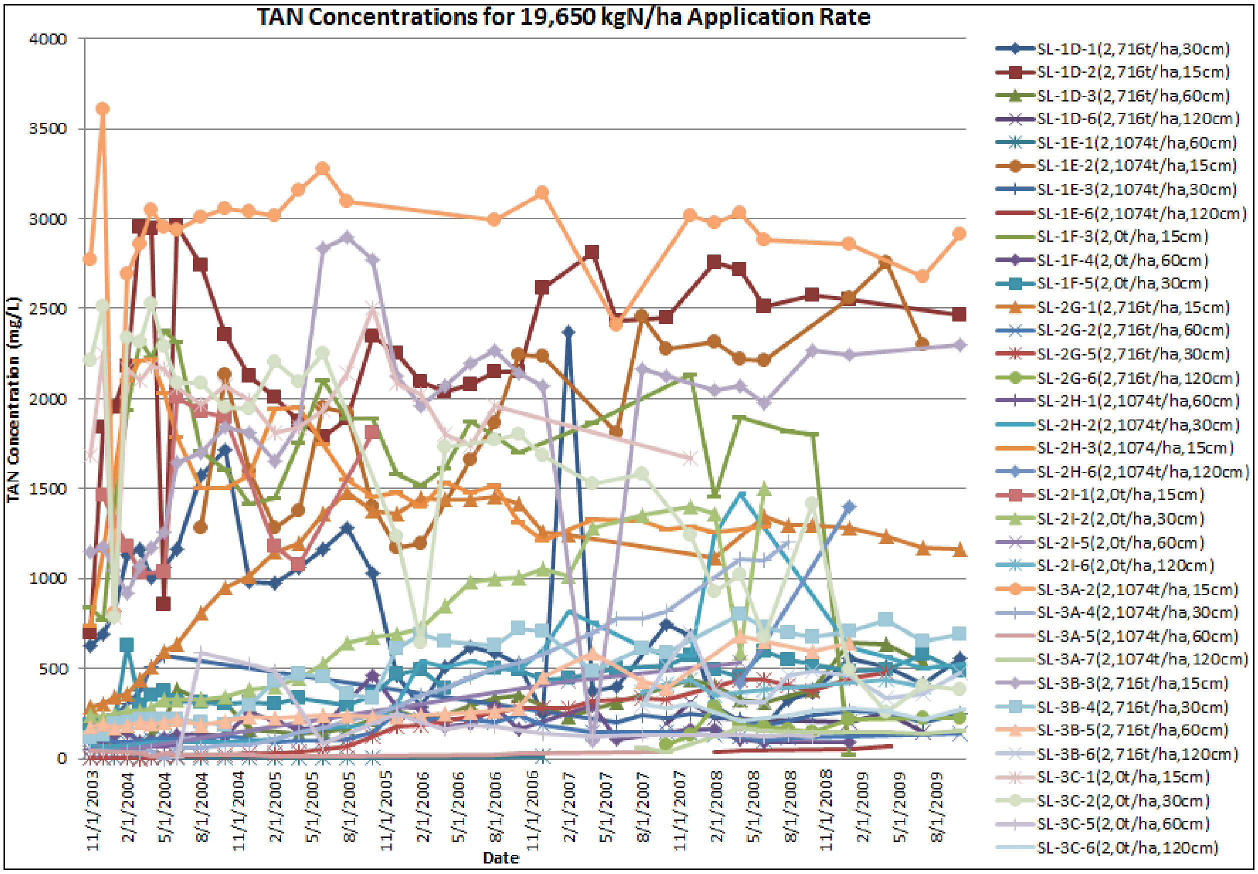

Figure 64. TAN Concentrations for 19,650 kgN/ha (17,400 lbs.N/ac.) Application Rate.
In the legend, "2" represents the application rate, the number preceding "t/ha" refers to the tree density (0, 716, and 1,074 trees/ha or 0, 290, and 435 trees/ac.), and the number before "cm" refers to the depth (15, 30, 60, and 120 cm or 6, 12, 24, and 48 in.).

Another suction lysimeter that has not followed the trends of suction lysimeters with similar conditions is SL-1C-4 with 39,300 kgN/ha (34,800 lbs.N/ac.) application rate, 0 trees/ha (0 trees/ac.) tree density, and 15 cm (6 in.) depth. The earlier samples taken between 2003 and 2005 had high TAN values, at times 2,000 mg/L higher than the next highest value for application rate, tree density, and depth. From 2007 to 2009 the TAN values dropped and fell lower than the majority of the samples under similar conditions. Figure 65 shows the striking difference between SL-1C-4 and the suction lysimeters with the same tree density (0 trees/ha or 0 trees/ac.) for TAN concentrations.

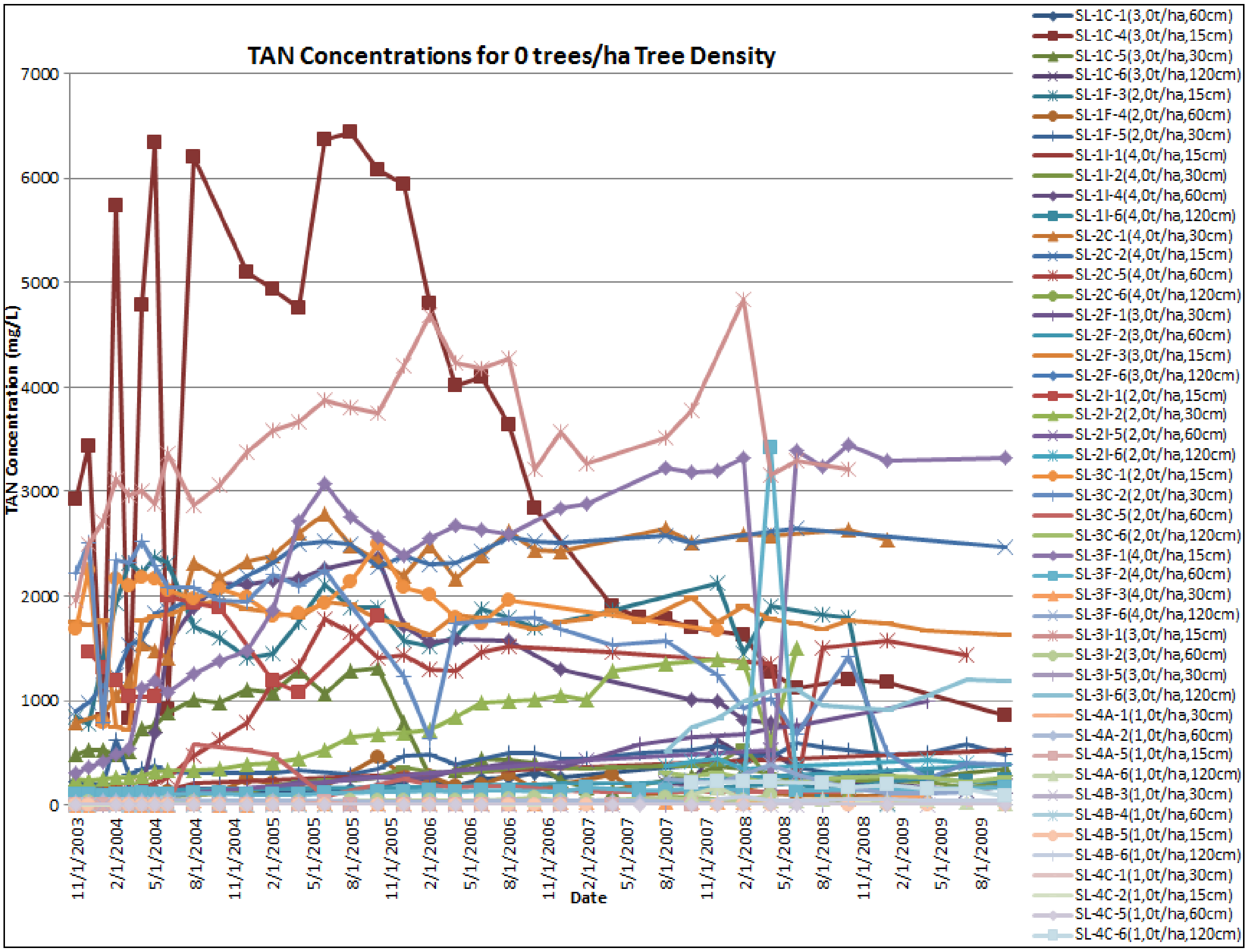

Figure 65. TAN Concentrations for 0 trees/ha (0 trees/ac.) tree density displaying outlier SL-1C-4. In the legend, the first number in parentheses represents the application rate in numerical order following 0, 19,650, 39,300, and 59,800 kgN/ha (0, 17,400, 34,800, and 52,000 lbs.N/ac.). The number preceding "t/ha" refers to the tree density (0 trees/ha or 0 trees/ac.), and the number before "cm" refers to the depth (15, 30, 60, and 120 cm or 6, 12, 24, and 48 in.).

Table 13 shows the minimum, maximum, mean, standard deviation, and average NO_3-N and TAN values for all samples with 0 trees/ha (0 trees/ac.) tree density and SL-1C-4 throughout the study. The mean NO_3-N value for SL-1C-4 was 0.0007 mg/L or below detectable limits, which is lower than the mean NO_3-N value of 5.91 mg/L for samples 0 trees/ha (0 trees/ac.). The mean TAN value for SL-1C-4 was 3,399 mg/L which is higher than the mean of all TAN values (560.80 mg/L) for the 0 trees/ha (0 trees/ac.) tree density, and higher than the mean plus two standard deviations (2,426 mg/L).

Table 13. NO_3-N and TAN Comparisons for 0 trees/ha (0 trees/ac.) Tree Density and Sample SL-1C-4

	NO_3-N 0 trees/ha (0 trees/ac.) Tree Density	NO_3-N SL-1C-4	TAN 0 trees/ha (0 trees/ac.) Tree Density	TAN SL-1C-4
Minimum	<0.002[2]	<0.002[2]	<0.002[2]	<0.002[2]
Maximum	404.6	0.1628	6,439	821.4
Mean	5.91	0.00	560.8	6,438
Std Dev[1]	25.72	0.0491	932.8	3,399
Mean + 2 Std Dev[1]	57.35	N/A[3]	2,426	N/A[3]

1- Standard Deviation
2- Below detection limit, 0.0007 used in calculations.
3- Not applicable

Table 14 summarizes the outliers and subsequently samples that were removed from further analyses and discussion. The table also includes a list of suction lysimeters that did not produce at least 10 samples from the 38 total sampling events since one-quarter of the experiment is not a full representation of nutrient transport throughout the biosolids. Similarly, suction lysimeters at depth 120 cm (48 in.) installed in July 2007 with less than 3 of the possible 12 samples were removed.

Table 14. Summary of Outliers and Removal Justifications

Sample	Sample Characteristics	Justification for Removal
12/2007 All samples	All application rates, All depths, All tree densities (58 samples in all)	Blank field results had NO_3-N values significantly greater than 0 mg/L.
SL-1B-5	Depth: 15 cm (6 in.) Application: 39,300 kg N/ha (34,800 lbs.N/ac.) Tree Density: 1,074 trees/ha (435 trees/ac.)	Produced 7samples throughout 38 sampling event study.
SL-1C-4	Depth: 15 cm (6 in.) Application: 39,300 kg N/ha (34,800 lbs.N/ac.) Tree Density: 0 trees/ha (0 trees/ac.)	TAN values were 2 standard deviations greater than the mean of suction lysimeters with the same tree density.
SL-1E-2	Depth: 15 cm (6 in.) Application: 19,650 kg N/ha (17,400 lbs.N/ac.) Tree Density: 1,074 trees/ha (435 trees/ac.)	NO_3-N values were 2 standard deviations greater than the means of suction lysimeters with the same application rate, tree density, and

		depth.
SL-1F-6	Depth: 120 cm (48 in.) Application: 19,650 kg N/ha (17,400 lbs.N/ac.) Tree Density: 0 trees/ha (0 trees/ac.)	No samples produced out of 12 possible sampling events since installation in July 2007.
SL-1G-1	Depth: 60 cm (24 in.) Application: 58,900 kgN/ha (52,000 lbs.N/ac.) Tree Density: 716 trees/ha (290 trees/ac.)	Produced 1 sample throughout 38 sampling event study.
SL-1I-1	Depth: 15 cm (6 in.) Application: 58,900 kgN/ha (52,000 lbs.N/ac.) Tree Density: 0 trees/ha (0 trees/ac.)	Produced 9 samples throughout 38 sampling event study.
SL-2D-5	Depth: 30 cm (12 in.) Application: 39,300 kgN/ha (34,800 lbs.N/ac.) Tree Density: 716 trees/ha (290 trees/ac.)	Produced 2 samples throughout 38 sampling event study.
SL-2F-6	Depth: 120 cm (48 in.) Application: 39,300 kgN/ha (34,800 lbs.N/ac.) Tree Density: 0 trees/ha (0 trees/ac.)	Produced 1 sample out of 12 possible sampling events since installation in July 2007.
SL-2H-1	Depth: 60 cm (24 in.) Application: 19,650 kg N/ha (17,400 lbs.N/ac.) Tree Density: 1,074 trees/ha (435 trees/ac.)	Produced 8 samples throughout 38 sampling event study.
SL-2H-6	Depth: 120 cm (48 in.) Application: 19,650 kg N/ha (17,400 lbs.N/ac.) Tree Density: 1,074 trees/ha (435 trees/ac.)	Produced 2 samples out of 12 possible sampling events since installation in July 2007.
SL-2I-5	Depth: 60 cm (24 in.) Application: 19,650 kg N/ha (17,400 lbs.N/ac.) Tree Density: 0 trees/ha (0 trees/ac.)	Produced 5 samples throughout 38 sampling event study.
SL-3H-2	Depth: 30 cm (12 in.) Application: 39,300 kgN/ha (34,800 lbs.N/ac.) Tree Density: 716 trees/ha (290 trees/ac.)	No samples produced out of 38 possible sampling events since 2003.

Soil Water Analysis and Results: Overview

Number of Samples Collected

At the conclusion of the 38 field sampling events in October 2009 2,604 suction lysimeter samples were collected from below the biosolids row; including 112 blank field samples. Initially, the actual samples collected each year were greater than 80% of the total possible samples, but dropped to as low as 28% in 2007. Despite the addition of 30 suction lysimeters at 120 cm (48 in.) depth, the year 2007 experienced the least amount of rainfall (82 cm or 32 in.). Although 2009 had the second lowest actual to total possible samples percentage of 42%, the annual rainfall of 117 cm (46 in.) is the second highest behind 2003's 133 cm (52 in.). The actual to total possible samples percentages also indicate equipment failures may have reduced the sample quantities. Most equipment failures were probably related to ultraviolet radiation damage to the suction lysimeters' external tubes. Several tubes were repaired in the summer of 2007 and as needed in 2008, which may be reflected in the increased percentage for 2008 (55%), despite the second lowest precipitation of 94 cm (37 in.). Although 2,604 samples were collected, a total of 4,140 samples could have been collected throughout the experiment. Figure 66 shows the difference between the actual and possible number of samples from 2003 to 2009 along with the cumulative precipitation prior to removing outliers. After removing the outliers, there are 2,444 samples remaining for analysis which includes 109 blank field samples.

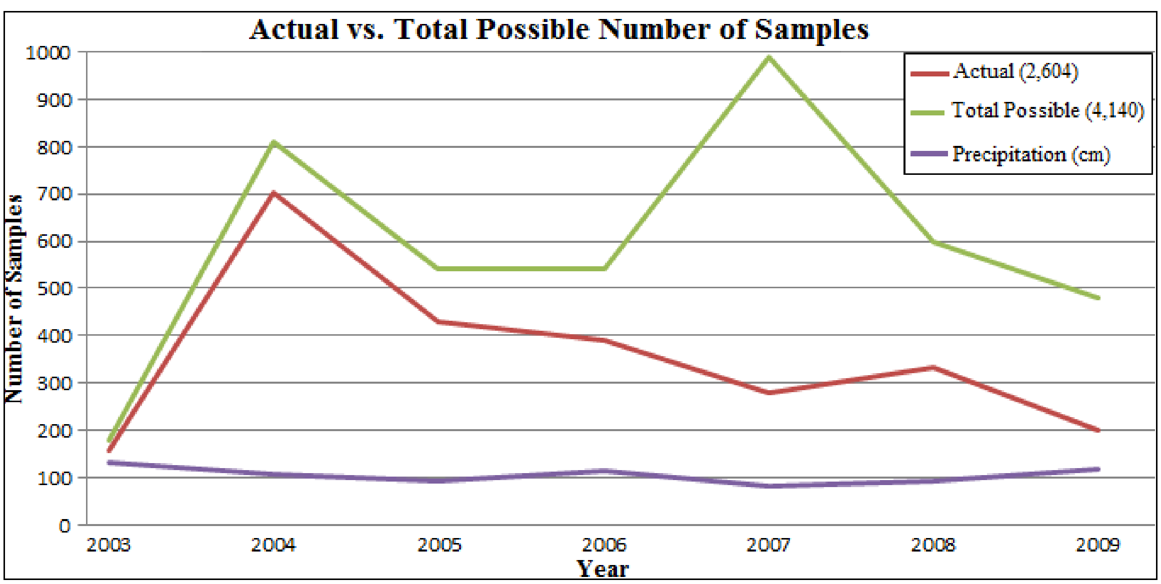

Figure 66. Actual versus Total Possible Number of Samples Collected with Cumulative Precipitation

Sample pH Values

Overall pH ranged from as low as 5.28 to as high as 11.9 in the suction lysimeters. Suction lysimeter SL-2I-1 at 19,650 kg N/ha (17,400 lbs. N/ac.) application rate, 0 trees/ha (0 trees/ac.) tree density, and 15 cm (6 in.) depth had erratic pH values between 2003 and 2005. Suction lysimeter SL-2I-1 had the highest pH value of 11.90 in June 2005 and the second highest pH value of 11.33 in February 2004. In between the second highest pH and the highest pH value, the pH for SL-2I-1 approached 8, much like SL-2I-2 at 19,650 kg N/ha (17,400 lbs. N/ac.) application rate, 0 trees/ha (0 trees/ac.) tree density, and 30 cm (15 in.) depth and SL-3C-1 with the same conditions as SL-2I-1. Samples for SL-2I-1 cease after October 2005. Figure 67 shows the pH of SL-2I-1, SL-2I-2, and SL-3C-1 throughout the study. Table 15 shows the minimum, maximum, and average pH values for the field, control and error blank suction lysimeter samples in addition to the standard deviation and variance. Slight improvements in pH standard deviation and variance were observed in the data once SL-2I-1 was removed.

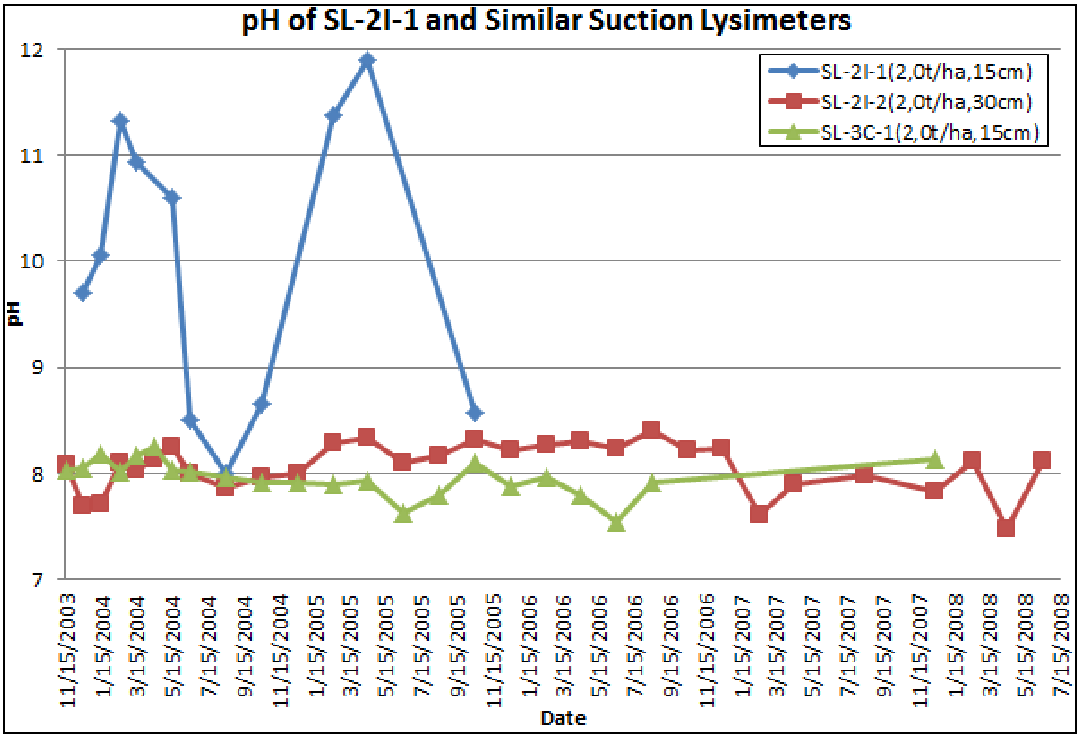

Figure 67. pH of SL-2I-1 and Similar Suction Lysimeters

In the legend, the first number in parentheses represents the application rate of 19,650 kgN/ha (17,400 lbs.N/ac.). The number preceding "t/ha" refers to the tree density of 0 trees/ha or 0 trees/ac., and the number before "cm" refers to the depth of 15 cm (6 in.).

Table 15. Project pH Value Ranges

	Field Samples	**Control Samples**	**Error Blank Samples (Distilled Water)**
Minimum pH	5.28/5.28[2]	5.10/5.10[2]	4.49/4.49[2]
Maximum pH	11.9, 8.70[1]	8.00/8.00[2]	8.00/8.00[2]
Average pH	7.56, 7.55[1]	6.83/6.83[2]	5.78/5.79[2]
Standard Deviation	0.64, 0.61[1]	0.58/0.58[2]	0.651/0.657[2]
Variance	0.41, 0.37[1]	0.34/0.34[2]	0.424/0.432[2]

[1] Denotes values once SL-1I-1 was removed from the data set.

[2] Updated Maximum, Average, Standard Deviation and Variance after initial outliers were removed.

Despite the unusual pH values for SL-2I-1, when NO_3-N and TAN concentrations were graphed for SL-2I-1, SL-2I-2, and SL-3C-1, the SL-2I-1 NO_3-N and TAN values are reasonable compared to similar lysimeters. The NO_3-N and TAN concentrations for SL-2I-1 and similar samples may be seen in Figures 68 and 69. Because of this information in conjunction with the standard deviation and variance for pH, SL-2I-1 was retained in the data sets for analyses.

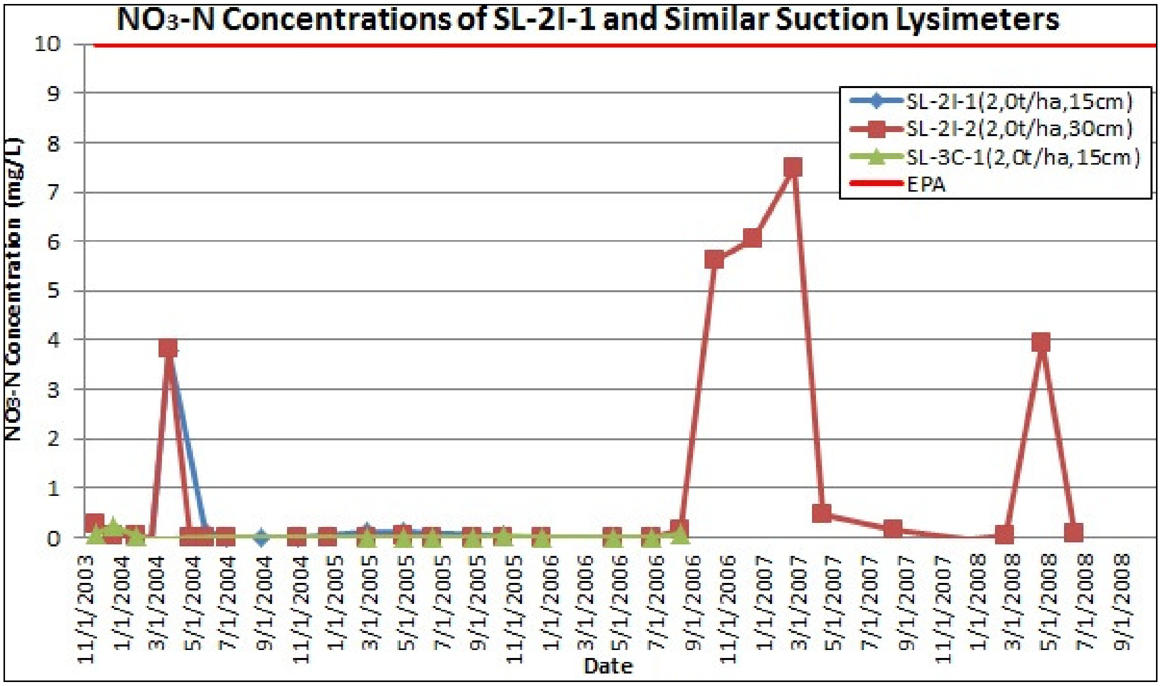

Figure 68. NO_3-N Concentrations of SL-2I-1 and Similar Suction Lysimeters

In the legend, the first number in parentheses represents the application rate of 19,650 kgN/ha (17,400 lbs.N/ac.). The number preceding "t/ha" refers to the tree density of 0 trees/ha or 0 trees/ac., and the number before "cm" refers to the depth of 15 cm (6 in.).

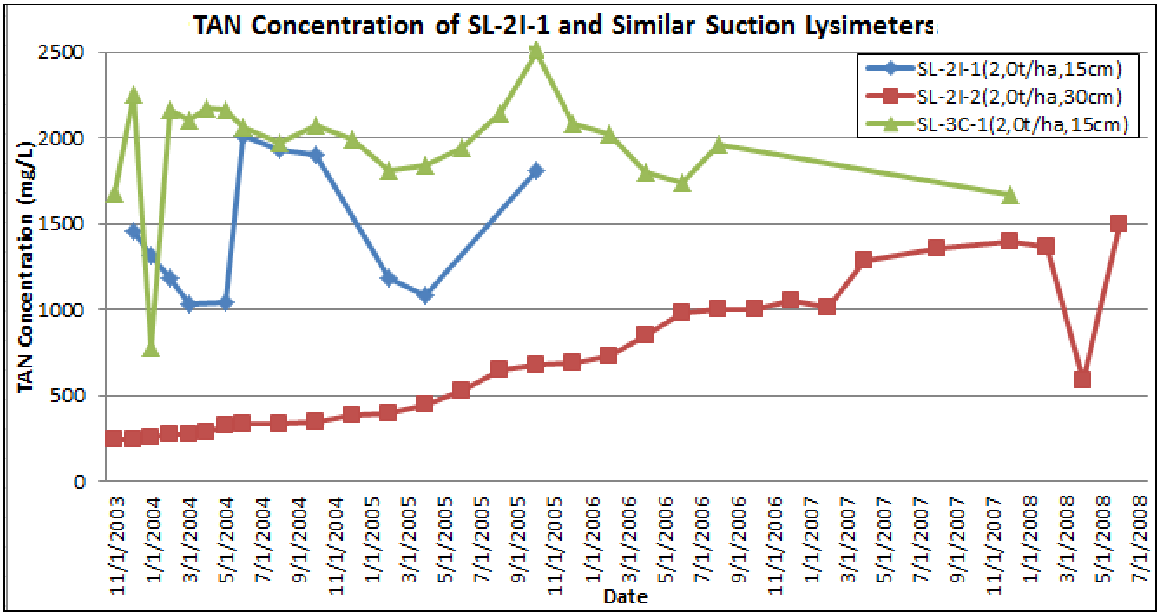

Figure 69. TAN Concentrations of SL-2I-1 and Similar Suction Lysimeters

In the legend, the first number in parentheses represents the application rate of 19,650 kgN/ha (17,400 lbs.N/ac.). The number preceding "t/ha" refers to the tree density of 0 trees/ha or 0 trees/ac., and the number before "cm" refers to the depth of 15 cm (6 in.).

Data Distribution

Buswell's data from 2003 to 2004 met the normal distribution and homogeneity of variance assumptions for proper application of ANOVA after log transformation of the quarterly averaged data. The data from 2003 to 2009 did not meet these assumptions after log transformation of the quarterly averaged data with and without the control data were run in XLSTAT 2012©. Furthermore, the data did not meet the assumptions required for ANOVA after annual averages were log transformed with and without the control data.

Wilcoxon Rank Sum Test for Nonparametric Data

Of the 58 tests run for NO_3-N and TAN, 40 showed significant differences between the variables. Most notably there were significant differences found between control and non-control conditions and among application rates, depths, and replicates. Refer to the appendix for the Wilcoxon Rank Sum Tests results.

Study Layout

To test if the layout of the study may contribute to variation among results, Wilcoxon Rank Sum Tests were run for replicates (vertical location within the sample layout) and blocks (horizontal location within the sample layout). Replicates 1 and 3 were significantly different for both NO_3-N and TAN. Significant differences were found between replicates 1 and 2 for TAN. There were no differences between replicates 2 and 3 for NO_3-N and TAN. The differences between soil types, slope, and terrain may account for some variation between sample treatments. Figures 70 and 71 show the average NO_3-N and TAN concentrations by replicate (vertical location), respectively.

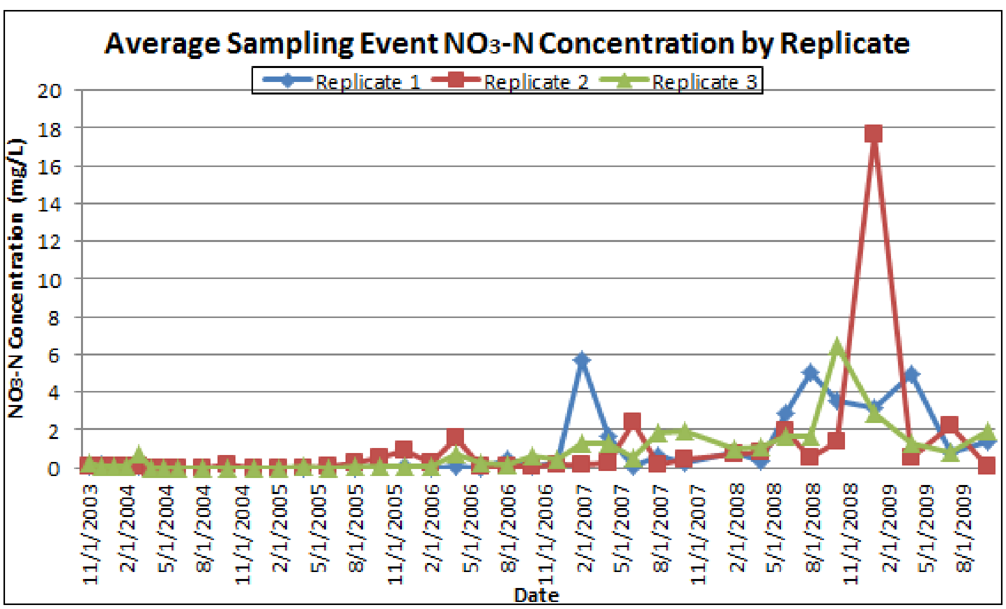

Figure 70. NO_3-N Concentrations by Replicate (vertical location).

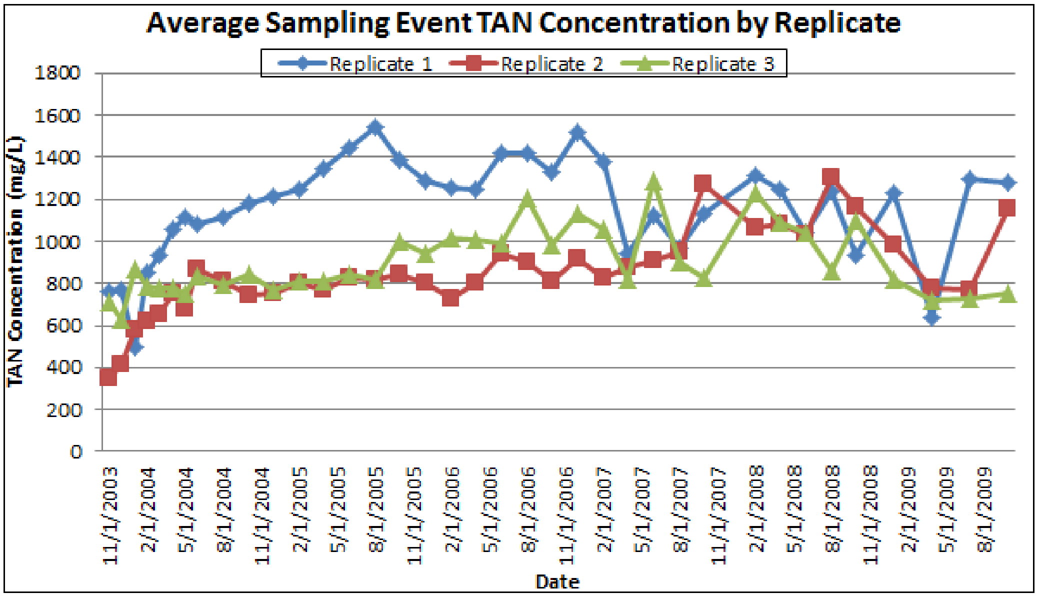

Figure 71. TAN Concentrations by Replicate (vertical location).

As expected there were significant differences found among the blocks (horizontal location within the sample layout), excluding Block 2 and Control Block 2 for NO_3-N, Block 1 and Block 3 for TAN, and Block 2 and Block 3 for NO_3-N. The significant differences for the replicates and blocks indicate that the soil type, slope, and general terrain may account for some variation between sample treatments. Figures 72 and 73 show the average NO_3-N and TAN concentrations by block (horizontal location), respectively.

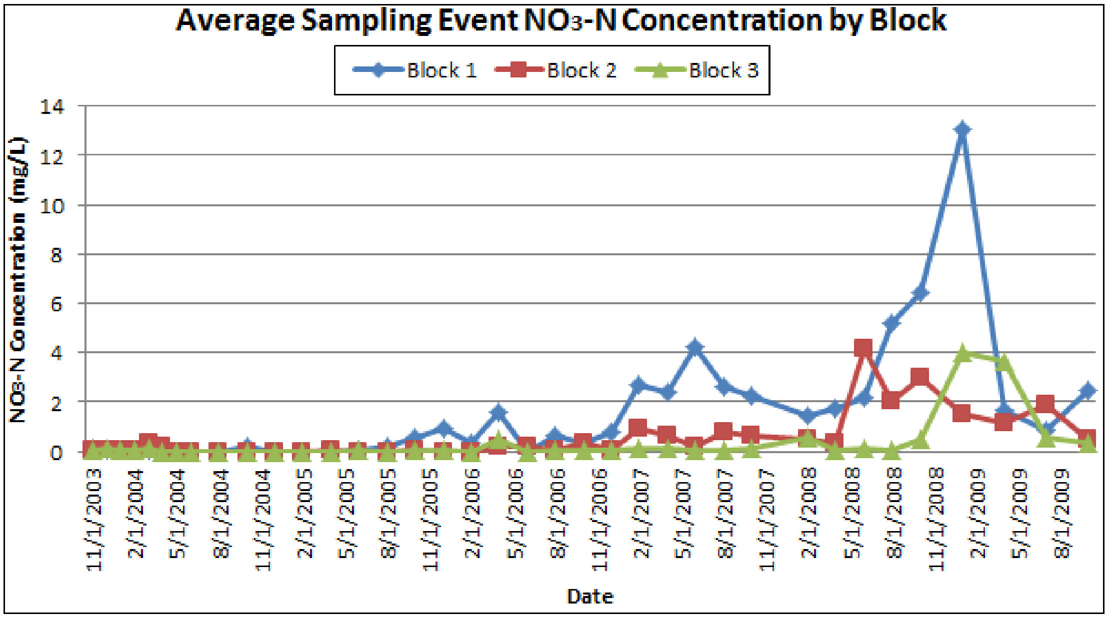

Figure 72. NO_3-N Concentrations by Block (horizontal location).

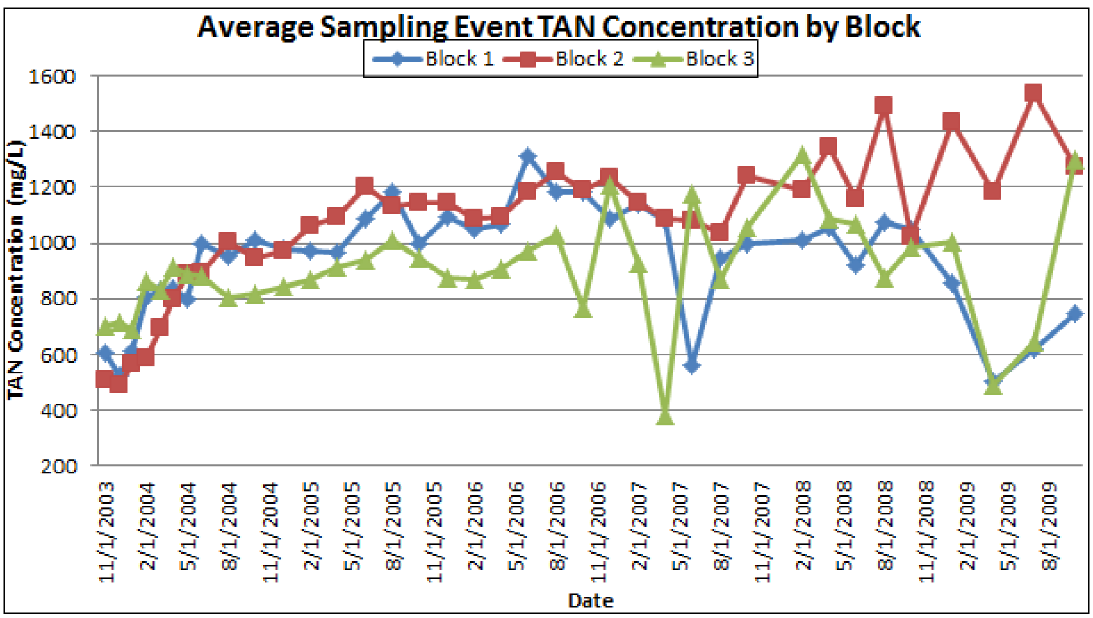

Figure 73. TAN Concentrations by Block (horizontal location).

Controls

Wilcoxon Rank Sum Tests were run between each treatment and its coordinating control. For example the 15 cm (6 in) depth suction lysimeters were tested with the control 15 cm (6 in.) depth suction lysimeters and the 0 trees/ha (0 trees/ac.) suction lysimeters were tested with the control 0 trees/ha (0 trees/ac.) suction lysimeters. There were significant differences among all of the individual treatments and their corresponding control results for NO_3-N and TAN, except for the 120 cm (48 in.) suction lysimeter and control 120 cm (48 in.) suction lysimeter NO_3-N results.

Application Rate

As expected the control application rate of 0 kg N/ha (0 lbs. N/ac.) were significantly different from all of the treatments (19,650 kg N/ha or 17,400 lbs. N/ac., 39,300 kg N/ha or 34,800 lbs. N/ac., and 58,900 kg N/ha or 52,000 lbs. N/ac.) for both NO_3-N and TAN. There were no significant differences found between application rates 19,650 kg N/ha (17,400 lbs. N/ac.) and 39,300 kg N/ha (34,800 lbs. N/ac.) for either NO_3-N or TAN. The highest application rate of 58,900 kg N/ha (52,000 lbs .N/ac.) did not show any significant differences for TAN results between the lower application rates of 19,650 kg N/ha (17,400 lbs. N/ac.) and 39,300 kg N/ha (34,800 lbs. N/ac.), however it did show significant differences for NO_3-N results compared to the lower application rates.

Depth

As NO_3-N migrates away from a source, there is little or no binding with the soil. Conversely, as TAN migrates away from a source, it tends to bind with clay and organic matter, resulting in reduced concentrations with distance from the source.

There were significant differences found among all depths and TAN except for 60 cm (24 in.) and 120 cm (48 in.). Significant differences only occurred for NO_3-N results between 15 cm (6 in.) and 30 cm (12 in.), 15 cm (6 in.) and 60 cm (24 in.), and 30 cm (12 in.) and 120 cm (48 in.). Despite being twice as deep as the next closest depth, the 120 cm (48 in.) sample results for NO_3-N were not significantly different from 60 cm (24 in.). The deepest suction lysimeter (120 cm or 48 in.) was not significantly different from 15 cm (6 in.) for NO_3-N results. Similarly, the 30 cm (12 in.) lysimeter was significantly different than the 60 cm (24 in.) lysimeter NO_3-N results.

Tree Density

The non-control suction lysimeters without trees on the subplots (0 trees/ha or 0 trees/ac.) were significantly different from the next tree density of 716 trees/ha (290 trees/ac.) for NO_3-N and TAN values. There were no significant differences between the 716 trees/ha (290 trees/ac.) tree density and the highest tree density of 1,074 trees/ha (435 trees/ac.) for NO_3-N and TAN values. Comparing the lowest and highest tree density results showed TAN significant differences between 0 trees/ha (0 trees/ac.) and 1,074 trees/ha (435 trees/ac.), but no significant differences for NO_3-N results.

Pearson Correlation Coefficients

Focusing on Pearson Correlation Coefficients (Table 16) with an absolute value of 0.1 or greater, there is a correlation between application rates and tree densities and NO_3-N, TAN, Log NO_3-N, Log TAN, and pH values. Correlations for depth occurred with TAN, Log NO_3-N, Log TAN, and pH values. Though the dates are correlated with NO_3-N values, temperature was not correlated with NO_3-N. Precipitation volumes had no correlation with any of the results.

Table 16. Pearson Correlation Matrix

Variables	**NO_3-N (mg/L)**	**TAN (mg/L)**	**LOG NO_3-N**	**LOG TAN**	**pH**
Block	-0.034	**-0.054**	**-0.043**	**-0.184**	**-0.222**
Application Rate (kg N/ha)	**-0.113**	**0.261**	**-0.240**	**0.416**	**0.266**
Tree Density (trees/ha)	**-0.116**	**0.110**	**-0.156**	**0.244**	**0.119**

Depth (cm)	0.007	**-0.371**	**0.124**	**-0.156**	**-0.344**
Date	**0.163**	**0.084**	**0.404**	**0.088**	**-0.079**
Temperature (^oC)	-0.028	**0.058**	-0.034	**0.064**	0.002
Rain (cm)	-0.013	0.003	0.012	0.001	-0.026

*Values in bold are different from 0 with a significance level alpha = 0.05.

Pearson Correlation Time Scatter Plots

As mentioned previously, Pearson Correlation Scatter Plots are useful in visualizing the impacts of treatments on the resulting parameter. For comparison purposes, Figure 74 shows the correlation scatter plot for the NO_3-N and TAN as functions of time. From these images it is clear that the range of TAN values is much greater than the range of NO_3-N values. The TAN values show difference in concentration over time, but there are slight increases in NO_3-N values with time. The date scatter plots do not give additional information regarding the application rate, lysimeter depth, or tree density that the NO_3-N and TAN values represent. Individual scatter plots were created to see direct effects of the treatments on the nitrogen levels.

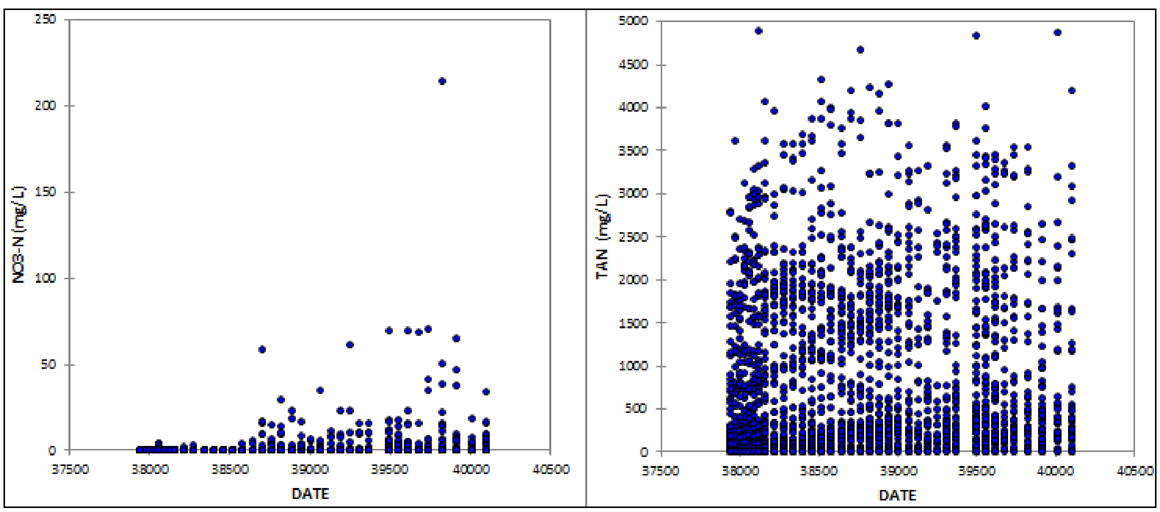

Figure 74. Correlation Scatter Plots: NO_3-N and TAN as Functions of Time.

Pearson Correlation NO_3-N Scatter Plots

The Pearson Correlation Scatter Plots for NO_3-N do not indicate strong correlations between application rates and NO_3-N concentration and tree density and

NO_3-N concentration. The next observation in the Pearson Correlation Scatter Plots for NO_3-N (Figure 75) is a much higher NO_3-N value of 214.7 mg/L occurred in January 2009 from SL-1F-3 with 19,650 kg N/ha (17,400 lbs. N/ac.) application rate, 0 trees/ha (0 trees/ac.) tree density, and 15 cm (6 in.) depth below the biosolids. This NO_3-N value was more than double the other individual sampling results. Since it was a one-time occurrence for an abnormal result, SL-1F-3 remained in the data set for further analyses.

Aside from the January 2009 SL-1F-3 NO_3-N value, the highest NO_3-N values occurred in the subplots without trees. The scatter plots support the Wilcoxon Rank Sum Tests indicating no significant difference for the 120 cm (48 in.) suction lysimeter and control 120 cm (48 in.) suction lysimeter NO_3-N results, since NO_3-N values are not correlated with depth and are weakly correlated with application rate. Additional Pearson Correlation Scatter Plots for NO_3-N may be found in the appendix.

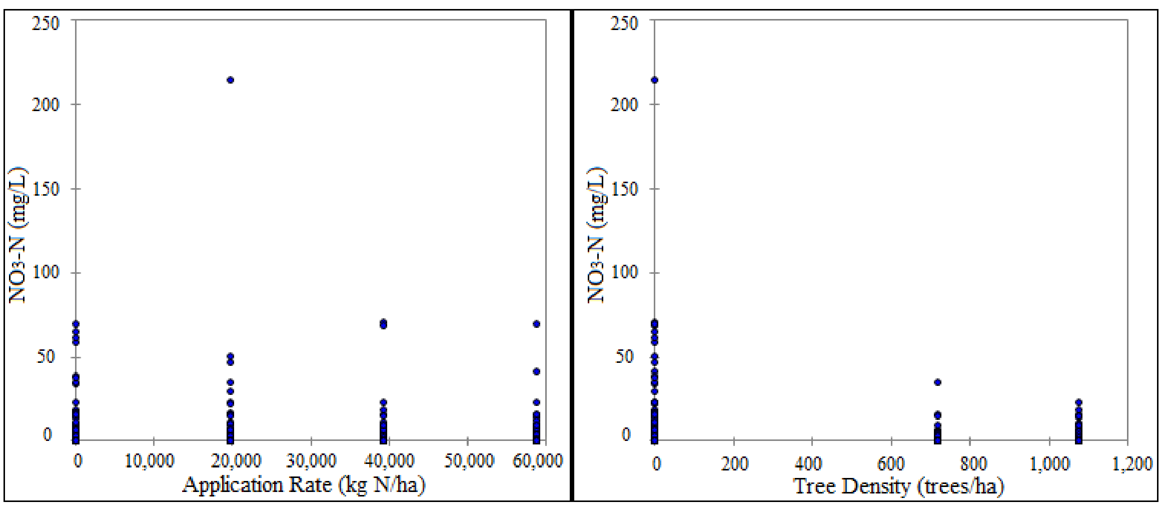

Figure 75. Correlation Scatter Plots: NO_3-N as a Function of Application Rate and Tree Density

Pearson Correlation TAN Scatter plots

The Pearson Correlation Scatter plots for TAN do not indicate strong correlations between application rates and TAN concentration and tree density and TAN concentration. However, there is a stronger illustration shown in the TAN values as a result of biosolids application rate. As the application rate increases, the TAN values increase. From the scatter plot, the two highest application rates of 39,300 and 58,900 kg N/ha (34,800 and 52,000 lbs. N/ac.) show similar results (Figure 76). The correlation between TAN values and tree density is less defined. All three tree densities (0, 716, and 1,074 trees/ha or 0, 290 and 435 trees/ac.) produce similar results.

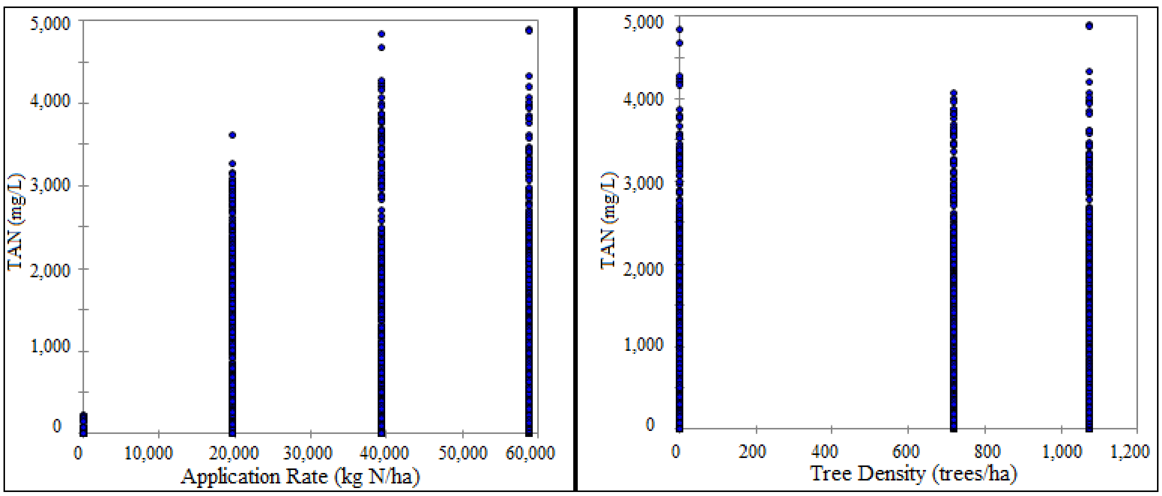

Figure 76. Correlation Scatter plots: TAN as a function of Application Rate and Tree Density

Figure 77 illustrates that TAN values are most correlated with depth. This relationship was acknowledged initially by Buswell (2006) and became the foundation for further research and the additional suction lysimeter located 120 cm (48 in.) below the biosolids. From the scatter plot TAN values decrease significantly between the 30 cm (12 in.) depth and the 60 cm (24 in.) depth below the biosolids. At the 120 cm (48 in.) depth below the biosolids the majority of the TAN concentrations align with the 60 cm (24 in.) TAN concentrations. There are several TAN concentrations that are higher than the highest TAN value at 60 cm (24 in.) below the biosolids. Additional Pearson Correlation Scatter Plots for TAN may be found in the appendix.

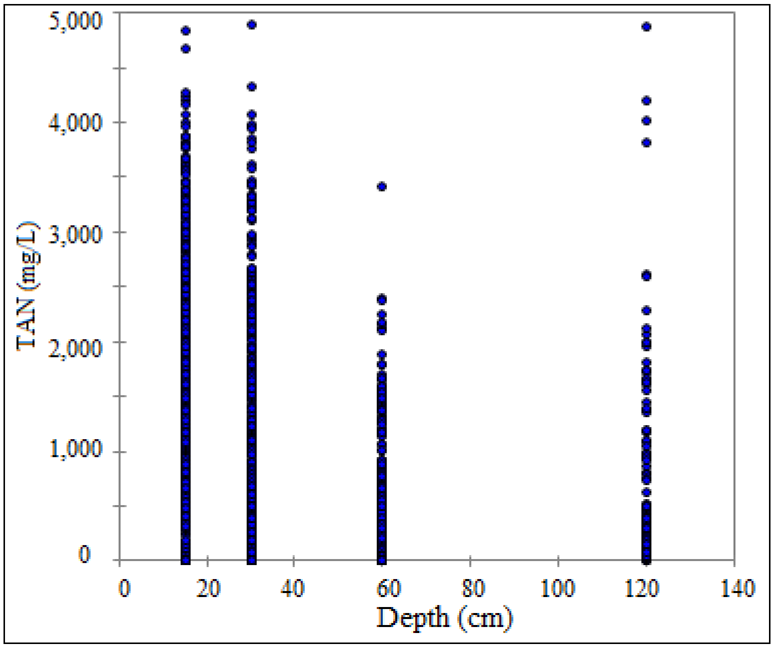

Figure 77. Correlation Scatter plot: TAN as a function of Depth

Soil Water Results: Nitrate-Nitrogen (NO_3-N)

Nitrate-Nitrogen (NO_3-N) Overview

Of the 2,492 samples taken, the highest NO_3-N value was 557.7 mg/L from SL-1E-2 (19,650 kgN/ha or 17,400 lbs.N/ac., 1,074 trees/ha or 435 trees/ac., and 15 cm or 6 in. depth). In fact the SL-1E-2 had 9 of the highest 20 NO_3-N values in the data set, including the top five highest NO_3-N values (557.7, 393.0, 376.2, 353.1, and 329.3 mg/L). Since SL-1E-2 was previously identified as an outlier, the average was taken both with outliers and without outliers. The average prior to removing the initial outliers was 2.246 mg/L NO_3-N. After removing the initial outliers, the average dropped to 0.6744 mg/L NO_3-N. A total of 2,257 samples or 90.6% of the NO_3-N samples returned concentrations below 1.0 mg/L. Table 17 shows the average, minimum, maximum, standard deviation, and variance associated with NO_3-N concentrations before and after removing the outliers.

Table 17. NO_3-N Concentration Overview

	Field Samples	Control Samples	Error Blank Samples (Distilled Water)
Minimum NO_3-N (mg/L)	<0.002 (below detection limit)	<0.002 (below detection limit)	<0.002 (below detection limit)
Maximum NO_3-N (mg/L)	557.7/214.7[2]	151.1/65.20[2]	27.86/1.070[1]
Average NO_3-N (mg/L)	2.246/0.6744[2]	4.868/3.579[2]	0.290/0.030[2]
Standard Deviation	22.63/6.002[2]	16.39/9.994[2]	0.111/0.109[2]
Variance	512.3/36.02[2]	268.7/99.87[2]	0.012/0.012[2]

[1]After removing the field blank sample SL-4E-1 from December 2007 with a NO_3-N value of 27.86 mg/L instead of 0 mg/L, the next highest error blank sample NO_3-N concentration was 1.07 mg/L from SL-4F-1 on December 8, 2003. After the t-test confirmed a problem with December 2007error samples, the t-test was re –run. The 1.07mg/L NO_3-N value in December 2003 was not significant.

[2] Updated after outliers were removed.

There were 2,399 samples or 96.3% that were less than the EPA MCL drinking water standard of 10 mg/L NO_3-N. Figure 78 shows a histogram with the breakdown of the samples with NO_3-N concentrations greater than 10 mg/L.

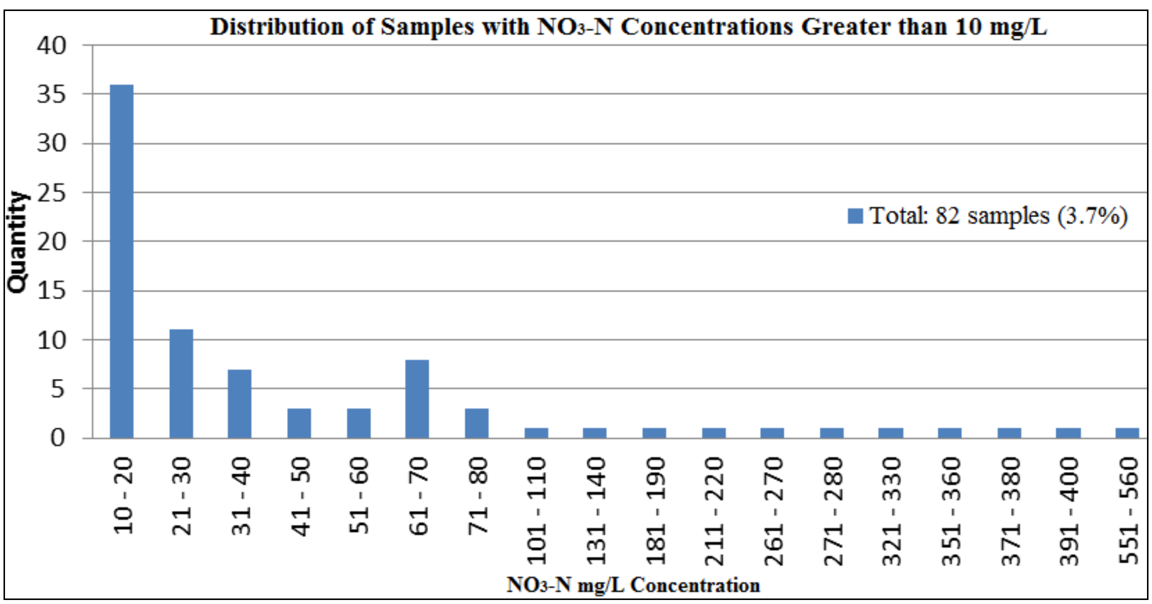

Figure 78. Number of Samples with NO_3-N Concentrations Greater than 10 mg/L

As noted in the Pearson Correlation Scatter plots for NO_3-N, the highest NO_3-N value of 214.7 mg/L, once the outliers were removed, occurred in January 2009 from SL-1F-3 with 19,650 kg N/ha (17,400 lbs. N/ac.) application rate, 0 trees/ha (0 trees/ac.) tree density, and 15 cm (6 in.) depth below the biosolids. This NO_3-N value was more than double the other individual sampling results. The January 2009 NO_3-N result from SL-1F-3 was used in all statistical analyses since individual sample event results were not removed from data.

NO_3-N Concentration by Application Rate

After averaging the data excluding outliers by application rate, the control without biosolids (0 kg N/ha or 0 lbs. N/ac.) had the highest NO_3-N value of 36.02 mg/L in August 2007. In addition to having the highest NO_3-N value by application rate, the control data set also crossed the EPA MCL 10 mg/L NO_3-N threshold five times. Average NO_3-N values in the average control set did not follow a clear temporal pattern, since the high concentrations were spread among the months of February, April, June, and December. The only other application rate to cross the 10 mg/L NO_3-N threshold was 19,650 kg N/ha (17,400 lbs. N/ac.) with a value of 15.10 mg/L NO_3-N on January 2009.

The highest application rate of 58,900 kg N/ha (52,000 lbs. N/ac.) had the least variation for NO_3-N values and ranged between 0.0017 and 4.088 mg/L NO_3-N. The low NO_3-N concentrations may indicate that the biosolids in the 58,900 kg N/ha (52,000 lbs. N/ac.) application rate have not decomposed as much as the lower application rates and therefore the nutrients are less available for leaching and still held within the biosolids pack. From Figure 79 it is clear that more NO_3-N is leaching from the lower application rates than the higher application rates. Recall that biosolids were trench applied with depths ranging from 31.8 cm (12.5 in.) to 95.3 cm (37.5 in.). Therefore the highest application rate of 58,900 kg N/ha (52,000 lbs. N/ac.) had the deepest biosolids which may retard microbial activity at the bottom of the trench. This may further explain why the samples from lower application rates had higher NO_3-N values.

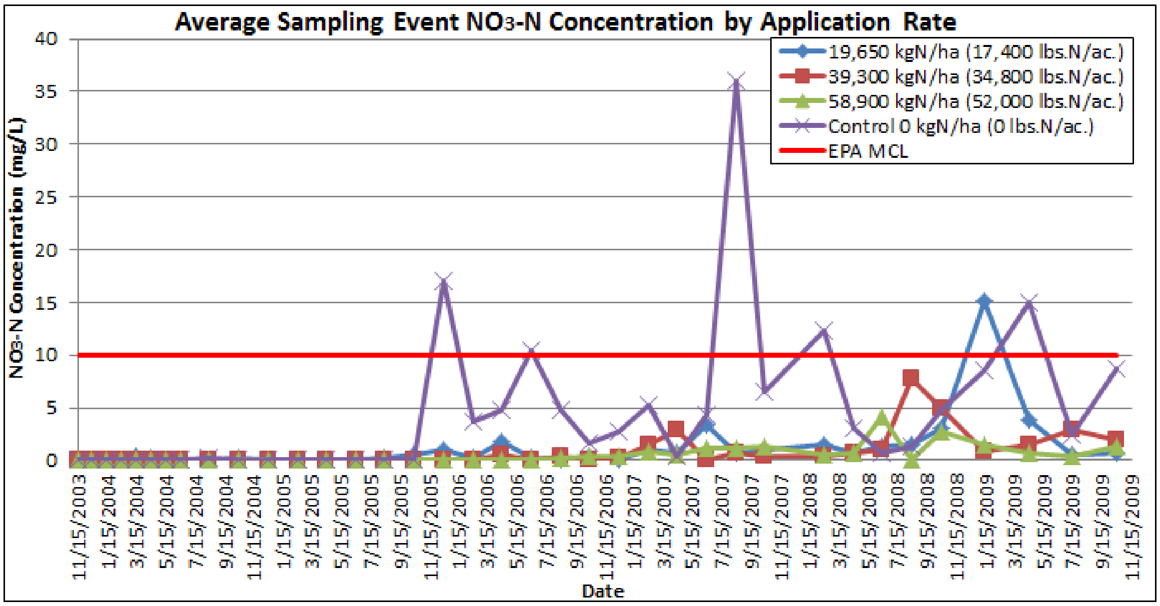

Figure 79. Average NO_3-N Concentration by Application Rate

Because biosolids contain additional nutrients vital for microorganism survival, especially C, H, O, and N needed for cell growth ($C_5H_7O_2N$), subplots with higher application rates may encourage microbial growth (Rittmann and McCarty, 2001). As the microorganism population increases, the amount of biosolids components decreases in the leachate as a result of microbial consumption. On the other hand the control group without biosolids lacks nutritional support for a microbial population and NO_3-N in the leachate will not be filtered by microbes.

NO_3-N Concentration by Depth

The highest NO_3-N value after averaging the samples by depth was 40.03 mg/L in February 2008 by the 60 cm (24 in.) sample lysimeters in the control plot (0 kg N/ha or 0 lbs. N/ac.). The 60 cm (24 in.) averaged control samples had eight results higher than the 10 mg/L NO_3-N EPA MCL. Also in the control plots, lysimeters at 30 cm (12 in.) and 15 cm (6 in.) exceeded 10 mg/L NO_3-N five times throughout the course of the study. The only non-control sample lysimeter averaged by depth to exceed 10 mg/L NO_3-N was 15 cm (6 in.), which had a value of 21.51 mg/L NO_3-N in January 2009.

The highest NO_3-N value for the deepest suction lysimeters at 120 cm (48 in.) below the biosolids was 6.992 mg/L NO_3-N in August 2008. All other values for the 120 cm (48 in.) samples were below 1 mg/L NO_3-N. The highest NO_3-N value for the average control lysimeters at 120 cm (48 in.) below the biosolids was 5.526 mg/L NO_3-N during the last sampling event in October 2009. All other control samples at 120 cm (48 in.) were below 1.5 mg/L NO_3-N.

All depths except 15 cm (6 in.) and control 60 cm (24 in.) peaked in the summer (June to October) of 2008. The control 60 cm (24 in.) values had a maximum NO_3-N value of 40.03 mg/L in February 2008. The last depth to peak was the 15 cm (6 in.) group in January 2009 with a value of 21.52 mg/L NO_3-N. These peak values occurred during a dry summer with total rainfall accumulation for the June, August, and October months of 13 cm (5 in.). For comparison purposes there was a total rainfall accumulation of 26.5 cm (10.4 in.) for the June, August, and October months in 2007. Figure 80 shows the average NO_3-N values by depth. It is possible that prolonged periods of dryness created cracks in the soil surface and preferential flow patterns for water to move unfiltered through the system, resulting in higher NO_3-N concentrations. Also, the rainwater adds oxygen to the system, which fuels nitrification and the production of NO_3-N.

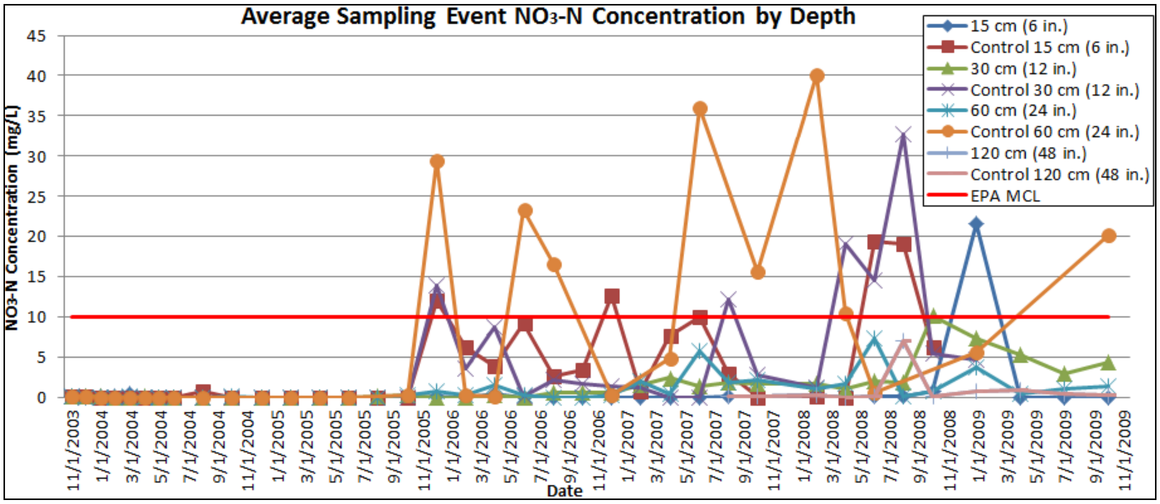

Figure 80. Average NO_3-N Concentration by Depth

Related to application rate and biosolids age, the controls had the highest NO_3-N concentrations. As expected the higher concentrations of NO_3-N are found closest to the biosolids pack. The NO_3-N plume disperses with distance from the biosolids pack. Similar to the study conducted by Randall et al. (1997), most of the NO_3-N concentration was found in the top 0.6 m (2 ft.) of soil. For comparison, Randall et al.'s (1997) highest NO_3-N concentration by average depth was 20 mg/L for continuous corn with a maximum fertilizer application rate of 177 kg NO_3-N/ha (158 lbs. NO_3-N/ac.) at 10 cm (4 in.) in 1989.

NO_3-N Concentration by Tree Density

The control samples with 0 trees/ha (0 trees/ac.) and 0 kg N/ha (0 lbs. N/ac.) had the highest NO_3-N concentration of 36.02 mg/L in August 2007 and the most sampling events (five) with averages higher than the 10 mg/L EPA MCL. The only other sampling set to exceed 10 mg/L NO_3-N had a tree density of 0 trees/ha (0 trees/ac.) with a mixture of all application rates. The 0 trees/ha (0 tree/ac.) subset had a NO_3-N value of 19.34 mg/L in January 2009. Both of the higher tree densities, 716 and 1,074 trees/ha (290 and 435 trees/ac.) had NO_3-N values less than 2 mg/L throughout the study as shown in Figure 81.

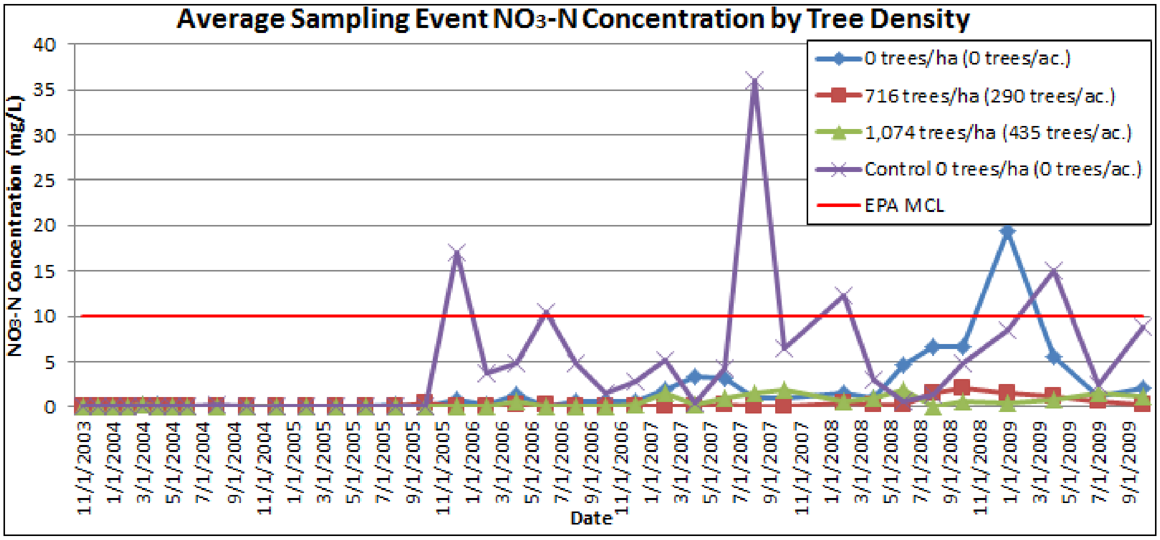

Figure 81. Average NO_3-N Concentration by Tree Density

As expected, the leachate beneath subplots with trees had lower NO_3-N values than areas without tree growth, both with biosolids and without biosolids. The trees consume NO_3-N for growth. At a tree density nearly 10 times higher than the ERCO plots of 1,074 trees/ha (435 trees/ac.), Licht and Schnoor (1993) found that poplars planted at 11,000 trees/ha (4,452 trees/ac.) could reduce 33 mg/L to1.8 mg/L NO_3-N via phytoremediation. The results from Licht and Schnoor (1993) parallel the results from ERCO since no NO_3-N values within tree plots exceeded 2 mg/L throughout the study. The poplar trees are an essential component for NO_3-N reductions in the leachate.

NO$_3$-N Concentration by Application Rate and Tree Density

To better understand the effects of tree density on NO$_3$-N concentration, Figure 82 separates subplots by application rate and tree density. All peaks of NO$_3$-N belong to subplots without trees. As noted previously, the majority of the NO$_3$-N peaks belong to the control group without trees and without biosolids application. However, the highest NO$_3$-N value of 57.95 mg/L occurred in January 2009 within the 19,650 kg N/ha (17,400 lbs. N/ac.) and 0 trees/ha (0 trees/ac.) subplots. This information further supports that the trees are utilizing NO$_3$-N and the subplots without trees result in higher NO$_3$-N values than those with trees.

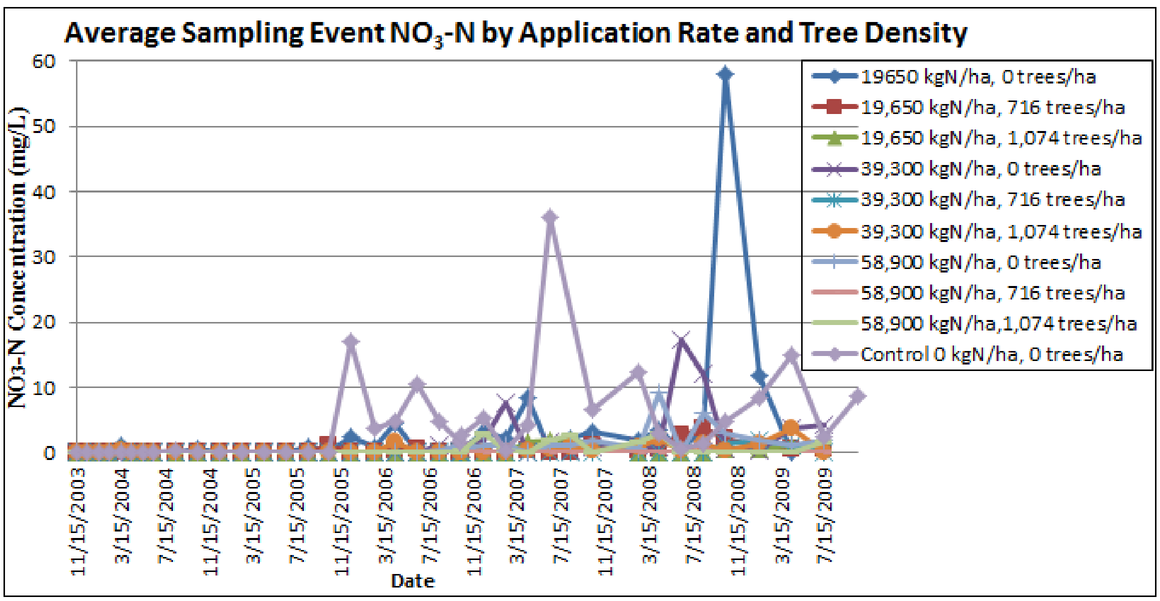

Figure 82. Average NO$_3$-N Concentration by Application Rate and Tree Density

NO$_3$-N Concentration by Depth and Tree Density

After samples were averaged by depth and tree density, the results were plotted in Figure 83. Again the peak NO$_3$-N value was in January 2009, this time with a value of 71.58 mg/L for the 15 cm (6 in.) and 0 trees/ha (0 trees/ac.). Although the peak belonged to the 15 cm (6 in.) and 0 trees/ha (0 trees/ac.) subgroup, the 60 cm (24 in.) with 0 trees/ha (0 trees/ac.) and 0 kg N/ha (0 lbs. N/ac.) control group had the majority of NO_3-N peaks for the remaining sampling events. As seen in Figure 83, no NO_3-N values within tree plots exceeded 2 mg/L throughout the study.

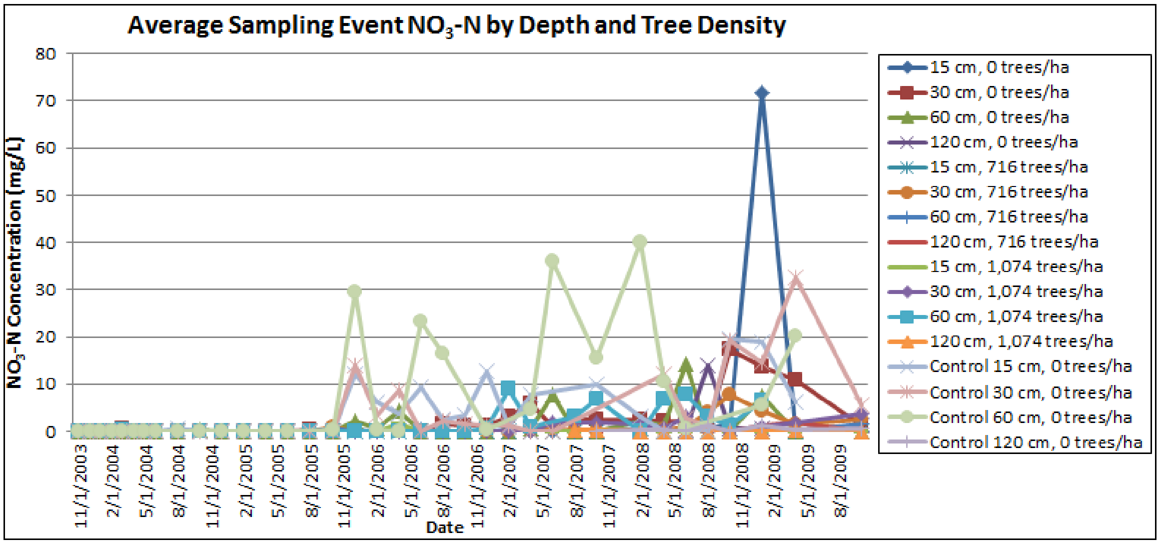

Figure 83. Average NO_3-N Concentration by Depth and Tree Density

NO_3-N Concentration in the Control Subplot

As noted in the previous sections, there were elevated NO_3-N values in the control groups. Recall from the site discussion that the control areas are not completely void of biosolids since they contain 105 dry Mg biosolids/ha (39 dry tons biosolids/ac.) installed in 1989. Although this rate is less than a third of the lowest application rate (386 dry Mg biosolids/ha or 172 dry tons/ac.) and less than a tenth of the highest application rate (1,159 dry Mg biosolids/ha or 517 dry tons biosolids/ac.), the control group still had the highest average NO_3-N values. The biosolids in the control group have had 20 years to mineralize. As the biosolids dry, it reduces in volume creating space in the soil profile. Fissures and cracks develop, which may lead to preferential flow allowing the water and oxygen to infiltrate faster throughout the soil and biosolids profile and reach the suction lysimeter faster without natural filtration from microorganisms housed in the subsurface. This may explain the elevated NO_3-N values observed in the control subplots.

The control group in this scenario serves as a long-term view of the effects of biosolids on groundwater quality. Since there were no trees planted one does know the effect that poplar tree growth would have on the nutrient levels in the control group. Even without plant life, however the values of NO_3-N were less than 40 mg/L on average, which are similar to the values of NO_3-N from the continuous corn system of Randall's 1991 data (Randall et al., 1997).

Soil Water Results: Total Ammoniacal-Nitrogen (TAN)

TAN Overview

Of the 2,492 samples taken, the highest TAN value was 6,438.90 mg/L from SL-1C-4 (39,300 kg N/ha or 34,800 lbs. N/ac., 0 trees/ha or 0 trees/ac., and 15 cm or 6 in. depth). In fact the SL-1C-4 had 13 of the highest 20 TAN values in the data set. Since SL-1C-4 was previously identified as an outlier, the average was taken both with outliers and without outliers. The TAN average prior to removing the initial outliers was 993.2 mg/L. After removing the initial outliers, the average TAN dropped to 959.6 mg/L. Table 18 shows the average, minimum, maximum, standard deviation, and variance associated with TAN concentrations before and after removing the outliers.

Table 18. TAN Concentration Overview

	Field Samples	**Control Samples**	**Error Blank Samples (Distilled Water)**
Minimum TAN(mg/L)	<0.002 (below detection limit)	<0.002 (below detection limit)	<0.002 (below detection limit)
Maximum TAN (mg/L)	6,438/4,895[1]	227.1/226.9[1]	8.46/8.46[1,2]
Average TAN (mg/L)	993.2/959.6[1]	20.06/18.18[1]	0.11/0.12[1,2]
Standard Deviation	1,058/1,002[1]	51.49/48.16[1]	0.803/0.817[1,2]

Variance	1,119,109 / 1,004,048[1]	2,651/2,320[1]	0.645/0.668[1,2]

[1] Updated after outliers were removed.

[2] SL-4E-1 had a value of 8.46 mg/L TAN in August 2008. Even though this value should be closer to 0, it did not affect the result of the t-test. The August 2008 sampling event shall be noted for any unusual TAN values during analysis.

Less than 5% of TAN samples were lower than 10 mg/L. The majority (83.5%) of the TAN values were less than 2,000 mg/L. Only 0.20% of the TAN results were between 4,500 and 4,900 mg/L. About 2.4% of the samples had values at the ERCO TAN background concentration of 4 to 9 mg/L. Figure 84 shows a histogram with the breakdown of the samples with TAN concentrations less than, equal to, and greater than the ERCO TAN background levels of 4 to 9 mg/L.

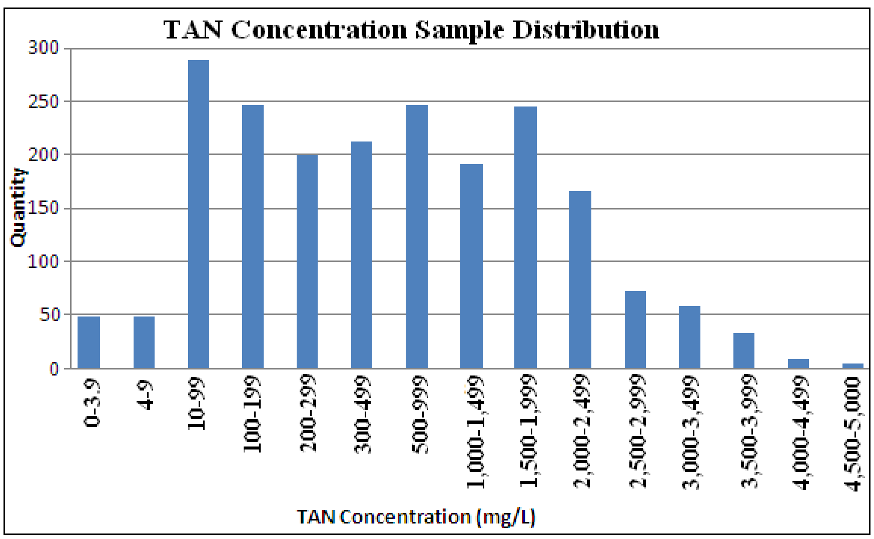

Figure 84. Sample Distribution of TAN Concentrations

TAN Concentration by Application Rate

The control group (0 kg N/ha or 0 lbs. N/ac.) had the lowest TAN concentrations, barely higher than the ERCO background levels of 4 to 9 mg/L, which is in stark contrast to its high NO_3-N concentrations. In August 2008, the highest application rate (58,900 kg N/ha or 52,000 lbs. N/ac.) had the highest TAN value of 2,091 mg/L. There are only five sampling events where the highest application rate did not have the highest TAN concentrations. Two of these events belong to the 39,300 kg N/ha (34,800 lbs. N/ac.) and three of these events belong to the 19,650 kg N/ha (17,400 lbs. N/ac.) application rates.

At the beginning of the study until December 2004 TAN rose steadily from 400 mg/L to 625 mg/L among all application rates. From 2005 until the end of the study, the lowest application rate resulted in lower TAN values than the other application rates' TAN concentrations. The lowest application rate had a peak TAN value of 1,022 mg/L in August 2005, but the higher application rates did not peak until three years later. The peak TAN value of 1,177 mg/L occurred in October 2008 for the 39,300 kg N/ha (34,000 lbs. N/ac.) application rate. With a value of 2,091 mg/L, the highest application rate reached its peak in August 2008. In April 2009 all application rates had low TAN values. In fact at 448 mg/L TAN, the lowest application rate had its lowest average TAN value for the entire study, and the two higher application rates had their lowest average TAN values for nearly two years. The TAN values began to climb for the final two sampling events in July and October of 2009. Figure 85 shows the TAN concentrations by application rate.

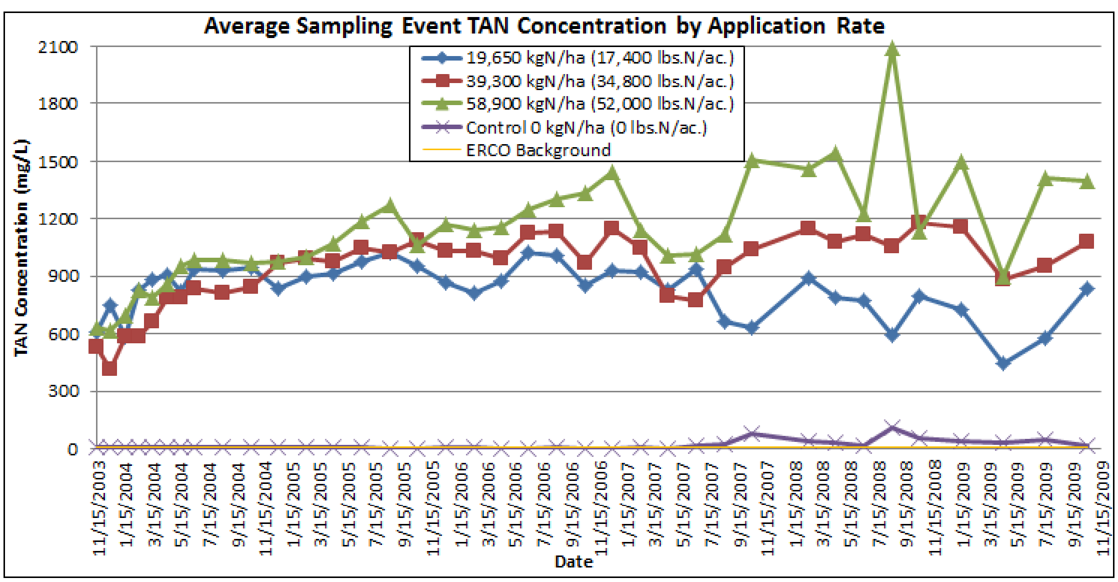

Figure 85. Average TAN Concentration by Application Rate

Sikora's research team (1978) found that organic N and TAN leached downward throughout the sludge profile, with the highest concentrations located at the bottom of the row and the lowest concentrations located at the top of the row. The higher application rates have deeper rows of biosolids. Based on these findings, one should expect that the higher application rates would have higher TAN concentrations until tree roots encourage microbial growth in the rhizosphere and introduce oxygen to the system.

TAN Concentration by Depth

During Buswell's (2006) study there was a clear relationship between depth from the biosolids and TAN concentrations. The TAN concentrations decreased as the distance from the biosolids increased. To investigate this further the 120 cm (48 in.) lysimeters were installed in 2007 with the assumption that the TAN concentrations at 120 cm (48 in.) would be lower than those at 60 cm (24 in.). However the Wilcoxon rank sum tests showed no significant difference between the depths of 60 cm (24 in.) and 120 cm (48 in.). During the first 6 out of the 11 sampling events, the 120 (48 in.) samples had higher TAN concentrations than the 60 cm (24 in.) samples. Likewise, the 120 cm (48 in.) control subplot (0 kg N/ha and 0 lbs. N/ac.) has TAN values higher than the 60 cm (24 in.) control subplot samples throughout the experiment.

The other depths followed the same patterns as those in Buswell's study except in July 2009 when the 60 cm (24 in.) had a TAN value of 1,152 mg/L and the 30 cm (12 in.) had a TAN value of 937.1 mg/L, as shown in Figure 86. Figure 87 is a closer look at TAN concentrations by depth for 60 cm (24 in.) control and non-control samples compared to 120 cm (48 in.) control and non-control samples.

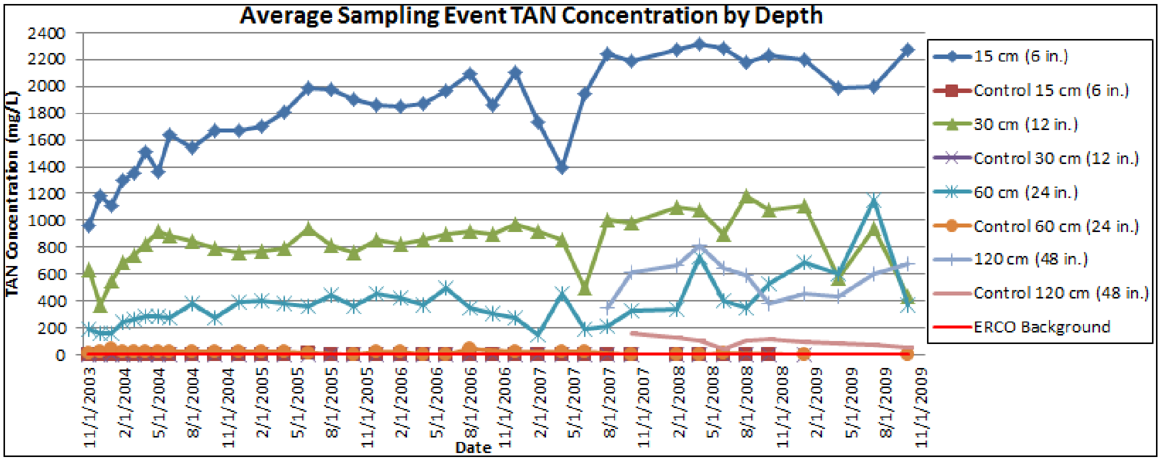

Figure 86. Average TAN Concentration by Depth

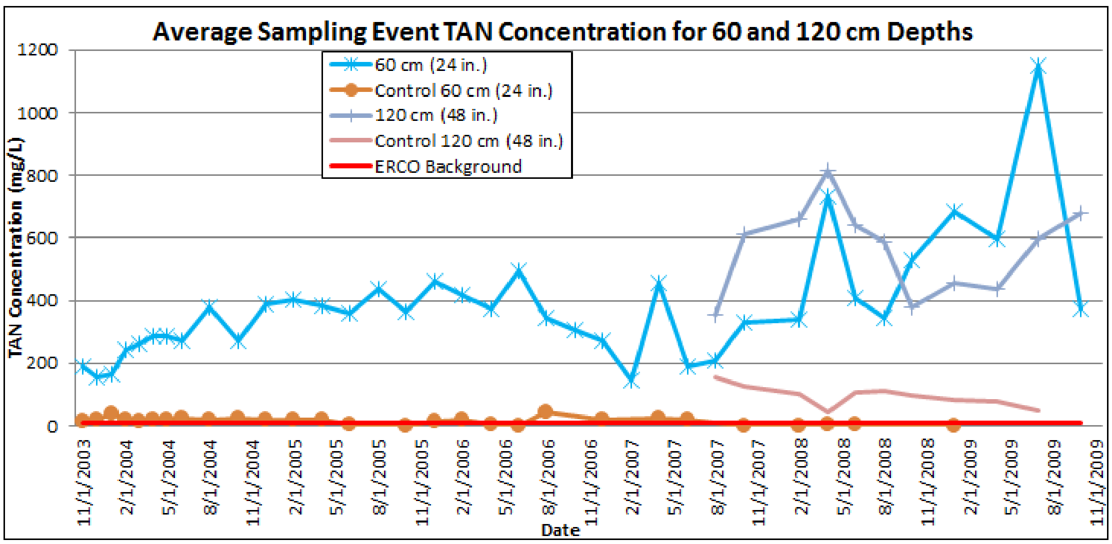

Figure 87. Average TAN Concentration for 60 and 120 cm Depths

One possibility for no significant difference between TAN results for depths 60 cm (24 in.) and 120 cm (48 in.) could be that the assumption of the bentonite seals around the newly installed 120 cm (48 in.) lysimeters did not prevent water from flowing down the drilled hole through fissures or other preferential flow. If the area of the most recent installation was still disturbed water would flow directly from the biosolids without the soil profile filtering out nutrients.

Although TAN values at or near the ERCO background concentration of 4 to 9 mg/L were expected for the control 120 cm (48 in.) samples, the lowest TAN value was

45 mg/L in April 2008. The first sampling event in August 2007 was also the peak TAN value for the recently installed control 120 cm (48 in.) samples with 153 mg/L TAN. From April to August 2008 the TAN values rose until they reached 114 mg/L and then began to decrease until the last sample in October 2009 at 48 mg/L TAN. At no point in the 12 samples did the control 120 cm (48 in.) TAN values equal the ERCO background concentration of 4 to 9 mg/L.

Another explanation for the higher or equal TAN concentration of 120 cm (48 in.) depth to 60 cm (24 in.) depth could be tree root growth. The 120 cm (48 in.) depth lysimeters were purposefully installed in areas without tree roots to represent a worst-case scenario for nutrient leaching. It is also possible that even if trees were established where the new lysimeters were installed, that due to unfavorable weather conditions the tree roots may not have been able to reach the 183 to 244 cm (72-96 in.) depth where the deepest lysimeter is located, but could reach the 120 to 183 cm (48 -72 in.) depth where the 60 cm (24 in.) lysimeter is located.

TAN Concentration by Tree Density

From the beginning of the study in November 2003 until June 2006 the non-control 0 trees/ha (0 trees/ac.) had the highest TAN values, peaking in August 2005 at 1,411 mg/L. Beginning in August 2006 to the end of the study in October 2009 the highest tree density of 1,074 trees/ha (435 trees/ac.) had the highest TAN values with four exceptions. All four exceptions belonged to the 716 trees/ha (290 trees/ac.) in August 2007, October 2008, January 2009, and April 2009. The peak TAN value by tree density averages was 1,536 mg/L in July 2009 in the 1,074 trees/ha (435 trees/ac.) group. The control group with 0 kg N/ha (0 lbs. N/ac.) and 0 trees/ha (0 trees/ac.) had TAN values within the ERCO soil background range of 4-9 mg/L until August 2007 when the values begin to rise and eventually peak at 106 mg/L in August 2008 as seen in Figure 88.

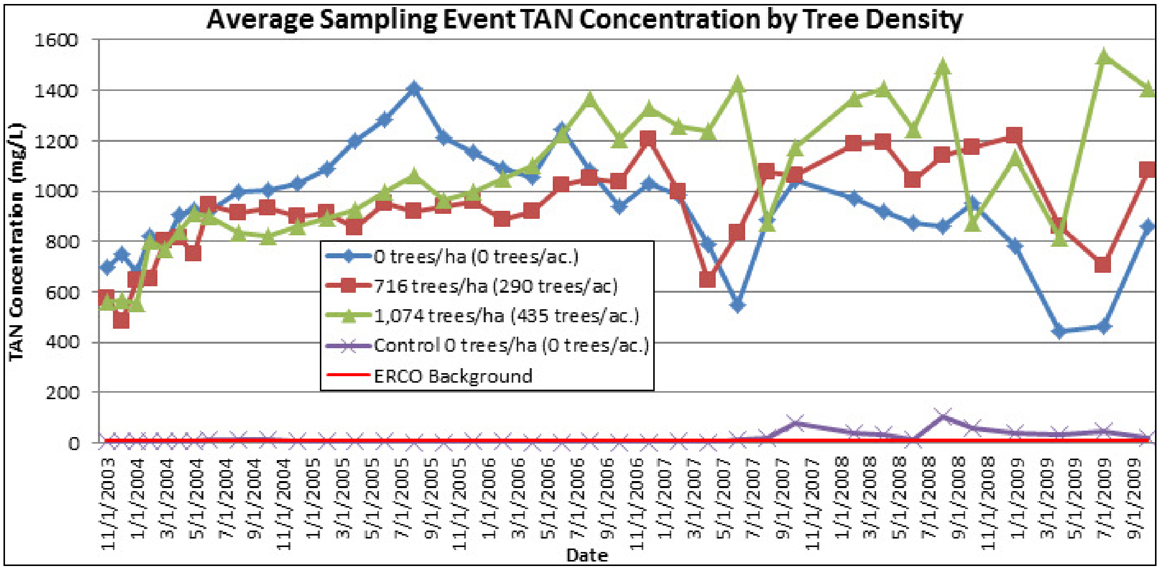

Figure 88. Average TAN Concentration by Tree Density

TAN Concentration by Application Rate and Tree Density

In the beginning of the study, the higher TAN rates belonged to the 19,650 kg N/ha (17,400 lbs. N/ac.) and 58,900 kg N/ha (52,000 lbs. N/ac.) with 0 trees/ha (0 trees/ac.). By April 2007 the peak TAN values belong to the highest biosolids application rate of 58,900 kg N/ha (52,000 lbs. N/ac.) with 716 trees/ha (290 trees//ac.) and 1,074 trees/ha (435 trees/ac.). The highest TAN value of 2,550 occurred in June of 2007 in the 58,900 kg N/ha (52,000 lbs. N/ac.) and 1,074 trees/ha (435 trees/ac.) subplot. Figure 89 shows the average TAN concentration per sampling event by biosolids application rate and tree density.

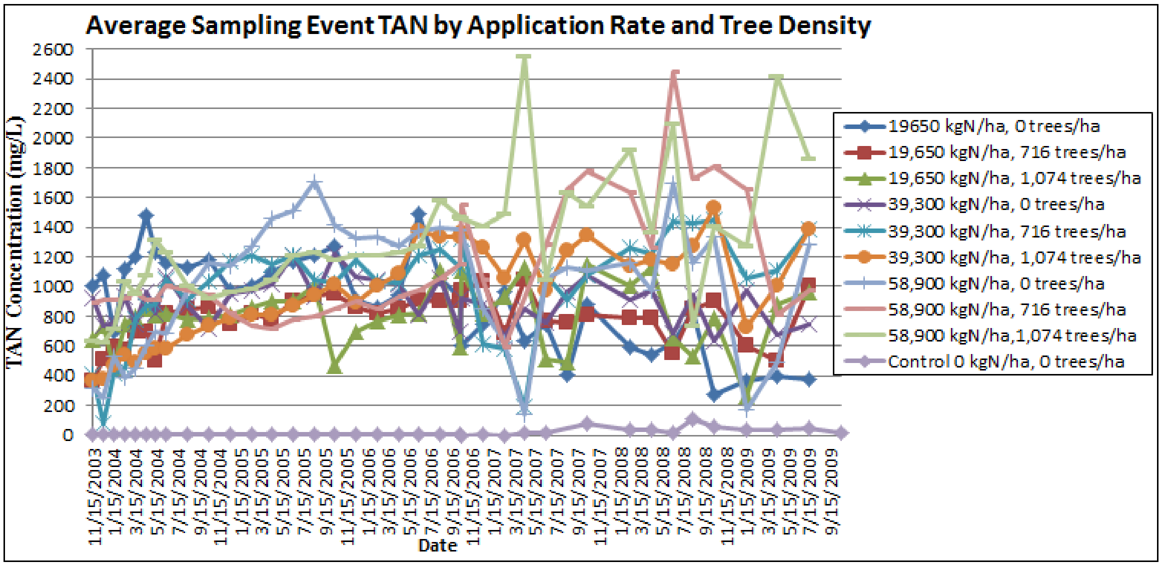

Figure 89. Average TAN Concentration by Application Rate and Tree Density

TAN Concentration by Depth and Tree Density

Once the samples were averaged by depth and tree density, the majority of event and the maximum peak TAN values belonged to the 15 cm (6 in.) and 0 trees/ha (0 trees/ac.) subgroup. The maximum TAN value was 3,108 mg/L for the 15 cm (6 in.) and 0 trees/ha (0 trees/ac.) subgroup in August 2007. January 2009 was the only sampling event that the 15 cm (6 in.) and 0 trees/ha (0 trees/ac.) subgroup did not have the peak TAN value. Instead, the 15 cm (6 in.) and 1,074 trees/ha (435 trees/ac.) subgroup's TAN value was 2,445 mg/L, followed closely by the 15 cm (6 in.) and 716 trees/ha (290 tress/ac.) subgroup's TAN value of 2,402 mg/L. Throughout the study, the shallowest sampling point at 15 cm (6 in.) was more susceptible to change as a result of available precipitation and proximity to the biosolids. Figure 90 also shows the general trend of TAN concentrations decreasing as depth from the biosolids increases.

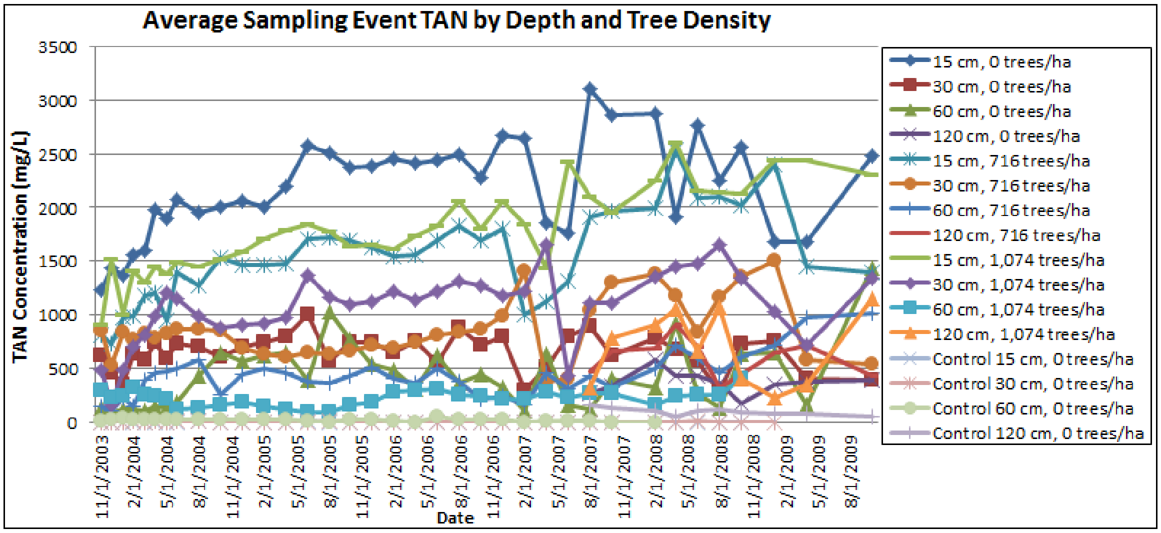

Figure 90. Average TAN Concentration by Depth and Tree Density

Distance from the biosolids is clearly the primary factor concerning TAN concentrations. Application rate is a contributing factor for TAN concentration, but to a lesser extent than distance from the biosolids. To accommodate the higher biosolids application rates, the trenches were deeper. The deeper trenches affected NO_3-N and TAN migration in two distinct ways. First, water from a precipitation event took longer to infiltrate to and through the biosolids with deeper application rates, resulting in delayed NO_3-N and TAN responses. Second, the hybrid poplar tree roots took longer to completely penetrate the biosolids pack at the higher application rates than at the lower application rates. Therefore, oxygen interactions within the bottom portion of the higher application rate biosolids pack were delayed and less frequent than oxygen interactions with the lower application rate biosolids. The reduced oxygen interactions resulted in less NO_3-N and TAN migration from the higher application rate biosolids at the beginning of the experiment.

The trees grew well during the first two years with survival rates of 86% and 97% respectively. From 2005 to 2007 significant reductions in rainfall inhibited tree growth and survival rates fell to as low as 65% (Kays and Felton, 2008). During this period from 2005 to 2007 the TAN values were fairly constant while the NO_3-N values had isolated peaks. The isolated NO_3-N peaks most likely coincide with rain events that penetrated the cracks in the surface and macropores beneath the surface creating preferential flow and introducing oxygen to the system. Tree survival was not dependent on application rate or density, but was linked to location in the experimental plot. Trees grew better in areas with higher percentages of clay in the soil. The clayey soils retain moisture and sustain tree growth. Therefore, according to Kays and Felton (2008), the trees in Block 3 had a 20% increased survival rate over those in Block 1 with more sand and gravel composition. Tree survival rates from 2003 to 2007 are shown in Figure 91.

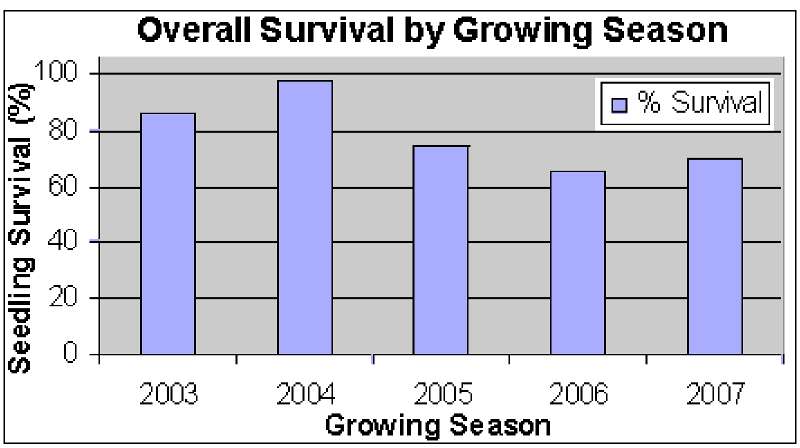

Figure 91. ERCO Tree Survival Rates 2003-2007 (Kays and Felton, 2008)

As the trees grew during the initial years of the study the areas with trees had less TAN concentration in the leachate by as much as 491 mg/L in August 2005. Beginning in 2006, however tree subplot leachates were higher in TAN than subplots without trees by as much as 1,075 mg/L. Even though plants uptake nitrogen in water-soluble, inorganic forms, such as NH_4^+/NH_3 and NO_3^-, no explanation is available for why TAN concentrations are higher in areas with tree growth for the second half of the study.

Though there are no trees planted in the 0 trees/ha (0 trees/ac.) plots, the plots are covered with vegetation. Grasses, weeds, and small bushes are receiving a nutrient source, most likely from the biosolids. The volunteer vegetation establishes shorter roots faster and may be removing nutrients from the biosolids before they are leached to the groundwater and sample lysimeters, especially since Walker (1974) found that sludge dewatering proceeds from the top of the row to the bottom of the row.

<u>*Biosolids Analysis*</u>

2003 Biosolids Results

Prior to installation in 2003, the biosolids were dewatered and stabilized to a pH of 12 with lime. A summary of the monthly samples collected prior to biosolids installation is shown in Tables 19 and 20. According to Buswell's (2006) thesis, the biosolids nutrient concentrations were steady throughout the monthly sampling with the exception of magnesium (Mg) and TAN. The TAN outlier valued at 15,100 mg/kg (1.51%) dry weight occurred on 3/26/2003. The average TAN concentration was 2,700 mg/kg (0.27%) dry weight. The Mg outlier valued at 28,500 mg/kg (2.85%) dry weight occurred on 11/27/2003 and was significantly higher than the average Mg concentration of 3,100 mg/kg (0.31%) dry weight. Removing outliers decreases the coefficient of variation from 0.81 to 0.30 for TAN and from 1.4 to 0.16 for Mg, resulting in more consistent biosolids characteristics throughout the months. Table 20 shows the changes in the Coefficient of Variation after removing the TAN and Mg outliers.

Table 19. 2003 Biosolids Analysis Results on a Dry Weight Basis in Percent (Buswell, 2006)

Descriptive Statistic	% Total Solids	% TN	% TAN	% P_2O_5
Mean	28.24	4.12	0.27	2.99
Standard Deviation	3.55	0.43	0.22	0.36
Coefficient of Variation	0.1257	0.1044	0.8148	0.1204

Table 20. 2003 Biosolids TAN and Magnesium Comparisons (dry weight basis) (Buswell, 2006)

Descriptive Statistic	TAN %, with Outlier	TAN %, without Outlier	Mg %, with Outlier	Mg %,without Outlier
Mean	0.27	0.23	0.31	0.24
Standard Deviation	0.22	0.07	0.43	0.04
Coefficient of Variation	0.8148	0.3043	1.3871	0.1667

2008 Biosolids Results

In 2008 biosolids were taken from all 30 subplots. None of the samples contained tree roots as the samples were taken in areas without tree growth to indicate a worst case scenario of deep row applied biosolids without plant uptake. Table 21 shows the mean, standard deviation and coefficient of variation without adjustment for the control plots without biosolids. Results that were below the detection limit were calculated at two-thirds the detection limit to match the calculations in Buswell's study for comparison (Buswell, 2006).

The coefficient of variation for the percentage of total solids, total N, TKN, TAN, and organic carbon were equal to or less than 0.33, indicating a strong representation of the mean. Total phosphorus on the other hand had a coefficient of variation of 0.50, indicating more variation in the mean than for total solids, total N, TKN, TAN, and organic carbon. The NO_2+NO_3 coefficient of variation was the highest for the control biosolids at 1.0. This would normally indicate a poor representation of the mean, however in this circumstance most of the NO_2+NO_3 values were below the detection limit.

Essentially the NO_2+NO_3 mean of 0.0002 is equivalent to 0 with a standard deviation of 0.0002.

Table 21. 2008 Control Solids (0 kgN/ha, 0 lbs. N/ac.) Analysis Results (Dry Weight Basis)

Descriptive Statistic	% Total Solids	%TN	%TKN	%TAN	% NO_2+NO_3	% Total Phosphorus (TP)	% Organic Carbon (OC)
Mean	86.35	0.04	0.03	0.02	0.0002	0.02	1.53
Standard Deviation	3.30	0.01	0.01	0.00	0.0002	0.01	0.18
Coefficient of Variation	0.0382	0.2500	0.3333	0.0000	1.0000	0.5000	0.1176

Averaging all of the treatment results (27 in all) without regard to the application rate results in decreases in total nitrogen and moisture content from the original application in 2003. Table 22 summarizes the mean, standard deviation, and coefficient of variation for the 2008 biosolids characterization samples. All of the parameters for the 2008 biosolids samples had coefficient of variation values greater than 0.3767, indicating large variation among the values. Of particular interest is the coefficient of variation for NO_2+NO_3 at 19. As previously discussed, the NO_2+NO_3 values were mostly below the detection limit and had a computed mean of 0.0002, essentially 0 with a standard deviation of 0.0038, which is also nearly 0.

Table 22. 2008 Unadjusted Biosolids Analysis Results (Dry Weight Basis)

Descriptive Statistic	% Total Solids	% TN	% TKN	% TAN	% NO_2+NO_3	% TP	% OC
Mean	39.74	2.21	2.21	0.93	0.0002	1.32	21.59
Standard Deviation	14.97	0.9236	0.9253	0.4625	0.0038	0.6057	10.41
Coefficient of Variation	0.3767	0.4179	0.4187	0.4973	19.0000	0.4589	0.4822

All of the results, including the control plots, except plot 2I had NO_2-N results below the detection limit of 1 mg/kg. Sample 2I had 2.1 mg/kg NO_2-N. The average nitrite-nitrate (NO_2+NO_3) concentration for the 27 treatment plots was 11.04 mg/kg NO_2+NO_3 on a dry basis. Sample 3D had 198.8 mg/kg NO_2+NO_3, more than ten times the average. Based on these inflated results, samples 2I and 3D are designated as outliers and removed from further calculations. Both 2I and 3D are in the 19,650 kg N/ha (17,400 lbs. N/ac.) treatment with 0 trees/ha (0 trees/ac). This application rate was the lowest biosolids application rate (481 dry Mg/ha or 215 dry ton/ac.) and shallowest depth of biosolids (0.32 m or 12.5 in.) Table 23 summarizes the individual results for samples 2I and 3D in mg/kg instead of percent for NO_2-N and NO_2+NO_3 in order to better illustrate the differences. Changes in the biosolids results after removing outliers 2I and 3D are shown in Table 24. After the outliers were removed, the coefficients of variation for total solids, total N, TKN, TAN, NO_2+NO_3, total P, and organic carbon were still above 0.3, indicating large variation around the mean. Again, the largest coefficient of variation value belonged to NO_2+NO_3 at 0.67. Most NO_2+NO_3 values were below detection limits. The NO_2+NO_3 mean was 0.0003 with a standard deviation of 0.0002, both values being equivalent to 0.

Table 23. 2008 Biosolids Analysis Results for Outliers (Dry Weight Basis)

Descriptive Statistic	% Total Solids	% TN	% TKN	% TAN	NO_2+NO_3 mg/kg	NO_2-N mg/kg	% TP	% OC
2I	34.69	2.26	2.26	0.23	13.8	6.054	0.98	27.64
3D	84.99	0.18	0.16	0.11	198.8	0.788	0.03	1.907
Unadjusted Mean (27 samples)	39.74	2.21	2.21	0.93	11.04	2.01	1.32	21.59

Table 24. 2008 Adjusted Biosolids Analysis Results without Outliers on a Dry Weight Basis

Descriptive Statistic	% Total Solids	% TN	% TKN	% TAN	% NO_2+NO_3	% TP	% OC
Mean	38.14	2.29	2.29	0.99	0.0003	1.39	22.14
Standard Deviation	12.40	0.86	0.86	0.42	0.0002	0.56	9.97
Coefficient of Variation	0.3251	0.3755	0.3755	0.4242	0.6667	0.4029	0.4503

Comparisons of 2003 and 2008 Biosolids Analyses

The following discussion incorporates the results without the controls and outliers (2I and 3D). Overall, the average total solids increased from 28.24% in 2003 to 38.14% in 2008. Total nitrogen has decreased on average from 4.12% in 2003 to 2.29% in 2008. In 2003 the biosolids phosphorus was analyzed in phosphorus oxide (P_2O_5) to show the available phosphorus for plant consumption, similar to fertilizer labels. The available phosphorus in P_2O_5 in 2003 was 2.99%. In 2008 the total phosphorus was 1.39%. Since P_2O_5 was not measured in 2008, a direct comparison cannot be made, other than the total phosphorus in the biosolids decreased with time. Similarly organic carbon was not measured in 2003 and metals were not measured in 2008, so no comparisons can be made for these constituents.

Plotting the major constituents remaining in the biosolids as of 2008 did not show any trends by application rate or tree density. The controls without biosolids and trees had the highest percentage of total solids and the least amount of organic carbon, total phosphorus, NO_3-N, and TAN. From Figures 92 and 93, it appears as though the organic carbon decreases as the moisture content decreases. Even though plot 3E had the highest application rate of 58,900 kg N/ha (52,000 lbs. N/ac.) and no trees, its solids content of 66.71% was higher than the mean solids content of 38.14%. On a percentage basis, NO_3-N concentrations for all of the biosolids were negligible.

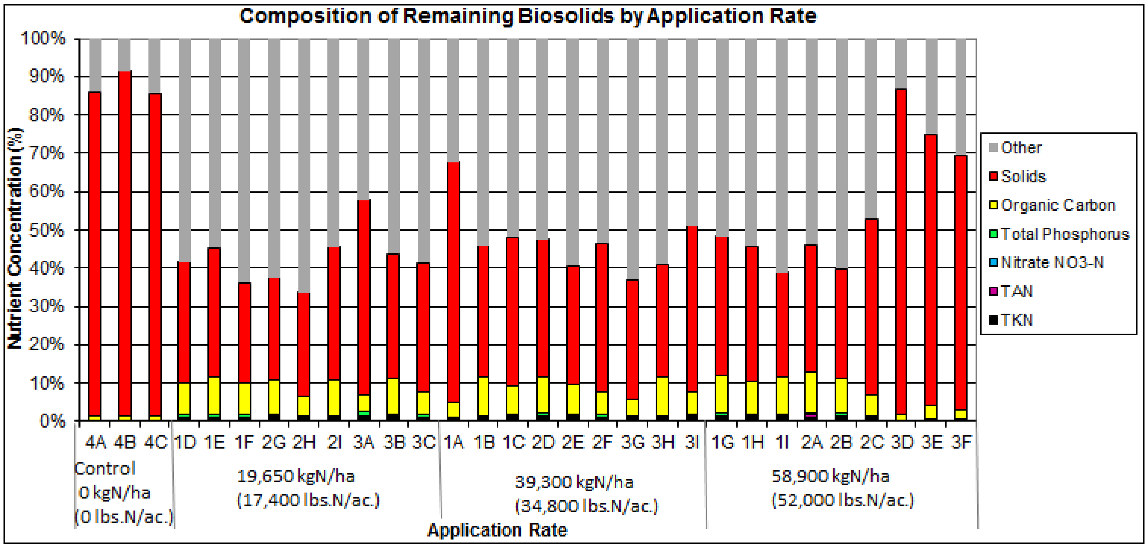

Figure 92. Composition of Remaining Biosolids in 2008 by Application Rate

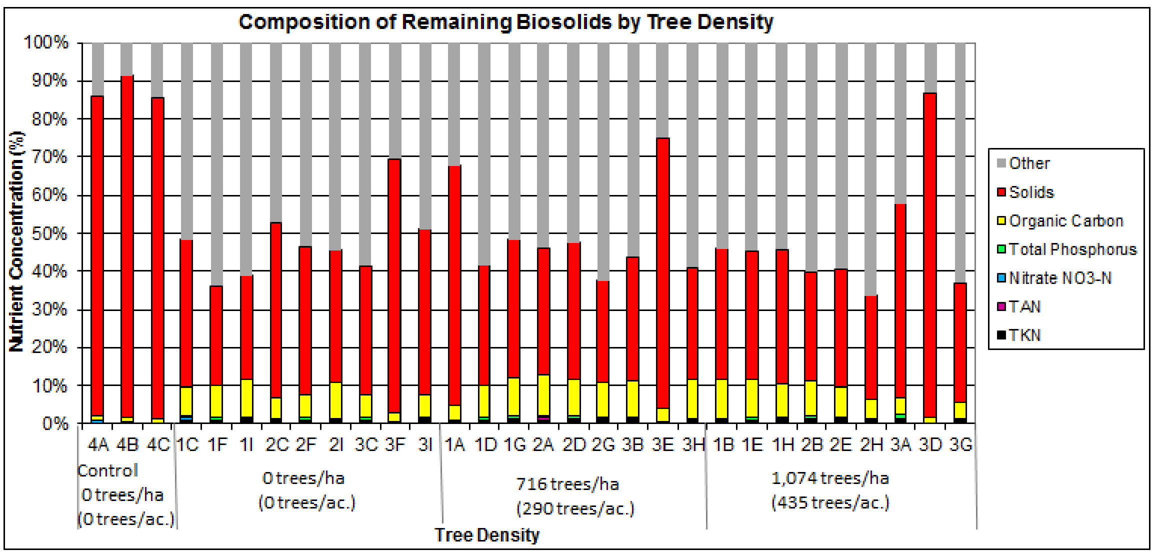

Figure 93. Composition of Remaining Biosolids in 2008 by Tree Density

During the installation of the lysimeter at 120 cm (48 in.) depth, it was noted that the biosolids in Block 3 at the top of the hill were drier than the biosolids in other blocks. Figure 94 shows the difference in moisture content in July 2007 for plots 2D with 36.12% solids (39,300 kg N/ha or 34,800 lbs. N/ac., 716 trees/ha or 290 trees/ac.) and 3D with 84.99% solids (58,900 kg N/ha or 52,000 lbs. N/ac., 1,074 trees/ha or 435 trees/ac.).

Figure 94. July 2007 biosolids moisture content differences
On the left is a sample from Plots 2D with 36.12% solids and on the right is a sample from Plot 3D with 84.99% solids.

Comparisons of ERCO Biosolids to Sikora et al. Studies (1982)

Sikora et al. (1982) noted that within two years of the application of sludge, the upper most part of the sludge, about 5-20 cm (2-8 in.) from the top of the trench was significantly dry and contained dense root masses. Dewatering did not occur in the lower parts of the sludge rows until the fourth year. Similarly, Walker (1974) found that sludge dewatering proceeded from the top of the row to the bottom of the row. When the 120 cm (48 in.) suction lysimeters were installed the top layers of biosolids were also drier than those at the bottom of the trench. The 2008 biosolids samples also had less moisture content than the original biosolids applied in 2003 following the results of Sikora et al. (1982). Root masses were not observed in the ERCO 2007 lysimeter installation or 2008 biosolids sampling since drilling avoided areas of tree growth.

Effects of Biosolids Decomposition on Soil Water Samples

To best see the effects of biosolids decomposition on the soil water leachate, the data for each application rate were averaged per year and graphed (Figures 86 and 87).

The overall trends for soil water leachate NO_3-N and TAN concentrations increase over time contrary to the NO_3-N and TAN concentrations decreasing over time in the biosolids. This is particularly evident in the control (0 kg N/ha or 0 lbs. N/ac.) group which had negligible NO_3-N concentrations in the biosolids with the highest NO_3-N soil water leachate concentrations throughout the study. Therefore, as the biosolids decomposed and the nutrients in the biosolids decreased, the nutrients in the leachate increased in concentration because decomposition produces soluble compounds which leach out of the soil profile as shown in Figures 95 and 96 (Ferguson, 2008).

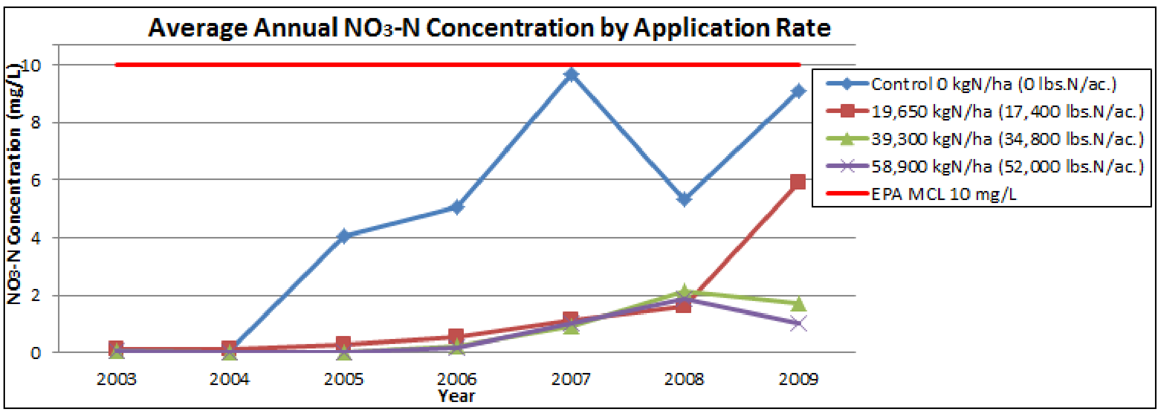

Figure 95. Effects of Biosolids Decomposition on NO_3-N Concentrations

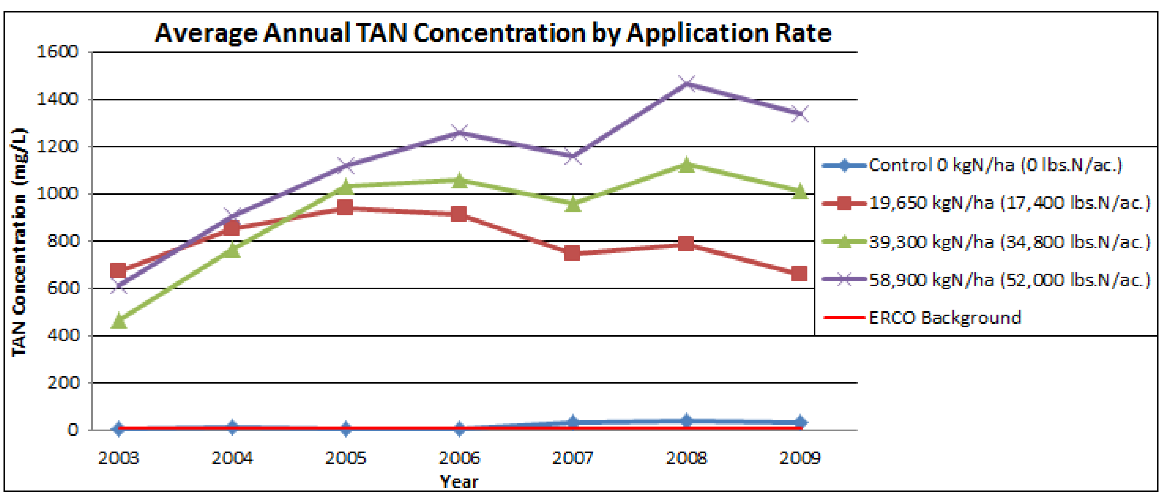

Figure 96. Effects of Biosolids Decomposition on TAN Concentrations

Weather Conditions

Rain Gauge Data

The average monthly rainfall volumes were estimated from the recorded monthly rainfall volumes of each month between 2003 and 2009. On average, June was the month with the highest average rainfall (12.1 cm or 4.78 in.) and the months of January through March had the lowest average precipitation which was about half of June's average (6 cm or 2.3 in.). Extremely low precipitation volumes occurred September 2005 (0.33 cm or 0.13 in.) and March 2006 (0.38 cm or 0.15 in.). Despite having one of the record lows for precipitation in March, 2006 also had the highest rainfall in July of 20.85 cm (8.21 in.).

Overall, the average annual precipitation was about 106 cm (42 in.), which is above the maximum estimated water usage for poplars of 226 cm/ha-year (36 in./ac.-year) (EPA[2], 1999). Figure 97 is a graph of the monthly precipitation averages of the onsite data throughout the study compared to the average calculated by The Weather Channel (2012). Missing data points from the rain gauge were supplemented with data from the National Oceanic Atmospheric Administration (NOAA) (2012).

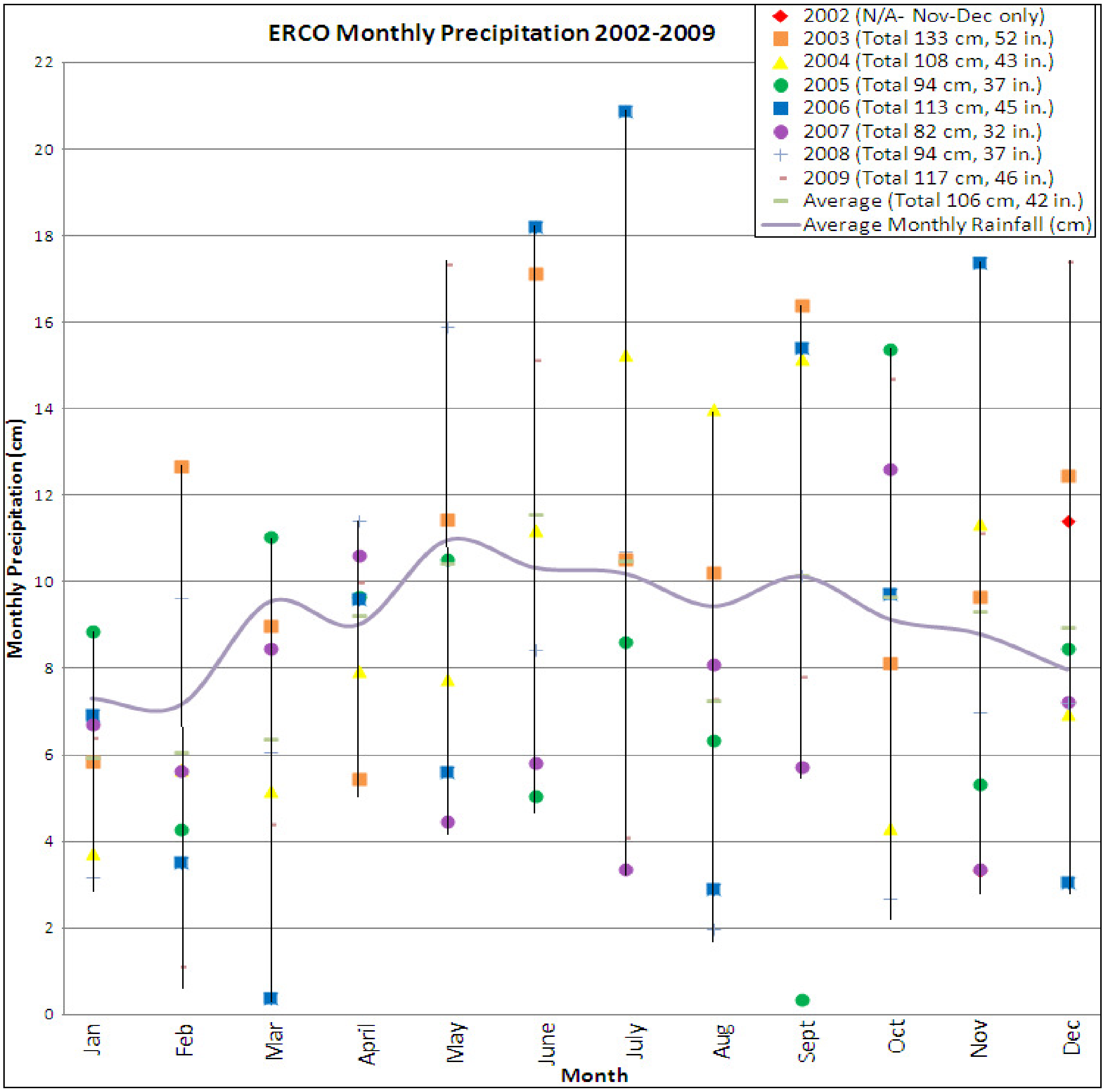

Figure 97. ERCO Average Monthly Precipitation Data 2002-2009 (The Weather Channel, 2012; NOAA[1], 2012)

Ambient Temperature

Although the ambient temperature does not directly affect the microbial activity beneath the surface, the ambient temperature does affect the hybrid poplar's tree growth. During the winter the hybrid poplar is dormant with some mild root growth below the surface (Fast Growing Trees Nursery, 2009). With no leaves or branch growth, the hybrid poplar does not uptake as many nutrients during dormancy as it does during growth seasons.

From 2003 to 2009, the yearly average temperature was 14.14°C (57.45°F) (NOAA[2], 2012). Throughout the study the lowest average monthly temperature was -1.270 °C (29.72 °F) in January 2004 and the highest average monthly temperature was 26.67 °C (80.01 °F). The month of January had the largest variability ranging from -1°C to 6°C (30°F–43°F). Typically the monthly temperature lows and high values were less than a 4°C difference. A graphical display of the average monthly temperatures compared to the overall average temperature expected each month is shown in Figure 98.

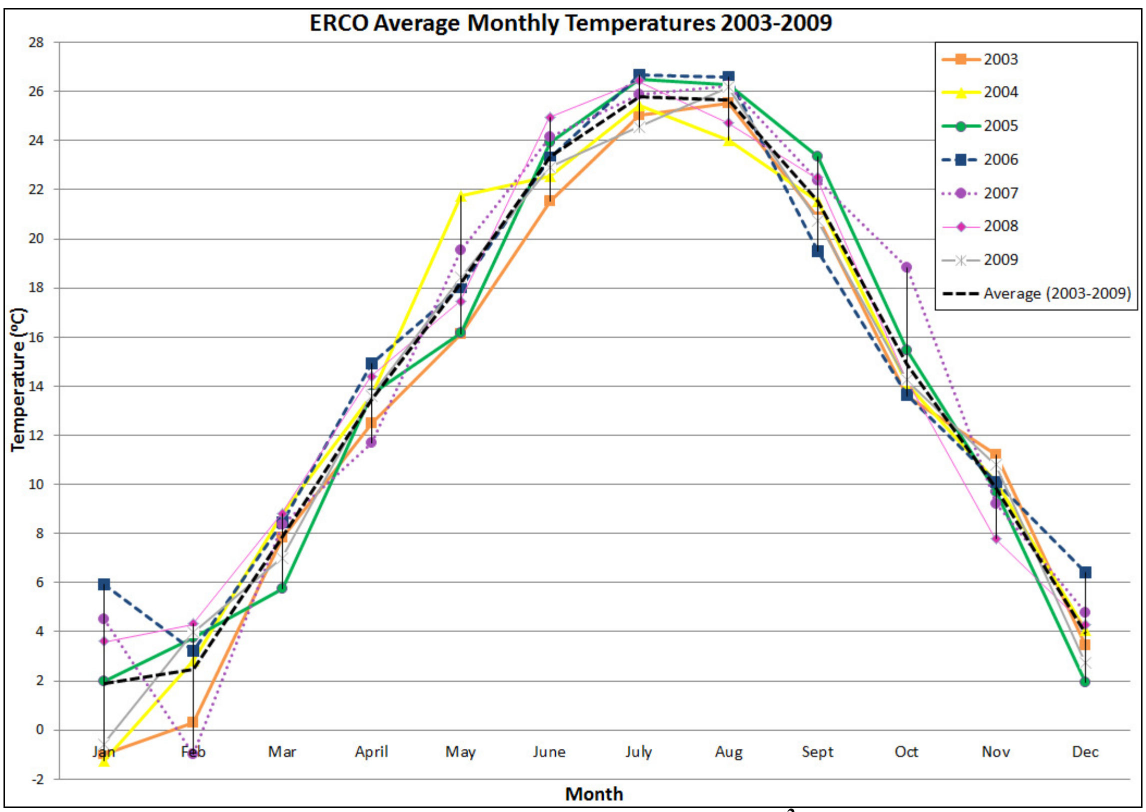

Figure 98. ERCO Average Monthly Temperatures 2002-2009 (NOAA[2], 2012)

Soil Temperature

USDA classifies the thermal properties of ERCO's soil as "mesic" (USDA, 2003). This classification refers to soils with mean temperatures between 8-15^{o}C (46-59^{o}F) at a minimum depth of 50 cm (20 in.) below the surface (USDA, 2010). As described earlier the top layer of biosolids sit under 46–76 cm (18-30 in.) of backfill. Therefore the depths of the microbial activity within the biosolids and the depths of the soil water sampling sites meet the USDA mesic definition. The assumed soil temperature throughout the study is 8-15^{o}C (46-59^{o}F) based on ERCO's location in Figure 99.

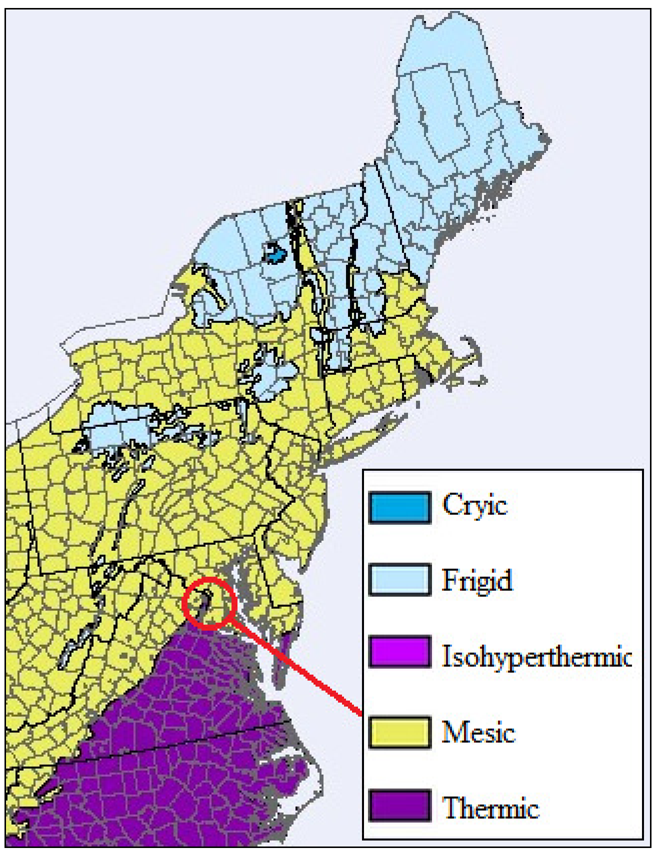

Figure 99. USDA Soil Regimes (2003)- ERCO resides within the red circle

Recall that the optimal temperature for microbial growth rate is around 38^{o}C (100^{o}F) (Gaudy and Gaudy, 1980). The soil temperature at ERCO is far below the optimal temperature. In fact nitrification at 11°C (52°F) takes 12 weeks for completion (Ferguson, 2008). After 12 weeks at 8°C (47°F) nitrification is estimated at 70-percent complete according to Ferguson (2008).

Effects of Weather and Soil Conditions on Soil Water Samples

Samples excluding outliers were averaged by month for each year of the study (2003-2009) to see if there were seasonal variations. The highest NO_3-N values occurred in the winter months of December and January as seen in Figure 100. The control group varies more with seasonal conditions, including temperature and rainfall than samples beneath biosolids rows.

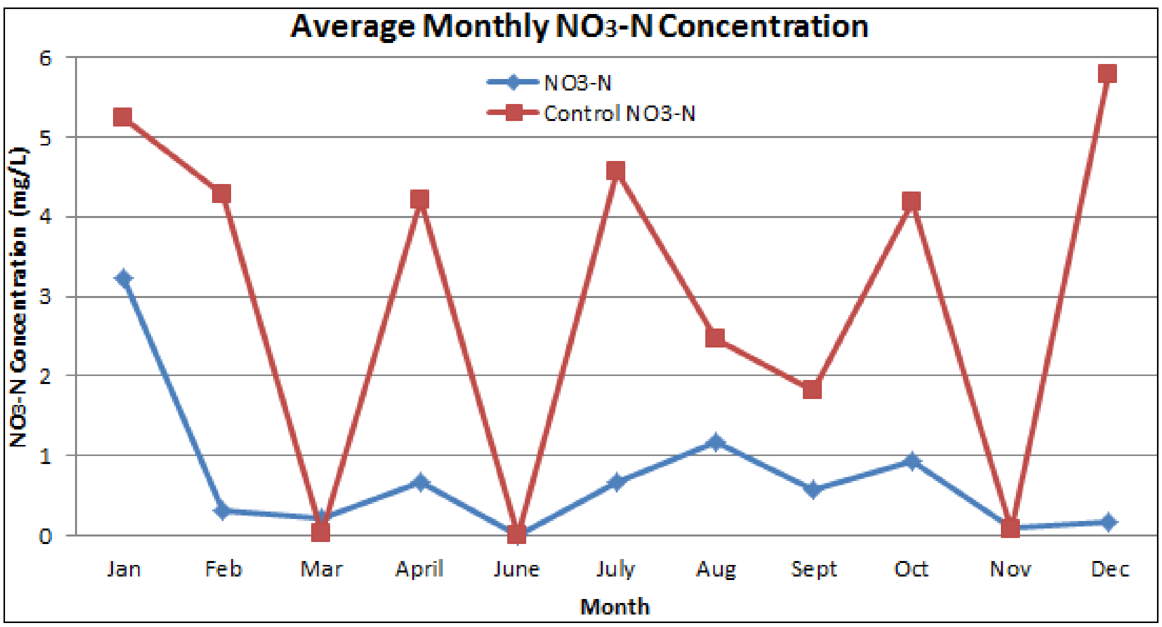

Figure 100. Average Monthly NO_3-N Concentration from 2003-2009

Unlike the NO_3-N concentrations the average TAN of samples averaged by month throughout the study more variability among non-control samples. November had the lowest average TAN value of 595 mg/L for non-control samples and 6.30 mg/L for samples in the control group. Coincidently, November had the second lowest NO_3-N concentrations of 0.091 mg/L and 0.067 mg/L for samples in treatment conditions and control samples, respectively. Figure 101 shows the average monthly TAN values throughout the study.

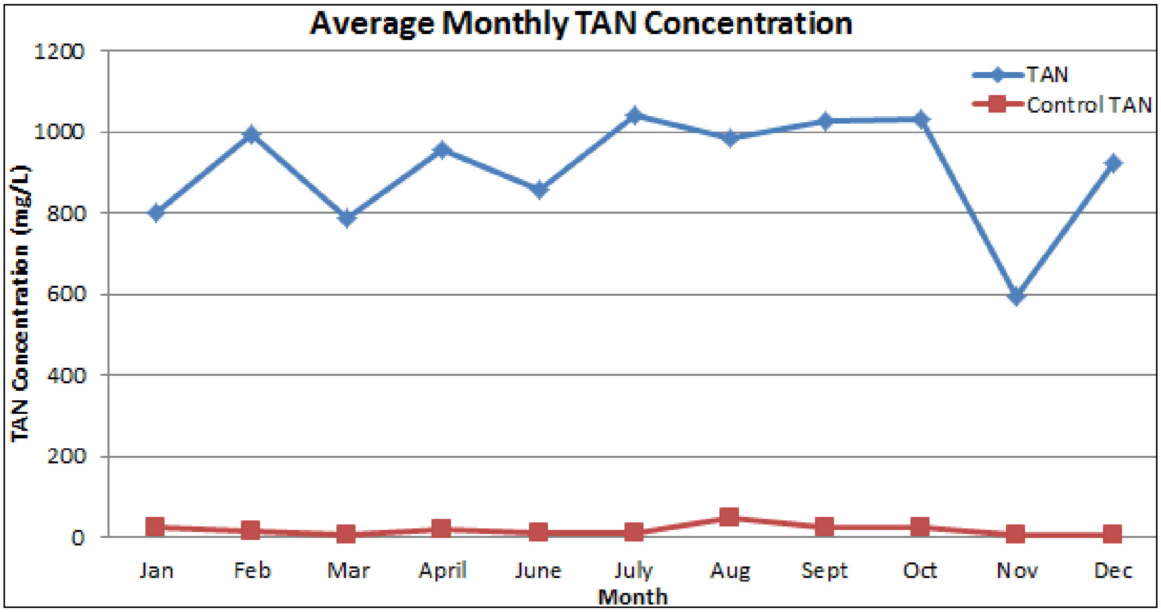

Figure 101. Average Monthly TAN Concentration from 2003-2009

Chapter 6: Conclusions

Soil Water Nitrate-Nitrogen (NO_3-N) Concentrations

- For the first two years of the study (November 2003-2005) no NO_3-N leached from the deep-row applied biosolids and hybrid poplar tree system.
- Despite having at least 100 times more nitrogen in the deep-row biosolids applications than in corn fertilizer applications, the NO_3-N leachate concentrations were no worse than those found from corn leachate.
- When samples were averaged by month, the concentrations ranged from 0 to 3 mg/L NO_3-N for samples with biosolids treatment and 0 to 6 mg/L NO_3-N for samples without biosolids treatment.
    - Control samples were more susceptible to seasonal changes in NO_3-N than samples from biosolids subplots.
- After removing the initial outliers, the NO_3-N average was 0.6744 mg/L.
    - A total of 2,257 samples or 90.6% of the NO_3-N samples returned concentrations below 1.0 mg/L. There were 2,399 samples or 96.3% that were less than the EPA MCL drinking water standard of 10 mg/L NO_3-N.
- More NO_3-N is leaching from the lower application rates than the higher application rates, which may indicate the shallower biosolids packs have increased mineralization rates.

- All depths except 15 cm (6 in.) and control 60 cm (24 in.) exhibited peak NO_3-N levels in the dry summer (June to October) of 2008. The control 60 cm (24 in.) values had a maximum NO_3-N value of 40.03 mg/L in February 2008.
- No NO_3-N values within tree plots exceeded 2 mg/L throughout the study.

Soil Water Total Ammoniacal Nitrogen (TAN) Concentration

- After removing the initial outliers, the average TAN was 959.6 mg/L.
    - Less than 5% of TAN samples were lower than 10 mg/L.
    - The majority (83.5%) of the TAN values were less than 2,000 mg/L.
    - About 2.4% of the samples had values at the ERCO TAN background concentration of 4 to 9 mg/L.
- The control group (0 kg N/ha or 0 lbs. N/ac.) had the lowest TAN concentrations, barely higher than the ERCO background levels of 4 to 9 mg/L
- TAN concentrations followed application rates.
    - TAN values increased with higher application rates and decreased with lower application rates.
    - The lowest application rate resulted in lower TAN values than the other application rates' TAN concentrations from 2005 until the end of the study.
- TAN decreases as the distance from the biosolids increases up to 60 cm (24 in.).
- Beginning in 2006, tree subplot leachates were higher in TAN than subplots without trees by as much as 1,075 mg/L.

  - Though there are no trees planted in the 0 trees/ha (0 trees/ac.) plots, the plots are covered with vegetation. The volunteer vegetation may be removing nutrients from the biosolids before they are leached to the groundwater and sample lysimeters, especially since Walker (1974) found that sludge dewatering proceeds from the top of the row to the bottom of the row.
- When samples were averaged by month, the concentrations ranged from 595 to 1,042 mg/L TAN for samples with biosolids treatment and 6.30 to 46.6 mg/L TAN for samples without biosolids treatment.
  - Samples beneath biosolids rows were more susceptible to seasonal changes than control samples.

Biosolids

Nutrient Concentrations and Decomposition

- As the biosolids decompose and the nutrients in the biosolids decrease, the nutrients in the leachate increase in concentration because decomposition produces soluble compounds which leach out of the soil profile (Ferguson, 2008).
  - Comparing the 2003 and 2008 biosolids samples showed that organic Carbon decreases as the moisture content decreases.
  - The controls without biosolids and trees had the highest percentage of total solids and the least amount of organic Carbon, total Phosphorus, NO_3-N, and TAN.
  - The installation depth of the biosolids impacts the dewatering process. Higher application rates had deeper biosolids packs.

Chapter 7: Future Work

Despite the seven years of data from 38 sampling events, and 2,604 non-lateral suction lysimeter samples; the intrinsic nature of science toward improvement and precision lends this study to future modifications. Recommendations to improve data collected in future studies with similar goals and scopes include:

- **Observation:** In 2007 significant damage from animal interactions and the sun's ultraviolet rays were observed in the tubing. Several attempts were made to repair and replace external portions of the affected tubes; however there still were declines in sample volumes.
  - Recommendation: Use more UV resistant tubing or replace tubing after 2 years on all apparatuses.

- **Observation:** Nutrient sample analyses did not follow recommended compliance standards and holding times.
  - Recommendation: Adhere to approved methods and holding times for more direct comparisons to other studies and regulatory limits. This may also meet compliance for groundwater monitoring permit requirements. The holding times range from 48 hours for NO_3-N and NO_2-N to 28 days for Total Kjeldahl Nitrogen (TKN) and TAN (NAVSEA, 2009).

- **Observation:** In the winter of 2007 one blank sample that should have contained 0 mg/L NO_3-N had a result of 27.86 mg/L NO_3-N, showing contamination from improper handling.
  - Recommendation: "Clean Hands, Clean Jar" (Delta Environmental, 2004) - Typically the "Clean Hands, Clean Jar" sampling method is used for bacteriological sampling and drinking water sampling to prevent cross contamination. However, since the December 2007 samples showed obvious signs of sampling and/or analysis error, adopting this sampling technique may decrease cross contamination. The "Clean Hands, Clean Jar" sampling method involves a new pair of gloves and a clean jar for each sampling location. This sampling technique deposits the sample directly into the container, which would remove the graduated cylinder from the study's procedure. With 183 suction lysimeter (including 3 blank samples) and 33 pan lysimeter (including 3 blank samples) samples per month, this sampling technique may become costly and is recommended for a smaller scale study.
  - Recommendation: "Clean Hands, Dirty Hands" (CAEPA, 2011) – If two people are available for sampling, one team member would perform sampling duties requiring "clean hands", while another member would perform duties designated as "dirty hands". For the ERCO study, the "dirty hands" team member would be responsible for connecting the suction lysimeter tubes to the pump, opening the sampling tubes, applying pressure to the pump for sample release, recording field notes, and labeling bottles. The "clean hands" ERCO team member would rinse the sampling tube with distilled water to wash away any foreign debris and particles, hold a clean jar to the tube for sample collection, and cap the sample. An added bonus to the

"Clean Hands, Dirty Hands" method is increased safety from sampling in teams of two or more.

- **Observation:** Several unknowns in this study are linked to microorganism involvement in the soil and root zones.
    - Recommendation: Classify and identify microorganisms in the soil to better understand the underground biosolids ecosystem.

- **Observation:** Biosolids samples were taken prior to application and again in 2007. Both biosolids samples did not include areas near tree roots to show "worst-case scenarios".
    - Recommendation: Collect and analyze biosolids located beside tree roots, under tree roots, and in the control plots without trees. The biosolids samples should be taken seasonally to see how the tree growth affects biosolids decomposition rates and microbial interaction.

- **Observation:** Precipitation and temperature data were collected to assist in explaining data trends; however the climate data is not an accurate representation of underground soil and biosolids conditions.
    - Recommendation: Install tensiometers in line with lysimeters to provide soil moisture information which will help determine the accessibility of water for the hybrid poplar trees. Tensiometers should also be installed in the biosolids rows.

- Recommendation: While taking lysimeter samples, it would be helpful to collect the soil and biosolids pH, oxygen concentration, and temperature.

- **Observation:** Lysimeter samples were taken on a scheduled basis, rather than with respect to climate or precipitation changes.
  - Recommendation: Samples should be taken prior to storm events and 72 hours after storm events to see the immediate effects of precipitation on nutrient levels in the leachate.

- **Observation:** Samples deemed outliers in this study may lead to more information about the underground microbial processes, nitrogen cycle, or preferential flow.
  - Recommendation: Outliers should be further investigated to try and determine the source of their abnormal responses to the treatments.

- **Observation:** The control data with a biosolids application rate of 0 kg N/ha (0 lbs.N/ac.) and tree density of 0 trees/ha (0 trees/ac.) has unexplainable results and higher NO_3-N and ammonia concentrations than expected, even exceeding the concentrations of samples with higher application rates.
  - Recommendation: In future studies the control plots should located in virgin plots that did not receive previous applications of biosolids in 1989.
  - Recommendation: Control plots should be further divided to incorporate all tree densities to see the effects of trees on the water quality.

- Recommendation: Different tillage options may be used to remove fissures and reduce preferential flow, encouraging natural filtration of nutrients by the soil profile and its native microbes.

- **Observation:** The Wilcoxon Rank Sum Test for Nonparametric Data (*t* Test) were significantly different between replicates for NO_3-N and TAN as shown in the Appendix. The natural, underlying conditions within the replicates, such as soil type, groundwater depth, and slope may increase variability in consequential NO_3-N and TAN concentrations.
    - Recommendation: In future studies the designated area should have less variation in soil type, groundwater depth, and slope to decrease variability in resulting NO_3-N and TAN concentrations.

Appendix 1: Sample Frequencies and Overall Summary

Table 25. 2003-2009 Summary Statistics for N Concentrations without Outliers

Variable	Observations	Obs. missing data	Min	Max	Mean	Std. Dev
NO_3-N (mg/L)	2333	0	0.000	214.709	0.971	6.607
TAN (mg/L)	2333	2	0.000	4894.591	870.360	994.369
LOG NO_3-N	2333	0	-4.187	2.332	-1.894	1.126
LOG TAN	2333	2	-3.155	3.690	2.345	1.096
pH	2333	2	4.650	11.900	7.454	0.713

Table 26. Summary Statistics Samples without Outliers

Variable	Observations	Obs. with missing data	Min	Max	Mean	Std. dev
Application Rate (kg N/ha)	2330	0	0.000	58900	35767	19416
Tree Density (trees/ha)	2330	0	0.000	1074	532.852	454.16
Depth(cm)	2330	0	15.000	120	41.652	30.032
Date	2330	0	37940	40101	38779	636.112
NO_3-N (mg/L)	2330	0	0.000	214.709	0.964	6.600
TAN (mg/L)	2330	0	0.000	4894.591	870.849	994.391
LOG NO_3-N	2330	0	-4.187	2.332	-1.895	1.124
LOG TAN	2330	0	-3.155	3.690	2.346	1.094
pH	2330	0	4.650	11.900	7.454	0.713

Table 27. Frequencies of Samples by Application Rate and Tree Density

Application Rate	Freq.	%		Tree Density	Freq.	%
Control 0 kgN/ha(0 lbsN/ac)	228	9.773		0 trees/ha (0 trees/ac.)	698	29.919
19,650 kgN/ha(17,400 lbsN/ac)	704	30.176		Control 0 trees/ha (0 trees/ac.)	228	9.773
39,300 kgN/ha(34,800 lbsN/ac)	659	28.247		716 trees/ha (290 trees/ac.)	748	32.062
58,900 kgN/ha(52,000 lbsN/ac)	742	31.805		1,074 trees/ha (435 trees/ac.)	659	28.247

Table 28. Frequencies of Samples by Depth and Block (Location)

Depth	Freq.	%		Block	Freq.	%
15 cm (6 in.)	635	27.218		1	683	29.276
Control 15 cm (6 in.)	76	3.258		Control 1	83	3.558
30 (12 in.)	715	30.647		2	699	29.961
Control 30 (12 in.)	63	2.700		Control 2	81	3.472
60 (24 in.)	574	24.604		3	723	30.990
Control 60 (24 in.)	62	2.658		Control 3	64	2.743
120 (48 in.)	181	7.758				
Control 120 (48 in.)	27	1.157				

Table 29. Frequencies of Samples by Sampling Event

Sampling Date	Sampling Date (#)	Frequencies	%
11/15/2003	37940	72	3.086
12/15/2003	37970	69	2.958
1/15/2004	38001	66	2.829
2/15/2004	38032	74	3.172
3/15/2004	38061	75	3.215
4/15/2004	38092	73	3.129
5/15/2004	38122	76	3.258
6/15/2004	38153	78	3.343
8/15/2004	38214	78	3.343
10/15/2004	38275	76	3.258
12/15/2004	38336	76	3.258
2/15/2005	38398	77	3.300
4/15/2005	38457	75	3.215
6/15/2005	38518	69	2.958
8/15/2005	38579	60	2.572
10/15/2005	38640	64	2.743
12/15/2005	38701	71	3.043
2/15/2006	38763	69	2.958
4/15/2006	38822	68	2.915
6/15/2006	38883	62	2.658
8/15/2006	38944	67	2.872
10/15/2006	39005	57	2.443
12/15/2006	39066	59	2.529
2/15/2007	39128	31	1.329
4/15/2007	39187	40	1.715
6/15/2007	39248	19	0.814
8/15/2007	39309	60	2.572
10/15/2007	39370	66	2.829
2/15/2008	39493	77	3.300
4/15/2008	39553	81	3.472
6/15/2008	39614	75	3.215
8/15/2008	39675	34	1.457
10/15/2008	39736	49	2.100
1/15/2009	39828	54	2.315
4/15/2009	39918	49	2.100
7/15/2009	40009	41	1.757
10/15/2009	40101	46	1.972

Table 30. Sample Frequencies without Outliers

Sample ID	Freq	%		Sample ID	Freq	%
SL-1A-1(3,716t/ha,15cm)	31	1.329		SL-1D-2(2,716t/ha,15cm)	32	1.372
SL-1A-2(3,716t/ha,60cm)	29	1.243		SL-1D-3(2,716t/ha,60cm)	30	1.286
SL-1A-3(3,716t/ha,30cm)	26	1.114		SL-1D-6(2,716t/ha,120cm)	5	0.214
SL-1A-6(3,716t/ha,120cm)	11	0.471		SL-1E-1(2,1074t/ha,60cm)	17	0.729
SL-1B-1(3,1074t/ha,60cm)	13	0.557		SL-1E-3(2,1074t/ha,30cm)	19	0.814
SL-1B-2(3,1074t/ha,30cm)	31	1.329		SL-1E-6(2,1074t/ha,120cm)	4	0.171
SL-1B-6(3,1074t/ha,120cm)	11	0.471		SL-1F-3(2,0t/ha,15cm)	28	1.200
SL-1C-1(3,0t/ha,60cm)	28	1.200		SL-1F-4(2,0t/ha,60cm)	27	1.157
SL-1C-5(3,0t/ha,30cm)	32	1.372		SL-1F-5(2,0t/ha,30cm)	33	1.414
SL-1C-6(3,0t/ha,120cm)	11	0.471		SL-1G-2(4,716t/ha,15cm)	32	1.372
SL-1D-1(2,716t/ha,30cm)	36	1.543		SL-1G-3(4,716t/ha,30cm)	32	1.372

Sample ID	Freq	%	Sample ID	Freq	%
SL-1G-6(4,716t/ha,120cm)	6	0.257	SL-3D-4(4,1074t/ha,60cm)	22	0.943
SL-1H-1(4,1074t/ha,15cm)	29	1.243	SL-3D-5(4,1074t/ha,30cm)	12	0.514
SL-1H-2(4,1074t/ha,30cm)	29	1.243	SL-3D-6(4,1074t/ha,120cm)	6	0.257
SL-1H-3(4,1074t/ha,60cm)	28	1.200	SL-3E-1(4,716t/ha,60cm)	24	1.029
SL-1H-6(4,1074t/ha,120cm)	9	0.386	SL-3E-2(4,716t/ha,15cm)	24	1.029
SL-1I-2(4,0t/ha,30cm)	33	1.414	SL-3E-5(4,716t/ha,30cm)	27	1.157
SL-1I-4(4,0t/ha,60cm)	23	0.986	SL-3E-6(4,716t/ha,120cm)	5	0.214
SL-1I-6(4,0t/ha,120cm)	8	0.343	SL-3F-1(4,0t/ha,15cm)	32	1.372
SL-2A-1(4,716t/ha,15cm)	22	0.943	SL-3F-2(4,0t/ha,60cm)	30	1.286
SL-2A-2(4,716t/ha,60cm)	26	1.114	SL-3F-3(4,0t/ha,30cm)	30	1.286
SL-2A-5(4,716t/ha,30cm)	28	1.200	SL-3F-6(4,0t/ha,120cm)	9	0.386
SL-2A-6(4,716t/ha,120cm)	9	0.386	SL-3G-1(3,1074t/ha,30cm)	16	0.686
SL-2B-1(4,1074t/ha,15cm)	33	1.414	SL-3G-2(3,1074t/ha,15cm)	30	1.286
SL-2B-2(4,1074t/ha,30cm)	32	1.372	SL-3G-5(3,1074t/ha,60cm)	17	0.729
SL-2B-3(4,1074t/ha,60cm)	30	1.286	SL-3G-6(3,1074t/ha,120cm)	5	0.214
SL-2B-6(4,1074t/ha,120cm)	5	0.214	SL-3H-1(3,716t/ha,15cm)	27	1.157
SL-2C-1(4,0t/ha,30cm)	28	1.200	SL-3H-3(3,716t/ha,60cm)	24	1.029
SL-2C-2(4,0t/ha,15cm)	28	1.200	SL-3H-6(3,716t/ha,120cm)	7	0.257
SL-2C-5(4,0t/ha,60cm)	25	1.072	SL-3I-1(3,0t/ha,15cm)	30	1.286
SL-2C-6(4,0t/ha,120cm)	3	0.129	SL-3I-2(3,0t/ha,60cm)	22	0.943
SL-2D-1(3,716t/ha,15cm)	18	0.772	SL-3I-5(3,0t/ha,30cm)	30	1.286
SL-2D-2(3,716t/ha,60cm)	20	0.857	SL-3I-6(3,0t/ha,120cm)	10	0.429
SL-2D-6(3,716t/ha,120cm)	8	0.343	SL-4A-1(1,0t/ha,30cm)	10	0.429
SL-2E-1(3,1074t/ha,60cm)	29	1.243	SL-4A-2(1,0t/ha,60cm)	22	0.943
SL-2E-2(3,1074t/ha,15cm)	33	1.414	SL-4A-5(1,0t/ha,15cm)	23	0.986
SL-2E-5(3,1074t/ha,30cm)	32	1.372	SL-4A-6(1,0t/ha,120cm)	9	0.386
SL-2E-6(3,1074t/ha,120cm)	5	0.214	SL-4B-3(1,0t,30cm)	29	1.243
SL-2F-1(3,0t/ha,30cm)	23	0.986	SL-4B-4(1,0t,60cm)	14	0.600
SL-2F-2(3,0t/ha,60cm)	16	0.686	SL-4B-5(1,0t,15cm)	29	1.243
SL-2F-3(3,0t/ha,15cm)	35	1.500	SL-4B-6(1,0t,120cm)	9	0.386
SL-2G-1(2,716t/ha,15cm)	32	1.372	SL-4C-1(1,0t,30cm)	24	1.029
SL-2G-2(2,716t/ha,60cm)	30	1.286	SL-4C-2(1,0t,15cm)	24	1.029
SL-2G-5(2,716t/ha,30cm)	33	1.414	SL-4C-5(1,0t,60cm)	26	1.114
SL-2G-6(2,716t/ha,120cm)	9	0.386	SL-4C-6(1,0t,120cm)	9	0.386
SL-2H-2(2,1074t/ha,30cm)	33	1.414			
SL-2H-3(2,1074/ha,15cm)	28	1.200			
SL-2I-1(2,0t/ha,15cm)	11	0.471			
SL-2I-2(2,0t/ha,30cm)	29	1.243			
SL-2I-6(2,0t/ha,120cm)	6	0.257			
SL-3A-2(2,1074t/ha,15cm)	24	1.029			
SL-3A-4(2,1074t/ha,30cm)	29	1.243			
SL-3A-5(2,1074t/ha,60cm)	17	0.729			
SL-3A-7(2,1074t/ha,120cm)	9	0.386			
SL-3B-3(2,716t/ha,15cm)	32	1.372			
SL-3B-4(2,716t/ha,30cm)	33	1.414			
SL-3B-5(2,716t/ha,60cm)	30	1.286			
SL-3B-6(2,716t/ha,120cm)	10	0.429			
SL-3C-1(2,0t/ha,15cm)	21	0.900			
SL-3C-2(2,0t/ha,30cm)	30	1.286			
SL-3C-5(2,0t/ha,60cm)	17	0.729			
SL-3C-6(2,0t/ha,120cm)	10	0.429			
SL-3D-3(4,1074t/ha,15cm)	23	0.986			

Appendix 2: Wilcoxon Rank Sum Tests for Nonparametric Data

Table 31. Wilcoxon Rank Sum Test by Application Rate

	Significant Difference	
Application Rate Comparisons	**NO_3-N**	**TAN**
Control 0 kgN/ha (0 lbs.N/ac.) vs. 19,650 kgN/ha (17,400 lbs.N/ac.)	Yes	Yes
Control 0 kgN/ha (0 lbs.N/ac.) vs. 39,300 kgN/ha (34,800 lbs.N/ac.)	Yes	Yes
Control 0 kgN/ha (0 lbs.N/ac.) vs. 58,900 kgN/ha (52,000 lbs.N/ac.)	Yes	Yes
19,650 kgN/ha (17,400 lbs.N/ac.) vs. 39,300 kgN/ha (34,800 lbs.N/ac.)	No	No
19,650 kgN/ha (17,400 lbs.N/ac.) vs. 58,900 kgN/ha (52,000 lbs.N/ac.)	No	Yes
39,300 kgN/ha (34,800 lbs.N/ac.) vs. 58,900 kgN/ha (52,000 lbs.N/ac.)	No	Yes

Table 32. Wilcoxon Rank Sum Test by Depth

	Significant Difference	
Depth Comparisons	**NO_3-N**	**TAN**
15 cm (6 in.) vs. Control 15 cm (6 in.)	Yes	Yes
30 cm (12 in.) vs. Control 30 cm (12 in.)	Yes	Yes
60 cm (24 in.) vs. Control 60 cm (24 in.)	Yes	Yes
120 cm (48 in.) vs. Control 120 cm (48 in.)	No	Yes
15 cm (6 in.) vs. 30 cm (12 in.)	Yes	Yes
15 cm (6 in.) vs. 60 cm (24 in.)	Yes	Yes
15 cm (6 in.) vs. 120 cm (48 in.)	No	Yes
30 cm (12 in.) vs. 60 cm (24 in.)	No	Yes
30 cm (12 in.) vs. 120 cm (48 in.)	Yes	Yes
60 cm (24 in.) vs. 120 cm (48 in.)	No	No

Table 33. Wilcoxon Rank Sum Test by Tree Density

	Significant Difference	
Tree Density Comparisons	**NO_3-N**	**TAN**
0 trees/ha (0 trees/ac.) vs. Control 0 trees/ha (0 trees/ac.)	Yes	Yes
0 trees/ha (0 trees/ac.) vs. 716 trees/ha (290 trees/ac.)	Yes	Yes
0 trees/ha (0 trees/ac.) vs. 1,074 trees/ha (435 trees/ac.)	No	Yes
716 trees/ha (290 trees/ac.) vs. 1,074 trees/ha (435 trees/ac.)	No	No

Table 34. Wilcoxon Rank Sum Test by Block and Replicate

	Significant Difference	
Block Comparisons	**NO_3-N**	**TAN**
Block 1 vs. Control Block 1	Yes	Yes
Block 2 vs. Control Block 2	No	Yes
Block 3 vs. Control Block 3	Yes	Yes
Block 1 vs. Block 2	Yes	Yes
Block 1 vs. Block 3	Yes	No
Block 2 vs. Block 3	No	Yes

	Significant Difference	
Replicate Comparisons	**NO_3-N**	**TAN**
Replicate 1 vs. Replicate 2	No	Yes
Replicate 1 vs. Replicate 3	Yes	Yes
Replicate 2 vs. Replicate 3	No	No

Appendix 3: Correlation Matrix and Scatter Plots

Table 35. Pearson Correlation Matrix

Variables	NO3-N (mg/L)	TAN (mg/L)	LOG NO3	LOG TAN	pH
Block	-0.034	**-0.054**	**-0.043**	**-0.184**	**-0.222**
Application Rate (kg N/ha)	**-0.113**	**0.261**	**-0.240**	**0.416**	**0.266**
Tree Density (trees/ha)	**-0.116**	**0.110**	**-0.156**	**0.244**	**0.119**
Depth (cm)	0.007	**-0.371**	**0.124**	**-0.156**	**-0.344**
Date	**0.163**	**0.084**	**0.404**	**0.088**	**-0.079**
NO_3-N (mg/L)	**1**	**-0.097**	**0.415**	**-0.130**	**-0.131**
TAN (mg/L)	**-0.097**	**1**	**-0.220**	**0.692**	**0.665**
LOG NO_3-N	**0.415**	**-0.220**	**1**	**-0.207**	**-0.190**
LOG TAN	**-0.130**	**0.692**	**-0.207**	**1**	**0.749**
pH	**-0.131**	**0.665**	**-0.190**	**0.749**	**1**
Temperature (^oC)	-0.028	**0.058**	-0.034	**0.064**	0.002
Rain (cm)	-0.013	0.003	0.012	0.001	-0.026

*Values in bold are different from 0 with a significance level alpha = 0.05.

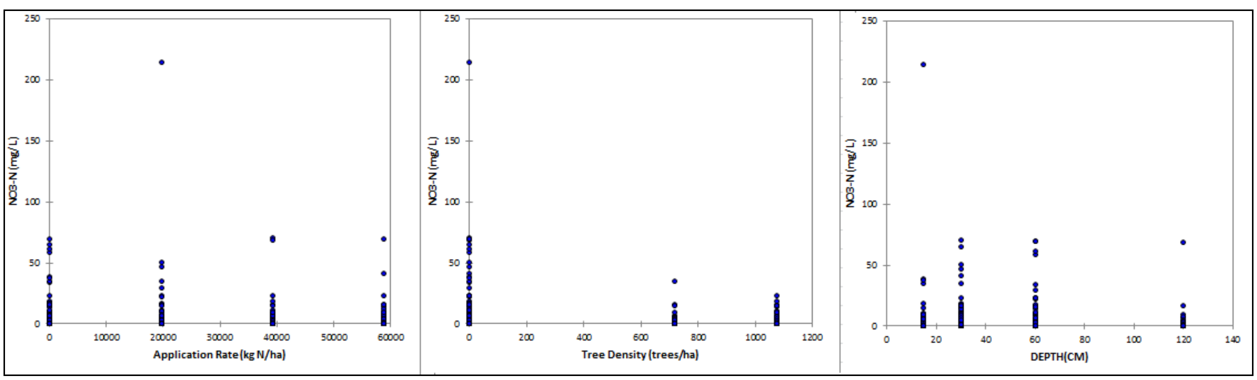

Figure 102. Correlation Scatter Plots-NO_3-Nas a Function of Application Rate, Tree Density, and Depth

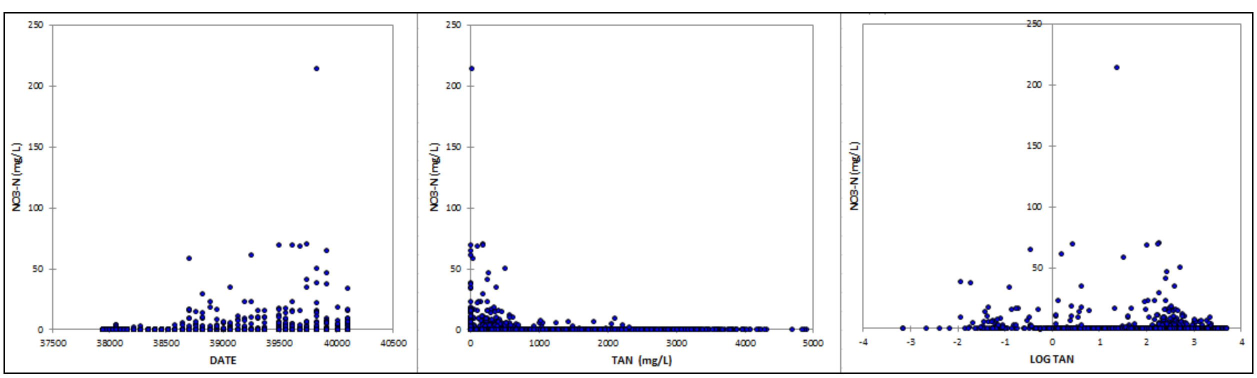

Figure 103. Correlation Scatter Plots- NO_3-Nas a Function of Date, TAN and Log TAN

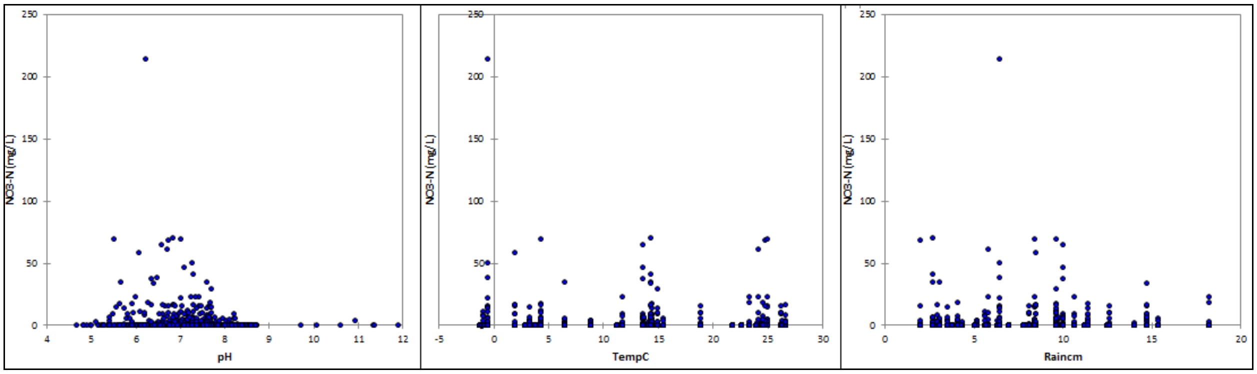

Figure 104. Correlation Scatter Plots- NO_3-Nas a Function of pH, Temperature, and Precipitation

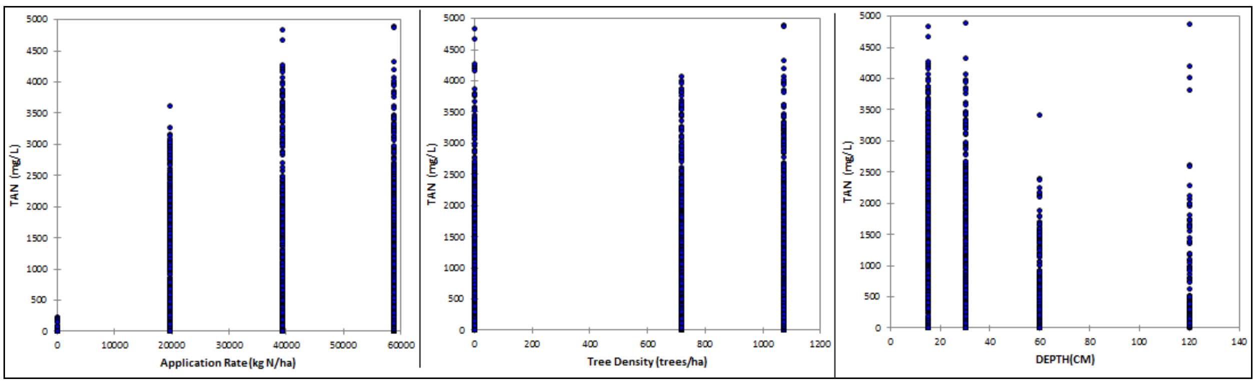

Figure 105. Correlation Scatter Plots- TAN as a Function of Application Rate, Tree Density, and Depth

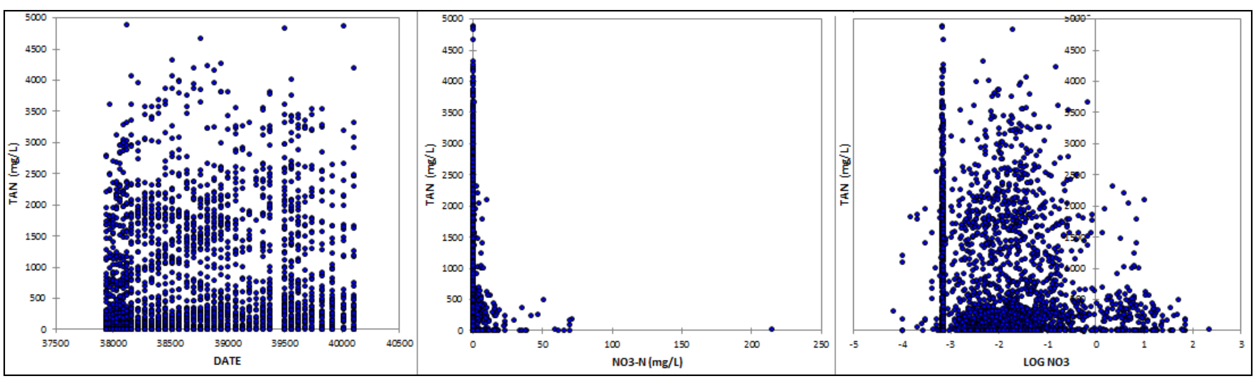

Figure 106. Correlation Scatter Plots- TAN as a Function of Date, NO_3-N, and Log NO_3-N

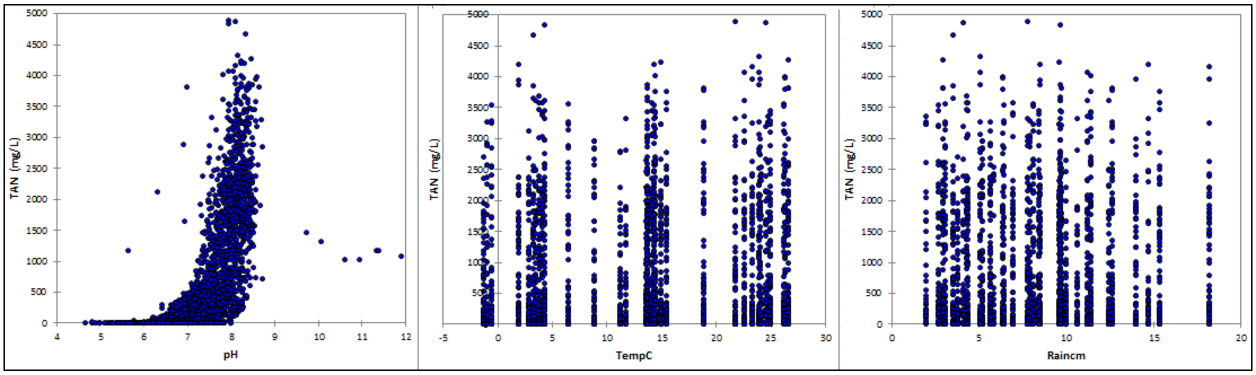

Figure 107. Correlation Scatter Plots- TAN as a Function of pH, Temperature, and Precipitation

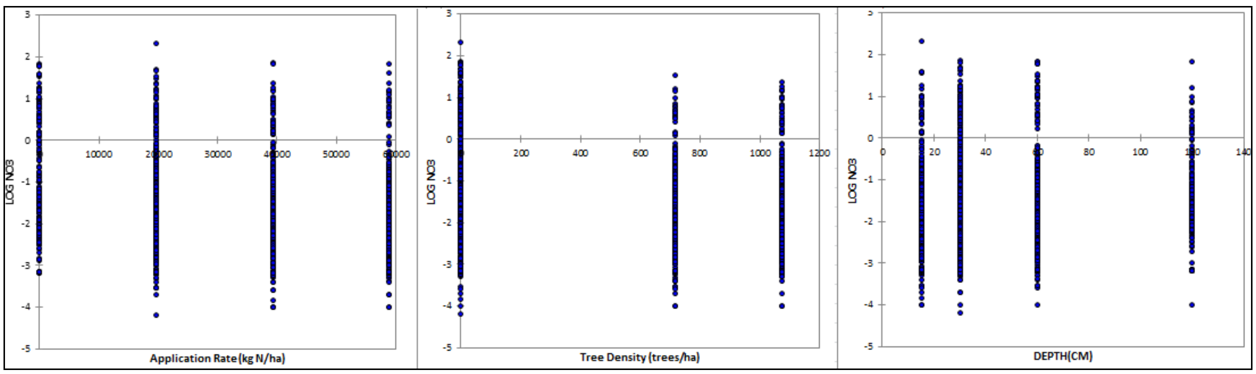

Figure 108. Correlation Scatter Plots - Log NO_3-N as a Function of Application Rate, Tree Density, and Depth

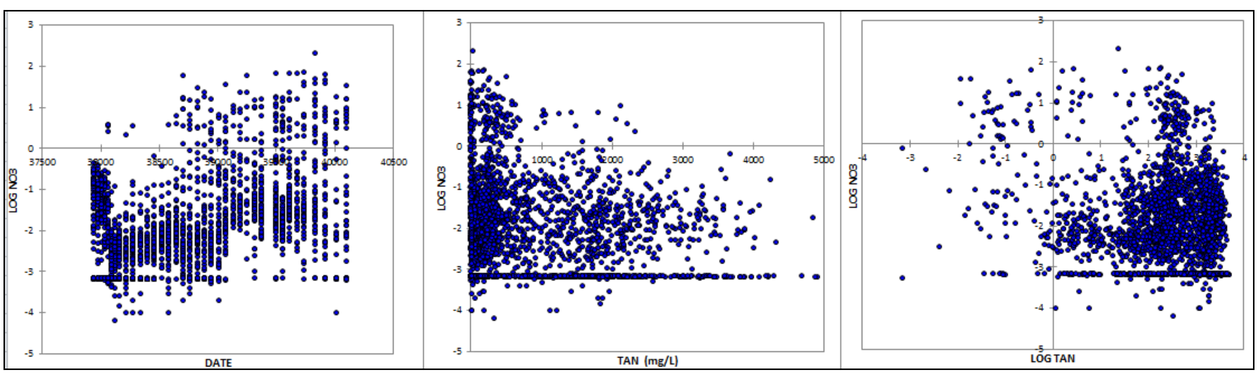

Figure 109. Correlation Scatter Plots -Log NO_3-N as a Function of Date, TAN, and Log TAN

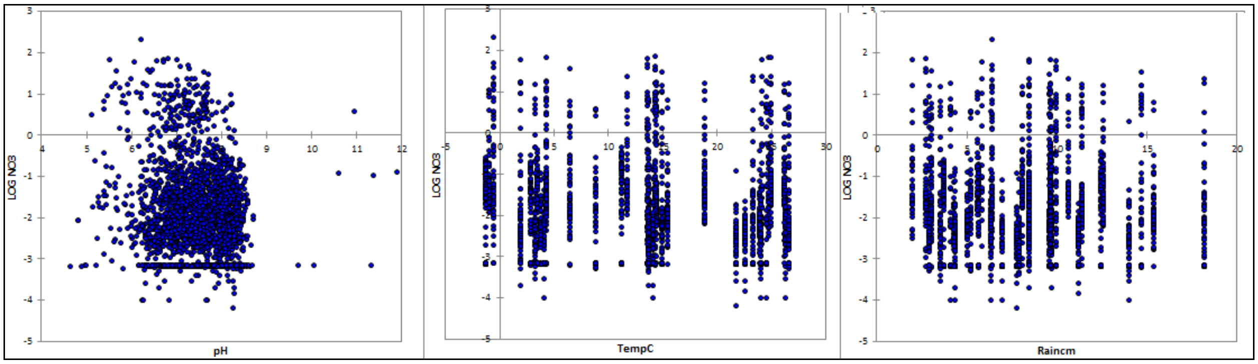

Figure 110. Correlation Scatter Plots -Log NO_3-N as a Function of pH, Temperature, and Precipitation

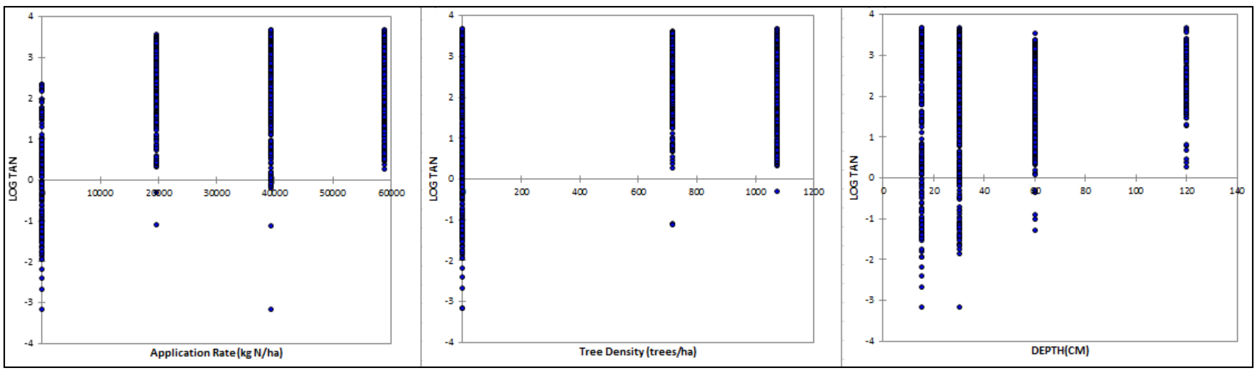

Figure 111. Correlation Scatter Plots for Log TAN as a Function of Application Rate, Tree Density, and Depth

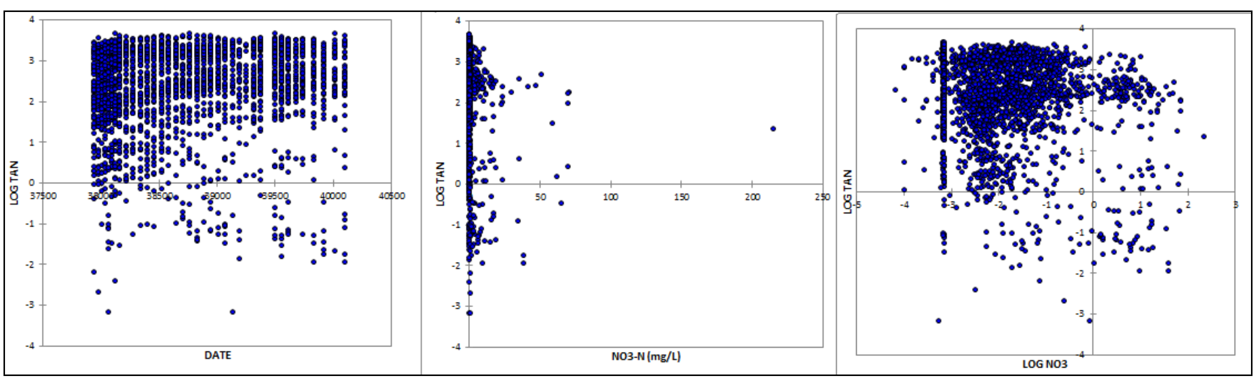

Figure 112. Correlation Scatter Plots for Log TAN as a Function of Date, NO_3-N, Log NO_3-N

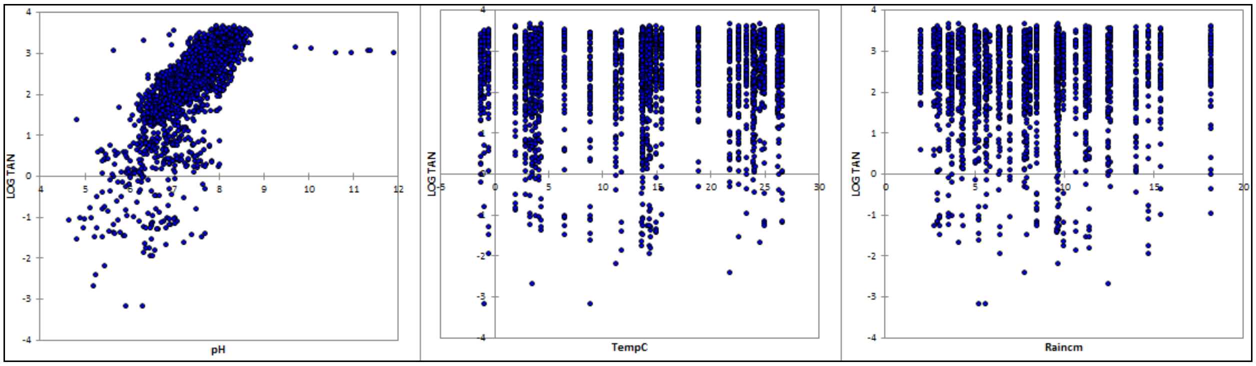

Figure 113. Correlation Scatter Plots for Log TAN as a Function of pH, Temperature, and Precipitation

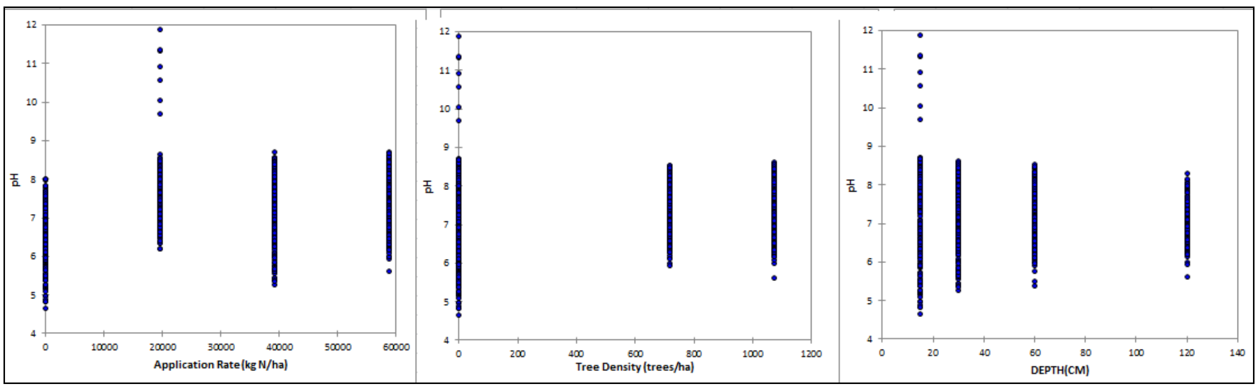

Figure 114. Correlation Scatter Plots for pH as a Function of Application Rate, Tree Density, and Depth

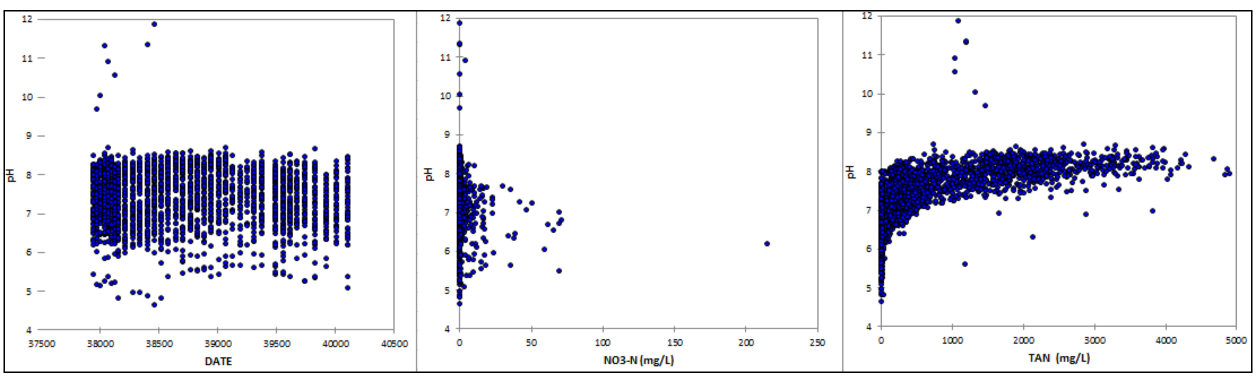

Figure 115. Correlation Scatter Plots for pH as a Function of Date, NO_3-N, and TAN

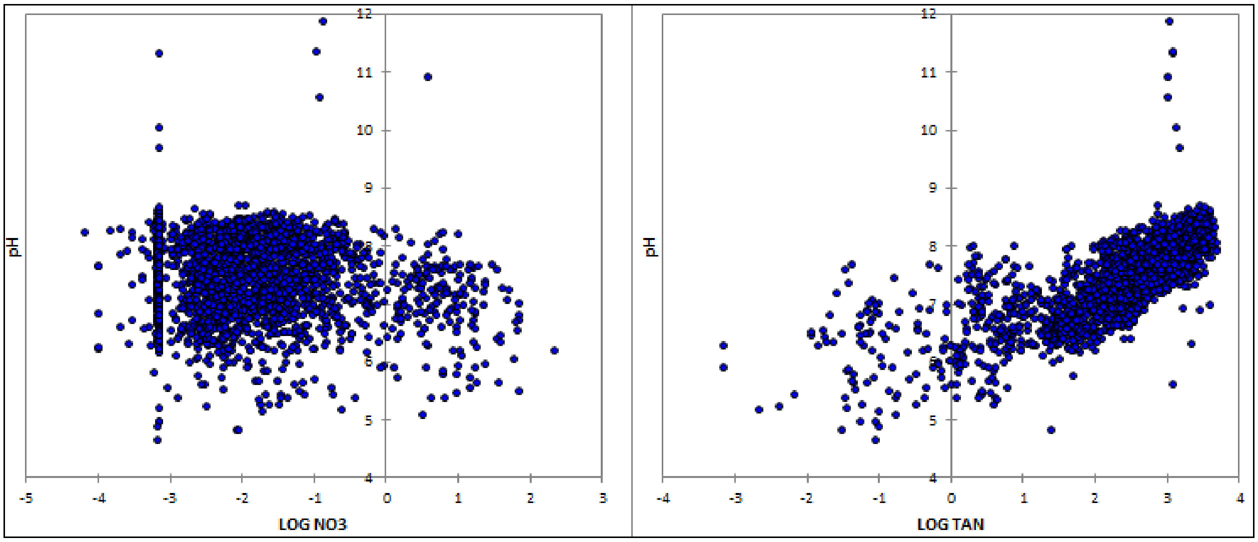

Figure 116. Correlation Scatter Plots for pH as a Function of Log NO_3-N and Log TAN

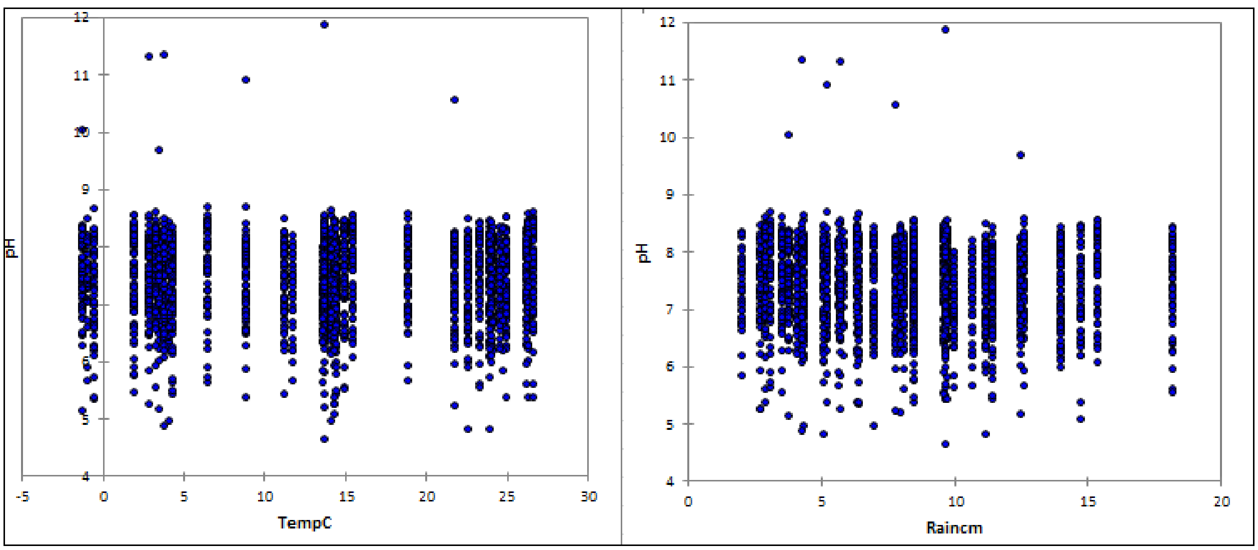

Figure 117. Correlation Scatter Plots for pH as a Function of Temperature and Precipitation

Appendix 4: Biosolids Field Notes from 120 cm (48in.) Lysimeter Installation

Table 36. Field Notes from 120 cm (48 in.) Lysimeter Installation

Plot	Block	App Rate kgN/ha	Tree Density trees/ha (trees/ac.)	Pan Install Date	SL 48 in. Install Date	Base of Biosolids (ft.) / Location of 48 in. SL (ft.) from Surface down	7/2007 Field Notes
4A	3	0	0 (0)	2/14/2003	7/25/2007	4ft /6 ft	Installed at 19,650 kgN/ha depth (Row 24": 12.5" biosolids, 12 " cover)
4B	2	0	0 (0)	3/19/2003	7/25/2007	4ft /6 ft	Installed at 19,650 kgN/ha depth (Row 24": 12.5" biosolids, 12 " cover)
4C	1	0	0 (0)	3/25/2003	7/25/2007	4ft /6 ft	Installed at 19,650 kgN/ha depth (Row 24": 12.5" biosolids, 12 " cover)
1D	1	19,650	716(290)	11/18/2002	7/23/2007	4 ft./8 ft.	
1E	1	19,650	1,074 (435)	12/2/2002	7/30/2007	2.7 ft./6.7 ft.	Hit large rock at 6.5 ft. Used sand for backfill and gravel for mudpack.
1F	1	19,650	0 (0)	1/9/2003	7/30/2007	2.7 ft./6.7 ft.	Hit large rock at 6.5 ft. Used sand for backfill and gravel for mudpack.
2G	2	19,650	716(290)	1/10/2003	7/26/2007	3.2ft. / 7.2 ft	
2H	2	19,650	1,074 (435)	1/3/2003	7/26/2007	3 ft./7 ft	
2I	2	19,650	0 (0)	1/20/2003	7/26/2007	4.9 ft./8.9 ft	
3A	3	19,650	1,074 (435)	7/19/2002	7/11/2007	3.4 ft./7.4 ft.	Label 3A-7 (3A-6 =redo)
3B	3	19,650	716(290)	7/16/2002	7/11/2007	3.7 ft./7.7 ft.	Water at 5.7 ft.
3C	3	19,650	0 (0)	7/25/2002	7/12/2007	4 ft./8 ft.	
1A	1	39,300	716(290)	8/1/2002	7/17/2007	4.3 ft./8.3 ft.	Hard to find biosolids, blends in with soil material utnil 5.3 ft.
1B	1	39,300	1,074 (435)	8/6/2002	7/27/2007	4.ft-/7.8 ft.	Water at 6 ft.
1C	1	39,300	0 (0)	8/6/2002	7/10/2007	4.4 ft./8.4 ft.	Water at 4.5 ft.
2D	2	39,300	716(290)	10/23/2002	7/23/2007	3 ft./7 ft.	Photo comparison with 3D
2E	2	39,300	1,074 (435)	10/7/2002	7/23/2007	4 ft./8ft.	
2F	2	39,300	0 (0)	10/28/2002	7/23/2007	3.7 ft./7.7 ft.	
3G	3	39,300	1,074 (435)	12/23/2002	7/25/2007	3.4 ft./7.5 ft	Dry biosolids
3H	3	39,300	716(290)	1/7/2003	7/25/2007	3.5 ft./7.6 ft	Dry biosolids
3I	3	39,300	0 (0)	1/8/2003	7/25/2007	3.7 ft./7.7 ft	Biosolids caved in. SL mudpack created with overburden soil.
1G	1	58,900	716(290)	1/21/2003	8/7/2007	4.4 ft./8.4ft.	
1H	1	58,900	1,074 (435)	2/5/2003	8/7/2007	4.4 ft./8.4ft.	
1I	1	58,900	0 (0)	1/27/2003	8/7/2007	3.6 ft./7.6 ft.	
2A	2	58,900	716(290)	7/29/2002	7/12/2007	4.2 ft./8.2ft.	
2B	2	58,900	1,074 (435)	7/30/2002	7/17/2007	4.6 ft/8.6 ft.	
2C	2	58,900	0 (0)	8/1/2002	7/17/2007	5.4 ft./9.4 ft.	
3D	3	58,900	1,074 (435)	10/2/2002	7/19/2007	4.9 ft./9.0 ft.	Top 2-3 in. of biosolids very dry. Photo
3E	3	58,900	716(290)	10/14/2002	7/19/2007	4.7 ft./8.7 ft.	
3F	3	58,900	0 (0)	10/21/2002	7/20/2007	4.7 ft./8.7 ft.	Water at 8.5 ft.

Appendix 5: Laboratory Preparation of Samples

Procedures for Measuring pH with a Fisher Scientific Accumet Basic AB15 pH meter

- Remove the pH probe from its electrode storage solution of potassium hydrogen phthalate-potassium chloride (Fisher Catalog No. SE40-1)
- Rinse the pH probe with deionized water and wipe with a Kim® wipe.
- Place the pH probe into a beaker with about 5 mL of pH 4 red buffer potassium biphthalate solution (Fisher Catalog No. SB101-500).
- Take the pH meter out of standby settings.
- Begin the calibration process by pressing the "setup" key twice followed by the "enter" key once. This erases stored standard values.
- Press the "std" button twice to begin standardization.
- Once the pH stabilizes for the first buffer of pH 4, remove the probe and rinse it with deionized water over a 600 mL beaker to collect waste solutions.
- Rinse the sampling beaker with deionized water and pour waste solutions into the waste beaker.
- Pour 5 mL of pH 7 yellow buffer potassium phosphate monobasic and sodium hydroxide (Fisher Catalog No. SB107-500).
- Place the probe into the beaker with the buffer.
- Press the "std" button twice to begin standardization.
- Once the pH stabilizes for the second buffer of pH 7, remove the probe.
- Rinse the probe and sampling beaker with deionized water and pour waste solutions into the waste beaker.
- Pour 5 mL of pH 10 blue buffer potassium carbonate, potassium borate, and potassium hydroxide (Fisher Catalog No. SB115-500).
- Once the pH stabilizes for the last buffer of pH 10, remove the probe and rinse it with deionized water over the 600 mL beaker to collect waste solutions.
- Rinse the sampling beaker with deionized water and pour waste solutions into the waste beaker.
- Pour about 5 mL of the first sample into the beaker.

- Seal the original sampling bottle and put into the refrigerator until filtering.
- Lower the probe into the sample.
- Record qualitative information about the sample, including odors, particulates, insects, and color. Figure 108 shows the variance of sample colors.
- Once the display reads “stable”, record the pH of the sample.
- Repeat the process until all samples are logged.
- After the last sample’s pH is recorded, rinse the probe with deionized water over the waste beaker. Then, wipe the probe with a Kim® wipe.
- Return the probe to its electrode storage solution vial and press the “stdby” button to set the pH meter in standby mode.

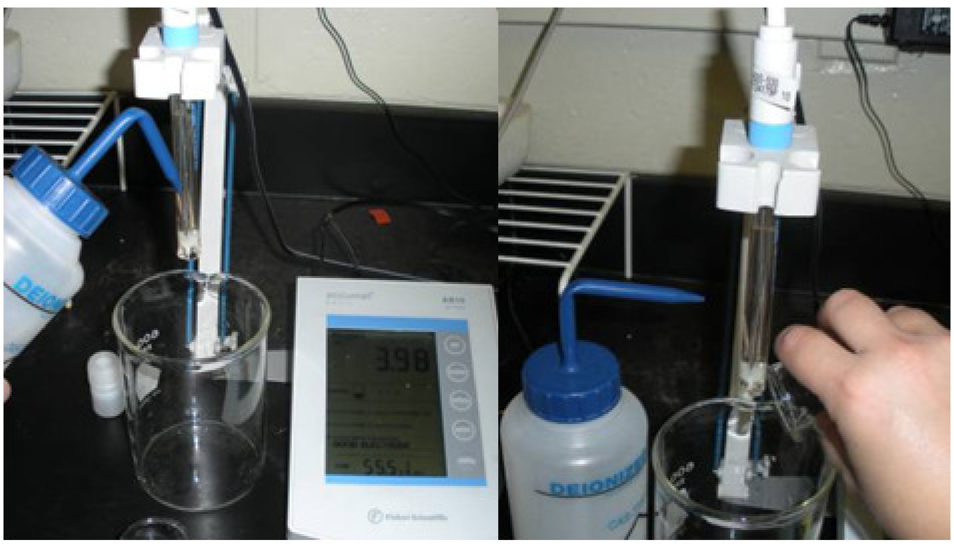

Figure 118. Cleaning the pH probe

Figure 119. Variety of soil water sample colors from four different lysimeters during the same event.

Figure 120. Filtered and original samples in labeled, sealed, plastic bags in the freezer.

Appendix 6: Biosolids Results (dry weight basis)

Table 37. 2008 Biosolids Results (A&L Eastern Lab, 2008)

Sample	TKN %	TAN %	NO3-N+NO2-N mg/kg	NO2-N mg/kg	TP %	Solids %	Org.C%
1A	0.44	0.32	4.0	< 1	0.20	62.92	3.79
1B	0.81	0.16	1.9	< 1	0.53	34.49	9.96
1C	0.80	0.35	1.6	< 1	0.46	38.81	7.62
2A	1.11	0.49	1.7	< 1	0.56	33.25	10.66
2B	1.02	0.50	2.1	< 1	0.47	28.58	9.23
2C	0.78	0.40	1.3	< 1	0.35	45.90	5.45
3A	0.92	0.35	1.5	< 1	1.31	50.79	4.44
3B	0.79	0.36	1.2	< 1	0.51	32.57	9.49
3C	0.77	0.33	< 1	< 1	0.55	33.76	6.03
4A	0.02	0.01	< 1	< 1	0.02	84.71	1.28
1D	0.81	0.23	< 1	< 1	0.51	31.75	8.35
1E	0.74	0.34	1.8	< 1	0.56	33.85	9.91
1F	0.82	0.30	< 1	< 1	0.51	26.28	8.41
2D	1.03	0.46	< 1	< 1	0.61	36.12	9.32
2E	0.83	0.39	1.7	< 1	0.52	31.03	7.87
2F	0.75	0.30	< 1	< 1	0.53	38.68	6.27
3D	0.14	0.10	169	< 1	0.03	84.99	1.62
3E	0.20	0.13	4.5	< 1	0.04	70.97	3.73
3F	0.38	0.20	< 1	< 1	0.09	66.71	2.18
4C	0.04	0.01	3.8	< 1	0.01	84.20	1.44
1G	0.97	0.45	< 1	< 1	0.55	36.21	10.19
1H	0.90	0.43	< 1	< 1	0.55	35.45	8.46
1I	0.88	0.46	1.2	< 1	0.42	27.27	9.80
2G	1.00	0.48	< 1	< 1	0.46	26.70	9.07
2H	0.72	0.29	<1	< 1	0.41	27.28	5.03
2I	0.78	0.08	4.8	2.1	0.34	34.69	9.59
3G	0.57	0.32	< 1	< 1	0.33	31.16	4.57
3H	0.72	0.15	< 1	< 1	0.48	29.52	10.16
3I	0.83	0.42	< 1	< 1	0.50	43.33	6.10
4B	0.02	0.02	< 1	< 1	0.03	90.15	1.22

Appendix 7: Appalachian Laboratory Procedures

- Total nitrogen: Standard Methods, Method 4500-N B. In-Line UV/Persulfate Digestion and Oxidation with Flow Injection Analysis (APHA, 1998).
- Ammonium nitrogen: Lachet QuickChem Method 10-107-06-3-D, Revision Date August 26, 2003 (Sodium salicylate-based method).
- Nitrite/nitrate:
  - For samples collected March 2004 and later: Methods for Chemical Analysis of Water and Wastes (MCAWW) Method 353.2 Determination of Nitrate+Nitrite Nitrogen by Automated Colorimetry (using a Lachet Quick Chem 8000 Flow Injection Analyzer) (EPA, 1983). Both nitrite and nitrite+nitrate are determined; nitrate is computed as the difference between the nitrite+nitrate concentration and the nitrite concentration. Performed by the Appalachian Laboratory at the University of Maryland Center for Environmental Studies in Frostburg, MD. Figure 70 shows an Appalachian Laboratory technician determining the nitrogen content of the samples with the Lachet Quick Chem 8000 Flow Injection Analyzer.

  OR

  - For samples collected prior to March 2004: Bran and Luebbe Method 696E-82W (nitrite) and 696F-82W (nitrite+nitrate), based on Methods 4500- NO_2 B and 4500- NO_3 H, respectively from the Standard Methods for the Examination of Water and Wastewater (APHA, 1998). Nitrate is computed as the difference between the nitrite+nitrate concentration and the nitrite concentration. Performed by the University of Maryland's Water Quality Laboratory in the Biological Resources Engineering Department in College Park, MD.

Appendix 8: University of Maryland's Cooperative Extension Soils Laboratory Procedures

Adapted from Buswell, 2006

- Analyze the sample for moisture content with Equation 14.
- Ammonium nitrogen: An aliquot that has not been previously dried is distilled with MgO (Association of Official Analytical Chemists {AOAC} Section #2.057.
- The remaining analyses use sample aliquots dried at 80°C (176°F) and ground in a Wiley Mill to pass through a 20 Mesh sieve.
- Organic nitrogen: Leco CHN combustion determination (Campbell, C.R. 1992. In plant analysis reference procedures for the southern region of the U.S. Southern Cooperative Research Ser. Bulletin 368. USDA, Washington, D.C. pp. 21-23).
- Total nitrogen: The added total of ammonium and organic nitrogen concentrations.
- Magnesium, Phosphorus, Potassium, and Calcium: Perchloric/Nitric acid digestion followed by Technicon AutoAnalyzer determination (Walsh, L.M., 1971).
- Manganese, Zinc, and Copper: Perchloric/Nitric acid digestion followed by Atomic Absorption determination (Gorsuch, 1970).
- Sulfur: Leco S132 combustion determination (Leco Application Bulletin 203-601-073).

Appendix 9: A&L Eastern Laboratories, Inc. Procedures

Biosolids Samples

- Total solids: Weigh 0.01 g (2.2 x 10^{-5} lbs.) in a weighing pan. Dry samples overnight in a Fisher Scientific Isotemp 500 oven at 98°C (208.4°F) over night to evaporate most of the water and avoid spattering. Dry at 103°C (217.4°F) for an additional hour. Let the sample cool down, then weigh and record the new weight. Repeat these steps until the difference in weight from the previous record is less than 4% or 0.05 g (1.1 x 10^{-4} lbs.), whichever is less. Calculate the percentage of total solids by Equation 14. Total solids procedure is based on the Methods for Chemical Analysis of Water and Wastes Method 160.3 (EPA-600/4-79-020) and the Standard Methods for the Examination of Water and Wastewater Method 2540G (A&L Eastern Laboratories, Inc., 2007).

Equation 14. Total Solids in Biosolids Sample (A&L Eastern Laboratories, Inc., 2008)

$$\text{Total Solids} = \frac{(A - B) \times 100}{(C - B)}$$

where:
A = weight of dry sample + dish in g
B = weight of dish in g
C = weight of wet sample in g

- Total Ammoniacal Nitrogen (TAN): Based on Methods For Chemical Analysis of Water and Wastes Method 350.2 (EPA-600/4-79-020) and Standard Methods for the Examination of Water and Wastewater Method 4500 NH_3 B and C, add 25 mL borate buffer solution and one dropper of antifoam to a biosolids sample of weight between 2 and 8 grams (4.4x10^{-3} - 1.8 x 10^{-2} lbs.). Add NaOH until the pH is 9.5. Using a distillation system, distill the sample into a 2% boric acid solution and back titrate to a pH of 4.2 using a standard solution of sulfuric acid (H_2SO_4). The distillation system calculates the values automatically, however the percent of ammonium nitrogen can be found with Equation 15 (A&L Eastern Laboratories, Inc., 2008).

Equation 15. % TAN wet weight basis of biosolids sample (A&L Eastern Laboratories, Inc., 2008)

$$\frac{(H_2SO_4\ mLs_{titrated} - H_2SO_4\ mLs_{blank}) \times (1.005) \times (0.1)}{\text{sample weight in grams}}$$

- Nitrate+Nitrite-Nitrogen (NO_3+NO_2-N) and Nitrite-nitrogen (NO_2-N): Add 20 mL 2N KCl and 1 scoop of activated carbon to 5 g (1.1 x 10^{-2} lb.) of the sludge sample. Record the new weight of the mixture. Filter the mixture through a Whatman #1 filter. Enter the weights of the sample and the sample mixture on the Lachat Quikchem 8000 with CETAC autosampler. Run the samples after the standards have been run with at least a 0.995 "R" value. These are based on the Methods for Chemical Analysis of Water and Wastes Method 350.2 (EPA-600/4-79-020) and Standard Methods for the Examination of Water and Wastewater Method 4500 NO_3 F (A&L Eastern Laboratories, Inc., 2009).
- Total Kjeldahl Nitrogen: The added total of ammonium, ammonia, and organic nitrogen concentrations.
- Total Phosphorus: Place 0.2 g (4.4 x 10^{-4} lb.) of biosolids into a Teflon sample vessel with single-ported cap and pressure relief valve. Add 4 mL of concentrated trace metal grade nitric acid, HNO_3 to the vessel under a fume hood. Cap the vessel once the reaction is completed. Next, put the vessel in the microwave carousel in the CEM rotating, programmable microwave; model number MARS5 with pressure and temperature monitoring and control. Set the microwave program to ramp to 165°C (329°F) in 2 minutes with maximum 20.4 atm (300 psi), then ramp to 175°C (347°F) in 3 minutes, with maximum 20.4 (300 psi) and hold the temperature and pressure for 5 minutes at 175°C (347° F) and 20.4 (300 psi), respectively. Record the weight once the vessel is below 50°C (122°F) and 3.4 (50 psi). Use the SW-846 6010B ICP method to determine elemental concentrations. (A&L Eastern Laboratories, Inc., 2009[3])
- Organic Carbon: The A&L Eastern Laboratories, Inc. organic carbon procedures are based on the Methods for Chemical Analysis of Water and Wastes Method 350.2 (EPA-600/4-79-020) and Standard Methods for the Examination of Water and Wastewater Method 2540G, ASTM Method D 2947C, and Method of Soil Analysis 29-4.2. Place 1 g (2.2 x 10^{-3} lb.) of the biosolids sample into a crucible in a Paragon muffle furnace with DTC600 controller, Model TNF II. Keep the sample in the furnace with both exhaust fans on and the temperature at 550°C

(1,022°F) for two hours. After the sample is completely cooled, record its weight.

Use Equations 16 through 18 to determine the percentage of organic carbon.

Equation 16. Percent Ash (A&L Eastern Laboratories, Inc., 2009[2])

$$\%Ash = \frac{[(g\ of\ crucible + ash) - g\ of\ crucible] \times 100}{1.00\ g\ sample}$$

Equation 17. Percent Volatile Solids (A&L Eastern Laboratories, Inc., 2009[2])

$$\%\ Volatile\ Solids = 100 - \%\ Ash$$

Equation 18. Percent Organic Carbon (A&L Eastern Laboratories, Inc., 2009[2])

$$\%\ Organic\ Carbon = \frac{(\%Volatile\ Solids)}{1.72}$$

Appendix 10: Effects of Freezing on Pan 3B Sample Results

#	Sent to Frostburg	Frostburg Analysis	NO2	NO2+NO3	NO_3-N	TAN	Inorganic N	Total N	% Recovery
1	11/2/2007	11/3/2007	0.7298	32.3033	31.5735	302.05	334.35	320.0664	0.96
2	12/4/2007	12/5/2007	0.7246	32.1652	31.4406	296.53	328.69	310.0425	0.94
3	5/2/2008	5/3/2008	0.4568	30.4090	29.9522	301.2844	331.6934	339.4398	1.0234
4	8/1/2008*	8/5/2008	0.5061	34.4804	33.9743	312.2513	346.7317	338.3904	0.9759
5	11/1/2008*	11/14/2008	0.05649	35.10869	35.0522	299.4464		334.9352	99.8
				Mean	32.6045	302.38			
				Std Dev	2.328	6.868			

*Samples were thawed for about 24 hours on or around 6/9/2008, when the freezer stopped working.

Appendix 11: Field Blank (Error) Sample Results

Sample I.D.	Sample Date	NO3-N (mg/L)	TAN (mg/L)	pH	NO_2 (mg/L)
SL-4F-1	11/18/03	-0.017	0.08	7.37	0.016
SL-4D-1	11/23/03	0.132	0.00	7.07	-0.141
SL-4E-1	11/30/03	0.214	0.01	5.51	0.011
SL-4F-1	12/8/03	1.070	0.01	7.31	0.003
SL-4D-1	12/21/03	-0.010	0.01	6.24	0.017
SL-4E-1	1/6/04	0.012	0.09	5.28	-0.011
SL-4F-1	1/12/04	0.018	0.01	8.00	-0.014
SL-4D-1	1/30/04	0.029	0.01	7.04	-0.013
SL-4E-1	2/11/04	0.075	0.00	5.77	-0.004
SL-4F-1	2/18/04	0.032	0.02	7.86	-0.005
SL-4D-1	2/26/04	0.010	0.15	6.11	-0.007
SL-4E-1	3/10/04	0.023	0.01	5.93	-0.008
SL-4F-1	3/19/04	0.011	0.00	6.57	-0.001
SL-4D-1	3/26/04	0.045	0.01	6.10	-0.004
SL-4E-1	4/9/04	0.000	0.01	6.82	0.000
SL-4F-1	4/23/04	0.000	0.01	6.39	0.000
SL-4D-1	4/30/04	0.000	0.07	5.97	0.000
SL-4E-1	5/14/04	0.000	0.01	5.62	0.000
SL-4F-1	5/21/04	0.000	0.01	6.22	0.000
SL-4D-1	5/27/04	0.000	0.0007	5.70	0.000
SL-4E-1	6/16/04	0.007	0.07	5.65	0.003
SL-4F-1	6/23/04	0.008	0.13	6.12	0.004
SL-4D-1	6/30/04	0.004	0.0007	5.59	0.000
SL-4E-1	8/18/04	0.014	0.02	5.45	0.000
SL-4F-1	8/25/04	0.008	0.01	4.91	0.000
SL-4D-1	8/31/04	0.006	0.01	6.08	0.000
SL-4E-1	10/16/04	0.007	0.01	5.20	0.000
SL-4F-1	10/23/04	0.015	0.01	5.80	0.000
SL-4D-1	10/30/04	0.011	0.01	5.54	0.000
SL-4E-1	12/4/04	0.012	0.01	5.31	0.000
SL-4F-1	12/13/04	0.014	0.01	5.69	0.000
SL-4D-1	12/22/04	0.000	0.01	5.19	0.000
SL-4E-1	2/10/05	0.001	0.01	5.28	< 0.002
SL-4F-1	2/19/05	0.001	0.01	5.37	< 0.020
SL-4D-1	2/26/05	0.002	0.00	5.61	0.000

Sample I.D.	Sample Date	NO3-N (mg/L)	TAN (mg/L)	pH	NO_2 (mg/L)
SL-4E-1	10/1/06	0.001	0.01	5.46	< 0.0019
SL-4F-1	10/9/06	0.001	0.01	5.96	< 0.0019
SL-4D-1	10/14/06	0.001	0.05	4.67	< 0.0019
SL-4E-1	12/3/06	0.021	0.05	4.49	0.002
SL-4F-1	12/10/06	0.014	0.17	5.88	0.002
SL-4D-1	12/16/06	0.001	0.05	5.16	< 0.0019
SL-4E-1	2/12/07	0.035	0.12	5.57	0.001
SL-4F-1	2/21/07	0.109	0.03	6.06	0.002
SL-4D-1	2/24/07	0.011	0.01	5.89	0.002
SL-4E-1	4/6/07	0.041	0.06	6.9	0.003
SL-4F-1	4/13/07	0.030	0.05	6.9	0.006
SL-4D-1	4/20/07	0.017	0.03	7	0.002
SL-4E-1	6/5/07	0.056	0.28	7.33	0.003
SL-4F-1	6/13/07	0.060	0.05	5.75	0.009
SL-4D-1	6/21/07	0.030	0.03	5.34	0.003
SL-4E-1	8/1/07	0.046	0.06	5.61	0.002
SL-4F-1	8/9/07	0.023	0.01	6.05	0.002
SL-4D-1	8/15/07	0.027	0.05	5.45	0.002
SL-4E-1	10/1/07	0.051	0.00	5.46	0.002
SL-4F-1	10/10/07	0.037	0.30	5.74	0.003
SL-4D-1	10/17/07	0.013	0.05	5.57	0.002
SL-4E-1	12/7/07	27.864	0.06	5.33	0.005
SL-4F-1	12/14/07	0.042	0.01	5.35	0.006
SL-4D-1	12/19/07	0.272	0.03	5.48	0.005
SL-4E-1	2/6/08	0.104	0.03	6.14	0.001
SL-4F-1	2/15/08	0.246	0.02	6.38	0.001
SL-4D-1	2/20/08	0.155	0.04	6.75	0.003
SL-4E-1	4/9/08	0.057	0.02	5.79	0.001
SL-4F-1	4/16/08	0.057	0.02	6.61	0.002
SL-4D-1	4/23/08	0.080	0.01	6.56	0.000
SL-4E-1	6/2/08	0.060	0.03	5.74	0.002
SL-4F-1	6/11/08	0.072	0.04	5.61	0.002
SL-4D-1	6/16/08	0.071	0.05	5.47	0.007
SL-4E-1	8/4/08	0.024	8.46	6.39	0.000
SL-4F-1	8/11/08	0.028	0.01	5.35	0.000

SL-4E-1	4/14/05	0.001	0.01	5.24	< 0.002
SL-4F-1	4/22/05	0.001	0.00	6.09	0.000
SL-4D-1	4/29/05	0.001	0.01	5.57	< 0.002
SL-4E-1	6/4/05	0.000	0.01	5.17	0.000
SL-4F-1	6/11/05	0.000	0.00	5.66	0.000
SL-4D-1	6/18/05	0.000	0.01	4.93	0.000
SL-4E-1	8/11/05	0.000	0.00	5.42	0.000
SL-4F-1	8/20/05	0.000	0.01	5.55	0.000
SL-4D-1	8/25/05	0.000	0.00	5.86	0.000
SL-4E-1	10/6/05	0.000	0.02	6.22	0.001
SL-4F-1	10/13/05	0.001	0.02	5.46	0.000
SL-4D-1	10/18/05	0.001	0.02	5.46	0.000
SL-4E-1	12/8/05	0.008	0.00	5.54	0.000
SL-4F-1	12/17/05	0.002	0.00	5.46	0.000
SL-4D-1	12/21/05	0.006	0.00	5.05	0.000
SL-4E-1	2/5/06	0.001	0.01	5.36	< 0.0019
SL-4F-1	2/20/06	0.000	0.00	?	0.000
SL-4D-1	2/26/06	0.001	0.01	5.37	< 0.0019
SL-4E-1	4/10/06	0.001	0.01	5.32	< 0.0019
SL-4F-1	4/14/06	0.001	0.01	5.82	< 0.0019
SL-4D-1	4/23/06	0.001	0.01	5.25	< 0.0019
SL-4E-1	6/16/06	0.001	0.02	5.59	< 0.0019
SL-4F-1	6/21/06	0.019	0.05	5.55	< 0.0019
SL-4D-1	6/28/06	0.001	0.01	5.42	< 0.0019
SL-4E-1	8/2/06	0.001	0.01	5.17	< 0.0019
SL-4F-1	8/11/06	0.001	0.00	5.38	< 0.0019
SL-4D-1	8/16/06	0.001	0.01	5.29	< 0.0019

SL-4D-1	8/17/08	0.029	1.36	6.26	0.004
SL-4E-1	10/2/08	0.015	0.01	5.42	0.000
SL-4D-1	10/5/08	0.015	0.01	6.22	0.004
SL-4F-1	10/5/08	0.011	0.02	5.22	0.001
SL-4D-1	1/11/09	0.004	0.00	4.85	0.000
SL-4E-1	1/11/09	0.004	0.00	4.95	0.000
SL-4F-1	1/11/09	0.013	0.00	5.15	0.000
SL-4E-1	4/5/09	0.002	0.00	4.81	0.000
SL-4F-1	4/8/09	0.000	0.01	5.05	0.000
SL-4D-1	4/18/09	0.000	0.01	5.26	0.000
SL-4E-1	7/1/09	0.000	0.01	5.79	
SL-4F-1	7/8/09	0.000	0.03	5.88	
SL-4D-1	7/16/09	0.000	0.01	6	
SL-4E-1	10/3/09	0.151	0.03	5.82	
SL-4D-1	10/18/09	0.236	0.03	6.38	
	Mean	**0.029**	**0.0167**	**5.80**	**-0.003**
	Std Dev	**0.137**	**0.0290**	**0.67**	**0.021**

Without December 2007

	Mean	**0.037**	**0.1285**	**5.79**	**-0.002**
	Std Dev	**0.122**	**0.9044**	**0.64**	**0.018**

Appendix 12: Suction Lysimeter Results

Sample I.D.	Block	Sample Date	NO_3-N (mg/L)	TAN (mg/L)	pH	NO_2-N (mg/L)
SL-1A-1(3,716t/ha,15cm)	1	11/10/03	-0.0068	1950.55	8.00	0.0054
SL-1A-1(3,716t/ha,15cm)	1	11/30/03	0.2097	198.31	8.32	0.1052
SL-1A-1(3,716t/ha,15cm)	1	1/6/04	-0.0213	1197.08	8.20	0.0254
SL-1A-1(3,716t/ha,15cm)	1	2/11/04	-0.0165	2138.10	8.40	0.0341
SL-1A-1(3,716t/ha,15cm)	1	3/10/04	-0.0395	2833.51	8.12	0.0410
SL-1A-1(3,716t/ha,15cm)	1	4/9/04	-0.0068	3009.69	8.30	0.0551
SL-1A-1(3,716t/ha,15cm)	1	5/14/04	-0.0130	3042.61	8.24	0.0611
SL-1A-1(3,716t/ha,15cm)	1	6/16/04	-0.0174	3617.64	8.14	0.0609
SL-1A-1(3,716t/ha,15cm)	1	8/18/04	-0.0508		8.23	0.0702
SL-1A-1(3,716t/ha,15cm)	1	10/16/04	-0.0400	3579.79	8.15	0.0783
SL-1A-1(3,716t/ha,15cm)	1	12/4/04	-0.0257	3590.43	8.20	0.0758
SL-1A-1(3,716t/ha,15cm)	1	2/10/05	0.0007	3697.27	8.11	0.0781
SL-1A-1(3,716t/ha,15cm)	1	4/14/05	0.0007	3864.78	8.10	0.0542
SL-1A-1(3,716t/ha,15cm)	1	6/4/05	0.0356	4076.22	7.93	0.0770
SL-1A-1(3,716t/ha,15cm)	1	8/11/05	0.0033	3996.07	8.23	0.1487
SL-1A-1(3,716t/ha,15cm)	1	10/6/05	0.0536	3473.14	8.40	0.0704
SL-1A-1(3,716t/ha,15cm)	1	12/8/05	0.0095	3875.30	8.40	0.0862
SL-1A-1(3,716t/ha,15cm)	1	2/5/06	-0.0186	3656.90	8.29	0.0860
SL-1A-1(3,716t/ha,15cm)	1	4/10/06	-0.0120	3232.19	8.21	0.0789
SL-1A-1(3,716t/ha,15cm)	1	6/16/06	-0.0101	3964.23	8.10	0.0736
SL-1A-1(3,716t/ha,15cm)	1	8/2/06	-0.0146	3812.78	8.32	0.0870
SL-1A-1(3,716t/ha,15cm)	1	10/1/06	-0.0048	3809.80	8.23	0.0861
SL-1A-1(3,716t/ha,15cm)	1	12/3/06	0.0006	3238.28	8.39	0.0686
SL-1A-1(3,716t/ha,15cm)	1	6/5/07	0.0089	186.83	8.17	0.1122
SL-1A-1(3,716t/ha,15cm)	1	8/1/07	0.0306	3568.50	8.08	0.0883
SL-1A-1(3,716t/ha,15cm)	1	10/1/07	0.1039	3270.18	8.23	0.0674
SL-1A-1(3,716t/ha,15cm)	1	2/6/08	-0.0246	3619.05	7.81	0.1125
SL-1A-1(3,716t/ha,15cm)	1	4/9/08	0.0081	3436.53	7.93	0.0525
SL-1A-1(3,716t/ha,15cm)	1	6/2/08	0.0176	3455.37	8.53	0.0782
SL-1A-1(3,716t/ha,15cm)	1	8/4/08	0.0158	3355.85	8.09	0.0710
SL-1A-1(3,716t/ha,15cm)	1	10/2/08	0.0016	3551.56	7.94	0.0815
SL-1A-1(3,716t/ha,15cm)	1	1/11/09	0.2684	3541.54	8.22	0.0594
SL-1A-1(3,716t/ha,15cm)	1	10/3/09	-0.0204	3093.30	8.39	
SL-1A-2(3,716t/ha,60cm)	1	11/10/03	-0.0249	94.04	7.34	0.0033
SL-1A-2(3,716t/ha,60cm)	1	11/30/03	-0.0944	134.85	7.96	0.0630
SL-1A-2(3,716t/ha,60cm)	1	1/6/04	-0.0588	208.34	8.00	0.0049
SL-1A-2(3,716t/ha,60cm)	1	2/11/04	-0.0522	308.07	8.09	0.0108

SL-1A-2(3,716t/ha,60cm)	1	3/10/04	-0.0717	707.50	7.65	0.0270
SL-1A-2(3,716t/ha,60cm)	1	4/9/04	-0.0018	898.78	8.24	0.0161
SL-1A-2(3,716t/ha,60cm)	1	5/14/04	-0.0081	1068.02	8.07	0.0315
SL-1A-2(3,716t/ha,60cm)	1	6/16/04	-0.0058	1600.47	7.79	0.0423
SL-1A-2(3,716t/ha,60cm)	1	8/18/04	-0.0349	2392.22	7.81	0.0539
SL-1A-2(3,716t/ha,60cm)	1	12/4/04	-0.0009	1789.23	7.66	0.0420
SL-1A-2(3,716t/ha,60cm)	1	2/10/05	0.0007	1372.05	7.48	0.0271
SL-1A-2(3,716t/ha,60cm)	1	4/14/05	0.0025	1164.96	7.80	0.0175
SL-1A-2(3,716t/ha,60cm)	1	6/4/05	0.0079	1184.46	7.33	0.0211
SL-1A-2(3,716t/ha,60cm)	1	8/11/05	0.0170	1070.09	7.59	0.0159
SL-1A-2(3,716t/ha,60cm)	1	10/6/05	0.0051	874.60	7.93	0.0191
SL-1A-2(3,716t/ha,60cm)	1	12/8/05	0.0093	1265.07	7.53	0.0218
SL-1A-2(3,716t/ha,60cm)	1	2/5/06	-0.0016	1393.44	7.96	0.0278
SL-1A-2(3,716t/ha,60cm)	1	4/10/06	-0.0001	1394.75	7.98	0.0247
SL-1A-2(3,716t/ha,60cm)	1	6/16/06	0.0007	1212.03	7.73	0.0253
SL-1A-2(3,716t/ha,60cm)	1	8/2/06	0.0022	1283.96	7.84	0.0233
SL-1A-2(3,716t/ha,60cm)	1	4/6/07	0.0292	831.10	7.2	0.0106
SL-1A-2(3,716t/ha,60cm)	1	2/6/08	0.0107	1012.85	7.24	0.0278
SL-1A-2(3,716t/ha,60cm)	1	4/9/08	0.0444	870.02	7.28	0.0103
SL-1A-2(3,716t/ha,60cm)	1	6/2/08	0.0395	786.93	7.6	0.0117
SL-1A-2(3,716t/ha,60cm)	1	8/4/08	0.0031	788.94	7.64	0.0100
SL-1A-2(3,716t/ha,60cm)	1	10/2/08	0.0158	834.10	7.32	0.0141
SL-1A-2(3,716t/ha,60cm)	1	1/11/09	0.0137	876.12	7.48	0.0128
SL-1A-2(3,716t/ha,60cm)	1	4/5/09	0.0048	832.72	7.78	0.0116
SL-1A-2(3,716t/ha,60cm)	1	10/3/09	0.0075	759.21	7.65	
SL-1A-3(3,716t/ha,30cm)	1	11/10/03	-0.0103	23.40	6.95	-0.0111
SL-1A-3(3,716t/ha,30cm)	1	11/30/03	-0.0557	25.04	7.03	0.0610
SL-1A-3(3,716t/ha,30cm)	1	1/6/04	-0.0418	20.23	6.98	0.0006
SL-1A-3(3,716t/ha,30cm)	1	2/11/04	-0.0110	25.75	7.27	0.0013
SL-1A-3(3,716t/ha,30cm)	1	3/10/04	0.0070	28.74	7.11	-0.0033
SL-1A-3(3,716t/ha,30cm)	1	4/9/04	0.0020	35.60	7.18	0.0038
SL-1A-3(3,716t/ha,30cm)	1	5/14/04	0.0018	34.19	7.03	0.0041
SL-1A-3(3,716t/ha,30cm)	1	6/16/04	0.0078	47.03	6.87	0.0051
SL-1A-3(3,716t/ha,30cm)	1	8/18/04	0.0011	49.57	6.85	0.0054
SL-1A-3(3,716t/ha,30cm)	1	10/16/04	0.0015	110.19	7.00	0.0072
SL-1A-3(3,716t/ha,30cm)	1	12/4/04	-0.0009	157.03	6.96	0.0420
SL-1A-3(3,716t/ha,30cm)	1	2/10/05	0.0073	182.01	7.11	0.0115
SL-1A-3(3,716t/ha,30cm)	1	4/14/05	0.0018	190.24	7.37	0.0048
SL-1A-3(3,716t/ha,30cm)	1	6/4/05	0.0072	187.96	6.94	0.0089
SL-1A-3(3,716t/ha,30cm)	1	8/11/05	0.0134	202.99	7.08	0.0039
SL-1A-3(3,716t/ha,30cm)	1	10/6/05	0.0104	195.85	7.61	0.0047

SL-1A-3(3,716t/ha,30cm)	1	12/8/05	0.0020	248.01	7.01	0.0062
SL-1A-3(3,716t/ha,30cm)	1	2/5/06	0.0372	280.62	7.71	0.0139
SL-1A-3(3,716t/ha,30cm)	1	4/10/06	0.0153	290.21	7.72	0.0050
SL-1A-3(3,716t/ha,30cm)	1	6/16/06	0.0023	309.27	7.33	0.0044
SL-1A-3(3,716t/ha,30cm)	1	8/2/06	0.0027	322.91	7.63	0.0067
SL-1A-3(3,716t/ha,30cm)	1	10/1/06	0.0082	322.63	7.31	0.0038
SL-1A-3(3,716t/ha,30cm)	1	4/6/07	0.0198	341.72	7.2	0.0045
SL-1A-3(3,716t/ha,30cm)	1	2/6/08	0.0167	529.26	7.2	0.0140
SL-1A-3(3,716t/ha,30cm)	1	4/9/08	0.0234	538.42	7.1	0.0073
SL-1A-3(3,716t/ha,30cm)	1	6/2/08	0.0750	411.10	7.74	0.0423
SL-1A-6(3,716t/ha,120cm)	1	8/1/07	0.0420	247.77	6.89	0.0171
SL-1A-6(3,716t/ha,120cm)	1	10/1/07	0.0266	205.20	7.16	0.0056
SL-1A-6(3,716t/ha,120cm)	1	12/7/07	53.5627	310.00	7.24	0.0535
SL-1A-6(3,716t/ha,120cm)	1	2/6/08	0.0092	232.05	7.04	0.0074
SL-1A-6(3,716t/ha,120cm)	1	4/9/08	0.0145	184.86	6.98	0.0071
SL-1A-6(3,716t/ha,120cm)	1	6/2/08	0.1165	119.83	6.93	0.0828
SL-1A-6(3,716t/ha,120cm)	1	8/4/08	0.0130	172.68	6.75	0.0079
SL-1A-6(3,716t/ha,120cm)	1	10/2/08	0.0259	314.62	7.01	0.0145
SL-1A-6(3,716t/ha,120cm)	1	1/11/09	7.1841	242.93	6.86	0.0751
SL-1A-6(3,716t/ha,120cm)	1	4/5/09	9.5605	217.76	6.86	0.0721
SL-1A-6(3,716t/ha,120cm)	1	7/1/09	0.0001	184.27	6.84	
SL-1A-6(3,716t/ha,120cm)	1	10/3/09	0.0040	305.20	6.99	
SL-1B-1(3,1074t/ha,60cm)	1	11/30/03	0.1300	46.70	8	0.0104
SL-1B-1(3,1074t/ha,60cm)	1	1/6/04	-0.0059	44.97	7.50	-0.0033
SL-1B-1(3,1074t/ha,60cm)	1	3/10/04	0.0005	41.60	7.80	-0.0027
SL-1B-1(3,1074t/ha,60cm)	1	4/9/04	0.0067	46.18	7.50	0.0023
SL-1B-1(3,1074t/ha,60cm)	1	5/14/04	0.0121	39.66	7.94	0.0062
SL-1B-1(3,1074t/ha,60cm)	1	6/16/04	0.0093	55.97	7.66	0.0103
SL-1B-1(3,1074t/ha,60cm)	1	8/18/04	0.0036	54.02	7.34	0.0057
SL-1B-1(3,1074t/ha,60cm)	1	10/16/04	0.0007	52.20	7.49	0.0060
SL-1B-1(3,1074t/ha,60cm)	1	12/4/04	0.0045	52.28	7.61	0.0094
SL-1B-1(3,1074t/ha,60cm)	1	2/10/05	0.0126	52.37	7.60	0.0135
SL-1B-1(3,1074t/ha,60cm)	1	4/14/05	0.0069	56.72	7.72	0.0054
SL-1B-1(3,1074t/ha,60cm)	1	6/4/05	0.0100	64.87	7.58	0.0087
SL-1B-1(3,1074t/ha,60cm)	1	12/8/05	0.0186	81.07	7.49	0.0079
SL-1B-2(3,1074t/ha,30cm)	1	11/10/03	0.0116	93.08	8.00	0.0170
SL-1B-2(3,1074t/ha,30cm)	1	11/30/03	-0.0004	170.29	8.12	0.0056
SL-1B-2(3,1074t/ha,30cm)	1	1/6/04	-0.0256	235.89	8.06	0.0005
SL-1B-2(3,1074t/ha,30cm)	1	2/11/04	-0.0241	336.84	8.20	0.0101
SL-1B-2(3,1074t/ha,30cm)	1	3/10/04	-0.0225	531.82	7.81	0.0030
SL-1B-2(3,1074t/ha,30cm)	1	5/14/04	-0.0065	953.12	8.10	0.0205

SL-1B-2(3,1074t/ha,30cm)	1	6/16/04	-0.0024	902.87	7.89	0.0319
SL-1B-2(3,1074t/ha,30cm)	1	8/18/04	-0.0228	1413.96	7.94	0.0401
SL-1B-2(3,1074t/ha,30cm)	1	10/16/04	-0.0175	1527.49	8.04	0.0393
SL-1B-2(3,1074t/ha,30cm)	1	12/4/04	-0.0062	1699.87	8.21	0.0437
SL-1B-2(3,1074t/ha,30cm)	1	2/10/05	0.0007	1823.95	8.07	0.0406
SL-1B-2(3,1074t/ha,30cm)	1	4/14/05	0.0025	1943.05	8.10	0.0375
SL-1B-2(3,1074t/ha,30cm)	1	6/4/05	0.0090	2267.22	7.90	0.0470
SL-1B-2(3,1074t/ha,30cm)	1	8/11/05	0.0837	1816.54	8.07	0.0450
SL-1B-2(3,1074t/ha,30cm)	1	10/6/05	0.0086	1688.70	8.23	0.0388
SL-1B-2(3,1074t/ha,30cm)	1	12/8/05	0.0121	1728.18	8.21	0.0352
SL-1B-2(3,1074t/ha,30cm)	1	2/5/06	0.0010	1505.34	8.21	0.0316
SL-1B-2(3,1074t/ha,30cm)	1	4/10/06	-0.0011	1543.86	8.08	0.0302
SL-1B-2(3,1074t/ha,30cm)	1	6/16/06	-0.0034	1821.86	7.92	0.0301
SL-1B-2(3,1074t/ha,30cm)	1	8/2/06	-0.0045	1666.29	8.21	0.0333
SL-1B-2(3,1074t/ha,30cm)	1	10/1/06	0.0071	1790.43	8.15	0.0417
SL-1B-2(3,1074t/ha,30cm)	1	4/6/07	0.0498	1909.89	7.7	0.0365
SL-1B-2(3,1074t/ha,30cm)	1	8/1/07	0.8167	1864.26	7.88	0.2725
SL-1B-2(3,1074t/ha,30cm)	1	10/1/07	1.4925	1965.55	8.15	0.5910
SL-1B-2(3,1074t/ha,30cm)	1	2/6/08	-0.0002	2089.69	7.77	0.0389
SL-1B-2(3,1074t/ha,30cm)	1	4/9/08	0.0156	2078.32	7.72	0.0393
SL-1B-2(3,1074t/ha,30cm)	1	6/2/08	0.0795	2023.08	7.86	0.0473
SL-1B-2(3,1074t/ha,30cm)	1	8/4/08	0.2588	2042.96	7.85	0.6367
SL-1B-2(3,1074t/ha,30cm)	1	10/2/08	0.0092	2209.26	7.77	0.0733
SL-1B-2(3,1074t/ha,30cm)	1	1/11/09	0.0816	2215.68	7.95	0.1133
SL-1B-2(3,1074t/ha,30cm)	1	7/1/09	0.0000	2149.96	8.24	
SL-1B-5(3,1074t/ha,15cm)	1	2/11/04	-0.0670	266.58	7.50	0.0187
SL-1B-5(3,1074t/ha,15cm)	1	3/10/04	0.0178		7.82	-0.0110
SL-1B-5(3,1074t/ha,15cm)	1	5/14/04	0.0019	223.51	8.09	0.0122
SL-1B-5(3,1074t/ha,15cm)	1	6/16/04	0.0095	256.70	8.12	0.0162
SL-1B-5(3,1074t/ha,15cm)	1	8/18/04	-0.0082	340.33	7.95	0.0128
SL-1B-5(3,1074t/ha,15cm)	1	10/16/04	-0.0029	420.40	8.14	0.0148
SL-1B-5(3,1074t/ha,15cm)	1	12/4/04	0.0252	414.66	8.50	0.0824
SL-1B-6(3,1074t/ha,120cm)	1	8/1/07	1.7049	229.80	7.05	0.2142
SL-1B-6(3,1074t/ha,120cm)	1	10/1/07	1.4182	156.73	7.37	0.0871
SL-1B-6(3,1074t/ha,120cm)	1	12/7/07	9.1817	384.94	7.1	0.0094
SL-1B-6(3,1074t/ha,120cm)	1	2/6/08	0.0183	270.58	7.03	0.0073
SL-1B-6(3,1074t/ha,120cm)	1	4/9/08	0.0143	216.73	7.01	0.0043
SL-1B-6(3,1074t/ha,120cm)	1	6/2/08	0.0261	188.68	6.89	0.0028
SL-1B-6(3,1074t/ha,120cm)	1	8/4/08	0.2039	246.10	6.83	0.0123
SL-1B-6(3,1074t/ha,120cm)	1	10/2/08	0.0332	294.98	6.84	0.0069
SL-1B-6(3,1074t/ha,120cm)	1	1/11/09	0.5042	297.52	6.98	0.2376

SL-1B-6(3,1074t/ha,120cm)	1	4/5/09	1.3855	275.51	6.92	0.0141
SL-1B-6(3,1074t/ha,120cm)	1	7/1/09	0.0000	253.89	6.89	
SL-1B-6(3,1074t/ha,120cm)	1	10/3/09	0.0093	286.16	7.72	
SL-1C-1(3,0t/ha,60cm)	1	11/10/03	0.0788	220.12	7.49	-0.0115
SL-1C-1(3,0t/ha,60cm)	1	11/30/03	0.0019	216.21	7.41	0.0201
SL-1C-1(3,0t/ha,60cm)	1	1/6/04	0.0201	155.29	7.30	0.0055
SL-1C-1(3,0t/ha,60cm)	1	2/11/04	0.0265	166.78	7.06	-0.0012
SL-1C-1(3,0t/ha,60cm)	1	3/10/04	0.0378	139.71	7.07	-0.0010
SL-1C-1(3,0t/ha,60cm)	1	4/9/04	0.0033	153.14	7.18	0.0024
SL-1C-1(3,0t/ha,60cm)	1	5/14/04	0.0047	140.45	7.09	0.0021
SL-1C-1(3,0t/ha,60cm)	1	6/16/04	0.0058	153.29	6.93	0.0037
SL-1C-1(3,0t/ha,60cm)	1	8/18/04	0.0066	134.40	6.81	0.0031
SL-1C-1(3,0t/ha,60cm)	1	10/16/04	0.0227	133.37	7.07	0.0065
SL-1C-1(3,0t/ha,60cm)	1	12/4/04	0.0293	119.39	6.72	0.0114
SL-1C-1(3,0t/ha,60cm)	1	2/10/05	0.0071	132.92	6.85	0.0074
SL-1C-1(3,0t/ha,60cm)	1	4/14/05	0.0027	132.03	6.72	0.0039
SL-1C-1(3,0t/ha,60cm)	1	6/4/05	0.0101	139.68	6.69	0.0057
SL-1C-1(3,0t/ha,60cm)	1	8/11/05	0.0092	158.36	6.88	0.0039
SL-1C-1(3,0t/ha,60cm)	1	10/6/05	0.0311	166.21	7.28	0.0133
SL-1C-1(3,0t/ha,60cm)	1	12/8/05	0.0125	239.15	6.88	0.0069
SL-1C-1(3,0t/ha,60cm)	1	2/5/06	0.0082	236.30	7.20	0.0044
SL-1C-1(3,0t/ha,60cm)	1	4/10/06	0.0131	182.85	7.10	0.0042
SL-1C-1(3,0t/ha,60cm)	1	6/16/06	0.0103	256.93	7.00	0.0057
SL-1C-1(3,0t/ha,60cm)	1	8/2/06	0.0155	263.30	7.28	0.0149
SL-1C-1(3,0t/ha,60cm)	1	10/1/06	0.0342	305.31	7.07	0.0137
SL-1C-1(3,0t/ha,60cm)	1	12/3/06	0.0082	262.79	6.97	0.0039
SL-1C-1(3,0t/ha,60cm)	1	2/6/08	0.0150	424.87	6.97	0.0083
SL-1C-1(3,0t/ha,60cm)	1	4/9/08	0.0234	493.57	7.17	0.0072
SL-1C-1(3,0t/ha,60cm)	1	6/2/08	0.0530	360.14	7.04	0.0086
SL-1C-1(3,0t/ha,60cm)	1	10/2/08	0.0317	276.42	6.9	0.0094
SL-1C-1(3,0t/ha,60cm)	1	1/11/09	0.1171	293.87	7.41	0.0198
SL-1C-4(3,0t/ha,15cm)	1	11/10/03	-0.0139	2924.11	8.00	0.0315
SL-1C-4(3,0t/ha,15cm)	1	11/30/03	0.0237	3436.30	8.27	0.0217
SL-1C-4(3,0t/ha,15cm)	1	1/6/04	-0.0485	821.42	8.32	0.0780
SL-1C-4(3,0t/ha,15cm)	1	2/11/04	-0.0456	5728.83	8.42	0.0786
SL-1C-4(3,0t/ha,15cm)	1	3/10/04	-0.0802	836.30	8.67	0.0963
SL-1C-4(3,0t/ha,15cm)	1	4/9/04	-0.0516	4784.45	7.74	0.1297
SL-1C-4(3,0t/ha,15cm)	1	5/14/04	-0.0446	6335.92	8.10	0.1092
SL-1C-4(3,0t/ha,15cm)	1	6/16/04	-0.0200	908.33	7.86	0.0890
SL-1C-4(3,0t/ha,15cm)	1	8/18/04	-0.0606	6200.55	7.91	0.0983
SL-1C-4(3,0t/ha,15cm)	1	10/16/04	-0.0577		8.03	0.1105

SL-1C-4(3,0t/ha,15cm)	1	12/4/04	-0.0476	5103.19	8.08	0.1063
SL-1C-4(3,0t/ha,15cm)	1	2/10/05	0.0007	4931.59	8.11	0.1104
SL-1C-4(3,0t/ha,15cm)	1	4/14/05	-0.0327	4759.24	8.06	0.0978
SL-1C-4(3,0t/ha,15cm)	1	6/4/05	0.0462	6366.40	8.02	0.1286
SL-1C-4(3,0t/ha,15cm)	1	8/11/05	0.0373	6438.90	7.77	0.1136
SL-1C-4(3,0t/ha,15cm)	1	10/6/05	0.0742	6080.73	8.23	0.1238
SL-1C-4(3,0t/ha,15cm)	1	12/8/05	0.0243	5933.79	8.47	0.1711
SL-1C-4(3,0t/ha,15cm)	1	2/5/06	-0.0514	4796.28	8.43	0.1739
SL-1C-4(3,0t/ha,15cm)	1	4/10/06	-0.0408	4006.99	8.22	0.1474
SL-1C-4(3,0t/ha,15cm)	1	6/16/06	-0.0229	4089.57	8.11	0.1047
SL-1C-4(3,0t/ha,15cm)	1	8/2/06	-0.0276	3642.46	8.29	0.1303
SL-1C-4(3,0t/ha,15cm)	1	10/1/06	-0.0235	2836.02	8.30	0.1357
SL-1C-4(3,0t/ha,15cm)	1	4/6/07	0.0110	1897.59	8.3	0.0940
SL-1C-4(3,0t/ha,15cm)	1	6/5/07	0.1628	1790.54	8.24	0.1028
SL-1C-4(3,0t/ha,15cm)	1	8/1/07	0.0661	1782.60	8.09	0.0851
SL-1C-4(3,0t/ha,15cm)	1	10/1/07	0.0208	1703.26	8.30	0.0668
SL-1C-4(3,0t/ha,15cm)	1	2/6/08	0.0006	1629.85	7.96	0.0545
SL-1C-4(3,0t/ha,15cm)	1	4/9/08	0.0174	1264.82	7.91	0.0407
SL-1C-4(3,0t/ha,15cm)	1	6/2/08	0.0341	1126.03	7.83	0.0417
SL-1C-4(3,0t/ha,15cm)	1	10/2/08	0.0312	1195.80	7.86	0.0354
SL-1C-4(3,0t/ha,15cm)	1	1/11/09	0.0271	1168.34	8.21	0.0313
SL-1C-4(3,0t/ha,15cm)	1	10/3/09	-0.0066	854.45	8.23	
SL-1C-5(3,0t/ha,30cm)	1	11/10/03	-0.0067	492.09	7.66	-0.0129
SL-1C-5(3,0t/ha,30cm)	1	11/30/03	0.0078	532.22	7.76	0.0997
SL-1C-5(3,0t/ha,30cm)	1	1/6/04	-0.0432	530.41	7.82	0.0114
SL-1C-5(3,0t/ha,30cm)	1	2/11/04	-0.0192	491.00	7.82	0.0115
SL-1C-5(3,0t/ha,30cm)	1	3/10/04	-0.0475	508.45	7.86	0.0050
SL-1C-5(3,0t/ha,30cm)	1	4/9/04	-0.0002	738.46	8.28	0.0159
SL-1C-5(3,0t/ha,30cm)	1	5/14/04	-0.0019	766.71	7.65	0.0144
SL-1C-5(3,0t/ha,30cm)	1	6/16/04	0.0028	884.78	7.63	0.0227
SL-1C-5(3,0t/ha,30cm)	1	8/18/04	-0.0078	1006.23	7.76	0.0281
SL-1C-5(3,0t/ha,30cm)	1	10/16/04	-0.0094	980.29	7.84	0.0298
SL-1C-5(3,0t/ha,30cm)	1	12/4/04	-0.0002	1110.88	7.72	0.0274
SL-1C-5(3,0t/ha,30cm)	1	2/10/05	0.0007	1079.19	7.87	0.0295
SL-1C-5(3,0t/ha,30cm)	1	4/14/05	0.0007	1287.84	7.71	0.0197
SL-1C-5(3,0t/ha,30cm)	1	6/4/05	0.0122	1059.98	7.63	0.0266
SL-1C-5(3,0t/ha,30cm)	1	8/11/05	0.0069	1278.89	7.88	0.0268
SL-1C-5(3,0t/ha,30cm)	1	10/6/05	0.0124	1312.86	8.27	0.0302
SL-1C-5(3,0t/ha,30cm)	1	12/8/05	0.0009	793.19	7.69	0.0138
SL-1C-5(3,0t/ha,30cm)	1	2/5/06	0.0019	284.36	7.66	0.0088
SL-1C-5(3,0t/ha,30cm)	1	4/10/06	0.0074	335.37	7.94	0.0070

SL-1C-5(3,0t/ha,30cm)	1	6/16/06	-0.0002	438.89	7.84	0.0236
SL-1C-5(3,0t/ha,30cm)	1	8/2/06	8.3388	426.06	7.60	0.3842
SL-1C-5(3,0t/ha,30cm)	1	10/1/06	0.2300	406.32	7.19	0.0138
SL-1C-5(3,0t/ha,30cm)	1	12/3/06	3.0940	242.16	7.38	0.1568
SL-1C-5(3,0t/ha,30cm)	1	2/12/07	11.3548	171.18	7.28	0.1565
SL-1C-5(3,0t/ha,30cm)	1	4/6/07	22.9776	146.40	7.4	0.7139
SL-1C-5(3,0t/ha,30cm)	1	8/1/07	9.6836	237.51	7.44	0.2520
SL-1C-5(3,0t/ha,30cm)	1	10/1/07	0.7141	285.39	7.19	0.0292
SL-1C-5(3,0t/ha,30cm)	1	12/7/07	-0.1433	378.71	7.21	0.2874
SL-1C-5(3,0t/ha,30cm)	1	2/6/08	7.0257	341.18	7.19	0.2841
SL-1C-5(3,0t/ha,30cm)	1	4/9/08	8.9342	307.21	7.15	0.0497
SL-1C-5(3,0t/ha,30cm)	1	6/2/08	5.1751	220.80	7.06	0.0651
SL-1C-5(3,0t/ha,30cm)	1	10/2/08	70.7075	183.52	6.82	0.2792
SL-1C-5(3,0t/ha,30cm)	1	10/3/09	15.9711	353.91	7.64	
SL-1C-6(3,0t/ha,120cm)	1	8/1/07	0.1150	208.76	7.14	0.0486
SL-1C-6(3,0t/ha,120cm)	1	10/1/07	0.0676	189.64	6.82	0.0069
SL-1C-6(3,0t/ha,120cm)	1	12/7/07	274.3613	622.88	7.24	0.0113
SL-1C-6(3,0t/ha,120cm)	1	2/6/08	0.0597	470.86	7.21	0.0127
SL-1C-6(3,0t/ha,120cm)	1	4/9/08	0.0649	525.92	7.3	0.0268
SL-1C-6(3,0t/ha,120cm)	1	6/2/08	1.7920	353.06	6.98	4.0319
SL-1C-6(3,0t/ha,120cm)	1	8/4/08	69.2120	97.45	6.72	15.8700
SL-1C-6(3,0t/ha,120cm)	1	10/2/08	1.9714	190.27	6.79	0.1791
SL-1C-6(3,0t/ha,120cm)	1	1/11/09	2.5856	208.81	6.85	0.1362
SL-1C-6(3,0t/ha,120cm)	1	4/5/09	1.4867	163.66	6.82	0.0939
SL-1C-6(3,0t/ha,120cm)	1	7/1/09	7.5329	142.70	6.71	
SL-1C-6(3,0t/ha,120cm)	1	10/3/09	4.6947	176.14	6.86	
SL-1D-1(2,716t/ha,30cm)	1	11/18/03	0.0924	628.99	7.88	0.0278
SL-1D-1(2,716t/ha,30cm)	1	12/8/03	0.1242	691.76	7.91	0.0185
SL-1D-1(2,716t/ha,30cm)	1	1/12/04	0.2325	814.57	8.14	-0.0008
SL-1D-1(2,716t/ha,30cm)	1	2/18/04	0.1713	1130.04	7.99	0.0050
SL-1D-1(2,716t/ha,30cm)	1	3/19/04	0.1467	1166.87	7.91	0.0168
SL-1D-1(2,716t/ha,30cm)	1	4/23/04	0.0005	1009.52	7.89	0.0134
SL-1D-1(2,716t/ha,30cm)	1	5/21/04	0.0011	1058.51	7.84	0.0144
SL-1D-1(2,716t/ha,30cm)	1	6/23/04	0.0044	1160.98	7.75	0.0234
SL-1D-1(2,716t/ha,30cm)	1	8/25/04	0.0098	1571.54	7.82	0.2159
SL-1D-1(2,716t/ha,30cm)	1	10/23/04	0.1552	1717.52	7.91	1.5721
SL-1D-1(2,716t/ha,30cm)	1	12/13/04	0.0265	986.08	7.70	1.2071
SL-1D-1(2,716t/ha,30cm)	1	2/19/05	0.0716	975.93	7.48	2.3652
SL-1D-1(2,716t/ha,30cm)	1	4/22/05	0.0537	1059.70	7.85	2.2769
SL-1D-1(2,716t/ha,30cm)	1	6/11/05	0.3736	1161.17	7.78	3.7741
SL-1D-1(2,716t/ha,30cm)	1	8/20/05	0.0262	1285.54	7.94	0.7190

SL-1D-1(2,716t/ha,30cm)	1	10/13/05	6.1763	1034.05	7.94	4.3292
SL-1D-1(2,716t/ha,30cm)	1	12/17/05	0.0145	462.56	7.20	0.0524
SL-1D-1(2,716t/ha,30cm)	1	2/20/06	0.0036	290.75	6.99	0.0138
SL-1D-1(2,716t/ha,30cm)	1	4/14/06	-0.0031	507.02	7.11	0.0143
SL-1D-1(2,716t/ha,30cm)	1	6/21/06	0.0157	620.07	7.37	0.0442
SL-1D-1(2,716t/ha,30cm)	1	8/11/06	0.0036	589.30	7.12	0.0117
SL-1D-1(2,716t/ha,30cm)	1	10/9/06	0.0212	528.21	7.23	0.0172
SL-1D-1(2,716t/ha,30cm)	1	12/10/06	0.2888	247.71	7.12	0.3506
SL-1D-1(2,716t/ha,30cm)	1	2/21/07	0.0454	2370.90	8.22	0.0345
SL-1D-1(2,716t/ha,30cm)	1	4/13/07	0.5927	373.22	7	0.1884
SL-1D-1(2,716t/ha,30cm)	1	6/13/07	0.5450	401.57	7.05	0.5124
SL-1D-1(2,716t/ha,30cm)	1	10/10/07	0.0062	749.10	7.7	0.0238
SL-1D-1(2,716t/ha,30cm)	1	12/14/07	-26.5382	684.06	7.65	26.9098
SL-1D-1(2,716t/ha,30cm)	1	2/15/08	0.5830	287.84	6.94	1.8321
SL-1D-1(2,716t/ha,30cm)	1	4/16/08	0.5475	208.35	6.85	1.1486
SL-1D-1(2,716t/ha,30cm)	1	6/11/08	0.1979	179.94	6.78	0.3284
SL-1D-1(2,716t/ha,30cm)	1	8/11/08	0.4609	326.37	7.19	0.3354
SL-1D-1(2,716t/ha,30cm)	1	10/5/08	3.5487	371.68	7.11	0.7194
SL-1D-1(2,716t/ha,30cm)	1	1/11/09	6.0499	559.33	7.17	0.2324
SL-1D-1(2,716t/ha,30cm)	1	4/8/09	0.1563	507.83	7.05	0.0259
SL-1D-1(2,716t/ha,30cm)	1	7/8/09	0.0062	418.50	7.11	
SL-1D-1(2,716t/ha,30cm)	1	10/9/09	0.0753	556.25	7.45	
SL-1D-2(2,716t/ha,15cm)	1	11/18/03	-0.0085	696.63	8.28	0.0192
SL-1D-2(2,716t/ha,15cm)	1	12/8/03	-0.0591	1840.44	8.05	0.0339
SL-1D-2(2,716t/ha,15cm)	1	1/12/04	-0.0397	1953.54	8.15	0.0239
SL-1D-2(2,716t/ha,15cm)	1	2/18/04	-0.0382	2177.04	8.14	0.0180
SL-1D-2(2,716t/ha,15cm)	1	3/19/04	-0.0996	2953.51	7.90	0.0284
SL-1D-2(2,716t/ha,15cm)	1	4/23/04	-0.0036	2945.45	7.97	0.0425
SL-1D-2(2,716t/ha,15cm)	1	5/21/04	-0.0053	860.37	8.14	0.0572
SL-1D-2(2,716t/ha,15cm)	1	6/23/04	-0.0063	2956.72	8.19	0.0596
SL-1D-2(2,716t/ha,15cm)	1	8/25/04	-0.0121	2742.34	8.16	0.0527
SL-1D-2(2,716t/ha,15cm)	1	10/23/04	-0.0023	2351.55	8.30	0.0525
SL-1D-2(2,716t/ha,15cm)	1	12/13/04	-0.0011	2127.76	8.31	0.0380
SL-1D-2(2,716t/ha,15cm)	1	2/19/05	0.0025	2005.92	8.23	0.0405
SL-1D-2(2,716t/ha,15cm)	1	4/22/05	0.0007	1873.81	8.29	0.0250
SL-1D-2(2,716t/ha,15cm)	1	6/11/05	0.0059	1787.52	8.24	0.0389
SL-1D-2(2,716t/ha,15cm)	1	8/20/05	0.0038	1892.03	8.34	0.0358
SL-1D-2(2,716t/ha,15cm)	1	10/13/05	0.0119	2344.73	8.14	0.0371
SL-1D-2(2,716t/ha,15cm)	1	12/17/05	0.0044	2251.00	8.30	0.0265
SL-1D-2(2,716t/ha,15cm)	1	2/20/06	0.0074	2095.98	8.36	0.0318
SL-1D-2(2,716t/ha,15cm)	1	4/14/06	0.0115	2035.84	8.43	0.0298

SL-1D-2(2,716t/ha,15cm)	1	6/21/06	0.0302	2077.40	8.26	0.0000
SL-1D-2(2,716t/ha,15cm)	1	8/11/06	0.0043	2147.97	8.17	0.0243
SL-1D-2(2,716t/ha,15cm)	1	10/9/06	0.0066	2145.42	8.33	0.0269
SL-1D-2(2,716t/ha,15cm)	1	12/10/06	0.0127	2611.47	8.27	0.0343
SL-1D-2(2,716t/ha,15cm)	1	4/13/07	0.0586	2809.27	8.2	0.0463
SL-1D-2(2,716t/ha,15cm)	1	6/13/07	0.0266	2435.01	8.19	0.0223
SL-1D-2(2,716t/ha,15cm)	1	10/10/07	0.0289	2445.55	8.26	0.0269
SL-1D-2(2,716t/ha,15cm)	1	2/15/08	0.0117	2757.16	7.97	0.0252
SL-1D-2(2,716t/ha,15cm)	1	4/16/08	0.0214	2715.33	8.02	0.0342
SL-1D-2(2,716t/ha,15cm)	1	6/11/08	0.0391	2508.21	8.07	0.0662
SL-1D-2(2,716t/ha,15cm)	1	10/5/08	0.0211	2573.59	8.02	0.0278
SL-1D-2(2,716t/ha,15cm)	1	1/11/09	0.0057	2547.81	8.20	0.0274
SL-1D-2(2,716t/ha,15cm)	1	10/9/09	0.0000	2462.38	7.92	
SL-1D-3(2,716t/ha,60cm)	1	11/18/03	0.0240	141.62	7.30	0.0091
SL-1D-3(2,716t/ha,60cm)	1	12/8/03	-0.0601	121.21	7.16	0.0195
SL-1D-3(2,716t/ha,60cm)	1	1/12/04	0.0310	86.21	6.94	-0.0143
SL-1D-3(2,716t/ha,60cm)	1	2/18/04	0.0407	68.67	7.03	0.0029
SL-1D-3(2,716t/ha,60cm)	1	3/19/04	-0.0425	78.59	7.01	0.0083
SL-1D-3(2,716t/ha,60cm)	1	4/23/04	0.0037	131.06	7.01	0.0045
SL-1D-3(2,716t/ha,60cm)	1	5/21/04	0.0007	203.95	7.11	0.0070
SL-1D-3(2,716t/ha,60cm)	1	6/23/04	0.0023	382.34	7.18	0.0108
SL-1D-3(2,716t/ha,60cm)	1	8/25/04	0.0014	329.51	7.11	0.0088
SL-1D-3(2,716t/ha,60cm)	1	10/23/04	0.0027	316.36	7.24	0.0123
SL-1D-3(2,716t/ha,60cm)	1	12/13/04	0.0032	160.79	6.95	0.0075
SL-1D-3(2,716t/ha,60cm)	1	4/22/05	0.0033	141.65	6.85	0.0037
SL-1D-3(2,716t/ha,60cm)	1	6/11/05	0.0047	145.46	6.88	0.0062
SL-1D-3(2,716t/ha,60cm)	1	8/20/05	0.0003	172.56	7.33	0.0062
SL-1D-3(2,716t/ha,60cm)	1	10/13/05	4.0729	215.17	6.95	0.3820
SL-1D-3(2,716t/ha,60cm)	1	12/17/05	0.0082	263.24	6.99	0.0074
SL-1D-3(2,716t/ha,60cm)	1	2/20/06	0.0046	223.19	7.13	0.0056
SL-1D-3(2,716t/ha,60cm)	1	4/14/06	0.0077	244.58	7.64	0.0047
SL-1D-3(2,716t/ha,60cm)	1	6/21/06	0.0094	294.46	7.65	0.0000
SL-1D-3(2,716t/ha,60cm)	1	8/11/06	0.0094	338.46	7.49	0.0157
SL-1D-3(2,716t/ha,60cm)	1	10/9/06	0.0078	354.15	7.49	0.0229
SL-1D-3(2,716t/ha,60cm)	1	2/21/07	0.6551	236.88	7.38	1.1353
SL-1D-3(2,716t/ha,60cm)	1	6/13/07	0.0955	310.22	7.8	0.2238
SL-1D-3(2,716t/ha,60cm)	1	12/14/07	36.9369	438.58	7.52	0.3466
SL-1D-3(2,716t/ha,60cm)	1	2/15/08	0.0888	407.95	7.43	0.0159
SL-1D-3(2,716t/ha,60cm)	1	4/16/08	0.0255	329.14	7.27	0.0245
SL-1D-3(2,716t/ha,60cm)	1	6/11/08	0.3013	310.93	7.33	0.1059
SL-1D-3(2,716t/ha,60cm)	1	10/5/08	0.0323	381.26	7.18	0.0125

SL-1D-3(2,716t/ha,60cm)	1	1/11/09	0.0465	641.91	7.59	0.0465
SL-1D-3(2,716t/ha,60cm)	1	4/8/09	0.0052	634.22	7.19	0.0129
SL-1D-3(2,716t/ha,60cm)	1	7/8/09	0.0000	535.52	7.67	
SL-1D-6(2,716t/ha,120cm)	1	10/10/07	0.0842	193.87	7.43	0.0288
SL-1D-6(2,716t/ha,120cm)	1	12/14/07	3.2462	312.32	6.92	0.0975
SL-1D-6(2,716t/ha,120cm)	1	2/15/08	0.0300	223.68	7.13	0.0019
SL-1D-6(2,716t/ha,120cm)	1	1/11/09	1.5260	206.72	6.84	0.0331
SL-1D-6(2,716t/ha,120cm)	1	4/8/09	0.0100	259.90	6.82	0.0050
SL-1D-6(2,716t/ha,120cm)	1	7/8/09	0.0000	147.76	6.86	
SL-1E-1(2,1074t/ha,60cm)	1	11/18/03	-0.0199	2.56	6.92	0.0044
SL-1E-1(2,1074t/ha,60cm)	1	12/8/03	-0.0338	2.50	7.00	0.0133
SL-1E-1(2,1074t/ha,60cm)	1	1/12/04	0.0030	2.71	6.92	-0.0112
SL-1E-1(2,1074t/ha,60cm)	1	2/18/04	0.0035	2.98	7.14	0.0008
SL-1E-1(2,1074t/ha,60cm)	1	3/19/04	-0.0486	2.13	7.23	0.0093
SL-1E-1(2,1074t/ha,60cm)	1	4/23/04	0.0041	3.25	7.04	0.0023
SL-1E-1(2,1074t/ha,60cm)	1	5/21/04	0.0041	2.24	6.91	0.0000
SL-1E-1(2,1074t/ha,60cm)	1	6/23/04	0.0047	2.52	6.79	0.0022
SL-1E-1(2,1074t/ha,60cm)	1	8/25/04	0.0058	2.67	6.82	0.0032
SL-1E-1(2,1074t/ha,60cm)	1	10/23/04	0.0079	6.90	6.93	0.0062
SL-1E-1(2,1074t/ha,60cm)	1	12/13/04	0.0092	6.79	6.88	0.0056
SL-1E-1(2,1074t/ha,60cm)	1	2/19/05	0.0075	4.01	7.34	0.0022
SL-1E-1(2,1074t/ha,60cm)	1	4/22/05	0.0063	3.29	7.51	0.0032
SL-1E-1(2,1074t/ha,60cm)	1	6/11/05	0.0092	3.82	7.38	0.0049
SL-1E-1(2,1074t/ha,60cm)	1	8/20/05	0.0275	5.69	7.40	0.0060
SL-1E-1(2,1074t/ha,60cm)	1	10/13/05	0.0166	5.58	7.79	0.0087
SL-1E-1(2,1074t/ha,60cm)	1	12/10/06	0.0661	12.01	7.65	0.0441
SL-1E-2(2,1074t/ha,15cm)	1	8/25/04	-0.0026	1280.79	8.17	0.0338
SL-1E-2(2,1074t/ha,15cm)	1	10/23/04	0.0036	2135.16	8.22	0.0366
SL-1E-2(2,1074t/ha,15cm)	1	12/13/04	0.0026	1595.09	8.00	0.0204
SL-1E-2(2,1074t/ha,15cm)	1	2/19/05	0.0033	1284.64	7.90	0.0122
SL-1E-2(2,1074t/ha,15cm)	1	4/22/05	0.0034	1373.61	7.82	0.0121
SL-1E-2(2,1074t/ha,15cm)	1	6/11/05	0.0043	1950.76	7.81	0.0253
SL-1E-2(2,1074t/ha,15cm)	1	8/20/05	0.0055	1922.84	8.20	0.0337
SL-1E-2(2,1074t/ha,15cm)	1	10/13/05	0.1586	1402.35	8.23	2.2795
SL-1E-2(2,1074t/ha,15cm)	1	12/17/05	2.5443	1168.16	8.04	141.0257
SL-1E-2(2,1074t/ha,15cm)	1	2/20/06	137.7571	1198.70	8.14	170.8383
SL-1E-2(2,1074t/ha,15cm)	1	6/21/06	1.1921	1661.64	8.23	15.5577
SL-1E-2(2,1074t/ha,15cm)	1	8/11/06	67.6860	1866.11	8.20	9.9905
SL-1E-2(2,1074t/ha,15cm)	1	10/9/06	24.7210	2243.72	8.37	32.7171
SL-1E-2(2,1074t/ha,15cm)	1	12/10/06	107.6831	2236.66	8.05	95.5170
SL-1E-2(2,1074t/ha,15cm)	1	6/13/07	557.6577	1811.66	7.91	105.4655

SL-1E-2(2,1074t/ha,15cm)	1	8/9/07	264.0801	2454.37	8.14	3.0285
SL-1E-2(2,1074t/ha,15cm)	1	10/10/07	329.2839	2271.88	8.39	123.1570
SL-1E-2(2,1074t/ha,15cm)	1	2/15/08	353.0555	2314.36	7.80	31.2776
SL-1E-2(2,1074t/ha,15cm)	1	4/16/08	376.2408	2221.61	7.94	4.2533
SL-1E-2(2,1074t/ha,15cm)	1	6/11/08	393.0107	2213.60	7.82	3.5152
SL-1E-2(2,1074t/ha,15cm)	1	1/11/09	34.9508	2556.07	8.17	53.4967
SL-1E-2(2,1074t/ha,15cm)	1	4/8/09	-0.0141	2751.87	7.79	0.0643
SL-1E-2(2,1074t/ha,15cm)	1	7/8/09	6.5851	2298.09	8.20	
SL-1E-3(2,1074t/ha,30cm)	1	11/18/03	0.0594	202.46	7.38	0.0042
SL-1E-3(2,1074t/ha,30cm)	1	12/8/03	0.0523	219.04	7.32	0.0260
SL-1E-3(2,1074t/ha,30cm)	1	1/12/04	0.0883	243.92	7.58	-0.0068
SL-1E-3(2,1074t/ha,30cm)	1	2/18/04	0.1062	302.52	7.52	0.0024
SL-1E-3(2,1074t/ha,30cm)	1	3/19/04	0.0567	372.76	7.48	0.0078
SL-1E-3(2,1074t/ha,30cm)	1	4/23/04	0.0039	509.16	7.85	0.0086
SL-1E-3(2,1074t/ha,30cm)	1	5/21/04	0.0028	575.52	8.20	0.0107
SL-1E-3(2,1074t/ha,30cm)	1	6/13/07	5.1432	200.14	7.3	17.0692
SL-1E-3(2,1074t/ha,30cm)	1	8/9/07	0.4283	240.49	7.08	4.7093
SL-1E-3(2,1074t/ha,30cm)	1	10/10/07	0.3509	230.28	7.23	2.9893
SL-1E-3(2,1074t/ha,30cm)	1	12/14/07	42.9011	248.98	7.01	3.2706
SL-1E-3(2,1074t/ha,30cm)	1	2/15/08	0.5895	234.26	6.94	3.0198
SL-1E-3(2,1074t/ha,30cm)	1	4/16/08	0.0036	217.64	6.96	0.3092
SL-1E-3(2,1074t/ha,30cm)	1	6/11/08	0.0819	188.28	6.9	2.5833
SL-1E-3(2,1074t/ha,30cm)	1	8/11/08	0.1746	210.95	6.88	4.0627
SL-1E-3(2,1074t/ha,30cm)	1	10/5/08	0.0418	240.42	7.02	1.9186
SL-1E-3(2,1074t/ha,30cm)	1	1/11/09	0.0502	266.68	7.02	0.2414
SL-1E-3(2,1074t/ha,30cm)	1	4/8/09	0.7553	255.64	6.98	7.5363
SL-1E-3(2,1074t/ha,30cm)	1	7/8/09	0.0138	206.38	6.87	
SL-1E-3(2,1074t/ha,30cm)	1	10/9/09	0.0171	252.86	6.84	
SL-1E-6(2,1074t/ha,120cm)	1	1/11/09	0.0195	52.62	6.65	0.0034
SL-1E-6(2,1074t/ha,120cm)	1	4/8/09	0.0025	66.43	6.67	0.0035
SL-1F-3(2,0t/ha,15cm)	1	11/18/03	-0.0262	839.40	8.19	0.0103
SL-1F-3(2,0t/ha,15cm)	1	12/8/03	0.0805	770.45	8.03	0.0336
SL-1F-3(2,0t/ha,15cm)	1	1/12/04	-0.0699	1406.94	8.31	0.0102
SL-1F-3(2,0t/ha,15cm)	1	2/18/04	-0.0602	1938.69	7.84	0.0138
SL-1F-3(2,0t/ha,15cm)	1	3/19/04	-0.1108	2323.44	7.69	0.0275
SL-1F-3(2,0t/ha,15cm)	1	4/23/04	-0.0028	2223.91	7.79	0.0257
SL-1F-3(2,0t/ha,15cm)	1	5/21/04	-0.0072	2379.32	7.97	0.0368
SL-1F-3(2,0t/ha,15cm)	1	6/23/04	0.0055	2317.71	8.00	0.0370
SL-1F-3(2,0t/ha,15cm)	1	8/25/04	-0.0054	1709.64	8.07	0.0387
SL-1F-3(2,0t/ha,15cm)	1	10/23/04	-0.0042	1606.98	8.28	0.0416
SL-1F-3(2,0t/ha,15cm)	1	12/13/04	0.0003	1413.05	8.25	0.0318

SL-1F-3(2,0t/ha,15cm)	1	2/19/05	0.0007	1444.85	8.09	0.0560
SL-1F-3(2,0t/ha,15cm)	1	4/22/05	0.0030	1754.53	8.11	0.0226
SL-1F-3(2,0t/ha,15cm)	1	6/11/05	0.1277	2105.28	8.05	0.2752
SL-1F-3(2,0t/ha,15cm)	1	8/20/05	0.0024	1889.17	8.39	0.0573
SL-1F-3(2,0t/ha,15cm)	1	10/13/05	0.1166	1890.01	8.24	0.0436
SL-1F-3(2,0t/ha,15cm)	1	12/17/05	1.3163	1578.57	8.29	0.0780
SL-1F-3(2,0t/ha,15cm)	1	2/20/06	0.2121	1514.99	8.40	0.0339
SL-1F-3(2,0t/ha,15cm)	1	4/14/06	-0.0003	1610.28	8.25	0.0282
SL-1F-3(2,0t/ha,15cm)	1	6/21/06	0.0404	1874.45	8.16	0.0000
SL-1F-3(2,0t/ha,15cm)	1	8/11/06	0.0069	1794.24	8.24	0.0411
SL-1F-3(2,0t/ha,15cm)	1	10/9/06	0.2507	1700.75	8.40	0.0451
SL-1F-3(2,0t/ha,15cm)	1	4/13/07	0.0426	1862.36	8	0.0345
SL-1F-3(2,0t/ha,15cm)	1	12/14/07	12.7686	2129.37	8.16	0.0383
SL-1F-3(2,0t/ha,15cm)	1	2/15/08	0.5823	1454.25	7.80	0.0351
SL-1F-3(2,0t/ha,15cm)	1	4/16/08	0.0236	1898.85	8.14	0.0610
SL-1F-3(2,0t/ha,15cm)	1	8/11/08	0.5432	1818.78	7.91	25.1730
SL-1F-3(2,0t/ha,15cm)	1	10/5/08	6.8658	1799.78	7.78	62.7689
SL-1F-3(2,0t/ha,15cm)	1	1/11/09	214.7092	22.54	6.21	2.1087
SL-1F-4(2,0t/ha,60cm)	1	11/18/03	-0.0064	110.53	7.46	-0.0018
SL-1F-4(2,0t/ha,60cm)	1	12/8/03	-0.0269	96.96	7.50	0.0188
SL-1F-4(2,0t/ha,60cm)	1	1/12/04	0.0052	134.37	7.58	-0.0100
SL-1F-4(2,0t/ha,60cm)	1	2/18/04	0.0755	144.20	7.57	0.0028
SL-1F-4(2,0t/ha,60cm)	1	3/19/04	-0.0704	94.22	7.96	0.0101
SL-1F-4(2,0t/ha,60cm)	1	4/23/04	0.0036	100.54	7.44	0.0032
SL-1F-4(2,0t/ha,60cm)	1	5/21/04	0.0066	112.31	8.00	0.0123
SL-1F-4(2,0t/ha,60cm)	1	6/23/04	0.0052	132.23	7.17	0.0040
SL-1F-4(2,0t/ha,60cm)	1	8/25/04	0.0458	137.51	7.19	0.0818
SL-1F-4(2,0t/ha,60cm)	1	10/23/04	3.4673	127.00	7.49	0.2513
SL-1F-4(2,0t/ha,60cm)	1	12/13/04	0.0075	257.48	7.29	0.0138
SL-1F-4(2,0t/ha,60cm)	1	2/19/05	0.0024	209.07	7.26	0.0048
SL-1F-4(2,0t/ha,60cm)	1	4/22/05	0.0094	160.22	7.64	0.0140
SL-1F-4(2,0t/ha,60cm)	1	6/11/05	0.0067	176.56	7.33	0.0064
SL-1F-4(2,0t/ha,60cm)	1	10/13/05	0.1249	462.84	7.86	0.1740
SL-1F-4(2,0t/ha,60cm)	1	12/17/05	16.8831	289.58	7.29	0.1517
SL-1F-4(2,0t/ha,60cm)	1	2/20/06	4.9389	283.18	7.27	0.0366
SL-1F-4(2,0t/ha,60cm)	1	4/14/06	29.7271	178.04	7.70	0.6133
SL-1F-4(2,0t/ha,60cm)	1	8/11/06	0.2036	196.65	7.71	0.3071
SL-1F-4(2,0t/ha,60cm)	1	10/9/06	0.0236	288.05	7.02	0.0088
SL-1F-4(2,0t/ha,60cm)	1	12/10/06	0.1293	160.30	7.07	0.0664
SL-1F-4(2,0t/ha,60cm)	1	4/13/07	1.6707	296.91	7.1	0.1323
SL-1F-4(2,0t/ha,60cm)	1	6/13/07	22.8813	105.05	7.23	4.9079

SL-1F-4(2,0t/ha,60cm)	1	12/14/07	2.4636	161.44	7	0.1266
SL-1F-4(2,0t/ha,60cm)	1	2/15/08	11.5305	160.31	7.00	1.6942
SL-1F-4(2,0t/ha,60cm)	1	4/16/08	9.5345	110.01	6.96	0.8941
SL-1F-4(2,0t/ha,60cm)	1	6/11/08	16.2473	93.63	6.73	0.3972
SL-1F-4(2,0t/ha,60cm)	1	1/11/09	22.3809	89.43	7.00	3.3607
SL-1F-5(2,0t/ha,30cm)	1	11/18/03	0.0440	187.17	7.31	0.0078
SL-1F-5(2,0t/ha,30cm)	1	12/8/03	0.0192	198.06	7.38	0.0254
SL-1F-5(2,0t/ha,30cm)	1	1/12/04	0.0715	210.34	7.38	-0.0094
SL-1F-5(2,0t/ha,30cm)	1	2/18/04	-0.0391	625.75	7.54	0.0097
SL-1F-5(2,0t/ha,30cm)	1	3/19/04	0.0170	296.00	7.54	0.0128
SL-1F-5(2,0t/ha,30cm)	1	4/23/04	0.0009	350.46	7.47	0.0090
SL-1F-5(2,0t/ha,30cm)	1	5/21/04	-0.0009	374.33	7.36	0.0115
SL-1F-5(2,0t/ha,30cm)	1	6/23/04	0.0102	323.51	7.28	0.0108
SL-1F-5(2,0t/ha,30cm)	1	8/25/04	0.0033	312.53	7.22	0.0207
SL-1F-5(2,0t/ha,30cm)	1	10/23/04	0.1274	307.67	7.41	0.0416
SL-1F-5(2,0t/ha,30cm)	1	12/13/04	0.0405	311.17	7.31	0.0279
SL-1F-5(2,0t/ha,30cm)	1	2/19/05	0.0024	306.49	7.29	0.0063
SL-1F-5(2,0t/ha,30cm)	1	4/22/05	0.0031	340.13	7.31	0.0064
SL-1F-5(2,0t/ha,30cm)	1	8/20/05	3.7468	295.96	7.67	0.2734
SL-1F-5(2,0t/ha,30cm)	1	10/13/05	0.1240	354.00	7.81	0.0406
SL-1F-5(2,0t/ha,30cm)	1	12/17/05	0.0947	472.69	7.31	0.0161
SL-1F-5(2,0t/ha,30cm)	1	2/20/06	0.4407	491.65	7.66	0.2819
SL-1F-5(2,0t/ha,30cm)	1	4/14/06	0.7810	390.58	7.38	0.0619
SL-1F-5(2,0t/ha,30cm)	1	8/11/06	0.0063	504.28	7.22	0.0102
SL-1F-5(2,0t/ha,30cm)	1	10/9/06	0.0164	495.59	7.21	0.0100
SL-1F-5(2,0t/ha,30cm)	1	12/10/06	1.0391	440.11	7.26	0.2561
SL-1F-5(2,0t/ha,30cm)	1	2/21/07	0.3635	444.97	7.46	0.0733
SL-1F-5(2,0t/ha,30cm)	1	6/13/07	1.7012	504.52	7.5	0.8004
SL-1F-5(2,0t/ha,30cm)	1	10/10/07	6.2005	521.01	7.65	0.7425
SL-1F-5(2,0t/ha,30cm)	1	12/14/07	-0.0938	571.69	7.23	0.1347
SL-1F-5(2,0t/ha,30cm)	1	2/15/08	0.5155	491.35	7.16	0.1253
SL-1F-5(2,0t/ha,30cm)	1	4/16/08	3.2013	453.23	7.17	0.3462
SL-1F-5(2,0t/ha,30cm)	1	6/11/08	2.6919	599.46	7.27	0.1016
SL-1F-5(2,0t/ha,30cm)	1	8/11/08	2.0074	549.75	7.39	0.1630
SL-1F-5(2,0t/ha,30cm)	1	10/5/08	2.9986	529.42	7.35	0.3644
SL-1F-5(2,0t/ha,30cm)	1	1/11/09	2.1005	487.39	7.30	0.4686
SL-1F-5(2,0t/ha,30cm)	1	4/8/09	0.1319	493.21	7.23	0.0176
SL-1F-5(2,0t/ha,30cm)	1	7/8/09	0.0993	582.74	7.19	
SL-1F-5(2,0t/ha,30cm)	1	10/9/09	0.0737	482.56	7.37	
SL-1G-1(4,716t/ha,60cm)	1	1/30/04	0.2206	971.49	8.30	0.0089
SL-1G-2(4,716t/ha,15cm)	1	11/23/03	0.4383	1851.66	8.04	-0.1482

SL-1G-2(4,716t/ha,15cm)	1	12/21/03	-0.0652	1794.76	7.85	0.3131
SL-1G-2(4,716t/ha,15cm)	1	1/30/04	0.2534	1795.72	7.97	-0.0020
SL-1G-2(4,716t/ha,15cm)	1	2/26/04	0.2861	1801.18	8.03	0.0019
SL-1G-2(4,716t/ha,15cm)	1	3/26/04	0.2553	1660.74	7.92	0.0066
SL-1G-2(4,716t/ha,15cm)	1	4/30/04	0.0016	1490.20	8.08	0.0158
SL-1G-2(4,716t/ha,15cm)	1	5/27/04	-0.0009	1597.32	7.98	0.0183
SL-1G-2(4,716t/ha,15cm)	1	6/30/04	0.0025	1702.25	7.69	0.0188
SL-1G-2(4,716t/ha,15cm)	1	8/31/04	-0.0070	1811.86	7.79	0.0253
SL-1G-2(4,716t/ha,15cm)	1	10/30/04	-0.0006	1781.37	7.64	0.0252
SL-1G-2(4,716t/ha,15cm)	1	12/22/04	0.0022	1399.90	7.60	0.0215
SL-1G-2(4,716t/ha,15cm)	1	2/26/05	0.0007	1266.94	7.62	0.0119
SL-1G-2(4,716t/ha,15cm)	1	4/29/05	0.0050	1331.44	7.61	0.0202
SL-1G-2(4,716t/ha,15cm)	1	6/18/05	0.0021	1455.94	7.56	0.0185
SL-1G-2(4,716t/ha,15cm)	1	8/25/05	0.0015	1841.77	7.88	0.0225
SL-1G-2(4,716t/ha,15cm)	1	10/18/05	0.0046	1707.43	7.74	0.0221
SL-1G-2(4,716t/ha,15cm)	1	12/21/05	0.0017	1384.82	7.55	0.0164
SL-1G-2(4,716t/ha,15cm)	1	2/26/06	-0.0007	1309.86	7.58	0.0153
SL-1G-2(4,716t/ha,15cm)	1	4/23/06	0.0023	1733.86	7.52	0.0210
SL-1G-2(4,716t/ha,15cm)	1	6/28/06	-0.0018	1653.86	7.44	0.0228
SL-1G-2(4,716t/ha,15cm)	1	8/16/06	-0.0046	2000.34	7.77	0.0256
SL-1G-2(4,716t/ha,15cm)	1	10/14/06	0.0013	1718.67	7.74	0.0295
SL-1G-2(4,716t/ha,15cm)	1	12/16/06	0.0092	1476.21	7.78	0.0164
SL-1G-2(4,716t/ha,15cm)	1	2/24/07	0.0245	1321.75	7.65	0.0185
SL-1G-2(4,716t/ha,15cm)	1	4/20/07	0.0134	1455.71	7.5	0.0205
SL-1G-2(4,716t/ha,15cm)	1	8/15/07	0.0299	1862.91	7.56	0.0259
SL-1G-2(4,716t/ha,15cm)	1	12/19/07	0.0239	1532.00	7.63	0.0247
SL-1G-2(4,716t/ha,15cm)	1	2/20/08	0.0117	2385.72	7.55	0.0233
SL-1G-2(4,716t/ha,15cm)	1	4/23/08	0.0035	1923.65	7.67	0.0223
SL-1G-2(4,716t/ha,15cm)	1	6/16/08	0.0184	1694.47	7.69	0.0252
SL-1G-2(4,716t/ha,15cm)	1	8/17/08	0.1354	1659.86	7.81	10.6048
SL-1G-2(4,716t/ha,15cm)	1	10/5/08	0.7705	1575.93	7.72	30.3868
SL-1G-2(4,716t/ha,15cm)	1	10/18/09	0.0901	1263.67	7.53	
SL-1G-3(4,716t/ha,30cm)	1	11/23/03	0.2600	2794.55	8.24	-0.1554
SL-1G-3(4,716t/ha,30cm)	1	12/21/03	0.0117	2239.34	7.96	0.0226
SL-1G-3(4,716t/ha,30cm)	1	1/30/04	0.2121	2360.27	8.00	0.0010
SL-1G-3(4,716t/ha,30cm)	1	2/26/04	0.0382	2252.89	8.18	0.0064
SL-1G-3(4,716t/ha,30cm)	1	3/26/04	-0.0895	2310.10	8.07	0.0081
SL-1G-3(4,716t/ha,30cm)	1	4/30/04	-0.0007	2184.19	8.20	0.0294
SL-1G-3(4,716t/ha,30cm)	1	5/27/04	-0.0060	2360.07	8.23	0.0331
SL-1G-3(4,716t/ha,30cm)	1	6/30/04	-0.0009	2962.08	8.00	0.0339
SL-1G-3(4,716t/ha,30cm)	1	8/31/04	-0.0109	2317.90	8.17	0.0388

SL-1G-3(4,716t/ha,30cm)	1	10/30/04	-0.0047	2203.14	7.96	0.0397
SL-1G-3(4,716t/ha,30cm)	1	12/22/04	0.0019	1683.35	7.96	0.0312
SL-1G-3(4,716t/ha,30cm)	1	2/26/05	0.0007	1066.36	7.76	0.0147
SL-1G-3(4,716t/ha,30cm)	1	4/29/05	0.0064	731.38	7.92	0.0304
SL-1G-3(4,716t/ha,30cm)	1	6/18/05	0.0063	756.50	7.79	0.0173
SL-1G-3(4,716t/ha,30cm)	1	8/25/05	0.0041	833.35	8.04	0.0204
SL-1G-3(4,716t/ha,30cm)	1	10/18/05	0.0076	1259.17	7.81	0.0153
SL-1G-3(4,716t/ha,30cm)	1	12/21/05	0.0037	1663.72	8.00	0.0221
SL-1G-3(4,716t/ha,30cm)	1	2/26/06	-0.0004	1832.57	8.16	0.0205
SL-1G-3(4,716t/ha,30cm)	1	4/23/06	0.0047	1915.07	7.95	0.0222
SL-1G-3(4,716t/ha,30cm)	1	6/28/06	0.0011	1931.56	8.18	0.0246
SL-1G-3(4,716t/ha,30cm)	1	8/16/06	-0.0005	2328.19	8.33	0.0318
SL-1G-3(4,716t/ha,30cm)	1	10/14/06	0.0052	2457.62	8.22	0.0341
SL-1G-3(4,716t/ha,30cm)	1	12/16/06	0.0097	2891.36	8.48	0.0403
SL-1G-3(4,716t/ha,30cm)	1	2/24/07	0.0358	2928.21	8.11	0.0495
SL-1G-3(4,716t/ha,30cm)	1	8/15/07	0.0010	3131.66	7.93	0.0487
SL-1G-3(4,716t/ha,30cm)	1	10/17/07	0.0103	2959.75	7.96	0.0433
SL-1G-3(4,716t/ha,30cm)	1	12/19/07	3.8810	3115.17	8.22	0.0479
SL-1G-3(4,716t/ha,30cm)	1	2/20/08	0.0071	3457.81	8.1	0.0384
SL-1G-3(4,716t/ha,30cm)	1	4/23/08	0.0179	3762.47	8.14	0.0434
SL-1G-3(4,716t/ha,30cm)	1	6/16/08	0.0056	3099.05	8.16	0.0400
SL-1G-3(4,716t/ha,30cm)	1	8/17/08	0.0239	3243.91	8.27	0.0833
SL-1G-3(4,716t/ha,30cm)	1	10/5/08	0.0279	3198.86	8.32	0.0528
SL-1G-3(4,716t/ha,30cm)	1	1/11/09	0.0100	3253.14	8.21	0.0550
SL-1G-6(4,716t/ha,120cm)	1	8/15/07	0.0253	367.06	7.54	0.2192
SL-1G-6(4,716t/ha,120cm)	1	10/17/07	0.0333	942.12	7.87	0.0238
SL-1G-6(4,716t/ha,120cm)	1	12/19/07	0.1936	1614.41	7.93	0.0339
SL-1G-6(4,716t/ha,120cm)	1	2/20/08	0.0182	1607.57	8	0.0235
SL-1G-6(4,716t/ha,120cm)	1	4/23/08	0.0200	2063.23	7.62	0.0304
SL-1G-6(4,716t/ha,120cm)	1	6/16/08	0.1162	626.56	7.7	0.0239
SL-1G-6(4,716t/ha,120cm)	1	1/11/09	0.0399	1380.73	7.93	0.0300
SL-1H-1(4,1074t/ha,15cm)	1	11/23/03	0.3424	616.97	7.85	-0.1763
SL-1H-1(4,1074t/ha,15cm)	1	12/21/03	0.1147	688.10	7.46	0.0075
SL-1H-1(4,1074t/ha,15cm)	1	1/30/04	0.1933	729.22	7.53	0.0083
SL-1H-1(4,1074t/ha,15cm)	1	2/26/04	0.1479	733.15	7.95	0.0017
SL-1H-1(4,1074t/ha,15cm)	1	3/26/04	0.0185	792.61	7.75	0.0045
SL-1H-1(4,1074t/ha,15cm)	1	4/30/04	0.0012	827.88	7.99	0.0145
SL-1H-1(4,1074t/ha,15cm)	1	5/27/04	-0.0006	802.50	7.79	0.0152
SL-1H-1(4,1074t/ha,15cm)	1	6/30/04	0.0035	819.41	7.45	0.0161
SL-1H-1(4,1074t/ha,15cm)	1	8/31/04	-0.0035	936.64	7.64	0.0193
SL-1H-1(4,1074t/ha,15cm)	1	10/30/04	-0.0189	1010.41	7.60	0.0543

SL-1H-1(4,1074t/ha,15cm)	1	12/22/04	-0.0134	1044.95	7.61	0.0439
SL-1H-1(4,1074t/ha,15cm)	1	2/26/05	0.0007	1214.16	7.60	0.0189
SL-1H-1(4,1074t/ha,15cm)	1	4/29/05	0.0219	1377.54	7.89	0.0289
SL-1H-1(4,1074t/ha,15cm)	1	6/18/05	0.0062	1438.76	8.04	0.0301
SL-1H-1(4,1074t/ha,15cm)	1	8/25/05	0.0072	1417.41	8.27	0.0379
SL-1H-1(4,1074t/ha,15cm)	1	10/18/05	0.0218	1473.93	8.24	0.0357
SL-1H-1(4,1074t/ha,15cm)	1	12/21/05	0.0029	1512.69	8.18	0.0297
SL-1H-1(4,1074t/ha,15cm)	1	2/26/06	-0.0204	1456.66	8.29	0.3112
SL-1H-1(4,1074t/ha,15cm)	1	4/23/06	-0.0021	1640.45	8.37	0.0337
SL-1H-1(4,1074t/ha,15cm)	1	6/28/06	-0.0186	1636.97	8.28	0.3830
SL-1H-1(4,1074t/ha,15cm)	1	8/16/06	-0.0041	1824.22	8.43	0.0371
SL-1H-1(4,1074t/ha,15cm)	1	10/14/06	0.0133	1668.39	8.41	0.0365
SL-1H-1(4,1074t/ha,15cm)	1	12/16/06	0.0192	1609.64	8.48	0.0303
SL-1H-1(4,1074t/ha,15cm)	1	2/24/07	0.0792	1421.97	8.19	0.0286
SL-1H-1(4,1074t/ha,15cm)	1	4/20/07	0.0139	1855.36	8.1	0.0317
SL-1H-1(4,1074t/ha,15cm)	1	10/17/07	0.0366	1789.90	8.15	0.0399
SL-1H-1(4,1074t/ha,15cm)	1	6/16/08	0.0208	1922.50	8.09	0.0335
SL-1H-1(4,1074t/ha,15cm)	1	4/18/09	-0.0020	2210.84	7.74	0.0312
SL-1H-1(4,1074t/ha,15cm)	1	7/16/09	0.0000	1996.24	8.13	
SL-1H-2(4,1074t/ha,30cm)	1	11/23/03	0.2657	131.14	7.85	-0.1741
SL-1H-2(4,1074t/ha,30cm)	1	12/21/03	0.0456	124.14	7.25	-0.0013
SL-1H-2(4,1074t/ha,30cm)	1	1/30/04	0.0870	119.17	7.19	-0.0064
SL-1H-2(4,1074t/ha,30cm)	1	2/26/04	0.0622	123.71	7.50	-0.0044
SL-1H-2(4,1074t/ha,30cm)	1	3/26/04	-0.0377	127.56	7.80	-0.0018
SL-1H-2(4,1074t/ha,30cm)	1	4/30/04	0.0080	132.14	7.86	0.0034
SL-1H-2(4,1074t/ha,30cm)	1	5/27/04	0.0052	152.62	7.81	0.0044
SL-1H-2(4,1074t/ha,30cm)	1	6/30/04	0.0051	133.29	7.56	0.0046
SL-1H-2(4,1074t/ha,30cm)	1	8/31/04	0.0020	133.51	7.45	0.0043
SL-1H-2(4,1074t/ha,30cm)	1	10/30/04	-0.0090	141.90	7.28	0.0310
SL-1H-2(4,1074t/ha,30cm)	1	12/22/04	0.0018	154.52	7.11	0.0167
SL-1H-2(4,1074t/ha,30cm)	1	2/26/05	0.0031	168.34	7.51	0.0038
SL-1H-2(4,1074t/ha,30cm)	1	4/29/05	0.0064	268.54	7.88	0.0314
SL-1H-2(4,1074t/ha,30cm)	1	6/18/05	0.0012	1123.86	7.66	0.0213
SL-1H-2(4,1074t/ha,30cm)	1	8/25/05	0.0019	649.10	8.20	0.0261
SL-1H-2(4,1074t/ha,30cm)	1	10/18/05	0.0173	765.96	8.09	0.0163
SL-1H-2(4,1074t/ha,30cm)	1	12/21/05	0.0052	808.48	8.09	0.0175
SL-1H-2(4,1074t/ha,30cm)	1	2/26/06	0.0008	905.56	8.10	0.0206
SL-1H-2(4,1074t/ha,30cm)	1	4/23/06	0.0033	1004.56	8.10	0.0183
SL-1H-2(4,1074t/ha,30cm)	1	6/28/06	-0.0014	1054.53	8.11	0.0252
SL-1H-2(4,1074t/ha,30cm)	1	8/16/06	-0.0014	1152.19	8.32	0.0219
SL-1H-2(4,1074t/ha,30cm)	1	10/14/06	0.0017	1145.58	8.23	0.0217

SL-1H-2(4,1074t/ha,30cm)	1	12/16/06	0.0067	1231.84	8.43	0.0208
SL-1H-2(4,1074t/ha,30cm)	1	4/20/07	0.0227	1591.53	8	0.0259
SL-1H-2(4,1074t/ha,30cm)	1	8/15/07	0.0025	1275.30	8.23	0.0299
SL-1H-2(4,1074t/ha,30cm)	1	12/19/07	29.8473	1576.35	7.94	0.1904
SL-1H-2(4,1074t/ha,30cm)	1	4/23/08	0.0620	1541.93	8.45	0.0280
SL-1H-2(4,1074t/ha,30cm)	1	6/16/08	0.0271	1559.89	8.12	0.0363
SL-1H-2(4,1074t/ha,30cm)	1	10/5/08	0.0218	1718.14	8.25	0.0723
SL-1H-2(4,1074t/ha,30cm)	1	7/16/09	0.0000	1677.55	8.04	
SL-1H-3(4,1074t/ha,60cm)	1	11/23/03	0.2821	1573.27	8.10	-0.1743
SL-1H-3(4,1074t/ha,60cm)	1	12/21/03	0.1303	812.93	7.59	0.0004
SL-1H-3(4,1074t/ha,60cm)	1	1/30/04	0.1455	926.34	7.56	-0.0008
SL-1H-3(4,1074t/ha,60cm)	1	2/26/04	0.0148	1196.06	8.11	0.0032
SL-1H-3(4,1074t/ha,60cm)	1	3/26/04	-0.0348	1149.69	7.94	0.0035
SL-1H-3(4,1074t/ha,60cm)	1	4/30/04	0.0012	657.48	7.96	0.0097
SL-1H-3(4,1074t/ha,60cm)	1	5/27/04	0.0014	743.84	7.87	0.0112
SL-1H-3(4,1074t/ha,60cm)	1	6/30/04	0.0021	26.11	7.41	0.0111
SL-1H-3(4,1074t/ha,60cm)	1	8/31/04	0.0007	338.47	7.19	0.0070
SL-1H-3(4,1074t/ha,60cm)	1	10/30/04	0.0009	269.58	7.10	0.0133
SL-1H-3(4,1074t/ha,60cm)	1	12/22/04	0.0041	153.73	6.93	0.0114
SL-1H-3(4,1074t/ha,60cm)	1	2/26/05	0.0025	151.88	7.03	0.0033
SL-1H-3(4,1074t/ha,60cm)	1	4/29/05	0.0110	144.51	7.34	0.0141
SL-1H-3(4,1074t/ha,60cm)	1	6/18/05	0.0054	153.56	7.39	0.0061
SL-1H-3(4,1074t/ha,60cm)	1	8/25/05	0.0070	191.68	7.78	0.0104
SL-1H-3(4,1074t/ha,60cm)	1	10/18/05	0.0017	230.88	7.70	0.0080
SL-1H-3(4,1074t/ha,60cm)	1	12/21/05	0.0005	188.21	7.08	0.0064
SL-1H-3(4,1074t/ha,60cm)	1	2/26/06	0.0022	166.69	7.22	0.0075
SL-1H-3(4,1074t/ha,60cm)	1	4/23/06	0.0031	179.69	7.45	0.0091
SL-1H-3(4,1074t/ha,60cm)	1	6/28/06	0.0015	227.72	7.57	0.0065
SL-1H-3(4,1074t/ha,60cm)	1	10/14/06	0.1539	239.28	7.87	0.0504
SL-1H-3(4,1074t/ha,60cm)	1	12/16/06	2.6746	218.78	7.55	0.5320
SL-1H-3(4,1074t/ha,60cm)	1	2/24/07	8.9027	214.13	7.65	0.1115
SL-1H-3(4,1074t/ha,60cm)	1	4/20/07	2.4386	206.70	7.7	0.3212
SL-1H-3(4,1074t/ha,60cm)	1	8/15/07	15.5555	244.52	7.42	1.1828
SL-1H-3(4,1074t/ha,60cm)	1	10/17/07	20.4643	265.10	7.6	1.6226
SL-1H-3(4,1074t/ha,60cm)	1	12/19/07	62.0886	239.53	7.56	0.3437
SL-1H-3(4,1074t/ha,60cm)	1	4/23/08	13.8051	294.21	7.59	0.1645
SL-1H-3(4,1074t/ha,60cm)	1	6/16/08	22.9104	249.02	7.33	0.2332
SL-1H-3(4,1074t/ha,60cm)	1	10/18/09	6.6733	405.84	7.28	
SL-1H-6(4,1074t/ha,120cm)	1	8/15/07	0.1914	234.43	7.6	0.7271
SL-1H-6(4,1074t/ha,120cm)	1	10/17/07	0.0432	346.06	7.47	0.0259
SL-1H-6(4,1074t/ha,120cm)	1	6/16/08	0.0346	371.55	6.8	0.0076

SL-1H-6(4,1074t/ha,120cm)	1	8/17/08	0.0151	355.21	7.13	0.0079
SL-1H-6(4,1074t/ha,120cm)	1	10/5/08	0.0359	374.87	7.22	0.0000
SL-1H-6(4,1074t/ha,120cm)	1	1/11/09	0.0045	394.30	6.88	0.0078
SL-1H-6(4,1074t/ha,120cm)	1	4/18/09	0.0129	372.27	6.91	0.0043
SL-1H-6(4,1074t/ha,120cm)	1	7/16/09	0.0026	337.61	6.71	
SL-1H-6(4,1074t/ha,120cm)	1	10/18/09	0.0066	378.61	6.92	
SL-1I-1(4,0t/ha,15cm)	1	11/23/03	0.1772	20.69	7.38	-0.1878
SL-1I-1(4,0t/ha,15cm)	1	12/21/03	-0.0143	20.41	7.19	0.0157
SL-1I-1(4,0t/ha,15cm)	1	2/26/04	0.0128	26.36	7.43	-0.0055
SL-1I-1(4,0t/ha,15cm)	1	3/26/04	-0.0773	41.03	7.52	0.0022
SL-1I-1(4,0t/ha,15cm)	1	4/30/04	0.0005	52.84	7.84	0.0088
SL-1I-1(4,0t/ha,15cm)	1	5/27/04	-0.0036	83.39	7.71	0.0140
SL-1I-1(4,0t/ha,15cm)	1	6/30/04	0.0051	139.04	7.69	0.0156
SL-1I-1(4,0t/ha,15cm)	1	8/31/04	-0.0050	208.37	7.83	0.0206
SL-1I-1(4,0t/ha,15cm)	1	10/18/09	5.1530	530.02	7.57	
SL-1I-2(4,0t/ha,30cm)	1	11/23/03	0.1845	67.31	7.33	-0.1833
SL-1I-2(4,0t/ha,30cm)	1	12/21/03	0.0016	62.47	7.07	-0.0067
SL-1I-2(4,0t/ha,30cm)	1	2/26/04	0.1063	65.55	7.35	-0.0046
SL-1I-2(4,0t/ha,30cm)	1	3/26/04	-0.0505	76.39	7.35	-0.0027
SL-1I-2(4,0t/ha,30cm)	1	4/30/04	0.0053	75.52	7.61	0.0031
SL-1I-2(4,0t/ha,30cm)	1	5/27/04	0.0039	87.06	7.72	0.0051
SL-1I-2(4,0t/ha,30cm)	1	6/30/04	0.0076	81.40	7.56	0.0070
SL-1I-2(4,0t/ha,30cm)	1	8/31/04	0.0219	99.43	7.45	0.0094
SL-1I-2(4,0t/ha,30cm)	1	10/30/04	0.0446	111.36	7.19	0.0400
SL-1I-2(4,0t/ha,30cm)	1	12/22/04	0.0299	129.55	7.19	0.0305
SL-1I-2(4,0t/ha,30cm)	1	2/26/05	0.0227	188.34	7.08	0.0145
SL-1I-2(4,0t/ha,30cm)	1	4/29/05	0.0139	223.24	7.09	0.0135
SL-1I-2(4,0t/ha,30cm)	1	6/18/05	0.0308	237.28	6.96	0.0152
SL-1I-2(4,0t/ha,30cm)	1	8/25/05	0.1424	241.29	7.71	0.2609
SL-1I-2(4,0t/ha,30cm)	1	10/18/05	0.1800	263.54	7.12	0.1195
SL-1I-2(4,0t/ha,30cm)	1	12/21/05	0.0915	360.66	7.17	0.1039
SL-1I-2(4,0t/ha,30cm)	1	2/26/06	0.1994	314.70	7.33	0.1200
SL-1I-2(4,0t/ha,30cm)	1	4/23/06	0.0860	308.35	7.14	0.0104
SL-1I-2(4,0t/ha,30cm)	1	6/28/06	1.2647	321.29	7.55	0.0478
SL-1I-2(4,0t/ha,30cm)	1	8/16/06	2.2319	353.73	7.49	0.1064
SL-1I-2(4,0t/ha,30cm)	1	10/14/06	5.8054	372.75	7.66	0.3413
SL-1I-2(4,0t/ha,30cm)	1	12/16/06	4.6769	355.78	7.65	0.8877
SL-1I-2(4,0t/ha,30cm)	1	2/24/07	3.6514	343.71	7.66	0.1531
SL-1I-2(4,0t/ha,30cm)	1	4/20/07	3.5994	360.27	7.5	0.6668
SL-1I-2(4,0t/ha,30cm)	1	8/15/07	10.3412	370.40	7.16	0.8708
SL-1I-2(4,0t/ha,30cm)	1	10/17/07	9.5266	371.53	7.4	1.1002

SL-1I-2(4,0t/ha,30cm)	1	12/19/07	0.6676	392.13	7.07	0.3799
SL-1I-2(4,0t/ha,30cm)	1	2/20/08	12.4298	571.96	7.17	0.6909
SL-1I-2(4,0t/ha,30cm)	1	4/23/08	4.5974	227.91	7.21	0.3252
SL-1I-2(4,0t/ha,30cm)	1	6/16/08	4.7903	224.54	7.02	0.2824
SL-1I-2(4,0t/ha,30cm)	1	10/5/08	41.4545	244.14	7.29	2.1978
SL-1I-2(4,0t/ha,30cm)	1	1/11/09	16.3085	237.09	7.04	1.8311
SL-1I-2(4,0t/ha,30cm)	1	4/18/09	7.9928	226.33	6.93	0.3177
SL-1I-2(4,0t/ha,30cm)	1	7/16/09	3.9560	175.23	6.9	
SL-1I-2(4,0t/ha,30cm)	1	10/18/09	9.1111	218.00	7.07	
SL-1I-4(4,0t/ha,60cm)	1	11/23/03	0.1715	37.58	7.13	-0.1808
SL-1I-4(4,0t/ha,60cm)	1	12/21/03	-0.0045	36.17	7.01	-0.0072
SL-1I-4(4,0t/ha,60cm)	1	2/26/04	0.0215	33.61	7.18	-0.0047
SL-1I-4(4,0t/ha,60cm)	1	3/26/04	-0.0485	59.56	7.19	-0.0023
SL-1I-4(4,0t/ha,60cm)	1	4/30/04	0.0015	166.07	7.37	0.0069
SL-1I-4(4,0t/ha,60cm)	1	5/27/04	-0.0016	695.44	7.51	0.0137
SL-1I-4(4,0t/ha,60cm)	1	6/30/04	0.0034	1540.82	7.94	0.0231
SL-1I-4(4,0t/ha,60cm)	1	8/31/04	-0.0117	1884.90	8.28	0.0402
SL-1I-4(4,0t/ha,60cm)	1	10/30/04	-0.0091	2119.92	8.22	0.0496
SL-1I-4(4,0t/ha,60cm)	1	12/22/04	-0.0014	2106.72	8.30	0.0579
SL-1I-4(4,0t/ha,60cm)	1	2/26/05	0.0007	2151.10	8.32	0.0431
SL-1I-4(4,0t/ha,60cm)	1	4/29/05	0.0085	2169.01	8.41	0.0802
SL-1I-4(4,0t/ha,60cm)	1	6/18/05	0.0327	2255.70	8.44	0.0966
SL-1I-4(4,0t/ha,60cm)	1	10/18/05	0.0119	2370.36	8.47	0.0571
SL-1I-4(4,0t/ha,60cm)	1	12/21/05	0.0061	1711.13	8.27	0.0389
SL-1I-4(4,0t/ha,60cm)	1	2/26/06	-0.0028	1560.64	8.36	0.0322
SL-1I-4(4,0t/ha,60cm)	1	4/23/06	0.0012	1593.30	8.33	0.0379
SL-1I-4(4,0t/ha,60cm)	1	8/16/06	0.0036	1577.47	8.52	0.0463
SL-1I-4(4,0t/ha,60cm)	1	12/16/06	0.1911	1292.49	8.48	0.0433
SL-1I-4(4,0t/ha,60cm)	1	10/17/07	0.0664	1007.62	8.04	0.0538
SL-1I-4(4,0t/ha,60cm)	1	12/19/07	-0.0083	1000.39	7.96	0.0401
SL-1I-4(4,0t/ha,60cm)	1	2/20/08	0.0350	821.09	7.96	0.0204
SL-1I-4(4,0t/ha,60cm)	1	4/23/08	0.0528	793.98	8.06	0.0259
SL-1I-4(4,0t/ha,60cm)	1	6/16/08	0.0544	730.13	7.73	0.0250
SL-1I-6(4,0t/ha,120cm)	1	8/15/07	0.0185	143.51	7.68	0.0862
SL-1I-6(4,0t/ha,120cm)	1	10/17/07	0.0080	161.48	7.68	0.0186
SL-1I-6(4,0t/ha,120cm)	1	12/19/07	0.2195	162.43	7.36	0.0131
SL-1I-6(4,0t/ha,120cm)	1	6/16/08	0.0605	205.92	7.28	0.0119
SL-1I-6(4,0t/ha,120cm)	1	8/17/08	0.2676	141.60	7.07	31.0518
SL-1I-6(4,0t/ha,120cm)	1	1/11/09	0.4476	219.54	7.28	13.1274
SL-1I-6(4,0t/ha,120cm)	1	4/18/09	0.9142	258.75	7.06	12.7791
SL-1I-6(4,0t/ha,120cm)	1	7/16/09	0.5328	224.01	7	

SL-1I-6(4,0t/ha,120cm)	1	10/18/09	0.2095	235.22	6.96	
SL-2A-1(4,716t/ha,15cm)	2	5/14/04	0.0013	903.21	8.03	0.0151
SL-2A-1(4,716t/ha,15cm)	2	6/16/04	0.0029	975.08	7.55	0.0185
SL-2A-1(4,716t/ha,15cm)	2	8/18/04	-0.0029	967.05	7.54	0.0185
SL-2A-1(4,716t/ha,15cm)	2	10/16/04	-0.0003	981.02	7.68	0.0221
SL-2A-1(4,716t/ha,15cm)	2	12/4/04	-0.0010	964.52	7.82	0.0217
SL-2A-1(4,716t/ha,15cm)	2	2/10/05	0.0007	998.17	7.84	0.0224
SL-2A-1(4,716t/ha,15cm)	2	4/14/05	0.0025	1065.51	7.85	0.0218
SL-2A-1(4,716t/ha,15cm)	2	6/4/05	0.0069	1110.08	7.73	0.0254
SL-2A-1(4,716t/ha,15cm)	2	8/11/05	0.0001	1111.09	7.67	0.0204
SL-2A-1(4,716t/ha,15cm)	2	10/6/05	0.0061	1085.87	7.88	0.0191
SL-2A-1(4,716t/ha,15cm)	2	12/8/05	0.0077	1164.17	7.72	0.0194
SL-2A-1(4,716t/ha,15cm)	2	2/5/06	0.0232	1088.74	8.06	0.0275
SL-2A-1(4,716t/ha,15cm)	2	4/10/06	0.0086	1137.47	8.09	0.0244
SL-2A-1(4,716t/ha,15cm)	2	6/16/06	-0.0019	1279.56	7.87	0.0245
SL-2A-1(4,716t/ha,15cm)	2	10/1/06	0.0612	1204.72	8.08	0.1604
SL-2A-1(4,716t/ha,15cm)	2	8/15/07	0.0230	1398.95	7.87	0.0343
SL-2A-1(4,716t/ha,15cm)	2	10/15/07	0.0175	1362.96	8.08	0.0298
SL-2A-1(4,716t/ha,15cm)	2	2/6/08	0.0173	1439.82	7.8	0.0283
SL-2A-1(4,716t/ha,15cm)	2	6/2/08	0.0308	1528.76	7.69	0.0340
SL-2A-1(4,716t/ha,15cm)	2	4/5/09	0.0585	1659.30	8.00	0.0398
SL-2A-1(4,716t/ha,15cm)	2	7/1/09	0.0000	1608.09	7.94	
SL-2A-1(4,716t/ha,15cm)	2	10/3/09	0.0171	1658.62	7.92	
SL-2A-2(4,716t/ha,60cm)	2	11/10/03	0.0120	202.24	6.94	-0.0100
SL-2A-2(4,716t/ha,60cm)	2	11/30/03	0.0051	222.08	7.24	0.0255
SL-2A-2(4,716t/ha,60cm)	2	1/6/04	0.0193	226.58	7.64	0.0067
SL-2A-2(4,716t/ha,60cm)	2	2/11/04	0.0719	257.52	7.47	-0.0012
SL-2A-2(4,716t/ha,60cm)	2	3/10/04	0.0784	256.18	7.12	-0.0060
SL-2A-2(4,716t/ha,60cm)	2	4/9/04	0.0016	264.36	7.55	0.0026
SL-2A-2(4,716t/ha,60cm)	2	5/14/04	0.0022	277.16	7.23	0.0029
SL-2A-2(4,716t/ha,60cm)	2	6/16/04	0.0043	265.20	6.95	0.0043
SL-2A-2(4,716t/ha,60cm)	2	8/18/04	0.0039	315.76	7.02	0.0052
SL-2A-2(4,716t/ha,60cm)	2	10/16/04	0.0065	313.33	7.12	0.0107
SL-2A-2(4,716t/ha,60cm)	2	12/4/04	0.0050	314.50	7.12	0.0086
SL-2A-2(4,716t/ha,60cm)	2	2/10/05	0.0065	318.53	7.20	0.0120
SL-2A-2(4,716t/ha,60cm)	2	4/14/05	0.0038	311.47	7.35	0.0060
SL-2A-2(4,716t/ha,60cm)	2	6/4/05	0.0081	305.89	6.90	0.0067
SL-2A-2(4,716t/ha,60cm)	2	8/11/05	0.0030	347.07	6.97	0.0053
SL-2A-2(4,716t/ha,60cm)	2	10/6/05	0.0053	336.92	7.36	0.0062
SL-2A-2(4,716t/ha,60cm)	2	12/8/05	0.0023	341.72	7.07	0.0076
SL-2A-2(4,716t/ha,60cm)	2	2/5/06	0.0051	321.60	7.57	0.0066

SL-2A-2(4,716t/ha,60cm)	2	4/10/06	0.0034	350.22	7.41	0.0049
SL-2A-2(4,716t/ha,60cm)	2	6/16/06	0.0029	357.99	7.38	0.0063
SL-2A-2(4,716t/ha,60cm)	2	8/2/06	0.0061	387.94	7.50	0.0074
SL-2A-2(4,716t/ha,60cm)	2	4/6/07	0.0350	676.67	7.6	0.0123
SL-2A-2(4,716t/ha,60cm)	2	10/1/07	0.0572	632.80	7.92	0.0226
SL-2A-2(4,716t/ha,60cm)	2	2/6/08	0.1064	848.11	7.19	0.0174
SL-2A-2(4,716t/ha,60cm)	2	4/9/08	0.0097	877.99	7.53	0.0182
SL-2A-2(4,716t/ha,60cm)	2	6/2/08	0.0291	1132.34	7.65	0.0253
SL-2A-5(4,716t/ha,30cm)	2	11/10/03	0.1068	1120.29	7.92	-0.0111
SL-2A-5(4,716t/ha,30cm)	2	11/30/03	0.0478	1231.11	8.07	0.0167
SL-2A-5(4,716t/ha,30cm)	2	1/6/04	0.0640	1544.03	8.32	0.0120
SL-2A-5(4,716t/ha,30cm)	2	2/11/04	0.0223	1684.04	8.14	0.0154
SL-2A-5(4,716t/ha,30cm)	2	3/10/04	0.0157	2046.68	8.12	0.0147
SL-2A-5(4,716t/ha,30cm)	2	4/9/04	-0.0013	1983.02	8.43	0.0216
SL-2A-5(4,716t/ha,30cm)	2	5/14/04	-0.0022	2010.87	8.24	0.0250
SL-2A-5(4,716t/ha,30cm)	2	6/16/04	-0.0019	1648.78	8.11	0.0303
SL-2A-5(4,716t/ha,30cm)	2	8/18/04	-0.0123	1843.29	8.09	0.0328
SL-2A-5(4,716t/ha,30cm)	2	10/16/04	-0.0020	1690.47	8.17	0.0326
SL-2A-5(4,716t/ha,30cm)	2	12/4/04	-0.0011	1601.95	8.25	0.0315
SL-2A-5(4,716t/ha,30cm)	2	2/10/05	0.0054	1668.66	8.25	0.0323
SL-2A-5(4,716t/ha,30cm)	2	4/14/05	0.0125	1663.89	8.32	0.0294
SL-2A-5(4,716t/ha,30cm)	2	6/4/05	0.0060	1847.06	8.06	0.0322
SL-2A-5(4,716t/ha,30cm)	2	8/11/05	0.0028	1656.51	8.18	0.0284
SL-2A-5(4,716t/ha,30cm)	2	10/6/05	0.0158	1605.00	8.38	0.0304
SL-2A-5(4,716t/ha,30cm)	2	12/8/05	0.0033	1796.34	8.31	0.0262
SL-2A-5(4,716t/ha,30cm)	2	2/5/06	0.0023	1460.80	8.29	0.0293
SL-2A-5(4,716t/ha,30cm)	2	4/10/06	0.0029	1527.38	8.31	0.0226
SL-2A-5(4,716t/ha,30cm)	2	6/16/06	-0.0046	1701.20	8.18	0.0253
SL-2A-5(4,716t/ha,30cm)	2	8/2/06	0.1493	1693.05	8.36	0.0416
SL-2A-5(4,716t/ha,30cm)	2	10/1/06	0.0017	1706.87	8.22	0.0286
SL-2A-5(4,716t/ha,30cm)	2	12/3/06	0.1894	1765.37	8.41	0.0329
SL-2A-5(4,716t/ha,30cm)	2	10/1/07	0.0759	1853.79	8.22	0.0407
SL-2A-5(4,716t/ha,30cm)	2	2/6/08	-0.0020	2234.95	7.94	0.0360
SL-2A-5(4,716t/ha,30cm)	2	4/9/08	0.0062	2376.40	7.83	0.0339
SL-2A-5(4,716t/ha,30cm)	2	10/2/08	0.0241	2148.22	7.9	0.0334
SL-2A-5(4,716t/ha,30cm)	2	1/11/09	0.0299	2553.28	8.17	0.0363
SL-2A-6(4,716t/ha,120cm)	2	8/1/07	0.4091	29.12	6.72	0.0966
SL-2A-6(4,716t/ha,120cm)	2	10/1/07	0.0357	19.36	6.71	0.0038
SL-2A-6(4,716t/ha,120cm)	2	2/6/08	0.0412	6.10	6.15	0.0043
SL-2A-6(4,716t/ha,120cm)	2	4/9/08	0.0076	2.37	6.01	0.0235
SL-2A-6(4,716t/ha,120cm)	2	6/2/08	0.0529	1.90	6.29	0.0021

SL-2A-6(4,716t/ha,120cm)	2	10/2/08	0.0123	2.87	5.93	0.0066
SL-2A-6(4,716t/ha,120cm)	2	1/11/09	0.0556	29.21	6.29	0.0064
SL-2A-6(4,716t/ha,120cm)	2	7/1/09	0.0000	6.64	6.3	
SL-2A-6(4,716t/ha,120cm)	2	10/3/09	0.0174	4.67	6.48	
SL-2B-1(4,1074t/ha,15cm)	2	11/10/03	-0.0246	25.92	6.32	0.0140
SL-2B-1(4,1074t/ha,15cm)	2	11/30/03	0.2454	29.17	6.38	0.0053
SL-2B-1(4,1074t/ha,15cm)	2	1/6/04	-0.0382	20.96	6.46	0.0097
SL-2B-1(4,1074t/ha,15cm)	2	2/11/04	-0.0111	27.62	6.53	0.0051
SL-2B-1(4,1074t/ha,15cm)	2	3/10/04	-0.0046	37.12	6.69	0.0043
SL-2B-1(4,1074t/ha,15cm)	2	4/9/04	-0.0023	44.30	6.65	0.0187
SL-2B-1(4,1074t/ha,15cm)	2	5/14/04	-0.0024	64.15	6.72	0.0143
SL-2B-1(4,1074t/ha,15cm)	2	6/16/04	0.0015	89.68	6.53	0.0147
SL-2B-1(4,1074t/ha,15cm)	2	8/18/04	-0.0059	103.71	6.75	0.0139
SL-2B-1(4,1074t/ha,15cm)	2	10/16/04	0.0023	160.79	6.93	0.0198
SL-2B-1(4,1074t/ha,15cm)	2	12/4/04	-0.0010	249.77	7.05	0.0172
SL-2B-1(4,1074t/ha,15cm)	2	2/10/05	0.0007	506.42	7.26	0.0180
SL-2B-1(4,1074t/ha,15cm)	2	4/14/05	0.0007	845.26	7.34	0.0140
SL-2B-1(4,1074t/ha,15cm)	2	6/4/05	0.0046	1077.79	7.32	0.0175
SL-2B-1(4,1074t/ha,15cm)	2	8/11/05	0.0020	1139.87	7.39	0.0172
SL-2B-1(4,1074t/ha,15cm)	2	10/6/05	0.0067	1195.59	7.63	0.0145
SL-2B-1(4,1074t/ha,15cm)	2	12/8/05	0.0018	1325.31	7.64	0.0157
SL-2B-1(4,1074t/ha,15cm)	2	2/5/06	-0.0030	1295.59	7.72	0.0158
SL-2B-1(4,1074t/ha,15cm)	2	4/10/06	-0.0027	1352.09	7.62	0.0131
SL-2B-1(4,1074t/ha,15cm)	2	6/16/06	-0.0036	1483.33	7.40	0.0151
SL-2B-1(4,1074t/ha,15cm)	2	8/2/06	-0.0003	1711.55	7.77	0.0159
SL-2B-1(4,1074t/ha,15cm)	2	10/1/06	0.0021	1621.43	7.51	0.0167
SL-2B-1(4,1074t/ha,15cm)	2	12/3/06	0.0054	1712.60	7.83	0.0173
SL-2B-1(4,1074t/ha,15cm)	2	4/6/07	0.0331	1927.98	7.3	0.0162
SL-2B-1(4,1074t/ha,15cm)	2	10/1/07	0.0279	1953.21	7.51	0.0268
SL-2B-1(4,1074t/ha,15cm)	2	2/6/08	0.0044	2152.33	7.58	0.0157
SL-2B-1(4,1074t/ha,15cm)	2	4/9/08	0.0133	2085.94	7.51	0.0167
SL-2B-1(4,1074t/ha,15cm)	2	6/2/08	0.0498	2234.44	7.73	0.0171
SL-2B-1(4,1074t/ha,15cm)	2	8/4/08	0.0049	2144.77	7.73	0.0153
SL-2B-1(4,1074t/ha,15cm)	2	1/11/09	0.0605	2410.89	7.95	0.0231
SL-2B-1(4,1074t/ha,15cm)	2	4/5/09	0.0275	2653.22	7.91	0.0191
SL-2B-1(4,1074t/ha,15cm)	2	7/1/09	0.0000	2397.75	7.72	
SL-2B-1(4,1074t/ha,15cm)	2	10/3/09	0.0000	2465.08	7.81	
SL-2B-2(4,1074t/ha,30cm)	2	11/10/03	0.0791	1684.37	8.14	-0.0001
SL-2B-2(4,1074t/ha,30cm)	2	11/30/03	0.0482	1818.94	8.25	-0.0004
SL-2B-2(4,1074t/ha,30cm)	2	1/6/04	0.0235	777.81	8.38	0.0159
SL-2B-2(4,1074t/ha,30cm)	2	2/11/04	0.0599	2182.13	8.27	0.0158

SL-2B-2(4,1074t/ha,30cm)	2	3/10/04	-0.0178	2572.58	8.30	0.0140
SL-2B-2(4,1074t/ha,30cm)	2	4/9/04	-0.0330	3284.11	8.17	0.0598
SL-2B-2(4,1074t/ha,30cm)	2	5/14/04	-0.0429	4894.59	7.94	0.0764
SL-2B-2(4,1074t/ha,30cm)	2	6/16/04	-0.0113	4073.85	8.04	0.0531
SL-2B-2(4,1074t/ha,30cm)	2	8/18/04	-0.0416	3965.85	8.27	0.0808
SL-2B-2(4,1074t/ha,30cm)	2	10/16/04	-0.0346	3456.02	8.30	0.0877
SL-2B-2(4,1074t/ha,30cm)	2	12/4/04	-0.0183	3425.76	8.30	0.0642
SL-2B-2(4,1074t/ha,30cm)	2	2/10/05	0.0007	3476.61	8.43	0.0557
SL-2B-2(4,1074t/ha,30cm)	2	4/14/05	0.0031	3619.83	8.38	0.0359
SL-2B-2(4,1074t/ha,30cm)	2	6/4/05	0.0046	4320.49	8.14	0.0507
SL-2B-2(4,1074t/ha,30cm)	2	8/11/05	0.0275	3982.29	8.58	0.0711
SL-2B-2(4,1074t/ha,30cm)	2	10/6/05	0.0363	3577.50	8.56	0.0757
SL-2B-2(4,1074t/ha,30cm)	2	12/8/05	0.0255	3952.50	8.57	0.0687
SL-2B-2(4,1074t/ha,30cm)	2	2/5/06	-0.0136	3861.21	8.49	0.0667
SL-2B-2(4,1074t/ha,30cm)	2	4/10/06	-0.0064	3236.69	8.40	0.0519
SL-2B-2(4,1074t/ha,30cm)	2	6/16/06	-0.0049	3258.73	8.30	0.0577
SL-2B-2(4,1074t/ha,30cm)	2	8/2/06	-0.0057	3810.62	8.63	0.0666
SL-2B-2(4,1074t/ha,30cm)	2	10/1/06	-0.0084	3436.85	8.34	0.0697
SL-2B-2(4,1074t/ha,30cm)	2	12/3/06	0.0007	3272.61	8.56	0.0756
SL-2B-2(4,1074t/ha,30cm)	2	2/12/07	0.0233	2584.96	8.22	0.2746
SL-2B-2(4,1074t/ha,30cm)	2	4/6/07	0.0267	3322.15	7.9	0.0820
SL-2B-2(4,1074t/ha,30cm)	2	8/1/07	0.0516	2671.31	8.28	0.0803
SL-2B-2(4,1074t/ha,30cm)	2	10/1/07	0.0166	3224.81	8.34	0.1280
SL-2B-2(4,1074t/ha,30cm)	2	2/6/08	0.0288	2972.05	8.27	0.0673
SL-2B-2(4,1074t/ha,30cm)	2	4/9/08	0.0026	3336.10	8.16	0.0542
SL-2B-2(4,1074t/ha,30cm)	2	6/2/08	0.0450	3232.13	8.34	0.0609
SL-2B-2(4,1074t/ha,30cm)	2	8/4/08	0.0620	3269.61	8.36	0.0929
SL-2B-2(4,1074t/ha,30cm)	2	7/1/09	0.0000	3201.99	8.36	
SL-2B-3(4,1074t/ha,60cm)	2	11/10/03	-0.0403	8.66	6.52	0.0197
SL-2B-3(4,1074t/ha,60cm)	2	11/30/03	0.2449	11.68	6.54	-0.0041
SL-2B-3(4,1074t/ha,60cm)	2	1/6/04	-0.0415	9.82	6.79	0.0005
SL-2B-3(4,1074t/ha,60cm)	2	2/11/04	-0.0183	6.89	6.45	0.0086
SL-2B-3(4,1074t/ha,60cm)	2	3/10/04	-0.0126	6.53	6.49	0.0030
SL-2B-3(4,1074t/ha,60cm)	2	4/9/04	-0.0125	4.91	6.39	0.0297
SL-2B-3(4,1074t/ha,60cm)	2	5/14/04	-0.0007	9.11	6.37	0.0074
SL-2B-3(4,1074t/ha,60cm)	2	6/16/04	0.0019	5.45	6.01	0.0078
SL-2B-3(4,1074t/ha,60cm)	2	8/18/04	-0.0181	4.56	6.17	0.0251
SL-2B-3(4,1074t/ha,60cm)	2	10/16/04	0.0001	5.61	6.24	0.0167
SL-2B-3(4,1074t/ha,60cm)	2	12/4/04	-0.0039	4.07	6.36	0.0143
SL-2B-3(4,1074t/ha,60cm)	2	2/10/05	0.0007	3.40	6.39	0.0160
SL-2B-3(4,1074t/ha,60cm)	2	4/14/05	0.0020	4.33	6.48	0.0070

SL-2B-3(4,1074t/ha,60cm)	2	6/4/05	0.0087	6.38	6.09	0.0071
SL-2B-3(4,1074t/ha,60cm)	2	8/11/05	0.0024	7.17	6.24	0.0054
SL-2B-3(4,1074t/ha,60cm)	2	10/6/05	0.0066	21.19	6.77	0.0050
SL-2B-3(4,1074t/ha,60cm)	2	12/8/05	0.0039	11.49	6.32	0.0143
SL-2B-3(4,1074t/ha,60cm)	2	2/5/06	0.0045	4.71	6.75	0.0050
SL-2B-3(4,1074t/ha,60cm)	2	4/10/06	0.0017	3.05	6.64	0.0055
SL-2B-3(4,1074t/ha,60cm)	2	6/16/06	0.0034	15.37	6.30	0.0052
SL-2B-3(4,1074t/ha,60cm)	2	8/2/06	0.0047	25.52	6.88	0.0054
SL-2B-3(4,1074t/ha,60cm)	2	10/1/06	0.0014	26.64	6.56	0.0051
SL-2B-3(4,1074t/ha,60cm)	2	12/3/06	0.0158	3.68	6.79	0.0067
SL-2B-3(4,1074t/ha,60cm)	2	4/6/07	0.1596	5.21	6.6	0.3892
SL-2B-3(4,1074t/ha,60cm)	2	8/1/07	0.0720	23.54	7.42	0.0107
SL-2B-3(4,1074t/ha,60cm)	2	2/6/08	0.0472	9.07	6.21	0.0099
SL-2B-3(4,1074t/ha,60cm)	2	4/9/08	0.0168	13.58	6.29	0.0158
SL-2B-3(4,1074t/ha,60cm)	2	6/2/08	0.0981	21.11	7	0.0219
SL-2B-3(4,1074t/ha,60cm)	2	8/4/08	0.1304	35.99	6.73	0.0383
SL-2B-3(4,1074t/ha,60cm)	2	10/2/08	0.1431	44.37	6.58	0.0475
SL-2B-3(4,1074t/ha,60cm)	2	4/5/09	-0.0030	59.72	6.17	0.0105
SL-2B-6(4,1074t/ha,120cm)	2	4/9/08	0.0061	4016.14	7.82	0.0684
SL-2B-6(4,1074t/ha,120cm)	2	6/2/08	0.1041	1363.16	7.69	0.3312
SL-2B-6(4,1074t/ha,120cm)	2	8/4/08	0.0563	2609.21	7.85	0.0566
SL-2B-6(4,1074t/ha,120cm)	2	7/1/09	0.0000	4867.54	8.08	
SL-2B-6(4,1074t/ha,120cm)	2	10/3/09	0.0000	4206.73	8.31	
SL-2C-1(4,0t/ha,30cm)	2	11/30/03	0.0612	789.00	7.97	-0.0153
SL-2C-1(4,0t/ha,30cm)	2	1/6/04	0.1843	876.39	8.20	0.0132
SL-2C-1(4,0t/ha,30cm)	2	2/11/04	0.1966	1049.74	8.12	0.0014
SL-2C-1(4,0t/ha,30cm)	2	3/10/04	0.1142	1186.02	7.96	0.0320
SL-2C-1(4,0t/ha,30cm)	2	4/9/04	-0.0080	1552.84	8.26	0.0226
SL-2C-1(4,0t/ha,30cm)	2	5/14/04	-0.0018	1476.74	8.07	0.0272
SL-2C-1(4,0t/ha,30cm)	2	6/16/04	0.0007	1407.98	7.91	0.0298
SL-2C-1(4,0t/ha,30cm)	2	8/18/04	-0.0169	2317.99	8.04	0.0452
SL-2C-1(4,0t/ha,30cm)	2	10/16/04	-0.0078	2177.92	8.18	0.0459
SL-2C-1(4,0t/ha,30cm)	2	12/4/04	-0.0033	2324.62	8.17	0.0475
SL-2C-1(4,0t/ha,30cm)	2	2/10/05	0.0007	2388.81	8.25	0.0540
SL-2C-1(4,0t/ha,30cm)	2	4/14/05	0.0007	2600.55	8.23	0.0397
SL-2C-1(4,0t/ha,30cm)	2	6/4/05	0.0079	2788.12	8.05	0.0472
SL-2C-1(4,0t/ha,30cm)	2	8/11/05	0.0094	2477.54	8.26	0.0539
SL-2C-1(4,0t/ha,30cm)	2	10/6/05	0.0224	2340.59	8.39	0.0502
SL-2C-1(4,0t/ha,30cm)	2	12/8/05	0.0096	2195.53	8.40	0.0407
SL-2C-1(4,0t/ha,30cm)	2	2/5/06	-0.0084	2482.82	8.33	0.0446
SL-2C-1(4,0t/ha,30cm)	2	4/10/06	-0.0103	2167.19	8.26	0.0424

SL-2C-1(4,0t/ha,30cm)	2	6/16/06	-0.0028	2390.22	8.29	0.0479
SL-2C-1(4,0t/ha,30cm)	2	8/2/06	-0.0046	2614.99	8.42	0.0488
SL-2C-1(4,0t/ha,30cm)	2	10/1/06	0.0012	2441.01	8.25	0.0438
SL-2C-1(4,0t/ha,30cm)	2	12/3/06	0.0034	2434.11	8.41	0.0451
SL-2C-1(4,0t/ha,30cm)	2	8/1/07	0.0037	2645.40	8.04	0.0532
SL-2C-1(4,0t/ha,30cm)	2	10/1/07	0.0142	2508.55	8.25	0.0622
SL-2C-1(4,0t/ha,30cm)	2	2/6/08	0.0000	2595.73	7.89	0.0354
SL-2C-1(4,0t/ha,30cm)	2	4/9/08	0.0079	2582.34	7.90	0.0329
SL-2C-1(4,0t/ha,30cm)	2	10/2/08	0.0018	2637.14	7.97	0.0341
SL-2C-1(4,0t/ha,30cm)	2	1/11/09	0.0912	2536.93	8.31	0.0355
SL-2C-2(4,0t/ha,15cm)	2	11/10/03	0.1196	896.60	8.00	-0.0119
SL-2C-2(4,0t/ha,15cm)	2	11/30/03	0.2524	984.97	8.23	-0.0057
SL-2C-2(4,0t/ha,15cm)	2	1/6/04	0.0778	1141.72	8.33	0.0127
SL-2C-2(4,0t/ha,15cm)	2	2/11/04	0.0509	1243.47	8.51	0.0064
SL-2C-2(4,0t/ha,15cm)	2	3/10/04	0.0761	1530.44	8.20	0.0133
SL-2C-2(4,0t/ha,15cm)	2	4/9/04	-0.0044	1581.49	8.48	0.0228
SL-2C-2(4,0t/ha,15cm)	2	5/14/04	-0.0025	1831.65	8.24	0.0249
SL-2C-2(4,0t/ha,15cm)	2	6/16/04	0.0036	1863.30	8.19	0.0298
SL-2C-2(4,0t/ha,15cm)	2	8/18/04	-0.0118	1986.32	8.13	0.0375
SL-2C-2(4,0t/ha,15cm)	2	10/16/04	-0.0047	2022.08	8.13	0.0387
SL-2C-2(4,0t/ha,15cm)	2	12/4/04	-0.0026	2194.71	8.30	0.0383
SL-2C-2(4,0t/ha,15cm)	2	2/10/05	0.0007	2317.70	8.20	0.0417
SL-2C-2(4,0t/ha,15cm)	2	4/14/05	0.0051	2490.09	8.27	0.0348
SL-2C-2(4,0t/ha,15cm)	2	6/4/05	0.0092	2531.10	8.08	0.0430
SL-2C-2(4,0t/ha,15cm)	2	8/11/05	0.0208	2497.89	8.33	0.0602
SL-2C-2(4,0t/ha,15cm)	2	10/6/05	0.0000	2276.47	8.41	0.0468
SL-2C-2(4,0t/ha,15cm)	2	12/8/05	0.0007	2386.98	8.38	0.0322
SL-2C-2(4,0t/ha,15cm)	2	2/5/06	-0.0061	2307.85	8.40	0.0380
SL-2C-2(4,0t/ha,15cm)	2	4/10/06	-0.0050	2324.16	8.31	0.0321
SL-2C-2(4,0t/ha,15cm)	2	6/16/06	-0.0031	2432.29	8.17	0.0459
SL-2C-2(4,0t/ha,15cm)	2	8/2/06	0.0005	2566.73	8.42	0.0376
SL-2C-2(4,0t/ha,15cm)	2	10/1/06	0.0033	2522.17	8.28	0.0391
SL-2C-2(4,0t/ha,15cm)	2	12/3/06	0.0027	2515.90	8.44	0.0416
SL-2C-2(4,0t/ha,15cm)	2	8/1/07	0.0493	2577.20	8.34	0.0699
SL-2C-2(4,0t/ha,15cm)	2	10/1/07	0.1047	2506.57	8.28	0.0557
SL-2C-2(4,0t/ha,15cm)	2	4/9/08	0.0150	2615.27	7.90	0.0331
SL-2C-2(4,0t/ha,15cm)	2	6/2/08	0.0370	2652.15	8.31	0.0408
SL-2C-2(4,0t/ha,15cm)	2	10/3/09	0.0000	2472.75	8.19	
SL-2C-5(4,0t/ha,60cm)	2	1/6/04	0.0019	113.69	7.00	-0.0026
SL-2C-5(4,0t/ha,60cm)	2	2/11/04	0.0074	133.30	7.70	-0.0031
SL-2C-5(4,0t/ha,60cm)	2	3/10/04	-0.0145	139.38	7.50	0.0060

SL-2C-5(4,0t/ha,60cm)	2	4/9/04	-0.0039	182.00	7.86	0.0111
SL-2C-5(4,0t/ha,60cm)	2	5/14/04	0.0063	205.79	8.02	0.0107
SL-2C-5(4,0t/ha,60cm)	2	6/16/04	0.0105	271.01	7.82	0.0155
SL-2C-5(4,0t/ha,60cm)	2	8/18/04	-0.0038	472.46	7.45	0.0149
SL-2C-5(4,0t/ha,60cm)	2	10/16/04	0.0011	620.12	7.67	0.0239
SL-2C-5(4,0t/ha,60cm)	2	12/4/04	-0.0016	794.40	7.93	0.0250
SL-2C-5(4,0t/ha,60cm)	2	2/10/05	0.0007	1176.57	7.83	0.0263
SL-2C-5(4,0t/ha,60cm)	2	4/14/05	0.0007	1319.81	7.96	0.0244
SL-2C-5(4,0t/ha,60cm)	2	6/4/05	0.0076	1786.21	7.78	0.0328
SL-2C-5(4,0t/ha,60cm)	2	8/11/05	0.0052	1655.60	8.01	0.0346
SL-2C-5(4,0t/ha,60cm)	2	10/6/05	0.0106	1411.68	8.22	0.0325
SL-2C-5(4,0t/ha,60cm)	2	12/8/05	0.0008	1440.24	7.91	0.0277
SL-2C-5(4,0t/ha,60cm)	2	2/5/06	-0.0029	1291.70	8.14	0.0283
SL-2C-5(4,0t/ha,60cm)	2	4/10/06	-0.0032	1278.35	8.07	0.0244
SL-2C-5(4,0t/ha,60cm)	2	6/16/06	-0.0027	1465.66	8.14	0.0290
SL-2C-5(4,0t/ha,60cm)	2	8/2/06	0.0007	1518.22	8.23	0.0282
SL-2C-5(4,0t/ha,60cm)	2	4/6/07	0.0305	1466.15	8	0.0254
SL-2C-5(4,0t/ha,60cm)	2	4/9/08	0.0140	1358.37	7.67	0.0220
SL-2C-5(4,0t/ha,60cm)	2	6/2/08	69.4401	170.46	7.01	0.1391
SL-2C-5(4,0t/ha,60cm)	2	10/2/08	0.0054	1511.07	7.7	0.0299
SL-2C-5(4,0t/ha,60cm)	2	1/11/09	0.0260	1572.17	7.92	0.0267
SL-2C-5(4,0t/ha,60cm)	2	7/1/09	0.0498	1439.44	8.06	
SL-2C-6(4,0t/ha,120cm)	2	8/1/07	0.0429	88.21	7.12	0.0139
SL-2C-6(4,0t/ha,120cm)	2	4/9/08	0.0291	36.05	6.76	0.0044
SL-2C-6(4,0t/ha,120cm)	2	10/2/08	0.0620	46.43	6.41	0.0085
SL-2D-1(3,716t/ha,15cm)	2	11/18/03	0.0054	64.25	7.12	0.0367
SL-2D-1(3,716t/ha,15cm)	2	12/8/03	-0.0202	66.02	6.80	0.0283
SL-2D-1(3,716t/ha,15cm)	2	1/12/04	-0.0061	72.24	7.02	-0.0105
SL-2D-1(3,716t/ha,15cm)	2	2/18/04	0.0042	84.34	7.08	0.0088
SL-2D-1(3,716t/ha,15cm)	2	3/19/04	-0.0484	91.18	6.93	0.0265
SL-2D-1(3,716t/ha,15cm)	2	4/23/04	0.0023	111.77	6.85	0.0105
SL-2D-1(3,716t/ha,15cm)	2	5/21/04	0.0025	137.52	7.77	0.0098
SL-2D-1(3,716t/ha,15cm)	2	6/23/04	0.0008	588.22	7.98	0.0197
SL-2D-1(3,716t/ha,15cm)	2	8/25/04	-0.0069	1726.21	8.18	0.0418
SL-2D-1(3,716t/ha,15cm)	2	10/23/04	-0.0051	1747.97	8.31	0.0548
SL-2D-1(3,716t/ha,15cm)	2	12/13/04	-0.0001	1785.97	8.33	0.0566
SL-2D-1(3,716t/ha,15cm)	2	2/19/05	0.0073	1801.48	8.21	0.0501
SL-2D-1(3,716t/ha,15cm)	2	6/11/05	0.0298	2044.00	8.36	0.0838
SL-2D-1(3,716t/ha,15cm)	2	8/11/06	-0.0002	1820.95	8.36	0.0468
SL-2D-1(3,716t/ha,15cm)	2	12/10/06	0.0351	1505.47	8.48	0.0529
SL-2D-1(3,716t/ha,15cm)	2	8/9/07	0.0581	1836.36	8.25	0.1271

SL-2D-1(3,716t/ha,15cm)	2	10/10/07	0.0319	1948.90	8.5	0.3826
SL-2D-1(3,716t/ha,15cm)	2	2/15/08	0.0141	1766.55	8.20	0.0556
SL-2D-2(3,716t/ha,60cm)	2	11/18/03	-0.0202	311.28	7.56	0.0473
SL-2D-2(3,716t/ha,60cm)	2	1/12/04	-0.0460	927.46	7.81	0.0055
SL-2D-2(3,716t/ha,60cm)	2	3/19/04	-0.0926	1676.33	8.06	0.0379
SL-2D-2(3,716t/ha,60cm)	2	4/23/04	0.0032	1661.99	7.71	0.0323
SL-2D-2(3,716t/ha,60cm)	2	5/21/04	0.0004	1581.78	7.48	0.0294
SL-2D-2(3,716t/ha,60cm)	2	6/23/04	0.0044	1374.10	7.50	0.0333
SL-2D-2(3,716t/ha,60cm)	2	8/25/04	0.0026	1251.01	7.54	0.0337
SL-2D-2(3,716t/ha,60cm)	2	10/23/04	0.0035	701.26	7.50	0.0548
SL-2D-2(3,716t/ha,60cm)	2	12/13/04	0.0015	835.96	7.50	0.0237
SL-2D-2(3,716t/ha,60cm)	2	2/19/05	0.0060	1370.03	7.84	0.0230
SL-2D-2(3,716t/ha,60cm)	2	4/22/05	0.0052	1570.99	7.67	0.0276
SL-2D-2(3,716t/ha,60cm)	2	6/11/05	0.0119	915.22	7.46	0.0380
SL-2D-2(3,716t/ha,60cm)	2	8/20/05	0.0060	880.24	7.50	0.0308
SL-2D-2(3,716t/ha,60cm)	2	10/13/05	0.0347	1494.67	7.97	0.0722
SL-2D-2(3,716t/ha,60cm)	2	12/17/05	0.0448	1588.90	7.90	0.0434
SL-2D-2(3,716t/ha,60cm)	2	2/20/06	0.0037	758.04	7.92	0.0347
SL-2D-2(3,716t/ha,60cm)	2	6/21/06	0.2173	1536.38	8.21	0.2085
SL-2D-2(3,716t/ha,60cm)	2	4/16/08	0.6543	1368.43	7.7	0.0921
SL-2D-2(3,716t/ha,60cm)	2	4/8/09	0.3853	1458.88	7.35	0.0744
SL-2D-2(3,716t/ha,60cm)	2	7/8/09	3.1843	1481.68	7.79	
SL-2D-5(3,716t/ha,30cm)	2	11/18/03	-0.0181	503.31	7.85	0.0699
SL-2D-5(3,716t/ha,30cm)	2	3/19/04	-0.1052	550.85	7.60	0.0190
SL-2D-6(3,716t/ha,120cm)	2	8/9/07	0.0835	159.46	7.18	0.0112
SL-2D-6(3,716t/ha,120cm)	2	10/10/07	0.0316	149.54	7.34	0.0053
SL-2D-6(3,716t/ha,120cm)	2	12/14/07	0.1906	1289.62	7.58	0.0455
SL-2D-6(3,716t/ha,120cm)	2	4/16/08	0.0093	1952.19	7.46	0.0382
SL-2D-6(3,716t/ha,120cm)	2	6/11/08	0.0084	1746.82	7.72	0.0455
SL-2D-6(3,716t/ha,120cm)	2	10/5/08	-0.0109	1551.47	7.65	0.0459
SL-2D-6(3,716t/ha,120cm)	2	1/11/09	0.0032	1722.31	8.13	0.0413
SL-2D-6(3,716t/ha,120cm)	2	4/8/09	-0.0125	1999.51	7.46	0.0427
SL-2D-6(3,716t/ha,120cm)	2	7/8/09	-0.0204	1656.41	7.92	
SL-2E-1(3,1074t/ha,60cm)	2	11/18/03	-0.0138	208.28	7.14	0.0045
SL-2E-1(3,1074t/ha,60cm)	2	12/8/03	0.0427	213.52	7.05	0.0123
SL-2E-1(3,1074t/ha,60cm)	2	1/12/04	0.1115	247.85	7.11	-0.0115
SL-2E-1(3,1074t/ha,60cm)	2	2/18/04	0.1437	287.66	7.26	-0.0034
SL-2E-1(3,1074t/ha,60cm)	2	3/19/04	-0.0634	273.12	7.22	0.0027
SL-2E-1(3,1074t/ha,60cm)	2	4/23/04	0.0058	326.09	7.21	0.0037
SL-2E-1(3,1074t/ha,60cm)	2	5/21/04	0.0051	302.75	7.21	0.0061
SL-2E-1(3,1074t/ha,60cm)	2	6/23/04	0.0063	341.85	6.93	0.0052

SL-2E-1(3,1074t/ha,60cm)	2	8/25/04	0.0266	328.31	7.01	0.0133
SL-2E-1(3,1074t/ha,60cm)	2	10/23/04	0.0758	400.96	7.05	0.0181
SL-2E-1(3,1074t/ha,60cm)	2	12/13/04	0.0853	395.98	7.11	0.0157
SL-2E-1(3,1074t/ha,60cm)	2	2/19/05	0.0203	388.90	7.10	0.0098
SL-2E-1(3,1074t/ha,60cm)	2	4/22/05	0.0380	357.24	7.59	0.0216
SL-2E-1(3,1074t/ha,60cm)	2	6/11/05	0.0376	162.52	6.94	0.0071
SL-2E-1(3,1074t/ha,60cm)	2	8/20/05	0.0256	218.33	7.39	0.0097
SL-2E-1(3,1074t/ha,60cm)	2	10/13/05	0.0141	337.60	6.94	0.0153
SL-2E-1(3,1074t/ha,60cm)	2	12/17/05	0.0182	594.45	7.10	0.0139
SL-2E-1(3,1074t/ha,60cm)	2	2/20/06	0.0190	475.39	7.23	0.0081
SL-2E-1(3,1074t/ha,60cm)	2	4/14/06	0.0104	537.46	7.15	0.0110
SL-2E-1(3,1074t/ha,60cm)	2	6/21/06	0.0293	547.46	7.36	0.0000
SL-2E-1(3,1074t/ha,60cm)	2	8/11/06	0.0060	599.53	7.70	0.0135
SL-2E-1(3,1074t/ha,60cm)	2	10/9/06	0.0250	640.39	7.09	0.0116
SL-2E-1(3,1074t/ha,60cm)	2	12/10/06	0.0241	616.89	7.61	0.0168
SL-2E-1(3,1074t/ha,60cm)	2	4/13/07	0.0731	628.97	7.5	0.0274
SL-2E-1(3,1074t/ha,60cm)	2	8/9/07	0.0760	488.19	7.68	0.0514
SL-2E-1(3,1074t/ha,60cm)	2	12/14/07	0.0851	570.86	7.65	0.0433
SL-2E-1(3,1074t/ha,60cm)	2	2/15/08	0.0719	519.10	7.66	0.0164
SL-2E-1(3,1074t/ha,60cm)	2	6/11/08	0.4045	429.33	7.78	0.1064
SL-2E-1(3,1074t/ha,60cm)	2	10/5/08	5.8386	459.05	7.55	1.1611
SL-2E-1(3,1074t/ha,60cm)	2	4/8/09	2.2025	436.82	7.47	0.3134
SL-2E-2(3,1074t/ha,15cm)	2	11/18/03	0.0036	251.95	7.38	0.0107
SL-2E-2(3,1074t/ha,15cm)	2	12/8/03	0.0294	293.53	7.34	0.0167
SL-2E-2(3,1074t/ha,15cm)	2	1/12/04	0.1143	348.71	7.64	-0.0086
SL-2E-2(3,1074t/ha,15cm)	2	2/18/04	0.1273	406.90	7.44	-0.0033
SL-2E-2(3,1074t/ha,15cm)	2	3/19/04	0.0280	415.41	7.50	0.0078
SL-2E-2(3,1074t/ha,15cm)	2	4/23/04	0.0024	559.99	7.49	0.0073
SL-2E-2(3,1074t/ha,15cm)	2	5/21/04	-0.0011	596.88	7.51	0.0081
SL-2E-2(3,1074t/ha,15cm)	2	6/23/04	0.0020	665.91	7.45	0.0109
SL-2E-2(3,1074t/ha,15cm)	2	8/25/04	-0.0015	890.36	7.55	0.0156
SL-2E-2(3,1074t/ha,15cm)	2	10/23/04	-0.0005	1118.65	7.90	0.0179
SL-2E-2(3,1074t/ha,15cm)	2	12/13/04	0.0001	1212.95	7.65	0.0174
SL-2E-2(3,1074t/ha,15cm)	2	2/19/05	0.0007	1057.34	7.55	0.0108
SL-2E-2(3,1074t/ha,15cm)	2	4/22/05	0.0007	1210.27	8.04	0.0119
SL-2E-2(3,1074t/ha,15cm)	2	6/11/05	0.0056	1408.63	7.59	0.0174
SL-2E-2(3,1074t/ha,15cm)	2	8/20/05	0.0011	1578.36	7.85	0.0206
SL-2E-2(3,1074t/ha,15cm)	2	10/13/05	0.0081	1631.16	7.60	0.0199
SL-2E-2(3,1074t/ha,15cm)	2	12/17/05	0.0024	1812.59	8.08	0.0224
SL-2E-2(3,1074t/ha,15cm)	2	2/20/06	0.0006	1817.20	8.12	0.0220
SL-2E-2(3,1074t/ha,15cm)	2	4/14/06	0.0033	1932.71	7.96	0.0247

SL-2E-2(3,1074t/ha,15cm)	2	6/21/06	0.0000	2212.12	7.87	0.0285
SL-2E-2(3,1074t/ha,15cm)	2	8/11/06	0.0033	2090.13	7.79	0.0267
SL-2E-2(3,1074t/ha,15cm)	2	10/9/06	0.0015	2022.74	7.97	0.0276
SL-2E-2(3,1074t/ha,15cm)	2	12/10/06	0.0155	2249.00	7.98	0.0294
SL-2E-2(3,1074t/ha,15cm)	2	4/13/07	0.0411	636.92	7.9	0.0302
SL-2E-2(3,1074t/ha,15cm)	2	6/13/07	0.0163	2325.79	7.85	0.0304
SL-2E-2(3,1074t/ha,15cm)	2	8/9/07	0.0227	2269.44	7.81	0.0425
SL-2E-2(3,1074t/ha,15cm)	2	10/10/07	0.0198	2038.03	7.85	0.0268
SL-2E-2(3,1074t/ha,15cm)	2	12/14/07	13.2041	2226.55	7.92	0.0344
SL-2E-2(3,1074t/ha,15cm)	2	2/15/08	0.0728	1994.39	7.64	0.0164
SL-2E-2(3,1074t/ha,15cm)	2	6/11/08	0.0185	2130.34	7.78	0.0300
SL-2E-2(3,1074t/ha,15cm)	2	10/5/08	0.0206	2132.68	8.16	0.0559
SL-2E-2(3,1074t/ha,15cm)	2	1/11/09	0.0916	2063.06	7.94	0.0594
SL-2E-2(3,1074t/ha,15cm)	2	4/8/09	-0.0050	2461.95	7.60	0.0293
SL-2E-2(3,1074t/ha,15cm)	2	7/8/09	-0.0177	2162.18	7.77	
SL-2E-5(3,1074t/ha,30cm)	2	11/18/03	0.0219	135.18	7.28	0.0081
SL-2E-5(3,1074t/ha,30cm)	2	12/8/03	0.0194	89.23	7.18	0.0196
SL-2E-5(3,1074t/ha,30cm)	2	1/12/04	0.0359	78.17	7.47	-0.0063
SL-2E-5(3,1074t/ha,30cm)	2	2/18/04	0.0465	70.35	7.21	-0.0062
SL-2E-5(3,1074t/ha,30cm)	2	3/19/04	0.0024	66.31	7.16	0.0021
SL-2E-5(3,1074t/ha,30cm)	2	4/23/04	0.0047	81.62	7.09	0.0029
SL-2E-5(3,1074t/ha,30cm)	2	5/21/04	0.0023	71.78	7.08	0.0031
SL-2E-5(3,1074t/ha,30cm)	2	6/23/04	0.0025	77.59	6.85	0.0049
SL-2E-5(3,1074t/ha,30cm)	2	8/25/04	0.0036	80.49	7.03	0.0060
SL-2E-5(3,1074t/ha,30cm)	2	10/23/04	0.0030	77.32	7.16	0.0122
SL-2E-5(3,1074t/ha,30cm)	2	12/13/04	-0.0014	93.50	7.14	0.0132
SL-2E-5(3,1074t/ha,30cm)	2	2/19/05	0.0056	101.90	7.05	0.0038
SL-2E-5(3,1074t/ha,30cm)	2	4/22/05	0.0007	124.14	7.52	0.0048
SL-2E-5(3,1074t/ha,30cm)	2	6/11/05	0.0041	138.27	7.20	0.0056
SL-2E-5(3,1074t/ha,30cm)	2	8/20/05	0.0030	136.10	7.31	0.0048
SL-2E-5(3,1074t/ha,30cm)	2	10/13/05	0.0062	129.79	7.19	0.0049
SL-2E-5(3,1074t/ha,30cm)	2	12/17/05	0.0023	129.48	7.38	0.0056
SL-2E-5(3,1074t/ha,30cm)	2	2/20/06	0.0044	148.50	7.79	0.0081
SL-2E-5(3,1074t/ha,30cm)	2	4/14/06	0.0028	168.58	7.73	0.0055
SL-2E-5(3,1074t/ha,30cm)	2	6/21/06	0.0067	184.52	7.71	0.0050
SL-2E-5(3,1074t/ha,30cm)	2	8/11/06	0.0033	205.95	7.49	0.0050
SL-2E-5(3,1074t/ha,30cm)	2	10/9/06	0.0090	203.86	7.58	0.0069
SL-2E-5(3,1074t/ha,30cm)	2	12/10/06	0.2694	216.69	7.8	0.0378
SL-2E-5(3,1074t/ha,30cm)	2	2/21/07	0.1852	251.02	7.64	0.0135
SL-2E-5(3,1074t/ha,30cm)	2	6/13/07	0.4774	311.71	7.64	0.0467
SL-2E-5(3,1074t/ha,30cm)	2	8/9/07	1.6356	308.74	7.82	0.1375

SL-2E-5(3,1074t/ha,30cm)	2	10/10/07	0.3177	293.65	7.78	0.0861
SL-2E-5(3,1074t/ha,30cm)	2	12/14/07	-0.2130	266.08	7.61	0.2796
SL-2E-5(3,1074t/ha,30cm)	2	2/15/08	2.8261	325.44	7.52	0.0967
SL-2E-5(3,1074t/ha,30cm)	2	4/16/08	4.2249	362.42	7.62	0.2591
SL-2E-5(3,1074t/ha,30cm)	2	6/11/08	15.3399	362.64	7.66	0.4257
SL-2E-5(3,1074t/ha,30cm)	2	4/8/09	6.7360	405.54	7.26	0.0239
SL-2E-5(3,1074t/ha,30cm)	2	7/8/09	18.6772	331.91	7.67	
SL-2E-6(3,1074t/ha,120cm)	2	8/9/07	0.2340	187.70	6.77	0.0226
SL-2E-6(3,1074t/ha,120cm)	2	2/15/08	0.0222	1669.48	7.45	0.0207
SL-2E-6(3,1074t/ha,120cm)	2	4/16/08	0.0177	1445.75	7.4	0.0212
SL-2E-6(3,1074t/ha,120cm)	2	6/11/08	0.0230	1747.13	7.31	0.0250
SL-2E-6(3,1074t/ha,120cm)	2	4/8/09	-0.0036	468.18	7.04	0.0112
SL-2F-1(3,0t/ha,30cm)	2	12/8/03	0.0170	156.07	7.98	0.0217
SL-2F-1(3,0t/ha,30cm)	2	1/12/04	0.0406	129.85	8.11	-0.0056
SL-2F-1(3,0t/ha,30cm)	2	8/25/04	0.0021	154.96	7.76	0.0076
SL-2F-1(3,0t/ha,30cm)	2	10/23/04	0.0085	150.63	7.90	0.0120
SL-2F-1(3,0t/ha,30cm)	2	12/13/04	0.0080	161.47	8.10	0.0191
SL-2F-1(3,0t/ha,30cm)	2	2/19/05	0.0087	164.10	8.00	0.0063
SL-2F-1(3,0t/ha,30cm)	2	4/22/05	0.0083	219.37	8.26	0.0105
SL-2F-1(3,0t/ha,30cm)	2	6/11/05	0.0107	209.50	7.99	0.0133
SL-2F-1(3,0t/ha,30cm)	2	8/20/05	0.0066	258.44	8.15	0.0118
SL-2F-1(3,0t/ha,30cm)	2	10/13/05	0.0112	262.53	8.15	0.0104
SL-2F-1(3,0t/ha,30cm)	2	12/17/05	0.0110	256.93	8.16	0.0157
SL-2F-1(3,0t/ha,30cm)	2	2/20/06	0.0087	264.11	8.27	0.0148
SL-2F-1(3,0t/ha,30cm)	2	4/14/06	0.0074	332.84	8.22	0.0104
SL-2F-1(3,0t/ha,30cm)	2	6/21/06	0.0375	361.22	8.16	0.0000
SL-2F-1(3,0t/ha,30cm)	2	8/11/06	0.0074	404.38	7.97	0.0422
SL-2F-1(3,0t/ha,30cm)	2	10/9/06	0.3800	393.09	8.03	10.4722
SL-2F-1(3,0t/ha,30cm)	2	12/10/06	0.1261	367.94	8.01	7.0718
SL-2F-1(3,0t/ha,30cm)	2	6/13/07	0.1882	583.34	7.94	2.1182
SL-2F-1(3,0t/ha,30cm)	2	10/10/07	0.9159	653.72	8.18	18.1309
SL-2F-1(3,0t/ha,30cm)	2	2/15/08	0.4633	673.28	7.82	4.4563
SL-2F-1(3,0t/ha,30cm)	2	4/16/08	0.0377	732.16	8.04	0.0787
SL-2F-1(3,0t/ha,30cm)	2	6/11/08	0.0535	759.50	7.9	0.0335
SL-2F-1(3,0t/ha,30cm)	2	4/8/09	0.0083	990.08	7.45	0.0190
SL-2F-2(3,0t/ha,60cm)	2	11/18/03	0.0130	176.66	8.00	0.0233
SL-2F-2(3,0t/ha,60cm)	2	2/18/04	0.0694	124.87	8.07	-0.0023
SL-2F-2(3,0t/ha,60cm)	2	3/19/04	0.0042	126.23	8.00	0.0025
SL-2F-2(3,0t/ha,60cm)	2	4/23/04	0.0090	139.08	8.00	0.0057
SL-2F-2(3,0t/ha,60cm)	2	5/21/04	0.0003	120.29	7.93	0.0062
SL-2F-2(3,0t/ha,60cm)	2	6/23/04	0.0047	136.63	8.00	0.0079

SL-2F-2(3,0t/ha,60cm)	2	10/23/04	0.0191	151.60	7.93	0.0152
SL-2F-2(3,0t/ha,60cm)	2	12/17/05	0.0049	169.71	7.60	0.0079
SL-2F-2(3,0t/ha,60cm)	2	2/20/06	0.0125	170.22	7.81	0.0101
SL-2F-2(3,0t/ha,60cm)	2	4/14/06	0.0059	180.56	7.80	0.0050
SL-2F-2(3,0t/ha,60cm)	2	6/21/06	0.0096	198.00	7.77	0.0063
SL-2F-2(3,0t/ha,60cm)	2	8/11/06	0.0092	201.37	7.83	0.0094
SL-2F-2(3,0t/ha,60cm)	2	10/9/06	0.0131	202.58	8.07	0.1773
SL-2F-2(3,0t/ha,60cm)	2	12/10/06	0.0180	213.74	7.61	0.0623
SL-2F-2(3,0t/ha,60cm)	2	6/13/07	0.1006	215.99	7.42	0.0539
SL-2F-2(3,0t/ha,60cm)	2	10/9/09	0.0286	387.52	7.03	
SL-2F-3(3,0t/ha,15cm)	2	11/18/03	-0.0042	1746.21	7.90	0.0229
SL-2F-3(3,0t/ha,15cm)	2	12/8/03	-0.0018	1718.55	8.27	0.0326
SL-2F-3(3,0t/ha,15cm)	2	1/12/04	0.0251	1765.39	8.37	0.0105
SL-2F-3(3,0t/ha,15cm)	2	2/18/04	-0.0294	741.99	8.55	0.0107
SL-2F-3(3,0t/ha,15cm)	2	3/19/04	0.0091	722.70	8.70	0.0170
SL-2F-3(3,0t/ha,15cm)	2	4/23/04	-0.0007	1771.24	8.43	0.0241
SL-2F-3(3,0t/ha,15cm)	2	5/21/04	-0.0031	1805.91	8.26	0.0256
SL-2F-3(3,0t/ha,15cm)	2	6/23/04	0.0001	1827.36	8.27	0.0250
SL-2F-3(3,0t/ha,15cm)	2	8/25/04	-0.0037	1922.12	8.35	0.0343
SL-2F-3(3,0t/ha,15cm)	2	10/23/04	-0.0017	1957.44	8.56	0.0429
SL-2F-3(3,0t/ha,15cm)	2	12/13/04	-0.0029	1875.78	8.46	0.0409
SL-2F-3(3,0t/ha,15cm)	2	2/19/05	0.0007	1844.34	8.41	0.0370
SL-2F-3(3,0t/ha,15cm)	2	4/22/05	0.0033	1793.96	8.52	0.0281
SL-2F-3(3,0t/ha,15cm)	2	6/11/05	0.0093	1946.39	8.48	0.0369
SL-2F-3(3,0t/ha,15cm)	2	8/20/05	0.0006	1921.02	8.32	0.0385
SL-2F-3(3,0t/ha,15cm)	2	10/13/05	0.0109	1779.24	8.30	0.0383
SL-2F-3(3,0t/ha,15cm)	2	12/17/05	0.0011	1723.17	8.37	0.0358
SL-2F-3(3,0t/ha,15cm)	2	2/20/06	-0.0019	1632.99	8.36	0.0353
SL-2F-3(3,0t/ha,15cm)	2	4/14/06	-0.0002	1822.56	8.20	0.0323
SL-2F-3(3,0t/ha,15cm)	2	6/21/06	-0.0003	1791.08	8.03	0.0340
SL-2F-3(3,0t/ha,15cm)	2	8/11/06	-0.0003	1741.15	8.15	0.0339
SL-2F-3(3,0t/ha,15cm)	2	10/9/06	-0.0009	1681.18	8.25	0.0350
SL-2F-3(3,0t/ha,15cm)	2	12/10/06	0.0096	1749.68	8.32	0.0348
SL-2F-3(3,0t/ha,15cm)	2	2/21/07	0.0187	1779.06	8.14	0.0299
SL-2F-3(3,0t/ha,15cm)	2	4/13/07	0.0149	1856.99	7.5	0.0370
SL-2F-3(3,0t/ha,15cm)	2	6/13/07	0.0020	1758.62	8.22	0.0327
SL-2F-3(3,0t/ha,15cm)	2	10/10/07	0.0069	1989.77	8.25	0.0746
SL-2F-3(3,0t/ha,15cm)	2	12/14/07	2.1916	1756.16	8.3	0.0412
SL-2F-3(3,0t/ha,15cm)	2	2/15/08	0.0271	1902.56	8.08	0.0269
SL-2F-3(3,0t/ha,15cm)	2	4/16/08	0.0119	1776.29	8.1	0.0251
SL-2F-3(3,0t/ha,15cm)	2	6/11/08	0.0339	1738.15	7.85	0.0283

Sample I.D.	Block	Sample Date	NO_3-N (mg/L)	TAN (mg/L)	pH	NO_2-N (mg/L)
SL-2F-3(3,0t/ha,15cm)	2	8/11/08	0.0255	1684.57	8.03	0.0488
SL-2F-3(3,0t/ha,15cm)	2	10/5/08	0.0234	1773.18	8.26	0.0357
SL-2F-3(3,0t/ha,15cm)	2	1/11/09	0.0282	1737.06	8.25	0.0318
SL-2F-3(3,0t/ha,15cm)	2	4/8/09	0.0000	1676.31	8.00	0.0246
SL-2F-3(3,0t/ha,15cm)	2	10/9/09	0.0000	1625.00	8.11	
SL-2F-6(3,0t/ha,120cm)	2	4/8/09	0.0012	22.42	6.35	0.0176
SL-2G-1(2,716t/ha,15cm)	2	11/23/03	0.2857	291.24	7.89	-0.1668
SL-2G-1(2,716t/ha,15cm)	2	12/21/03	0.0421	303.69	7.46	-0.0028
SL-2G-1(2,716t/ha,15cm)	2	1/30/04	0.0902	342.77	7.54	0.0053
SL-2G-1(2,716t/ha,15cm)	2	2/26/04	0.0734	358.66	7.86	0.0010
SL-2G-1(2,716t/ha,15cm)	2	3/26/04	0.0137	437.53	7.71	0.0067
SL-2G-1(2,716t/ha,15cm)	2	4/30/04	-0.0019	511.70	8.05	0.0156
SL-2G-1(2,716t/ha,15cm)	2	5/27/04	-0.0002	600.61	7.83	0.0174
SL-2G-1(2,716t/ha,15cm)	2	6/30/04	-0.0003	637.45	7.58	0.0234
SL-2G-1(2,716t/ha,15cm)	2	8/31/04	-0.0013	810.09	7.83	0.0263
SL-2G-1(2,716t/ha,15cm)	2	10/30/04	-0.0113	952.27	7.82	0.0325
SL-2G-1(2,716t/ha,15cm)	2	12/22/04	-0.0052	1017.15	7.81	0.0360
SL-2G-1(2,716t/ha,15cm)	2	2/26/05	-0.0052	1152.06	8.01	0.0282
SL-2G-1(2,716t/ha,15cm)	2	4/29/05	-0.0050	1197.71	8.16	0.0420
SL-2G-1(2,716t/ha,15cm)	2	6/18/05	0.0002	1358.36	7.99	0.0475
SL-2G-1(2,716t/ha,15cm)	2	8/25/05	0.0070	1476.71	8.27	0.0454
SL-2G-1(2,716t/ha,15cm)	2	10/18/05	0.0025	1378.04	8.27	0.0420
SL-2G-1(2,716t/ha,15cm)	2	12/21/05	0.0000	1362.49	7.92	0.0355
SL-2G-1(2,716t/ha,15cm)	2	2/26/06	-0.0079	1448.45	8.08	0.0348
SL-2G-1(2,716t/ha,15cm)	2	4/23/06	-0.0050	1440.70	7.84	0.0375
SL-2G-1(2,716t/ha,15cm)	2	6/28/06	-0.0068	1438.56	7.73	0.0409
SL-2G-1(2,716t/ha,15cm)	2	8/16/06	-0.0064	1453.16	7.93	0.0454
SL-2G-1(2,716t/ha,15cm)	2	10/14/06	-0.0054	1415.57	8.04	0.0552
SL-2G-1(2,716t/ha,15cm)	2	12/16/06	0.0029	1261.73	8.09	0.0364
SL-2G-1(2,716t/ha,15cm)	2	2/24/07	0.0165	1240.46	7.7	0.0332
SL-2G-1(2,716t/ha,15cm)	2	2/20/08	0.0466	1120.47	7.99	0.0296
SL-2G-1(2,716t/ha,15cm)	2	6/16/08	0.0495	1343.10	7.58	0.0336
SL-2G-1(2,716t/ha,15cm)	2	8/17/08	0.0102	1297.84	7.67	0.0424
SL-2G-1(2,716t/ha,15cm)	2	10/5/08	0.0165	1297.05	7.72	0.0561
SL-2G-1(2,716t/ha,15cm)	2	1/11/09	-0.0065	1278.96	7.53	0.0368
SL-2G-1(2,716t/ha,15cm)	2	4/18/09	0.0232	1232.66	7.65	0.0374

SL-2G-1(2,716t/ha,15cm)	2	7/16/09	0.0000	1169.47	7.44	
SL-2G-1(2,716t/ha,15cm)	2	10/18/09	0.0006	1166.75	7.62	
SL-2G-2(2,716t/ha,60cm)	2	11/23/03	0.1610	108.19	7.04	-0.1442
SL-2G-2(2,716t/ha,60cm)	2	12/21/03	0.0263	111.76	6.84	0.0029
SL-2G-2(2,716t/ha,60cm)	2	1/30/04	0.0562	92.00	7.40	-0.0052
SL-2G-2(2,716t/ha,60cm)	2	2/26/04	0.0216	93.20	6.86	0.0061
SL-2G-2(2,716t/ha,60cm)	2	3/26/04	-0.0523	102.05	6.85	-0.0011
SL-2G-2(2,716t/ha,60cm)	2	4/30/04	0.0029	107.95	6.88	0.0026
SL-2G-2(2,716t/ha,60cm)	2	5/27/04	0.0049	114.13	7.73	0.0053
SL-2G-2(2,716t/ha,60cm)	2	6/30/04	0.0061	107.91	6.76	0.0036
SL-2G-2(2,716t/ha,60cm)	2	8/31/04	0.0097	102.37	6.74	0.0031
SL-2G-2(2,716t/ha,60cm)	2	10/30/04	0.0041	135.46	6.73	0.0064
SL-2G-2(2,716t/ha,60cm)	2	12/22/04	0.0048	107.97	6.78	0.0099
SL-2G-2(2,716t/ha,60cm)	2	2/26/05	0.0027	89.73	6.70	0.0025
SL-2G-2(2,716t/ha,60cm)	2	4/29/05	0.0046	98.49	6.82	0.0083
SL-2G-2(2,716t/ha,60cm)	2	6/18/05	0.0036	96.91	6.88	0.0068
SL-2G-2(2,716t/ha,60cm)	2	8/25/05	0.0051	104.79	7.31	0.0033
SL-2G-2(2,716t/ha,60cm)	2	10/18/05	0.0150	147.83	7.12	0.0057
SL-2G-2(2,716t/ha,60cm)	2	12/21/05	0.0014	258.31	7.31	0.0069
SL-2G-2(2,716t/ha,60cm)	2	2/26/06	0.0409	218.62	7.75	0.0057
SL-2G-2(2,716t/ha,60cm)	2	4/23/06	0.3269	220.68	7.61	0.0211
SL-2G-2(2,716t/ha,60cm)	2	6/28/06	3.5525	217.01	7.54	0.0252
SL-2G-2(2,716t/ha,60cm)	2	8/16/06	0.0064	203.23	7.78	0.0059
SL-2G-2(2,716t/ha,60cm)	2	10/14/06	0.0131	243.24	7.98	0.0066
SL-2G-2(2,716t/ha,60cm)	2	12/16/06	0.0269	185.43	7.66	0.0037
SL-2G-2(2,716t/ha,60cm)	2	4/20/07	0.0359	151.35	7.3	0.0524
SL-2G-2(2,716t/ha,60cm)	2	10/17/07	0.0356	148.55	7.5	0.0072
SL-2G-2(2,716t/ha,60cm)	2	12/19/07	8.5514	143.69	7.33	0.0373
SL-2G-2(2,716t/ha,60cm)	2	2/20/08	0.0313	131.17	7.39	0.0058
SL-2G-2(2,716t/ha,60cm)	2	4/23/08	0.0394	120.15	7.35	0.0053
SL-2G-2(2,716t/ha,60cm)	2	6/16/08	0.0326	99.07	7.17	0.0055
SL-2G-2(2,716t/ha,60cm)	2	8/17/08	0.1837	117.04	7.3	0.0198
SL-2G-2(2,716t/ha,60cm)	2	10/18/09	0.0018	139.32	6.88	
SL-2G-5(2,716t/ha,30cm)	2	11/23/03	0.1661	7.27	7.00	-0.1709
SL-2G-5(2,716t/ha,30cm)	2	12/21/03	0.0198	6.36	6.93	-0.0155
SL-2G-5(2,716t/ha,30cm)	2	2/26/04	0.0043	6.02	6.95	-0.0006
SL-2G-5(2,716t/ha,30cm)	2	3/26/04	-0.0454	0.08	7.07	-0.0035
SL-2G-5(2,716t/ha,30cm)	2	4/30/04	0.0073	7.54	7.65	0.0019
SL-2G-5(2,716t/ha,30cm)	2	5/27/04	0.0017	10.14	7.16	0.0032
SL-2G-5(2,716t/ha,30cm)	2	6/30/04	0.0041	10.31	6.80	0.0034
SL-2G-5(2,716t/ha,30cm)	2	8/31/04	0.0062	17.70	6.78	0.0038

SL-2G-5(2,716t/ha,30cm)	2	10/30/04	0.0041	20.67	6.67	0.0068
SL-2G-5(2,716t/ha,30cm)	2	12/22/04	0.0044	25.78	6.69	0.0091
SL-2G-5(2,716t/ha,30cm)	2	2/26/05	0.0007	31.70	6.70	0.0043
SL-2G-5(2,716t/ha,30cm)	2	4/29/05	0.0032	39.90	7.18	0.0112
SL-2G-5(2,716t/ha,30cm)	2	6/18/05	0.0032	53.48	6.95	0.0052
SL-2G-5(2,716t/ha,30cm)	2	8/25/05	0.0050	65.94	7.23	0.0054
SL-2G-5(2,716t/ha,30cm)	2	10/18/05	0.0143	127.17	7.00	0.0055
SL-2G-5(2,716t/ha,30cm)	2	12/21/05	0.0040	175.28	6.91	0.0080
SL-2G-5(2,716t/ha,30cm)	2	2/26/06	0.0012	185.68	7.33	0.0059
SL-2G-5(2,716t/ha,30cm)	2	4/23/06	3.3007	206.98	6.85	0.0353
SL-2G-5(2,716t/ha,30cm)	2	6/28/06	0.6111	234.86	7.11	0.0168
SL-2G-5(2,716t/ha,30cm)	2	8/16/06	0.0390	254.34	7.84	0.0165
SL-2G-5(2,716t/ha,30cm)	2	10/14/06	0.1617	280.33	7.57	0.0102
SL-2G-5(2,716t/ha,30cm)	2	12/16/06	0.0277	280.44	7.55	0.0098
SL-2G-5(2,716t/ha,30cm)	2	2/24/07	0.0540	281.57	7.36	0.0186
SL-2G-5(2,716t/ha,30cm)	2	4/20/07	0.1518	321.70	7.4	0.0447
SL-2G-5(2,716t/ha,30cm)	2	8/15/07	0.4396	333.37	7.47	0.0638
SL-2G-5(2,716t/ha,30cm)	2	10/17/07	0.2083	326.57	7.49	0.0124
SL-2G-5(2,716t/ha,30cm)	2	2/20/08	1.2302	398.48	7.4	2.4755
SL-2G-5(2,716t/ha,30cm)	2	4/23/08	2.6420	435.74	7.43	2.3283
SL-2G-5(2,716t/ha,30cm)	2	6/16/08	5.1422	436.26	7.59	0.2207
SL-2G-5(2,716t/ha,30cm)	2	8/17/08	15.6190	404.77	7.46	0.0664
SL-2G-5(2,716t/ha,30cm)	2	10/5/08	35.1003	377.45	7.60	0.6967
SL-2G-5(2,716t/ha,30cm)	2	1/11/09	14.6346	445.32	7.68	0.1483
SL-2G-5(2,716t/ha,30cm)	2	4/18/09	4.6186	480.14	7.16	0.9968
SL-2G-6(2,716t/ha,120cm)	2	10/17/07	0.0678	77.39	6.53	0.0093
SL-2G-6(2,716t/ha,120cm)	2	12/19/07	6.3961	130.10	6.62	0.0551
SL-2G-6(2,716t/ha,120cm)	2	2/20/08	0.0570	293.15	6.62	0.0338
SL-2G-6(2,716t/ha,120cm)	2	4/23/08	0.0215	186.88	6.65	0.0057
SL-2G-6(2,716t/ha,120cm)	2	6/16/08	0.0271	180.08	6.62	0.0084
SL-2G-6(2,716t/ha,120cm)	2	8/17/08	0.2751	160.39	6.63	0.0142
SL-2G-6(2,716t/ha,120cm)	2	10/5/08	0.0062	150.06	6.78	0.0062
SL-2G-6(2,716t/ha,120cm)	2	1/11/09	0.0089	222.51	6.73	0.0056
SL-2G-6(2,716t/ha,120cm)	2	7/16/09	0.0000	227.88	6.67	
SL-2G-6(2,716t/ha,120cm)	2	10/18/09	0.0085	230.34	6.60	
SL-2H-1(2,1074t/ha,60cm)	2	11/23/03	0.1884	55.14	7.27	-0.1644
SL-2H-1(2,1074t/ha,60cm)	2	12/21/03	0.0476	53.32	6.89	0.0030
SL-2H-1(2,1074t/ha,60cm)	2	1/30/04	0.0468	54.74	6.88	-0.0001
SL-2H-1(2,1074t/ha,60cm)	2	2/26/04	0.0235	61.44	7.00	-0.0011
SL-2H-1(2,1074t/ha,60cm)	2	3/26/04	-0.0325	63.51	7.43	-0.0024
SL-2H-1(2,1074t/ha,60cm)	2	4/30/04	0.0066	68.77	7.80	0.0043

SL-2H-1(2,1074t/ha,60cm)	2	5/27/04	0.0039	71.35	7.94	0.0070
SL-2H-1(2,1074t/ha,60cm)	2	6/30/04	0.0046	72.72	7.81	0.0046
SL-2H-2(2,1074t/ha,30cm)	2	11/23/03	0.1956	80.03	6.92	-0.1671
SL-2H-2(2,1074t/ha,30cm)	2	12/21/03	0.0827	71.30	6.64	-0.0067
SL-2H-2(2,1074t/ha,30cm)	2	1/30/04	0.0564	72.25	6.92	-0.0053
SL-2H-2(2,1074t/ha,30cm)	2	2/26/04	0.0443	77.95	7.08	-0.0011
SL-2H-2(2,1074t/ha,30cm)	2	3/26/04	-0.0178	82.09	6.62	-0.0029
SL-2H-2(2,1074t/ha,30cm)	2	4/30/04	0.0031	89.38	7.02	0.0022
SL-2H-2(2,1074t/ha,30cm)	2	5/27/04	0.0010	90.43	6.54	0.0042
SL-2H-2(2,1074t/ha,30cm)	2	6/30/04	-0.0005	94.89	6.52	0.0084
SL-2H-2(2,1074t/ha,30cm)	2	8/31/04	0.0005	92.17	6.62	0.0067
SL-2H-2(2,1074t/ha,30cm)	2	10/30/04	0.0038	95.77	6.55	0.0059
SL-2H-2(2,1074t/ha,30cm)	2	12/22/04	0.0026	98.03	6.57	0.0133
SL-2H-2(2,1074t/ha,30cm)	2	2/26/05	0.0007	106.74	6.53	0.0080
SL-2H-2(2,1074t/ha,30cm)	2	4/29/05	0.0046	146.46	6.86	0.0119
SL-2H-2(2,1074t/ha,30cm)	2	6/18/05	0.0021	167.44	6.71	0.0071
SL-2H-2(2,1074t/ha,30cm)	2	8/25/05	0.0031	179.00	7.04	0.0065
SL-2H-2(2,1074t/ha,30cm)	2	10/18/05	0.0058	195.08	6.95	0.0059
SL-2H-2(2,1074t/ha,30cm)	2	12/21/05	0.0030	308.71	7.18	0.0093
SL-2H-2(2,1074t/ha,30cm)	2	2/26/06	-0.0002	544.11	7.61	0.0082
SL-2H-2(2,1074t/ha,30cm)	2	4/23/06	0.0015	512.74	7.24	0.0085
SL-2H-2(2,1074t/ha,30cm)	2	6/28/06	0.0068	540.17	7.24	0.0076
SL-2H-2(2,1074t/ha,30cm)	2	8/16/06	0.0161	514.07	7.40	0.0186
SL-2H-2(2,1074t/ha,30cm)	2	10/14/06	0.3273	496.43	7.68	1.0500
SL-2H-2(2,1074t/ha,30cm)	2	12/16/06	0.1820	606.16	7.76	0.1259
SL-2H-2(2,1074t/ha,30cm)	2	2/24/07	0.0999	820.54	8.03	0.0368
SL-2H-2(2,1074t/ha,30cm)	2	4/20/07	0.1248	757.30	7.4	0.0291
SL-2H-2(2,1074t/ha,30cm)	2	8/15/07	10.2916	620.57	7.5	0.8302
SL-2H-2(2,1074t/ha,30cm)	2	10/17/07	10.5346	572.08	7.19	1.5840
SL-2H-2(2,1074t/ha,30cm)	2	12/19/07	-0.7004	575.55	7.55	0.9725
SL-2H-2(2,1074t/ha,30cm)	2	2/20/08	6.1251	1245.29	7.36	0.7496
SL-2H-2(2,1074t/ha,30cm)	2	4/23/08	0.0333	1468.54	8.19	0.0278
SL-2H-2(2,1074t/ha,30cm)	2	1/11/09	3.0867	621.02	7.29	0.0803
SL-2H-2(2,1074t/ha,30cm)	2	4/18/09	1.8112	563.68	7.26	0.0279
SL-2H-2(2,1074t/ha,30cm)	2	7/16/09	4.2103	502.50	7.26	
SL-2H-2(2,1074t/ha,30cm)	2	10/18/09	5.5551	522.48	7.27	
SL-2H-3(2,1074/ha,15cm)	2	11/23/03	0.1578	740.41	8.27	-0.1544
SL-2H-3(2,1074/ha,15cm)	2	12/21/03	-0.0396	1153.70	7.86	-0.0126
SL-2H-3(2,1074/ha,15cm)	2	1/30/04	-0.0355	1567.14	7.79	0.0050
SL-2H-3(2,1074/ha,15cm)	2	2/26/04	-0.0477	2098.01	7.96	0.0104
SL-2H-3(2,1074/ha,15cm)	2	3/26/04	3.6648	2210.99	7.87	0.0126

SL-2H-3(2,1074/ha,15cm)	2	4/30/04	0.0025	2219.30	7.95	0.0245
SL-2H-3(2,1074/ha,15cm)	2	5/27/04	-0.0052	2029.18	8.02	0.0222
SL-2H-3(2,1074/ha,15cm)	2	6/30/04	0.0021	1788.70	8.17	0.0278
SL-2H-3(2,1074/ha,15cm)	2	8/31/04	-0.0090	1504.77	8.32	0.0329
SL-2H-3(2,1074/ha,15cm)	2	10/30/04	-0.0068	1505.21	8.23	0.0332
SL-2H-3(2,1074/ha,15cm)	2	12/22/04	-0.0013	1575.63	8.24	0.0287
SL-2H-3(2,1074/ha,15cm)	2	2/26/05	0.0007	1941.22	7.97	0.0174
SL-2H-3(2,1074/ha,15cm)	2	4/29/05	0.0050	1952.25	8.14	0.0306
SL-2H-3(2,1074/ha,15cm)	2	6/18/05	0.0029	1748.86	8.27	0.0431
SL-2H-3(2,1074/ha,15cm)	2	8/25/05	0.0083	1550.15	8.48	0.1371
SL-2H-3(2,1074/ha,15cm)	2	10/18/05	0.0279	1452.05	8.46	0.0276
SL-2H-3(2,1074/ha,15cm)	2	12/21/05	0.0008	1480.29	8.40	0.0227
SL-2H-3(2,1074/ha,15cm)	2	2/26/06	0.0008	1401.99	8.29	0.0220
SL-2H-3(2,1074/ha,15cm)	2	4/23/06	0.0045	1534.75	8.29	0.0240
SL-2H-3(2,1074/ha,15cm)	2	6/28/06	-0.0070	1478.27	8.25	0.3420
SL-2H-3(2,1074/ha,15cm)	2	8/16/06	0.0017	1520.68	8.46	0.0244
SL-2H-3(2,1074/ha,15cm)	2	10/14/06	0.0107	1312.68	8.43	0.0269
SL-2H-3(2,1074/ha,15cm)	2	12/16/06	0.0988	1209.24	8.41	1.2170
SL-2H-3(2,1074/ha,15cm)	2	4/20/07	0.0537	1329.40	7.8	0.0248
SL-2H-3(2,1074/ha,15cm)	2	8/15/07	0.1403	1321.40	7.89	0.0419
SL-2H-3(2,1074/ha,15cm)	2	10/17/07	0.1539	1271.95	7.82	0.0448
SL-2H-3(2,1074/ha,15cm)	2	12/19/07	78.1692	1292.44	7.97	0.1476
SL-2H-3(2,1074/ha,15cm)	2	2/20/08	0.0607	1257.18	8.14	0.0187
SL-2H-3(2,1074/ha,15cm)	2	6/16/08	0.0620	1292.32	7.88	0.0273
SL-2H-6(2,1074t/ha,120cm)	2	4/23/08	0.0716	424.01	7.65	0.0147
SL-2H-6(2,1074t/ha,120cm)	2	1/11/09	0.1024	1399.23	7.43	0.0388
SL-2I-1(2,0t/ha,15cm)	2	12/21/03	-0.0836	1460.27	9.71	0.0640
SL-2I-1(2,0t/ha,15cm)	2	1/30/04	-0.0128	1317.21	10.05	0.0430
SL-2I-1(2,0t/ha,15cm)	2	2/26/04	-0.0489	1183.76	11.33	0.0106
SL-2I-1(2,0t/ha,15cm)	2	3/26/04	3.7765	1031.22	10.94	0.0105
SL-2I-1(2,0t/ha,15cm)	2	5/27/04	0.1212	1037.82	10.59	0.0250
SL-2I-1(2,0t/ha,15cm)	2	6/30/04	0.0144	2007.41	8.50	0.0395
SL-2I-1(2,0t/ha,15cm)	2	8/31/04	0.0029	1926.94	8.00	0.0378
SL-2I-1(2,0t/ha,15cm)	2	10/30/04	0.0022	1896.04	8.66	0.0467
SL-2I-1(2,0t/ha,15cm)	2	2/26/05	0.1070	1181.59	11.37	0.0327
SL-2I-1(2,0t/ha,15cm)	2	4/29/05	0.1307	1081.04	11.90	0.0282
SL-2I-1(2,0t/ha,15cm)	2	10/18/05	0.0228	1809.06	8.57	0.0582
SL-2I-2(2,0t/ha,30cm)	2	11/23/03	0.2722	245.77	8.09	-0.1599
SL-2I-2(2,0t/ha,30cm)	2	12/21/03	0.0265	237.43	7.70	-0.0289
SL-2I-2(2,0t/ha,30cm)	2	1/30/04	0.0323	249.33	7.71	-0.0034
SL-2I-2(2,0t/ha,30cm)	2	2/26/04	-0.0032	268.40	8.10	-0.0082

SL-2I-2(2,0t/ha,30cm)	2	3/26/04	3.8212	268.17	8.03	-0.0016
SL-2I-2(2,0t/ha,30cm)	2	4/30/04	0.0010	285.38	8.13	0.0074
SL-2I-2(2,0t/ha,30cm)	2	5/27/04	0.0001	325.35	8.25	0.0065
SL-2I-2(2,0t/ha,30cm)	2	6/30/04	0.0027	331.73	7.99	0.0094
SL-2I-2(2,0t/ha,30cm)	2	8/31/04	-0.0003	330.93	7.87	0.0076
SL-2I-2(2,0t/ha,30cm)	2	10/30/04	0.0040	345.90	7.97	0.0179
SL-2I-2(2,0t/ha,30cm)	2	12/22/04	0.0051	386.68	7.99	0.0162
SL-2I-2(2,0t/ha,30cm)	2	2/26/05	0.0172	396.01	8.28	0.0104
SL-2I-2(2,0t/ha,30cm)	2	4/29/05	0.0237	443.25	8.33	0.0407
SL-2I-2(2,0t/ha,30cm)	2	6/18/05	0.0064	526.54	8.10	0.0226
SL-2I-2(2,0t/ha,30cm)	2	8/25/05	0.0053	645.56	8.17	0.0225
SL-2I-2(2,0t/ha,30cm)	2	10/18/05	0.0094	676.73	8.32	0.0225
SL-2I-2(2,0t/ha,30cm)	2	12/21/05	0.0027	690.81	8.21	0.0188
SL-2I-2(2,0t/ha,30cm)	2	2/26/06	-0.0017	724.86	8.26	0.0176
SL-2I-2(2,0t/ha,30cm)	2	4/23/06	0.0156	849.90	8.30	0.4045
SL-2I-2(2,0t/ha,30cm)	2	6/28/06	0.0047	985.47	8.24	0.0437
SL-2I-2(2,0t/ha,30cm)	2	8/16/06	0.1569	998.04	8.40	3.2511
SL-2I-2(2,0t/ha,30cm)	2	10/14/06	5.6129	1002.60	8.21	0.8334
SL-2I-2(2,0t/ha,30cm)	2	12/16/06	6.0480	1051.12	8.24	0.4364
SL-2I-2(2,0t/ha,30cm)	2	2/24/07	7.5054	1014.66	7.61	0.3594
SL-2I-2(2,0t/ha,30cm)	2	4/20/07	0.4861	1284.19	7.9	0.0704
SL-2I-2(2,0t/ha,30cm)	2	8/15/07	0.1685	1353.68	7.98	0.7380
SL-2I-2(2,0t/ha,30cm)	2	12/19/07	-0.0327	1398.89	7.83	0.1417
SL-2I-2(2,0t/ha,30cm)	2	2/20/08	0.0249	1364.05	8.12	0.0236
SL-2I-2(2,0t/ha,30cm)	2	4/23/08	3.9423	589.07	7.47	0.6019
SL-2I-2(2,0t/ha,30cm)	2	6/16/08	0.0637	1499.01	8.11	0.0490
SL-2I-5(2,0t/ha,60cm)	2	11/23/03	0.1655	48.30	7.34	-0.1548
SL-2I-5(2,0t/ha,60cm)	2	12/21/03	0.0563	45.62	7.01	-0.0144
SL-2I-5(2,0t/ha,60cm)	2	2/26/04	0.0174	55.09	7.80	-0.0029
SL-2I-5(2,0t/ha,60cm)	2	2/24/07	0.0608	434.29	7.81	0.0244
SL-2I-5(2,0t/ha,60cm)	2	4/23/08	4.3403	533.14	7.81	8.7607
SL-2I-6(2,0t/ha,120cm)	2	8/15/07	0.1302	371.59	7.69	0.0383
SL-2I-6(2,0t/ha,120cm)	2	10/17/07	0.0180	416.07	7.41	0.0255
SL-2I-6(2,0t/ha,120cm)	2	12/19/07	0.0779	439.63	7.83	0.0195
SL-2I-6(2,0t/ha,120cm)	2	2/20/08	0.0199	349.80	7.85	0.0060
SL-2I-6(2,0t/ha,120cm)	2	6/16/08	0.2399	380.56	7.61	0.0242
SL-2I-6(2,0t/ha,120cm)	2	4/18/09	0.0056	435.46	6.93	0.0043
SL-2I-6(2,0t/ha,120cm)	2	7/16/09	0.0061	397.61	7.59	
SL-3A-2(2,1074t/ha,15cm)	3	11/10/03	0.1843	2772.50	8.13	0.0093
SL-3A-2(2,1074t/ha,15cm)	3	11/30/03	0.1621	3609.19	8.12	0.0045
SL-3A-2(2,1074t/ha,15cm)	3	1/6/04	0.0982	808.61	8.16	0.0366

SL-3A-2(2,1074t/ha,15cm)	3	2/11/04	0.1401	2690.65	8.08	0.0183
SL-3A-2(2,1074t/ha,15cm)	3	3/10/04	0.0373	2858.52	8.12	0.0330
SL-3A-2(2,1074t/ha,15cm)	3	4/9/04	0.0865	3046.44	8.22	0.1596
SL-3A-2(2,1074t/ha,15cm)	3	5/14/04	0.0183	2956.59	7.99	0.0485
SL-3A-2(2,1074t/ha,15cm)	3	6/16/04	0.0042	2936.74	7.97	0.0448
SL-3A-2(2,1074t/ha,15cm)	3	8/18/04	-0.0184	3004.37	7.98	0.0522
SL-3A-2(2,1074t/ha,15cm)	3	10/16/04	0.0018	3059.10	8.09	0.0571
SL-3A-2(2,1074t/ha,15cm)	3	12/4/04	0.0112	3043.29	8.14	0.0538
SL-3A-2(2,1074t/ha,15cm)	3	2/10/05	0.0007	3017.40	8.01	0.0556
SL-3A-2(2,1074t/ha,15cm)	3	4/14/05	0.0097	3160.09	8.15	0.0510
SL-3A-2(2,1074t/ha,15cm)	3	6/4/05	0.0694	3278.78	7.99	0.0645
SL-3A-2(2,1074t/ha,15cm)	3	8/11/05	0.0225	3094.89	8.29	0.0783
SL-3A-2(2,1074t/ha,15cm)	3	8/2/06	0.0088	2994.53	8.49	0.0705
SL-3A-2(2,1074t/ha,15cm)	3	12/3/06	0.0053	3144.55	8.36	0.1082
SL-3A-2(2,1074t/ha,15cm)	3	6/5/07	0.0455	2405.59	8.35	0.0739
SL-3A-2(2,1074t/ha,15cm)	3	12/7/07	0.3324	3011.95	7.88	0.0684
SL-3A-2(2,1074t/ha,15cm)	3	2/6/08	0.0134	2976.25	7.88	0.1283
SL-3A-2(2,1074t/ha,15cm)	3	4/9/08	0.0119	3033.55	7.94	0.0490
SL-3A-2(2,1074t/ha,15cm)	3	6/2/08	0.0441	2883.24	6.89	0.0587
SL-3A-2(2,1074t/ha,15cm)	3	1/11/09	0.0102	2860.61	8.07	0.0576
SL-3A-2(2,1074t/ha,15cm)	3	7/1/09	-0.0096	2677.87	7.71	
SL-3A-2(2,1074t/ha,15cm)	3	10/3/09	0.0000	2916.73	8.18	
SL-3A-4(2,1074t/ha,30cm)	3	11/10/03	0.0182	46.77	7.50	-0.0059
SL-3A-4(2,1074t/ha,30cm)	3	11/30/03	0.0912	43.94	7.6	0.0095
SL-3A-4(2,1074t/ha,30cm)	3	2/11/04	0.0058	38.63	7.69	-0.0048
SL-3A-4(2,1074t/ha,30cm)	3	3/10/04	0.0066	38.55	7.34	0.0013
SL-3A-4(2,1074t/ha,30cm)	3	4/9/04	0.0042	41.35	7.50	0.0000
SL-3A-4(2,1074t/ha,30cm)	3	5/14/04	0.0022	0.50	7.68	0.0045
SL-3A-4(2,1074t/ha,30cm)	3	6/16/04	0.0043	59.04	7.30	0.0058
SL-3A-4(2,1074t/ha,30cm)	3	8/18/04	-0.0016	61.12	7.12	0.0090
SL-3A-4(2,1074t/ha,30cm)	3	10/16/04	0.0021	73.00	7.24	0.0059
SL-3A-4(2,1074t/ha,30cm)	3	12/4/04	0.0066	79.17	7.72	0.0156
SL-3A-4(2,1074t/ha,30cm)	3	2/10/05	0.0064	106.82	7.51	0.0144
SL-3A-4(2,1074t/ha,30cm)	3	4/14/05	0.0041	144.42	7.69	0.0098
SL-3A-4(2,1074t/ha,30cm)	3	6/4/05	0.0060	174.15	7.42	0.0121
SL-3A-4(2,1074t/ha,30cm)	3	8/11/05	0.0148	211.61	7.39	0.0087
SL-3A-4(2,1074t/ha,30cm)	3	10/6/05	0.0559	239.23	7.86	0.0251
SL-3A-4(2,1074t/ha,30cm)	3	12/8/05	0.0086	288.75	7.75	0.0153
SL-3A-4(2,1074t/ha,30cm)	3	2/5/06	0.0119	351.24	7.96	0.0130
SL-3A-4(2,1074t/ha,30cm)	3	4/10/06	0.0013	390.55	8.09	0.0127
SL-3A-4(2,1074t/ha,30cm)	3	6/16/06	0.0216	454.33	8.04	0.0156

SL-3A-4(2,1074t/ha,30cm)	3	8/2/06	0.0019	502.93	7.93	0.0156
SL-3A-4(2,1074t/ha,30cm)	3	10/1/06	-0.0025	536.64	7.84	0.0158
SL-3A-4(2,1074t/ha,30cm)	3	12/3/06	0.0099	580.82	8.04	0.0205
SL-3A-4(2,1074t/ha,30cm)	3	4/6/07	0.0541	699.06	8	0.0532
SL-3A-4(2,1074t/ha,30cm)	3	6/5/07	0.0414	778.80	7.56	0.0217
SL-3A-4(2,1074t/ha,30cm)	3	8/1/07	0.0533	777.64	8.13	0.0599
SL-3A-4(2,1074t/ha,30cm)	3	10/1/07	0.0421	814.85	7.84	0.0422
SL-3A-4(2,1074t/ha,30cm)	3	4/9/08	0.0153	1110.61	7.59	0.0185
SL-3A-4(2,1074t/ha,30cm)	3	8/4/08	0.1259	1103.77	7.88	0.0819
SL-3A-4(2,1074t/ha,30cm)	3	10/2/08	0.0039	1204.78	7.72	0.0220
SL-3A-5(2,1074t/ha,60cm)	3	11/30/03	0.1344	41.66	6.77	0.0110
SL-3A-5(2,1074t/ha,60cm)	3	1/6/04	-0.0197	39.20	6.98	0.0005
SL-3A-5(2,1074t/ha,60cm)	3	2/11/04	0.0053	37.60	7.54	-0.0013
SL-3A-5(2,1074t/ha,60cm)	3	3/10/04	0.0129	30.01	6.75	-0.0027
SL-3A-5(2,1074t/ha,60cm)	3	4/9/04	0.0019	17.65	7.08	0.0075
SL-3A-5(2,1074t/ha,60cm)	3	5/14/04	0.0020	26.97	6.60	0.0022
SL-3A-5(2,1074t/ha,60cm)	3	6/16/04	0.0051	24.14	6.37	0.0041
SL-3A-5(2,1074t/ha,60cm)	3	8/18/04	-0.0409	21.90	6.37	0.0500
SL-3A-5(2,1074t/ha,60cm)	3	10/16/04	-0.0155	18.85	6.47	0.0238
SL-3A-5(2,1074t/ha,60cm)	3	12/4/04	0.0041	24.12	6.60	0.0109
SL-3A-5(2,1074t/ha,60cm)	3	2/10/05	0.0030	16.47	6.52	0.0186
SL-3A-5(2,1074t/ha,60cm)	3	4/14/05	0.0036	11.67	6.63	0.0114
SL-3A-5(2,1074t/ha,60cm)	3	6/4/05	0.0153	12.71	6.35	0.0066
SL-3A-5(2,1074t/ha,60cm)	3	8/2/06	0.0349	25.47	6.89	0.0341
SL-3A-5(2,1074t/ha,60cm)	3	10/1/06	0.0054	26.91	6.49	0.0051
SL-3A-5(2,1074t/ha,60cm)	3	8/1/07	0.0746	33.90	6.65	0.0278
SL-3A-5(2,1074t/ha,60cm)	3	10/1/07	0.0528	38.03	6.49	0.0443
SL-3A-7(2,1074t/ha,120cm)	3	8/1/07	0.0470	61.84	7.35	0.0069
SL-3A-7(2,1074t/ha,120cm)	3	10/1/07	0.0298	37.75	7.00	0.0157
SL-3A-7(2,1074t/ha,120cm)	3	4/9/08	0.0118	172.47	6.62	0.0055
SL-3A-7(2,1074t/ha,120cm)	3	6/2/08	0.0188	156.30	7.25	0.0045
SL-3A-7(2,1074t/ha,120cm)	3	10/2/08	0.0712	145.92	6.98	0.0069
SL-3A-7(2,1074t/ha,120cm)	3	1/11/09	0.0326	144.22	6.67	0.0033
SL-3A-7(2,1074t/ha,120cm)	3	4/5/09	0.0052	151.04	7.00	0.0053
SL-3A-7(2,1074t/ha,120cm)	3	7/1/09	0.0092	139.52	6.56	
SL-3A-7(2,1074t/ha,120cm)	3	10/3/09	0.0000	152.29	6.64	
SL-3B-3(2,716t/ha,15cm)	3	11/10/03	0.0339	1150.97	8.26	-0.0093
SL-3B-3(2,716t/ha,15cm)	3	11/30/03	0.1267	1178.99	7.9	0.0111
SL-3B-3(2,716t/ha,15cm)	3	1/6/04	0.1551	1046.47	8.14	0.0032
SL-3B-3(2,716t/ha,15cm)	3	2/11/04	0.1658	922.19	7.88	-0.0008
SL-3B-3(2,716t/ha,15cm)	3	3/10/04	0.0709	1069.35	7.99	0.0103

SL-3B-3(2,716t/ha,15cm)	3	4/9/04	0.0020	1168.74	8.34	0.0129
SL-3B-3(2,716t/ha,15cm)	3	5/14/04	0.0013	1255.84	7.96	0.0196
SL-3B-3(2,716t/ha,15cm)	3	6/16/04	0.0020	1646.75	7.89	0.0290
SL-3B-3(2,716t/ha,15cm)	3	8/18/04	-0.0052	1696.01	7.86	0.0296
SL-3B-3(2,716t/ha,15cm)	3	10/16/04	-0.0036	1842.89	8.05	0.0307
SL-3B-3(2,716t/ha,15cm)	3	12/4/04	-0.0012	1807.04	8.18	0.0331
SL-3B-3(2,716t/ha,15cm)	3	2/10/05	0.0017	1651.78	8.12	0.0375
SL-3B-3(2,716t/ha,15cm)	3	4/14/05	0.0103	1854.54	8.13	0.0308
SL-3B-3(2,716t/ha,15cm)	3	6/4/05	0.0053	2832.13	7.75	0.0472
SL-3B-3(2,716t/ha,15cm)	3	8/11/05	0.0053	2896.02	8.35	0.0782
SL-3B-3(2,716t/ha,15cm)	3	10/6/05	0.0325	2773.30	8.43	0.0710
SL-3B-3(2,716t/ha,15cm)	3	12/8/05	0.0061	2124.60	8.16	0.0516
SL-3B-3(2,716t/ha,15cm)	3	2/5/06	0.0003	1959.70	8.16	0.0340
SL-3B-3(2,716t/ha,15cm)	3	4/10/06	-0.0030	2070.77	8.32	0.0415
SL-3B-3(2,716t/ha,15cm)	3	6/16/06	-0.0030	2195.12	8.17	0.0494
SL-3B-3(2,716t/ha,15cm)	3	8/2/06	0.0016	2270.18	8.47	0.0509
SL-3B-3(2,716t/ha,15cm)	3	10/1/06	0.0035	2140.82	8.05	0.4971
SL-3B-3(2,716t/ha,15cm)	3	12/3/06	0.0042	2068.50	8.42	0.0422
SL-3B-3(2,716t/ha,15cm)	3	4/6/07	0.0589	98.54	6.2	0.1129
SL-3B-3(2,716t/ha,15cm)	3	8/1/07	0.0035	2160.97	7.96	0.0461
SL-3B-3(2,716t/ha,15cm)	3	10/1/07	0.0081	2126.28	8.05	0.0519
SL-3B-3(2,716t/ha,15cm)	3	2/6/08	4.6428	2044.91	8.1	0.0326
SL-3B-3(2,716t/ha,15cm)	3	4/9/08	0.0261	2072.13	8.11	0.0342
SL-3B-3(2,716t/ha,15cm)	3	6/2/08	0.0876	1974.02	8.52	0.0569
SL-3B-3(2,716t/ha,15cm)	3	10/2/08	0.0011	2266.24	8.22	0.0342
SL-3B-3(2,716t/ha,15cm)	3	1/11/09	0.0126	2239.98	8.34	0.0619
SL-3B-3(2,716t/ha,15cm)	3	10/3/09	0.0000	2296.67	8.47	
SL-3B-4(2,716t/ha,30cm)	3	11/10/03	-0.0036	115.26	6.96	-0.0004
SL-3B-4(2,716t/ha,30cm)	3	11/30/03	0.3340	134.34	7.03	0.0180
SL-3B-4(2,716t/ha,30cm)	3	1/6/04	0.0150	194.23	7.30	0.0076
SL-3B-4(2,716t/ha,30cm)	3	2/11/04	0.0336	203.84	7.45	-0.0012
SL-3B-4(2,716t/ha,30cm)	3	3/10/04	0.0371	215.06	7.19	0.0033
SL-3B-4(2,716t/ha,30cm)	3	4/9/04	0.0039	217.77	7.72	0.0076
SL-3B-4(2,716t/ha,30cm)	3	5/14/04	0.0027	218.15	7.31	0.0065
SL-3B-4(2,716t/ha,30cm)	3	6/16/04	0.0031	215.55	6.99	0.0087
SL-3B-4(2,716t/ha,30cm)	3	8/18/04	-0.0012	205.08	7.08	0.0073
SL-3B-4(2,716t/ha,30cm)	3	10/16/04	0.0038	185.32	7.12	0.0057
SL-3B-4(2,716t/ha,30cm)	3	12/4/04	-0.0018	299.35	7.22	0.0141
SL-3B-4(2,716t/ha,30cm)	3	2/10/05	0.0042	427.56	7.29	0.0129
SL-3B-4(2,716t/ha,30cm)	3	4/14/05	0.0024	471.03	7.51	0.0080
SL-3B-4(2,716t/ha,30cm)	3	6/4/05	0.0142	457.03	7.22	0.0092

SL-3B-4(2,716t/ha,30cm)	3	8/11/05	0.0025	362.34	7.24	0.0058
SL-3B-4(2,716t/ha,30cm)	3	10/6/05	0.0142	338.64	7.85	0.0196
SL-3B-4(2,716t/ha,30cm)	3	12/8/05	0.0039	616.48	7.31	0.0095
SL-3B-4(2,716t/ha,30cm)	3	2/5/06	0.0004	689.31	7.44	0.0087
SL-3B-4(2,716t/ha,30cm)	3	4/10/06	0.0030	653.47	7.86	0.0074
SL-3B-4(2,716t/ha,30cm)	3	8/2/06	0.0030	632.04	7.73	0.0097
SL-3B-4(2,716t/ha,30cm)	3	10/1/06	0.0153	722.35	7.45	0.0073
SL-3B-4(2,716t/ha,30cm)	3	12/3/06	0.0097	704.19	7.62	0.0075
SL-3B-4(2,716t/ha,30cm)	3	4/6/07	0.0103	484.95	6.9	0.0056
SL-3B-4(2,716t/ha,30cm)	3	8/1/07	0.0185	612.52	7.9	0.0091
SL-3B-4(2,716t/ha,30cm)	3	10/1/07	0.0403	590.38	7.45	0.0107
SL-3B-4(2,716t/ha,30cm)	3	4/9/08	0.0101	802.29	7.41	0.0068
SL-3B-4(2,716t/ha,30cm)	3	6/2/08	0.0232	731.62	7.78	0.0083
SL-3B-4(2,716t/ha,30cm)	3	8/4/08	0.0501	698.59	7.53	0.0578
SL-3B-4(2,716t/ha,30cm)	3	10/2/08	0.5953	674.02	7.35	0.0934
SL-3B-4(2,716t/ha,30cm)	3	1/11/09	1.3687	709.40	7.68	0.0113
SL-3B-4(2,716t/ha,30cm)	3	4/5/09	0.3362	770.11	7.85	0.1199
SL-3B-4(2,716t/ha,30cm)	3	7/1/09	4.8342	654.84	7.61	
SL-3B-4(2,716t/ha,30cm)	3	10/3/09	4.3411	695.27	7.60	
SL-3B-5(2,716t/ha,60cm)	3	11/10/03	0.0443	178.25	6.72	-0.0116
SL-3B-5(2,716t/ha,60cm)	3	11/30/03	0.0934	191.45	6.8	0.0151
SL-3B-5(2,716t/ha,60cm)	3	1/6/04	0.0489	174.07	7.17	-0.0064
SL-3B-5(2,716t/ha,60cm)	3	2/11/04	0.0335	184.52	6.91	-0.0045
SL-3B-5(2,716t/ha,60cm)	3	3/10/04	0.0493	206.58	6.91	-0.0040
SL-3B-5(2,716t/ha,60cm)	3	4/9/04	0.0038	192.13	7.21	0.0036
SL-3B-5(2,716t/ha,60cm)	3	5/14/04	0.0051	201.93	6.87	0.0036
SL-3B-5(2,716t/ha,60cm)	3	6/16/04	0.0057	221.59	6.75	0.0052
SL-3B-5(2,716t/ha,60cm)	3	8/18/04	0.0003	188.11	6.74	0.0077
SL-3B-5(2,716t/ha,60cm)	3	10/16/04	0.0105	208.68	6.90	0.0037
SL-3B-5(2,716t/ha,60cm)	3	12/4/04	0.0019	234.70	6.83	0.0101
SL-3B-5(2,716t/ha,60cm)	3	2/10/05	0.0057	229.32	6.98	0.0108
SL-3B-5(2,716t/ha,60cm)	3	4/14/05	0.0037	230.41	7.05	0.0055
SL-3B-5(2,716t/ha,60cm)	3	6/4/05	0.0087	242.09	6.81	0.0053
SL-3B-5(2,716t/ha,60cm)	3	8/11/05	0.0058	241.69	6.77	0.0036
SL-3B-5(2,716t/ha,60cm)	3	10/6/05	0.0062	237.26	7.32	0.0039
SL-3B-5(2,716t/ha,60cm)	3	12/8/05	0.0020	235.79	6.95	0.0036
SL-3B-5(2,716t/ha,60cm)	3	2/5/06	0.0024	243.34	7.64	0.0060
SL-3B-5(2,716t/ha,60cm)	3	4/10/06	0.0046	246.18	7.68	0.0041
SL-3B-5(2,716t/ha,60cm)	3	6/16/06	0.0090	260.79	7.18	0.0046
SL-3B-5(2,716t/ha,60cm)	3	8/2/06	0.0041	266.58	7.38	0.0033
SL-3B-5(2,716t/ha,60cm)	3	10/1/06	0.0051	281.70	7.21	0.0027

SL-3B-5(2,716t/ha,60cm)	3	12/3/06	0.0086	456.58	7.61	0.0044
SL-3B-5(2,716t/ha,60cm)	3	4/6/07	0.0141	586.61	7.5	0.0061
SL-3B-5(2,716t/ha,60cm)	3	8/1/07	0.0232	431.41	7.88	0.0091
SL-3B-5(2,716t/ha,60cm)	3	10/1/07	0.0192	389.86	7.21	0.0078
SL-3B-5(2,716t/ha,60cm)	3	4/9/08	0.0088	686.52	7.21	0.0049
SL-3B-5(2,716t/ha,60cm)	3	6/2/08	0.0187	653.87	7.91	0.0103
SL-3B-5(2,716t/ha,60cm)	3	10/2/08	0.0444	600.61	7.44	0.0103
SL-3B-5(2,716t/ha,60cm)	3	1/11/09	0.0392	642.51	7.85	0.0109
SL-3B-6(2,716t/ha,120cm)	3	8/1/07	0.0324	300.15	7.06	0.0051
SL-3B-6(2,716t/ha,120cm)	3	10/1/07	0.0134	516.08	7.24	0.0142
SL-3B-6(2,716t/ha,120cm)	3	12/7/07	67.7708	703.00	7.02	0.1286
SL-3B-6(2,716t/ha,120cm)	3	2/6/08	3.1718	380.31	7.36	0.4767
SL-3B-6(2,716t/ha,120cm)	3	4/9/08	0.0085	311.80	6.89	0.0069
SL-3B-6(2,716t/ha,120cm)	3	6/2/08	0.0250	309.49	7.07	0.0077
SL-3B-6(2,716t/ha,120cm)	3	8/4/08	0.0828	460.73	6.98	0.0195
SL-3B-6(2,716t/ha,120cm)	3	10/2/08	0.1305	485.89	6.98	0.0606
SL-3B-6(2,716t/ha,120cm)	3	1/11/09	0.3482	464.37	7.06	0.0299
SL-3B-6(2,716t/ha,120cm)	3	4/5/09	0.0315	338.39	7.09	0.0226
SL-3B-6(2,716t/ha,120cm)	3	7/1/09	0.0549	356.96	6.84	
SL-3B-6(2,716t/ha,120cm)	3	10/3/09	0.0000	481.39	7.02	
SL-3C-1(2,0t/ha,15cm)	3	11/10/03	0.0599	1680.51	8.03	-0.0099
SL-3C-1(2,0t/ha,15cm)	3	11/30/03	0.2249	2250.53	8.05	0.0147
SL-3C-1(2,0t/ha,15cm)	3	1/6/04	0.0252	782.91	8.18	0.0138
SL-3C-1(2,0t/ha,15cm)	3	2/11/04	-0.0283	2168.07	8.02	0.0113
SL-3C-1(2,0t/ha,15cm)	3	3/10/04	-0.0257	2102.60	8.16	0.0297
SL-3C-1(2,0t/ha,15cm)	3	4/9/04	-0.0019	2177.86	8.25	0.0250
SL-3C-1(2,0t/ha,15cm)	3	5/14/04	-0.0030	2165.55	8.03	0.0281
SL-3C-1(2,0t/ha,15cm)	3	6/16/04	-0.0016	2060.89	8.02	0.0318
SL-3C-1(2,0t/ha,15cm)	3	8/18/04	-0.0116	1969.48	7.97	0.0361
SL-3C-1(2,0t/ha,15cm)	3	10/16/04	-0.0057	2070.50	7.92	0.0307
SL-3C-1(2,0t/ha,15cm)	3	12/4/04	-0.0021	1989.20	7.91	0.0333
SL-3C-1(2,0t/ha,15cm)	3	2/10/05	0.0007	1812.80	7.89	0.0312
SL-3C-1(2,0t/ha,15cm)	3	4/14/05	0.0025	1841.17	7.93	0.0256
SL-3C-1(2,0t/ha,15cm)	3	6/4/05	0.0143	1937.68	7.63	0.0318
SL-3C-1(2,0t/ha,15cm)	3	8/11/05	0.0092	2142.59	7.80	0.0389
SL-3C-1(2,0t/ha,15cm)	3	10/6/05	0.0325	2501.29	8.10	0.0460
SL-3C-1(2,0t/ha,15cm)	3	12/8/05	0.0000	2085.87	7.88	0.0404
SL-3C-1(2,0t/ha,15cm)	3	2/5/06	-0.0050	2020.36	7.96	0.0343
SL-3C-1(2,0t/ha,15cm)	3	4/10/06	0.0046	1800.50	7.80	0.0269
SL-3C-1(2,0t/ha,15cm)	3	6/16/06	0.0053	1740.28	7.54	0.0290
SL-3C-1(2,0t/ha,15cm)	3	8/2/06	0.0710	1958.40	7.92	0.4851

SL-3C-1(2,0t/ha,15cm)	3	12/7/07	-39.9216	1672.27	8.13	66.2293
SL-3C-2(2,0t/ha,30cm)	3	11/10/03	0.0365	2214.39	7.83	0.0222
SL-3C-2(2,0t/ha,30cm)	3	11/30/03	0.3851	2511.57	7.98	0.0344
SL-3C-2(2,0t/ha,30cm)	3	1/6/04	0.0194	789.19	8.14	0.0459
SL-3C-2(2,0t/ha,30cm)	3	2/11/04	-0.0236	2341.19	7.92	0.0309
SL-3C-2(2,0t/ha,30cm)	3	3/10/04	-0.0103	2313.17	7.96	0.0877
SL-3C-2(2,0t/ha,30cm)	3	4/9/04	-0.0031	2524.39	8.27	0.0576
SL-3C-2(2,0t/ha,30cm)	3	5/14/04	-0.0058	2293.84	7.98	0.0616
SL-3C-2(2,0t/ha,30cm)	3	6/16/04	-0.0010	2087.74	7.89	0.0623
SL-3C-2(2,0t/ha,30cm)	3	8/18/04	-0.0170	2084.37	7.82	0.0690
SL-3C-2(2,0t/ha,30cm)	3	10/16/04	-0.0121	1955.25	8.01	0.0595
SL-3C-2(2,0t/ha,30cm)	3	12/4/04	-0.0015	1941.51	8.10	0.0656
SL-3C-2(2,0t/ha,30cm)	3	2/10/05	0.0007	2205.13	7.80	0.0799
SL-3C-2(2,0t/ha,30cm)	3	4/14/05	0.0007	2096.74	8.13	0.0685
SL-3C-2(2,0t/ha,30cm)	3	6/4/05	0.0253	2254.34	7.94	0.0788
SL-3C-2(2,0t/ha,30cm)	3	12/8/05	0.0109	1234.12	7.60	0.1018
SL-3C-2(2,0t/ha,30cm)	3	2/5/06	0.0109	640.53	7.22	0.0785
SL-3C-2(2,0t/ha,30cm)	3	4/10/06	0.2020	1734.16	8.05	0.3328
SL-3C-2(2,0t/ha,30cm)	3	8/2/06	0.8445	1774.40	8.23	1.1796
SL-3C-2(2,0t/ha,30cm)	3	10/1/06	0.0002	1798.56	7.86	0.1398
SL-3C-2(2,0t/ha,30cm)	3	12/3/06	0.0621	1684.22	8.01	2.3646
SL-3C-2(2,0t/ha,30cm)	3	4/6/07	0.6805	1528.20	7.5	1.6461
SL-3C-2(2,0t/ha,30cm)	3	8/1/07	0.4234	1578.35	7.67	2.5799
SL-3C-2(2,0t/ha,30cm)	3	12/7/07	182.2408	1244.92	7.82	11.2084
SL-3C-2(2,0t/ha,30cm)	3	2/6/08	2.7502	926.71	7.62	1.3125
SL-3C-2(2,0t/ha,30cm)	3	4/9/08	0.0219	1020.19	7.24	0.0279
SL-3C-2(2,0t/ha,30cm)	3	6/2/08	0.8427	677.37	7.38	0.0372
SL-3C-2(2,0t/ha,30cm)	3	10/2/08	6.7050	1418.22	7.65	2.9083
SL-3C-2(2,0t/ha,30cm)	3	1/11/09	50.5499	492.94	7.25	1.0343
SL-3C-2(2,0t/ha,30cm)	3	4/5/09	46.6199	257.70	7.08	0.0691
SL-3C-2(2,0t/ha,30cm)	3	7/1/09	0.0000	406.14	7	
SL-3C-2(2,0t/ha,30cm)	3	10/3/09	0.0076	383.52	7.17	
SL-3C-5(2,0t/ha,60cm)	3	6/16/04	0.0047	8.93	7.12	0.0121
SL-3C-5(2,0t/ha,60cm)	3	8/18/04	0.0023	587.84	7.33	0.0223
SL-3C-5(2,0t/ha,60cm)	3	12/4/04	0.0077	526.29	7.66	0.0251
SL-3C-5(2,0t/ha,60cm)	3	2/10/05	0.0134	489.08	7.38	0.0190
SL-3C-5(2,0t/ha,60cm)	3	6/4/05	0.0152	84.41	6.36	0.0054
SL-3C-5(2,0t/ha,60cm)	3	12/8/05	0.2111	253.31	6.67	0.0099
SL-3C-5(2,0t/ha,60cm)	3	2/5/06	0.0266	198.94	7.30	0.0082
SL-3C-5(2,0t/ha,60cm)	3	4/10/06	0.5381	164.22	7.47	0.0050
SL-3C-5(2,0t/ha,60cm)	3	8/2/06	-0.0952	183.99	7.25	0.1250

SL-3C-5(2,0t/ha,60cm)	3	10/1/06	0.2665	177.43	6.65	0.0054
SL-3C-5(2,0t/ha,60cm)	3	12/3/06	0.0765	140.61	7.24	0.0049
SL-3C-5(2,0t/ha,60cm)	3	4/6/07	0.3070	123.21	6.4	0.0132
SL-3C-5(2,0t/ha,60cm)	3	8/1/07	0.0382	131.58	7.26	0.0162
SL-3C-5(2,0t/ha,60cm)	3	4/9/08	0.0256	131.50	6.56	0.0048
SL-3C-5(2,0t/ha,60cm)	3	6/2/08	0.0337	124.70	7.23	0.0112
SL-3C-5(2,0t/ha,60cm)	3	8/4/08	0.0603	128.19	7.00	0.0229
SL-3C-5(2,0t/ha,60cm)	3	10/2/08	0.1866	125.06	6.81	0.5541
SL-3C-6(2,0t/ha,120cm)	3	8/1/07	0.0203	303.71	7.1	0.0100
SL-3C-6(2,0t/ha,120cm)	3	10/1/07	0.1442	282.66	6.67	0.0839
SL-3C-6(2,0t/ha,120cm)	3	12/7/07	27.8056	307.00	7.05	0.0795
SL-3C-6(2,0t/ha,120cm)	3	4/9/08	0.0055	211.32	6.76	0.0033
SL-3C-6(2,0t/ha,120cm)	3	6/2/08	0.0247	223.11	7.12	0.0051
SL-3C-6(2,0t/ha,120cm)	3	8/4/08	0.0306	245.26	6.78	-0.0006
SL-3C-6(2,0t/ha,120cm)	3	10/2/08	0.0242	268.46	6.7	0.0054
SL-3C-6(2,0t/ha,120cm)	3	1/11/09	0.0227	285.19	6.68	0.0037
SL-3C-6(2,0t/ha,120cm)	3	4/5/09	0.0216	263.83	6.76	0.0067
SL-3C-6(2,0t/ha,120cm)	3	7/1/09	0.0000	221.34	6.63	
SL-3C-6(2,0t/ha,120cm)	3	10/3/09	0.0033	271.69	6.84	
SL-3D-3(4,1074t/ha,15cm)	3	11/18/03	-0.0025	1473.31	8.50	0.0400
SL-3D-3(4,1074t/ha,15cm)	3	12/8/03	-0.0543	1712.01	8.11	0.0402
SL-3D-3(4,1074t/ha,15cm)	3	1/12/04	0.0294	1829.94	8.20	0.0267
SL-3D-3(4,1074t/ha,15cm)	3	2/18/04	-0.0430	1975.90	8.05	0.0134
SL-3D-3(4,1074t/ha,15cm)	3	3/19/04	-0.0188	740.54	8.43	0.0204
SL-3D-3(4,1074t/ha,15cm)	3	6/23/04	0.0027	2337.42	8.29	0.0389
SL-3D-3(4,1074t/ha,15cm)	3	8/25/04	-0.0043	1866.66	8.24	0.0451
SL-3D-3(4,1074t/ha,15cm)	3	10/23/04	0.0002	1861.51	8.29	0.0493
SL-3D-3(4,1074t/ha,15cm)	3	12/13/04	-0.0005	1890.75	8.25	0.0419
SL-3D-3(4,1074t/ha,15cm)	3	2/19/05	0.0007	1934.22	8.16	0.0350
SL-3D-3(4,1074t/ha,15cm)	3	4/22/05	0.0060	1780.15	8.26	0.0299
SL-3D-3(4,1074t/ha,15cm)	3	10/13/05	0.0139	1853.36	8.39	0.0436
SL-3D-3(4,1074t/ha,15cm)	3	12/17/05	0.0091	1675.89	8.44	0.0451
SL-3D-3(4,1074t/ha,15cm)	3	4/14/06	0.0116	1848.42	8.47	0.0419
SL-3D-3(4,1074t/ha,15cm)	3	6/21/06	0.0360	2065.44	8.45	0.0136
SL-3D-3(4,1074t/ha,15cm)	3	8/11/06	0.0041	2156.93	8.30	0.0490
SL-3D-3(4,1074t/ha,15cm)	3	10/9/06	0.0029	2155.89	8.55	0.0494
SL-3D-3(4,1074t/ha,15cm)	3	12/10/06	0.0130	2167.71	8.44	0.0452
SL-3D-3(4,1074t/ha,15cm)	3	6/13/07	0.0148	2549.84	8.1	0.0463
SL-3D-3(4,1074t/ha,15cm)	3	8/9/07	0.0384	2386.95	8.1	0.0507
SL-3D-3(4,1074t/ha,15cm)	3	10/10/07	0.0377	2380.00	8.37	0.0547
SL-3D-3(4,1074t/ha,15cm)	3	2/15/08	0.0350	2516.74	8.16	0.0340

SL-3D-3(4,1074t/ha,15cm)	3	4/16/08	0.0276	2656.22	8.08	0.0332
SL-3D-4(4,1074t/ha,60cm)	3	11/18/03	-0.0428	194.43	7.50	0.0249
SL-3D-4(4,1074t/ha,60cm)	3	12/8/03	-0.0636	401.89	7.70	0.0200
SL-3D-4(4,1074t/ha,60cm)	3	1/12/04	-0.0232	407.47	8.34	-0.0042
SL-3D-4(4,1074t/ha,60cm)	3	2/18/04	-0.0205	668.32	7.85	0.0033
SL-3D-4(4,1074t/ha,60cm)	3	3/19/04	-0.0567	518.84	7.93	0.0069
SL-3D-4(4,1074t/ha,60cm)	3	4/23/04	0.0015	815.37	8.01	0.0157
SL-3D-4(4,1074t/ha,60cm)	3	5/21/04	0.0023	547.93	8.16	0.0133
SL-3D-4(4,1074t/ha,60cm)	3	6/23/04	0.0037	435.64	8.07	0.0123
SL-3D-4(4,1074t/ha,60cm)	3	8/25/04	0.0026	295.43	8.09	0.0121
SL-3D-4(4,1074t/ha,60cm)	3	10/23/04	0.0016	461.54	7.88	0.0184
SL-3D-4(4,1074t/ha,60cm)	3	12/13/04	-0.0001	784.56	7.61	0.0170
SL-3D-4(4,1074t/ha,60cm)	3	2/19/05	0.0007	493.89	N/A	0.0100
SL-3D-4(4,1074t/ha,60cm)	3	4/22/05	0.0139	340.05	8.25	0.0146
SL-3D-4(4,1074t/ha,60cm)	3	6/11/05	0.0268	342.35	8.06	0.0305
SL-3D-4(4,1074t/ha,60cm)	3	10/13/05	0.0042	326.07	7.71	0.0068
SL-3D-4(4,1074t/ha,60cm)	3	12/17/05	0.0091	227.64	8.07	0.0204
SL-3D-4(4,1074t/ha,60cm)	3	2/20/06	0.0055	781.85	8.09	0.0179
SL-3D-4(4,1074t/ha,60cm)	3	4/14/06	0.0036	558.29	8.27	0.0165
SL-3D-4(4,1074t/ha,60cm)	3	6/21/06	0.0192	441.14	8.34	0.0000
SL-3D-4(4,1074t/ha,60cm)	3	8/11/06	0.0050	385.18	8.14	0.0096
SL-3D-4(4,1074t/ha,60cm)	3	8/9/07	0.0660	331.95	8	0.0175
SL-3D-4(4,1074t/ha,60cm)	3	10/10/07	0.0578	503.50	8.26	0.0224
SL-3D-4(4,1074t/ha,60cm)	3	2/15/08	0.2503	264.72	8.06	0.0130
SL-3D-5(4,1074t/ha,30cm)	3	11/18/03	-0.0481	23.37	6.63	0.0349
SL-3D-5(4,1074t/ha,30cm)	3	12/8/03	-0.0128	25.20	6.75	0.0224
SL-3D-5(4,1074t/ha,30cm)	3	1/12/04	0.1263	1657.28	6.94	0.0141
SL-3D-5(4,1074t/ha,30cm)	3	2/18/04	-0.0580	2385.68	7.35	0.0145
SL-3D-5(4,1074t/ha,30cm)	3	3/19/04	-0.0952	2664.63	7.51	0.0238
SL-3D-5(4,1074t/ha,30cm)	3	4/23/04	-0.0004	2876.76	7.50	0.0308
SL-3D-5(4,1074t/ha,30cm)	3	5/21/04	-0.0047	3330.73	7.55	0.0296
SL-3D-5(4,1074t/ha,30cm)	3	6/23/04	-0.0009	3128.00	7.66	0.0311
SL-3D-5(4,1074t/ha,30cm)	3	8/25/04	0.0062	1405.13	8.44	0.0607
SL-3D-5(4,1074t/ha,30cm)	3	2/19/05	0.0297	903.14	8.50	0.0372
SL-3D-5(4,1074t/ha,30cm)	3	2/15/08	0.0921	1238.25	7.68	0.0226
SL-3D-5(4,1074t/ha,30cm)	3	4/8/09	0.0027	1389.45	7.55	0.0292
SL-3D-6(4,1074t/ha,120cm)	3	8/9/07	0.0537	1174.38	5.63	0.0629
SL-3D-6(4,1074t/ha,120cm)	3	10/10/07	0.0113	2599.62	7.48	0.0485
SL-3D-6(4,1074t/ha,120cm)	3	2/15/08	0.0156	1624.53	8.03	0.0487
SL-3D-6(4,1074t/ha,120cm)	3	4/16/08	0.0056	1401.70	7.82	0.0404
SL-3D-6(4,1074t/ha,120cm)	3	10/5/08	0.1458	812.44	7.53	0.1248

SL-3D-6(4,1074t/ha,120cm)	3	4/8/09	-0.0132	975.60	7.35	0.0486
SL-3E-1(4,716t/ha,60cm)	3	11/18/03	-0.0116	73.49	6.86	0.0226
SL-3E-1(4,716t/ha,60cm)	3	12/8/03	-0.0041	30.31	6.72	0.0255
SL-3E-1(4,716t/ha,60cm)	3	1/12/04	0.0492	30.47	6.76	-0.0094
SL-3E-1(4,716t/ha,60cm)	3	2/18/04	-0.0084	20.64	6.71	-0.0051
SL-3E-1(4,716t/ha,60cm)	3	3/19/04	-0.0968	19.33	6.57	0.0014
SL-3E-1(4,716t/ha,60cm)	3	4/23/04	0.0004	21.45	6.57	0.0120
SL-3E-1(4,716t/ha,60cm)	3	5/21/04	0.0000	30.67	6.49	0.0073
SL-3E-1(4,716t/ha,60cm)	3	6/23/04	0.0025	25.00	6.36	0.0054
SL-3E-1(4,716t/ha,60cm)	3	8/25/04	0.0010	20.66	6.35	0.0080
SL-3E-1(4,716t/ha,60cm)	3	10/23/04	0.0063	20.52	6.54	0.0108
SL-3E-1(4,716t/ha,60cm)	3	12/13/04	-0.0017	18.75	6.49	0.0163
SL-3E-1(4,716t/ha,60cm)	3	2/19/05	0.0030	17.99	6.45	0.0060
SL-3E-1(4,716t/ha,60cm)	3	4/22/05	0.0007	26.42	6.45	0.0070
SL-3E-1(4,716t/ha,60cm)	3	6/11/05	0.0075	27.57	6.38	0.0064
SL-3E-1(4,716t/ha,60cm)	3	8/20/05	0.0038	28.13	6.33	0.0078
SL-3E-1(4,716t/ha,60cm)	3	10/13/05	0.0018	34.22	6.39	0.0348
SL-3E-1(4,716t/ha,60cm)	3	12/17/05	0.0032	31.74	6.48	0.0147
SL-3E-1(4,716t/ha,60cm)	3	2/20/06	0.0018	28.90	6.60	0.0086
SL-3E-1(4,716t/ha,60cm)	3	4/14/06	0.0059	34.53	6.40	0.0087
SL-3E-1(4,716t/ha,60cm)	3	6/21/06	0.0182	47.03	6.42	0.0032
SL-3E-1(4,716t/ha,60cm)	3	8/11/06	0.0406	47.77	6.53	0.0186
SL-3E-1(4,716t/ha,60cm)	3	10/9/06	0.0441	59.16	6.79	0.0184
SL-3E-1(4,716t/ha,60cm)	3	2/21/07	0.2946	82.25	7.11	0.0297
SL-3E-1(4,716t/ha,60cm)	3	4/13/07	0.0510	72.80	7.2	0.0088
SL-3E-2(4,716t/ha,15cm)	3	11/18/03	0.1338	454.12	7.31	0.0136
SL-3E-2(4,716t/ha,15cm)	3	12/8/03	0.0571	418.78	7.42	0.0141
SL-3E-2(4,716t/ha,15cm)	3	1/12/04	0.1442	381.30	7.46	-0.0108
SL-3E-2(4,716t/ha,15cm)	3	2/18/04	0.1810	416.65	7.55	-0.0007
SL-3E-2(4,716t/ha,15cm)	3	3/19/04	-0.0551	395.82	7.57	0.0017
SL-3E-2(4,716t/ha,15cm)	3	4/23/04	0.0029	419.27	7.61	0.0046
SL-3E-2(4,716t/ha,15cm)	3	5/21/04	-0.0001	82.57	7.44	0.0056
SL-3E-2(4,716t/ha,15cm)	3	6/23/04	0.0033	437.09	7.41	0.0071
SL-3E-2(4,716t/ha,15cm)	3	8/25/04	-0.0006	472.53	7.46	0.0108
SL-3E-2(4,716t/ha,15cm)	3	10/23/04	0.0048	507.75	7.95	0.0175
SL-3E-2(4,716t/ha,15cm)	3	12/13/04	0.0024	521.39	7.84	0.0140
SL-3E-2(4,716t/ha,15cm)	3	2/19/05	0.0007	546.37	7.82	0.0105
SL-3E-2(4,716t/ha,15cm)	3	4/22/05	0.0022	572.42	8.05	0.0128
SL-3E-2(4,716t/ha,15cm)	3	6/11/05	0.0059	636.51	7.80	0.0201
SL-3E-2(4,716t/ha,15cm)	3	8/20/05	0.0004	520.93	8.12	0.0163
SL-3E-2(4,716t/ha,15cm)	3	10/13/05	0.0067	733.75	7.77	0.0146

SL-3E-2(4,716t/ha,15cm)	3	12/17/05	0.0018	765.99	8.06	0.0174
SL-3E-2(4,716t/ha,15cm)	3	2/20/06	0.0014	742.45	8.15	0.0180
SL-3E-2(4,716t/ha,15cm)	3	4/14/06	0.0049	725.47	8.25	0.0219
SL-3E-2(4,716t/ha,15cm)	3	6/21/06	0.0184	796.50	8.15	0.0000
SL-3E-2(4,716t/ha,15cm)	3	8/11/06	0.0006	889.39	8.26	0.0227
SL-3E-2(4,716t/ha,15cm)	3	10/9/06	0.0000	852.80	8.28	0.0187
SL-3E-2(4,716t/ha,15cm)	3	2/21/07	0.0154	804.92	7.9	0.0188
SL-3E-2(4,716t/ha,15cm)	3	4/13/07	0.0655	150.45	7.2	0.0658
SL-3E-5(4,716t/ha,30cm)	3	11/18/03	-0.0389	60.57	6.59	0.0639
SL-3E-5(4,716t/ha,30cm)	3	12/8/03	-0.0108	61.24	6.54	0.0217
SL-3E-5(4,716t/ha,30cm)	3	1/12/04	0.0278	54.89	6.50	-0.0096
SL-3E-5(4,716t/ha,30cm)	3	2/18/04	0.0765	50.33	6.63	-0.0014
SL-3E-5(4,716t/ha,30cm)	3	3/19/04	-0.0316	48.83	6.54	0.0015
SL-3E-5(4,716t/ha,30cm)	3	4/23/04	0.0024	50.72	6.57	0.0098
SL-3E-5(4,716t/ha,30cm)	3	5/21/04	0.0014	62.77	6.47	0.0047
SL-3E-5(4,716t/ha,30cm)	3	6/23/04	0.0013	51.13	6.42	0.0086
SL-3E-5(4,716t/ha,30cm)	3	8/25/04	0.0018	52.00	6.33	0.0072
SL-3E-5(4,716t/ha,30cm)	3	10/23/04	0.0056	50.60	6.50	0.0074
SL-3E-5(4,716t/ha,30cm)	3	12/13/04	-0.0017	49.43	6.45	0.0168
SL-3E-5(4,716t/ha,30cm)	3	2/19/05	0.0053	50.33	6.44	0.0068
SL-3E-5(4,716t/ha,30cm)	3	4/22/05	0.0007	51.60	6.52	0.0066
SL-3E-5(4,716t/ha,30cm)	3	6/11/05	0.0064	58.65	6.49	0.0061
SL-3E-5(4,716t/ha,30cm)	3	8/20/05	0.0026	52.76	6.58	0.0040
SL-3E-5(4,716t/ha,30cm)	3	10/13/05	0.0054	63.03	6.42	0.0092
SL-3E-5(4,716t/ha,30cm)	3	12/17/05	0.0002	55.70	6.60	0.0081
SL-3E-5(4,716t/ha,30cm)	3	2/20/06	0.0067	54.85	6.93	0.0040
SL-3E-5(4,716t/ha,30cm)	3	4/14/06	0.0067	52.93	6.82	0.0043
SL-3E-5(4,716t/ha,30cm)	3	6/21/06	0.0077	62.19	6.88	0.0000
SL-3E-5(4,716t/ha,30cm)	3	8/11/06	0.0056	67.81	6.68	0.0069
SL-3E-5(4,716t/ha,30cm)	3	10/9/06	0.0133	70.19	6.99	0.0072
SL-3E-5(4,716t/ha,30cm)	3	12/10/06	0.0130	64.97	7.07	0.0041
SL-3E-5(4,716t/ha,30cm)	3	2/21/07	0.1506	69.43	6.73	0.0132
SL-3E-5(4,716t/ha,30cm)	3	8/9/07	0.0298	76.97	7.26	0.0076
SL-3E-5(4,716t/ha,30cm)	3	4/16/08	0.0193	100.93	6.86	0.0155
SL-3E-5(4,716t/ha,30cm)	3	6/11/08	0.0819	182.53	7.1	0.0338
SL-3E-6(4,716t/ha,120cm)	3	8/9/07	0.0350	2124.10	6.31	0.0701
SL-3E-6(4,716t/ha,120cm)	3	10/10/07	0.0082	3816.13	6.98	0.1675
SL-3E-6(4,716t/ha,120cm)	3	12/14/07	-0.0195	2671.49	8.15	0.0784
SL-3E-6(4,716t/ha,120cm)	3	2/15/08	0.0090	2281.00	8.17	0.0663
SL-3E-6(4,716t/ha,120cm)	3	4/16/08	0.0010	2001.82	7.96	0.0498
SL-3E-6(4,716t/ha,120cm)	3	6/11/08	0.0345	1811.93	7.99	0.0665

SL-3F-1(4,0t/ha,15cm)	3	11/18/03	0.0607	302.98	7.76	0.0397
SL-3F-1(4,0t/ha,15cm)	3	12/8/03	0.0250	359.25	7.82	0.0203
SL-3F-1(4,0t/ha,15cm)	3	1/12/04	0.1228	417.27	8.04	-0.0075
SL-3F-1(4,0t/ha,15cm)	3	2/18/04	0.1227	480.24	7.98	0.0007
SL-3F-1(4,0t/ha,15cm)	3	3/19/04	0.0768	535.15	7.98	0.0050
SL-3F-1(4,0t/ha,15cm)	3	4/23/04	0.0033	1122.63	8.09	0.0117
SL-3F-1(4,0t/ha,15cm)	3	5/21/04	-0.0046	1183.96	8.04	0.0186
SL-3F-1(4,0t/ha,15cm)	3	6/23/04	0.0030	1079.83	8.15	0.0187
SL-3F-1(4,0t/ha,15cm)	3	8/25/04	-0.0006	1256.58	8.18	0.0256
SL-3F-1(4,0t/ha,15cm)	3	10/23/04	0.0074	1382.06	8.34	0.0350
SL-3F-1(4,0t/ha,15cm)	3	12/13/04	0.0007	1480.83	8.36	0.0307
SL-3F-1(4,0t/ha,15cm)	3	2/19/05	0.0007	1865.94	8.31	0.0244
SL-3F-1(4,0t/ha,15cm)	3	4/22/05	-0.0036	2713.55	8.24	0.0251
SL-3F-1(4,0t/ha,15cm)	3	6/11/05	0.0036	3074.57	8.19	0.0383
SL-3F-1(4,0t/ha,15cm)	3	8/20/05	0.0111	2764.86	8.45	0.0678
SL-3F-1(4,0t/ha,15cm)	3	10/13/05	0.0019	2565.09	8.47	0.0655
SL-3F-1(4,0t/ha,15cm)	3	12/17/05	0.0035	2380.30	8.57	0.0482
SL-3F-1(4,0t/ha,15cm)	3	2/20/06	-0.0006	2554.37	8.61	0.0474
SL-3F-1(4,0t/ha,15cm)	3	4/14/06	0.0032	2673.73	8.49	0.0395
SL-3F-1(4,0t/ha,15cm)	3	6/21/06	0.0322	2638.10	8.41	0.0000
SL-3F-1(4,0t/ha,15cm)	3	8/11/06	0.0025	2596.03	8.40	0.0390
SL-3F-1(4,0t/ha,15cm)	3	12/10/06	0.0108	2846.70	8.7	0.0535
SL-3F-1(4,0t/ha,15cm)	3	2/21/07	0.0710	2882.81	8.5	0.0412
SL-3F-1(4,0t/ha,15cm)	3	8/9/07	-0.0153	3226.93	8.17	0.1052
SL-3F-1(4,0t/ha,15cm)	3	10/10/07	0.0218	3185.86	8.58	0.0486
SL-3F-1(4,0t/ha,15cm)	3	12/14/07	0.0304	3194.27	8.54	0.0583
SL-3F-1(4,0t/ha,15cm)	3	2/15/08	0.0179	3317.62	8.37	0.0349
SL-3F-1(4,0t/ha,15cm)	3	4/16/08	0.0207	137.54	6.71	0.0049
SL-3F-1(4,0t/ha,15cm)	3	6/11/08	0.0067	3394.01	8.27	0.0417
SL-3F-1(4,0t/ha,15cm)	3	8/11/08	0.0212	3243.33	8.33	0.0569
SL-3F-1(4,0t/ha,15cm)	3	10/5/08	0.0121	3452.68	8.49	0.0509
SL-3F-1(4,0t/ha,15cm)	3	1/11/09	-0.0171	3298.35	8.69	0.0585
SL-3F-1(4,0t/ha,15cm)	3	10/9/09	0.0000	3328.79	8.45	
SL-3F-2(4,0t/ha,60cm)	3	11/18/03	0.0087	94.62	6.98	0.0300
SL-3F-2(4,0t/ha,60cm)	3	12/8/03	0.0148	100.65	6.99	0.0176
SL-3F-2(4,0t/ha,60cm)	3	1/12/04	0.0382	92.69	7.26	-0.0117
SL-3F-2(4,0t/ha,60cm)	3	2/18/04	0.0421	95.16	7.01	0.0001
SL-3F-2(4,0t/ha,60cm)	3	3/19/04	-0.0270	96.77	6.91	0.0024
SL-3F-2(4,0t/ha,60cm)	3	4/23/04	0.0014	107.15	6.94	0.0127
SL-3F-2(4,0t/ha,60cm)	3	5/21/04	0.0031	98.60	6.96	0.0028
SL-3F-2(4,0t/ha,60cm)	3	6/23/04	0.0040	102.36	6.70	0.0040

SL-3F-2(4,0t/ha,60cm)	3	8/25/04	0.0028	110.82	6.71	0.0042
SL-3F-2(4,0t/ha,60cm)	3	10/23/04	0.0063	106.79	6.90	0.0092
SL-3F-2(4,0t/ha,60cm)	3	12/13/04	0.0051	102.12	6.84	0.0070
SL-3F-2(4,0t/ha,60cm)	3	2/19/05	0.0056	105.67	6.79	0.0025
SL-3F-2(4,0t/ha,60cm)	3	4/22/05	0.0056	105.05	7.17	0.0027
SL-3F-2(4,0t/ha,60cm)	3	6/11/05	0.0083	116.95	6.92	0.0052
SL-3F-2(4,0t/ha,60cm)	3	10/13/05	0.0086	128.40	6.89	0.0033
SL-3F-2(4,0t/ha,60cm)	3	12/17/05	0.0041	133.97	6.99	0.0050
SL-3F-2(4,0t/ha,60cm)	3	2/20/06	0.0046	135.87	7.28	0.0036
SL-3F-2(4,0t/ha,60cm)	3	4/14/06	0.0052	133.06	7.31	0.0062
SL-3F-2(4,0t/ha,60cm)	3	6/21/06	0.0044	138.24	7.07	0.0030
SL-3F-2(4,0t/ha,60cm)	3	8/11/06	0.0045	142.22	7.14	0.0037
SL-3F-2(4,0t/ha,60cm)	3	12/10/06	0.0231	129.70	7.07	0.0162
SL-3F-2(4,0t/ha,60cm)	3	2/21/07	0.1711	162.42	7.08	0.0372
SL-3F-2(4,0t/ha,60cm)	3	6/13/07	0.0526	135.53	6.77	0.0205
SL-3F-2(4,0t/ha,60cm)	3	8/9/07	0.0430	140.16	7.22	0.0176
SL-3F-2(4,0t/ha,60cm)	3	10/10/07	0.0255	152.09	6.88	0.0089
SL-3F-2(4,0t/ha,60cm)	3	12/14/07	0.1289	160.48	7.17	0.0216
SL-3F-2(4,0t/ha,60cm)	3	2/15/08	0.0127	146.39	6.86	0.0027
SL-3F-2(4,0t/ha,60cm)	3	4/16/08	0.0187	3421.45	8.34	0.0321
SL-3F-2(4,0t/ha,60cm)	3	6/11/08	0.0545	139.64	6.94	0.0164
SL-3F-2(4,0t/ha,60cm)	3	4/8/09	-0.0025	160.11	6.52	0.0145
SL-3F-2(4,0t/ha,60cm)	3	10/9/09	0.0135	173.70	6.93	
SL-3F-3(4,0t/ha,30cm)	3	11/18/03	-0.0201	4.21	6.83	0.0373
SL-3F-3(4,0t/ha,30cm)	3	12/8/03	-0.0090	4.45	6.74	0.0239
SL-3F-3(4,0t/ha,30cm)	3	2/18/04	0.0384	11.99	6.84	-0.0013
SL-3F-3(4,0t/ha,30cm)	3	3/19/04	-0.0312	6.99	6.56	0.0002
SL-3F-3(4,0t/ha,30cm)	3	4/23/04	0.0107	3.30	6.71	0.0036
SL-3F-3(4,0t/ha,30cm)	3	5/21/04	0.0035	6.08	6.75	0.0021
SL-3F-3(4,0t/ha,30cm)	3	6/23/04	0.0061	7.55	6.56	0.0027
SL-3F-3(4,0t/ha,30cm)	3	8/25/04	0.0042	39.59	6.58	0.0062
SL-3F-3(4,0t/ha,30cm)	3	10/23/04	0.0074	8.97	6.83	0.0075
SL-3F-3(4,0t/ha,30cm)	3	12/13/04	0.0055	6.68	6.83	0.0062
SL-3F-3(4,0t/ha,30cm)	3	2/19/05	0.0023	13.91	6.77	0.0045
SL-3F-3(4,0t/ha,30cm)	3	4/22/05	0.0034	10.90	7.01	0.0026
SL-3F-3(4,0t/ha,30cm)	3	6/11/05	0.0089	14.42	6.91	0.0050
SL-3F-3(4,0t/ha,30cm)	3	8/20/05	0.0088	13.66	7.10	0.0052
SL-3F-3(4,0t/ha,30cm)	3	10/13/05	0.0060	17.98	6.77	0.0042
SL-3F-3(4,0t/ha,30cm)	3	12/17/05	0.0047	17.61	7.01	0.0042
SL-3F-3(4,0t/ha,30cm)	3	2/20/06	0.0067	15.97	7.26	0.0040
SL-3F-3(4,0t/ha,30cm)	3	4/14/06	0.0062	15.52	7.19	0.0041

SL-3F-3(4,0t/ha,30cm)	3	6/21/06	0.0082	13.08	7.08	0.0001
SL-3F-3(4,0t/ha,30cm)	3	8/11/06	0.0094	16.22	7.22	0.0040
SL-3F-3(4,0t/ha,30cm)	3	10/9/06	0.0058	21.46	7.09	0.0085
SL-3F-3(4,0t/ha,30cm)	3	12/10/06	0.0248	32.40	7.24	0.0153
SL-3F-3(4,0t/ha,30cm)	3	2/21/07	0.1711	30.68	7.06	0.0057
SL-3F-3(4,0t/ha,30cm)	3	4/13/07	0.0360	33.75	6.7	0.0102
SL-3F-3(4,0t/ha,30cm)	3	8/9/07	0.0307	37.79	7.11	0.0084
SL-3F-3(4,0t/ha,30cm)	3	10/10/07	0.0754	36.48	7.42	0.0186
SL-3F-3(4,0t/ha,30cm)	3	12/14/07	0.0262	35.08	7	0.0263
SL-3F-3(4,0t/ha,30cm)	3	2/15/08	0.0703	35.81	7.11	0.0106
SL-3F-3(4,0t/ha,30cm)	3	4/16/08	0.0268	46.00	7.12	0.0129
SL-3F-3(4,0t/ha,30cm)	3	10/5/08	0.0860	54.36	7.62	0.2497
SL-3F-3(4,0t/ha,30cm)	3	4/8/09	0.0020	79.48	6.55	0.0361
SL-3F-6(4,0t/ha,120cm)	3	8/9/07	0.0851	253.74	6.4	0.1294
SL-3F-6(4,0t/ha,120cm)	3	10/10/07	0.0070	232.41	6.88	0.0156
SL-3F-6(4,0t/ha,120cm)	3	12/14/07	25.8858	213.90	6.89	0.0567
SL-3F-6(4,0t/ha,120cm)	3	2/15/08	0.0060	296.38	6.82	0.0249
SL-3F-6(4,0t/ha,120cm)	3	4/16/08	0.0233	391.58	6.92	0.0318
SL-3F-6(4,0t/ha,120cm)	3	6/11/08	0.0121	293.05	7.15	0.0274
SL-3F-6(4,0t/ha,120cm)	3	10/5/08	0.0074	164.39	6.82	0.0175
SL-3F-6(4,0t/ha,120cm)	3	1/11/09	0.0281	116.39	6.77	0.0131
SL-3F-6(4,0t/ha,120cm)	3	4/8/09	-0.0008	112.08	6.45	0.0125
SL-3F-6(4,0t/ha,120cm)	3	7/8/09	0.0000	132.88	7.11	
SL-3G-1(3,1074t/ha,30cm)	3	11/23/03	0.2438	569.39	7.92	-0.1240
SL-3G-1(3,1074t/ha,30cm)	3	12/21/03	0.0651	571.61	7.68	-0.0259
SL-3G-1(3,1074t/ha,30cm)	3	1/30/04	0.1292	641.57	7.47	0.0007
SL-3G-1(3,1074t/ha,30cm)	3	2/26/04	0.0385	765.54	7.20	0.0041
SL-3G-1(3,1074t/ha,30cm)	3	3/26/04	-0.0417		8.12	-0.0043
SL-3G-1(3,1074t/ha,30cm)	3	4/30/04	-0.0062	852.93	8.38	0.0199
SL-3G-1(3,1074t/ha,30cm)	3	5/27/04	-0.0035	830.53	8.06	0.0195
SL-3G-1(3,1074t/ha,30cm)	3	6/30/04	0.0029	787.29	8.12	0.0187
SL-3G-1(3,1074t/ha,30cm)	3	8/31/04	0.0004	783.80	7.96	0.0182
SL-3G-1(3,1074t/ha,30cm)	3	10/30/04	-0.0033	754.43	8.02	0.0227
SL-3G-1(3,1074t/ha,30cm)	3	12/22/04	0.0050	748.12	7.95	0.0262
SL-3G-1(3,1074t/ha,30cm)	3	2/26/05	0.0007	721.21	8.00	0.0266
SL-3G-1(3,1074t/ha,30cm)	3	4/29/05	0.0575	606.25	8.44	0.1031
SL-3G-1(3,1074t/ha,30cm)	3	12/21/05	0.0451	682.49	8.32	0.0655
SL-3G-1(3,1074t/ha,30cm)	3	10/17/07	0.1409	687.81	7.9	0.0262
SL-3G-1(3,1074t/ha,30cm)	3	12/19/07	0.0975	359.93	7.98	0.0182
SL-3G-1(3,1074t/ha,30cm)	3	4/18/09	0.0104	966.35	7.28	0.1302
SL-3G-2(3,1074t/ha,15cm)	3	11/23/03	0.3162	1284.17	7.89	-0.1291

SL-3G-2(3,1074t/ha,15cm)	3	12/21/03	0.1004	1607.92	7.68	0.0026
SL-3G-2(3,1074t/ha,15cm)	3	1/30/04	0.1769	1705.38	7.80	0.0116
SL-3G-2(3,1074t/ha,15cm)	3	2/26/04	-0.0224	1944.02	8.03	0.0129
SL-3G-2(3,1074t/ha,15cm)	3	3/26/04	-0.0056	2088.82	7.97	0.0113
SL-3G-2(3,1074t/ha,15cm)	3	4/30/04	0.0408	1977.36	8.21	0.0516
SL-3G-2(3,1074t/ha,15cm)	3	5/27/04	0.0176	1858.11	8.15	0.0457
SL-3G-2(3,1074t/ha,15cm)	3	6/30/04	0.0221	1832.39	8.10	0.0506
SL-3G-2(3,1074t/ha,15cm)	3	8/31/04	0.0050	1811.56	8.17	0.1047
SL-3G-2(3,1074t/ha,15cm)	3	10/30/04	-0.0030	1931.26	7.99	0.0475
SL-3G-2(3,1074t/ha,15cm)	3	12/22/04	0.0031	2079.82	7.87	0.0516
SL-3G-2(3,1074t/ha,15cm)	3	2/26/05	0.0007	2321.23	7.90	0.0304
SL-3G-2(3,1074t/ha,15cm)	3	4/29/05	0.0058	2198.08	8.06	0.0445
SL-3G-2(3,1074t/ha,15cm)	3	6/18/05	0.0015	2081.46	8.07	0.0532
SL-3G-2(3,1074t/ha,15cm)	3	8/25/05	0.0152	1896.44	8.23	0.0442
SL-3G-2(3,1074t/ha,15cm)	3	10/18/05	0.0099	2271.33	8.11	0.0440
SL-3G-2(3,1074t/ha,15cm)	3	12/21/05	0.0092	2106.28	8.13	0.0605
SL-3G-2(3,1074t/ha,15cm)	3	2/26/06	0.0076	2061.60	8.26	0.0432
SL-3G-2(3,1074t/ha,15cm)	3	4/23/06	9.6851	2108.44	8.20	0.2697
SL-3G-2(3,1074t/ha,15cm)	3	6/28/06	0.0018	2126.86	8.09	0.0422
SL-3G-2(3,1074t/ha,15cm)	3	8/16/06	0.1920	2093.61	8.46	0.1121
SL-3G-2(3,1074t/ha,15cm)	3	10/14/06	0.1416	2000.71	8.29	0.1049
SL-3G-2(3,1074t/ha,15cm)	3	12/16/06	0.0163	2365.00	8.17	0.0819
SL-3G-2(3,1074t/ha,15cm)	3	2/24/07	0.0695	2265.95	8.15	0.0878
SL-3G-2(3,1074t/ha,15cm)	3	8/15/07	0.2496	2409.61	8.16	0.1367
SL-3G-2(3,1074t/ha,15cm)	3	10/17/07	2.2319	2318.18	8.07	0.2506
SL-3G-2(3,1074t/ha,15cm)	3	12/19/07	74.4448	2646.15	8.1	0.0805
SL-3G-2(3,1074t/ha,15cm)	3	2/20/08	0.0170	2576.80	7.89	0.0566
SL-3G-2(3,1074t/ha,15cm)	3	4/23/08	0.0651	2634.20	8.05	0.0834
SL-3G-2(3,1074t/ha,15cm)	3	6/16/08	0.3046	2441.39	8.11	0.4411
SL-3G-2(3,1074t/ha,15cm)	3	10/18/09	0.1211	2483.70	7.87	
SL-3G-5(3,1074t/ha,60cm)	3	11/23/03	0.1481	17.19	7.08	-0.1447
SL-3G-5(3,1074t/ha,60cm)	3	12/21/03	0.0315	21.22	6.87	-0.0418
SL-3G-5(3,1074t/ha,60cm)	3	2/26/04	0.0065	15.06	7.24	-0.0009
SL-3G-5(3,1074t/ha,60cm)	3	3/26/04	2.6804	30.23	7.07	-0.0021
SL-3G-5(3,1074t/ha,60cm)	3	4/30/04	0.0027	41.62	7.46	0.0050
SL-3G-5(3,1074t/ha,60cm)	3	5/27/04	0.0035	42.83	7.00	0.0039
SL-3G-5(3,1074t/ha,60cm)	3	6/30/04	0.0041	29.75	6.81	0.0036
SL-3G-5(3,1074t/ha,60cm)	3	8/31/04	0.0032	8.63	6.65	0.0061
SL-3G-5(3,1074t/ha,60cm)	3	10/30/04	0.0031	8.81	6.60	0.0070
SL-3G-5(3,1074t/ha,60cm)	3	12/22/04	0.0049	41.80	6.63	0.0095
SL-3G-5(3,1074t/ha,60cm)	3	2/26/05	0.0041	8.63	6.82	0.0027

SL-3G-5(3,1074t/ha,60cm)	3	4/29/05	0.0147	7.76	7.23	0.0192
SL-3G-5(3,1074t/ha,60cm)	3	6/18/05	0.0086	9.45	6.95	0.0108
SL-3G-5(3,1074t/ha,60cm)	3	8/25/05	0.0159	12.82	7.30	0.0090
SL-3G-5(3,1074t/ha,60cm)	3	10/18/05	0.0326	12.83	7.20	0.0327
SL-3G-5(3,1074t/ha,60cm)	3	12/21/05	0.2926	8.63	7.11	0.0081
SL-3G-5(3,1074t/ha,60cm)	3	2/26/06	0.0235	7.17	7.52	0.0191
SL-3G-5(3,1074t/ha,60cm)	3	4/23/06	0.0052	204.85	6.64	0.0123
SL-3G-6(3,1074t/ha,120cm)	3	8/15/07	0.0359	44.02	6.53	0.0132
SL-3G-6(3,1074t/ha,120cm)	3	4/23/08	0.0162	68.32	6.67	0.0047
SL-3G-6(3,1074t/ha,120cm)	3	6/16/08	0.0247	127.51	6.96	0.0145
SL-3G-6(3,1074t/ha,120cm)	3	4/18/09	0.0097	102.11	6.35	0.0047
SL-3G-6(3,1074t/ha,120cm)	3	7/16/09	0.0074	137.29	7.24	
SL-3H-1(3,716t/ha,15cm)	3	11/23/03	0.1424	5.84	6.49	-0.1344
SL-3H-1(3,716t/ha,15cm)	3	12/21/03	0.0517	4.88	6.53	-0.0501
SL-3H-1(3,716t/ha,15cm)	3	2/26/04	0.0006	5.14	6.50	0.0001
SL-3H-1(3,716t/ha,15cm)	3	3/26/04	-0.0393	0.08	6.52	-0.0026
SL-3H-1(3,716t/ha,15cm)	3	4/30/04	0.0015	5.72	6.54	0.0045
SL-3H-1(3,716t/ha,15cm)	3	5/27/04	-0.0102	6.18	6.28	0.0232
SL-3H-1(3,716t/ha,15cm)	3	6/30/04	0.0003	3.57	6.32	0.0082
SL-3H-1(3,716t/ha,15cm)	3	8/31/04	-0.0062	6.03	6.37	0.0143
SL-3H-1(3,716t/ha,15cm)	3	10/30/04	0.0041	7.20	6.37	0.0098
SL-3H-1(3,716t/ha,15cm)	3	12/22/04	-0.0038	6.75	6.36	0.0175
SL-3H-1(3,716t/ha,15cm)	3	2/26/05	0.0007	9.22	6.30	0.0095
SL-3H-1(3,716t/ha,15cm)	3	4/29/05	0.0023	13.41	6.33	0.0123
SL-3H-1(3,716t/ha,15cm)	3	6/18/05	0.0012	18.16	6.11	0.0102
SL-3H-1(3,716t/ha,15cm)	3	8/25/05	0.0070	24.67	6.30	0.0067
SL-3H-1(3,716t/ha,15cm)	3	10/18/05	0.0032	32.53	6.32	0.0034
SL-3H-1(3,716t/ha,15cm)	3	12/21/05	-0.0122	39.40	6.38	0.0314
SL-3H-1(3,716t/ha,15cm)	3	2/26/06	0.0032	64.37	6.61	0.0127
SL-3H-1(3,716t/ha,15cm)	3	4/23/06	0.0085	110.46	6.47	0.0110
SL-3H-1(3,716t/ha,15cm)	3	6/28/06	0.0012	156.87	6.76	0.0064
SL-3H-1(3,716t/ha,15cm)	3	8/16/06	0.0015	197.94	6.94	0.0062
SL-3H-1(3,716t/ha,15cm)	3	10/14/06	0.0073	310.23	7.55	0.0081
SL-3H-1(3,716t/ha,15cm)	3	12/16/06	0.0134	474.16	7.68	0.0116
SL-3H-1(3,716t/ha,15cm)	3	2/24/07	0.0151	617.28	7.74	0.0115
SL-3H-1(3,716t/ha,15cm)	3	8/15/07	0.0452	641.33	8.06	0.0161
SL-3H-1(3,716t/ha,15cm)	3	10/17/07	0.0294	660.21	7.9	0.0123
SL-3H-1(3,716t/ha,15cm)	3	12/19/07	0.0627	708.62	7.78	0.0136
SL-3H-1(3,716t/ha,15cm)	3	2/20/08	0.0362	802.39	7.73	0.0116
SL-3H-1(3,716t/ha,15cm)	3	10/5/08	0.0506	886.40	8.05	0.0146
SL-3H-3(3,716t/ha,60cm)	3	12/21/03	0.0720	33.24	6.48	-0.0523

SL-3H-3(3,716t/ha,60cm)	3	1/30/04	0.0443	67.59	6.53	-0.0078
SL-3H-3(3,716t/ha,60cm)	3	2/26/04	0.0373	117.76	6.51	-0.0060
SL-3H-3(3,716t/ha,60cm)	3	3/26/04	0.0057	90.17	6.56	-0.0014
SL-3H-3(3,716t/ha,60cm)	3	4/30/04	0.0012	339.21	6.73	0.0058
SL-3H-3(3,716t/ha,60cm)	3	5/27/04	0.0032	307.63	6.42	0.0060
SL-3H-3(3,716t/ha,60cm)	3	6/30/04	0.0025	62.13	6.38	0.0066
SL-3H-3(3,716t/ha,60cm)	3	8/31/04	0.0026	57.97	6.46	0.0068
SL-3H-3(3,716t/ha,60cm)	3	10/30/04	0.0060	56.06	6.47	0.0111
SL-3H-3(3,716t/ha,60cm)	3	12/22/04	0.0023	58.52	6.44	0.0200
SL-3H-3(3,716t/ha,60cm)	3	2/26/05	0.0028	60.97	6.50	0.0054
SL-3H-3(3,716t/ha,60cm)	3	4/29/05	0.0074	62.47	6.55	0.0128
SL-3H-3(3,716t/ha,60cm)	3	6/18/05	0.0046	70.87	6.28	0.0078
SL-3H-3(3,716t/ha,60cm)	3	8/25/05	0.0108	74.85	6.62	0.0122
SL-3H-3(3,716t/ha,60cm)	3	10/18/05	0.0114	73.09	6.53	0.0105
SL-3H-3(3,716t/ha,60cm)	3	12/21/05	0.0140	69.73	6.49	0.0062
SL-3H-3(3,716t/ha,60cm)	3	2/26/06	0.0110	68.92	6.69	0.0029
SL-3H-3(3,716t/ha,60cm)	3	4/23/06	0.0235	77.28	6.45	0.0035
SL-3H-3(3,716t/ha,60cm)	3	6/28/06	0.0075	91.84	6.43	0.0048
SL-3H-3(3,716t/ha,60cm)	3	8/16/06	0.0119	93.33	6.57	0.0035
SL-3H-3(3,716t/ha,60cm)	3	10/14/06	0.0141	92.39	6.90	0.0038
SL-3H-3(3,716t/ha,60cm)	3	12/16/06	0.0945	83.58	6.99	0.0043
SL-3H-3(3,716t/ha,60cm)	3	10/17/07	0.2057	105.69	6.78	0.1111
SL-3H-3(3,716t/ha,60cm)	3	12/19/07	0.0344	105.54	6.91	0.0145
SL-3H-3(3,716t/ha,60cm)	3	2/20/08	0.1182	115.76	6.88	0.0083
SL-3H-6(3,716t/ha,120cm)	3	8/15/07	0.0349	36.19	6.75	0.0086
SL-3H-6(3,716t/ha,120cm)	3	10/17/07	0.0863	41.10	6.93	0.0470
SL-3H-6(3,716t/ha,120cm)	3	12/19/07	3.7877	309.73	6.81	0.0399
SL-3H-6(3,716t/ha,120cm)	3	2/20/08	0.0120	521.42	7.1	0.0230
SL-3H-6(3,716t/ha,120cm)	3	4/23/08	0.0203	501.76	7.21	0.0208
SL-3H-6(3,716t/ha,120cm)	3	6/16/08	0.0198	798.23	7.59	0.0344
SL-3H-6(3,716t/ha,120cm)	3	1/11/09	-0.0114	864.27	7.84	0.0408
SL-3H-6(3,716t/ha,120cm)	3	4/18/09	-0.0106	763.76	7.24	0.0329
SL-3I-1(3,0t/ha,15cm)	3	11/23/03	0.1738	1955.54	7.66	-0.1269
SL-3I-1(3,0t/ha,15cm)	3	12/21/03	0.0249	2493.77	7.67	-0.0289
SL-3I-1(3,0t/ha,15cm)	3	1/30/04	0.0275	2711.36	7.84	0.0038
SL-3I-1(3,0t/ha,15cm)	3	2/26/04	-0.0082	3117.14	8.05	0.0092
SL-3I-1(3,0t/ha,15cm)	3	3/26/04	0.0052	2962.74	8.03	0.0106
SL-3I-1(3,0t/ha,15cm)	3	4/30/04	-0.0104	3006.59	8.25	0.0303
SL-3I-1(3,0t/ha,15cm)	3	5/27/04	-0.0134	2886.37	8.21	0.0328
SL-3I-1(3,0t/ha,15cm)	3	6/30/04	-0.0018	3369.18	8.17	0.0362
SL-3I-1(3,0t/ha,15cm)	3	8/31/04	-0.0174	2870.49	8.27	0.0519

SL-3I-1(3,0t/ha,15cm)	3	10/30/04	-0.0143	3068.05	8.23	0.0569
SL-3I-1(3,0t/ha,15cm)	3	12/22/04	-0.0096	3382.76	8.15	0.0502
SL-3I-1(3,0t/ha,15cm)	3	2/26/05	-0.0055	3583.69	8.18	0.0375
SL-3I-1(3,0t/ha,15cm)	3	4/29/05	< 0.002	3667.72	8.30	0.0449
SL-3I-1(3,0t/ha,15cm)	3	6/18/05	0.0099	3876.07	8.21	0.0571
SL-3I-1(3,0t/ha,15cm)	3	8/25/05	0.0425	3803.62	8.41	0.0600
SL-3I-1(3,0t/ha,15cm)	3	10/18/05	0.0071	3754.56	8.36	0.0567
SL-3I-1(3,0t/ha,15cm)	3	12/21/05	0.0007	4206.68	8.21	0.0660
SL-3I-1(3,0t/ha,15cm)	3	2/26/06	-0.0056	4681.93	8.32	0.0559
SL-3I-1(3,0t/ha,15cm)	3	4/23/06	0.1503	4229.16	8.22	0.0681
SL-3I-1(3,0t/ha,15cm)	3	6/28/06	-0.0033	4172.60	8.10	0.0524
SL-3I-1(3,0t/ha,15cm)	3	8/16/06	-0.0031	4279.44	8.46	0.0709
SL-3I-1(3,0t/ha,15cm)	3	10/14/06	0.0052	3216.30	8.40	0.0565
SL-3I-1(3,0t/ha,15cm)	3	12/16/06	0.0293	3571.35	8.38	0.0632
SL-3I-1(3,0t/ha,15cm)	3	2/24/07	0.0389	3265.19	8.1	0.0596
SL-3I-1(3,0t/ha,15cm)	3	8/15/07	0.0068	3520.19	7.95	0.0655
SL-3I-1(3,0t/ha,15cm)	3	10/17/07	0.0092	3774.53	8.15	0.0747
SL-3I-1(3,0t/ha,15cm)	3	2/20/08	0.0189	4837.69	7.93	0.0863
SL-3I-1(3,0t/ha,15cm)	3	4/23/08	0.0130	3161.71	8.01	0.0478
SL-3I-1(3,0t/ha,15cm)	3	6/16/08	0.0292	3296.61	7.95	0.0586
SL-3I-1(3,0t/ha,15cm)	3	10/5/08	0.0185	3210.50	8.06	0.0736
SL-3I-2(3,0t/ha,60cm)	3	12/21/03	0.0595	31.71	6.80	-0.0703
SL-3I-2(3,0t/ha,60cm)	3	6/30/04	0.0049	29.56	6.60	0.0043
SL-3I-2(3,0t/ha,60cm)	3	8/31/04	0.0190	25.11	6.00	0.0088
SL-3I-2(3,0t/ha,60cm)	3	10/30/04	0.0034	22.74	6.47	0.0094
SL-3I-2(3,0t/ha,60cm)	3	12/22/04	-0.0037	21.59	6.46	0.0259
SL-3I-2(3,0t/ha,60cm)	3	2/26/05	0.0033	33.75	6.57	0.0055
SL-3I-2(3,0t/ha,60cm)	3	4/29/05	0.0134	32.63	6.96	0.0237
SL-3I-2(3,0t/ha,60cm)	3	6/18/05	0.0048	33.92	6.57	0.0067
SL-3I-2(3,0t/ha,60cm)	3	8/25/05	0.0158	38.49	7.04	0.0132
SL-3I-2(3,0t/ha,60cm)	3	10/18/05	0.0083	39.73	7.95	0.0102
SL-3I-2(3,0t/ha,60cm)	3	12/21/05	0.0025	50.11	5.77	0.0089
SL-3I-2(3,0t/ha,60cm)	3	2/26/06	0.0071	44.08	6.82	0.0050
SL-3I-2(3,0t/ha,60cm)	3	4/23/06	0.0060	45.48	6.71	0.0034
SL-3I-2(3,0t/ha,60cm)	3	6/28/06	0.0030	46.42	6.85	0.0052
SL-3I-2(3,0t/ha,60cm)	3	8/16/06	0.0075	60.78	6.81	0.0058
SL-3I-2(3,0t/ha,60cm)	3	10/14/06	0.0057	74.10	6.81	0.0085
SL-3I-2(3,0t/ha,60cm)	3	12/16/06	0.0293	48.79	6.97	0.0044
SL-3I-2(3,0t/ha,60cm)	3	2/24/07	0.0204	40.26	7.43	0.0061
SL-3I-2(3,0t/ha,60cm)	3	8/15/07	0.0489	68.17	6.75	0.1226
SL-3I-2(3,0t/ha,60cm)	3	10/17/07	0.0233	59.95	7.13	0.0484

SL-3I-2(3,0t/ha,60cm)	3	2/20/08	0.0251	47.52	6.49	0.0125
SL-3I-2(3,0t/ha,60cm)	3	4/23/08	0.0548	93.95	6.61	0.0094
SL-3I-5(3,0t/ha,30cm)	3	11/23/03	0.1443	1.53	6.34	-0.1333
SL-3I-5(3,0t/ha,30cm)	3	12/21/03	0.1019	1.17	6.23	-0.0923
SL-3I-5(3,0t/ha,30cm)	3	1/30/04	0.0364	1.02	6.30	-0.0125
SL-3I-5(3,0t/ha,30cm)	3	2/26/04	0.0185	1.24	6.26	-0.0069
SL-3I-5(3,0t/ha,30cm)	3	3/26/04	0.0005	0.00	6.29	-0.0031
SL-3I-5(3,0t/ha,30cm)	3	4/30/04	0.0035	0.83	6.42	0.0018
SL-3I-5(3,0t/ha,30cm)	3	5/27/04	-0.0022	1.40	6.23	0.0022
SL-3I-5(3,0t/ha,30cm)	3	6/30/04	0.0024	1.24	6.06	0.0040
SL-3I-5(3,0t/ha,30cm)	3	8/31/04	0.0001	1.11	6.25	0.0048
SL-3I-5(3,0t/ha,30cm)	3	10/30/04	0.0047	1.34	6.17	0.0062
SL-3I-5(3,0t/ha,30cm)	3	12/22/04	0.0069	0.75	6.25	0.0116
SL-3I-5(3,0t/ha,30cm)	3	2/26/05	0.0024	1.51	6.08	0.0028
SL-3I-5(3,0t/ha,30cm)	3	4/29/05	0.0064	0.64	5.99	0.0063
SL-3I-5(3,0t/ha,30cm)	3	6/18/05	0.0051	0.73	5.73	0.0039
SL-3I-5(3,0t/ha,30cm)	3	8/25/05	0.0115	0.97	6.02	0.0053
SL-3I-5(3,0t/ha,30cm)	3	4/23/06	0.0009	0.83	5.57	0.0044
SL-3I-5(3,0t/ha,30cm)	3	6/28/06	0.0030	0.98	5.63	0.0046
SL-3I-5(3,0t/ha,30cm)	3	8/16/06	0.0027	1.16	5.62	0.0059
SL-3I-5(3,0t/ha,30cm)	3	10/14/06	0.0006	1.27	5.82	0.0057
SL-3I-5(3,0t/ha,30cm)	3	12/16/06	0.0118	1.30	5.9	0.0016
SL-3I-5(3,0t/ha,30cm)	3	2/24/07	0.0154	3.39	5.69	0.0031
SL-3I-5(3,0t/ha,30cm)	3	4/20/07	0.0402	1.11	6	0.0051
SL-3I-5(3,0t/ha,30cm)	3	8/15/07	0.0622	1.55	5.97	0.0054
SL-3I-5(3,0t/ha,30cm)	3	10/17/07	0.0170	1.95	5.67	0.0098
SL-3I-5(3,0t/ha,30cm)	3	12/19/07	0.0354	2.16	5.64	0.0266
SL-3I-5(3,0t/ha,30cm)	3	2/20/08	0.0340	2.50	5.43	0.0043
SL-3I-5(3,0t/ha,30cm)	3	4/23/08	0.0207	2.65	5.43	0.0059
SL-3I-5(3,0t/ha,30cm)	3	6/16/08	0.0349	4.11	5.38	0.0069
SL-3I-5(3,0t/ha,30cm)	3	8/17/08	0.0203	3.86	5.86	0.0113
SL-3I-5(3,0t/ha,30cm)	3	10/5/08	0.0180	3.96	5.28	0.0093
SL-3I-5(3,0t/ha,30cm)	3	1/11/09	0.0168	4.40	5.36	0.0000
SL-3I-6(3,0t/ha,120cm)	3	8/15/07	0.0677	507.40	7.7	0.0161
SL-3I-6(3,0t/ha,120cm)	3	10/17/07	0.0237	746.55	7.7	0.0157
SL-3I-6(3,0t/ha,120cm)	3	12/19/07	1.7861	836.38	7.85	0.0219
SL-3I-6(3,0t/ha,120cm)	3	2/20/08	0.0259	991.67	7.7	0.0263
SL-3I-6(3,0t/ha,120cm)	3	4/23/08	0.0071	1090.66	7.60	0.0366
SL-3I-6(3,0t/ha,120cm)	3	6/16/08	0.0069	1099.84	7.43	0.0633
SL-3I-6(3,0t/ha,120cm)	3	8/17/08	0.0342	956.39	7.8	0.0532
SL-3I-6(3,0t/ha,120cm)	3	1/11/09	0.0019	914.68	7.68	0.0467

SL-3I-6(3,0t/ha,120cm)	3	4/18/09	-0.0123	1051.26	7.38	0.0414
SL-3I-6(3,0t/ha,120cm)	3	7/16/09	0.0000	1197.96	7.49	
SL-3I-6(3,0t/ha,120cm)	3	10/18/09	0.0007	1190.95	7.33	
SL-4A-1(1,0t/ha,30cm)	3	11/10/03	0.0133	0.41	6.20	-0.0023
SL-4A-1(1,0t/ha,30cm)	3	12/8/05	9.2149	0.33	5.80	0.0114
SL-4A-1(1,0t/ha,30cm)	3	2/5/06	3.7428	0.06	6.30	0.0049
SL-4A-1(1,0t/ha,30cm)	3	12/3/06	0.7774	0.06	6.35	0.0492
SL-4A-1(1,0t/ha,30cm)	3	12/7/07	0.5159	0.96	5.86	0.0107
SL-4A-1(1,0t/ha,30cm)	3	2/6/08	18.1888	0.04	5.64	0.0054
SL-4A-1(1,0t/ha,30cm)	3	4/9/08	6.1617	0.04	5.78	0.0021
SL-4A-1(1,0t/ha,30cm)	3	6/2/08	3.4587	0.34	6.58	0.0059
SL-4A-1(1,0t/ha,30cm)	3	1/11/09	14.4948	3.76	5.73	0.0102
SL-4A-1(1,0t/ha,30cm)	3	7/1/09	5.9660	0.04	5.86	
SL-4A-1(1,0t/ha,30cm)	3	10/3/09	8.2201	0.08	6.20	
SL-4A-2(1,0t/ha,60cm)	3	11/10/03	-0.0186	30.02	6.88	0.0366
SL-4A-2(1,0t/ha,60cm)	3	11/30/03	0.1389	35.22	6.8	0.0197
SL-4A-2(1,0t/ha,60cm)	3	1/6/04	-0.0130	38.84	6.86	-0.0032
SL-4A-2(1,0t/ha,60cm)	3	2/11/04	-0.0247	42.09	6.91	0.0027
SL-4A-2(1,0t/ha,60cm)	3	3/10/04	0.0338	43.69	7.09	-0.0060
SL-4A-2(1,0t/ha,60cm)	3	4/9/04	0.0040	43.94	7.00	0.0023
SL-4A-2(1,0t/ha,60cm)	3	5/14/04	0.0034	48.35	7.03	0.0028
SL-4A-2(1,0t/ha,60cm)	3	6/16/04	0.0054	59.48	6.73	0.0047
SL-4A-2(1,0t/ha,60cm)	3	8/18/04	0.0038	50.87	6.70	0.0039
SL-4A-2(1,0t/ha,60cm)	3	10/16/04	0.0034	51.03	6.69	0.0023
SL-4A-2(1,0t/ha,60cm)	3	12/4/04	0.0061	46.65	6.80	0.0108
SL-4A-2(1,0t/ha,60cm)	3	2/10/05	0.0061	44.10	6.82	0.0109
SL-4A-2(1,0t/ha,60cm)	3	4/14/05	0.0015	42.63	6.64	0.0077
SL-4A-2(1,0t/ha,60cm)	3	12/8/05	58.6456	31.13	6.07	0.0888
SL-4A-2(1,0t/ha,60cm)	3	2/5/06	0.4464	34.11	6.68	0.0493
SL-4A-2(1,0t/ha,60cm)	3	8/2/06	16.5931	45.87	6.83	0.0424
SL-4A-2(1,0t/ha,60cm)	3	12/3/06	0.2320	38.52	6.52	0.0176
SL-4A-2(1,0t/ha,60cm)	3	4/6/07	9.3913	39.99	6.6	0.0550
SL-4A-2(1,0t/ha,60cm)	3	6/5/07	10.6025	39.47	6.73	1.3036
SL-4A-2(1,0t/ha,60cm)	3	2/6/08	69.5041	2.71	5.50	0.0168
SL-4A-2(1,0t/ha,60cm)	3	4/9/08	17.3172	4.03	5.91	0.0567
SL-4A-2(1,0t/ha,60cm)	3	10/3/09	33.9544	0.12	6.40	
SL-4A-5(1,0t/ha,15cm)	3	11/10/03	0.0721	0.01	5.43	-0.0251
SL-4A-5(1,0t/ha,15cm)	3	11/30/03	0.2420	0.00	5.18	0.0298
SL-4A-5(1,0t/ha,15cm)	3	1/6/04	0.0187	0.10	5.14	-0.0136
SL-4A-5(1,0t/ha,15cm)	3	2/11/04	0.0231	0.32	5.27	0.0015
SL-4A-5(1,0t/ha,15cm)	3	3/10/04	0.0437	0.17	5.38	-0.0023

SL-4A-5(1,0t/ha,15cm)	3	4/9/04	0.0000	0.03	5.21	0.0000
SL-4A-5(1,0t/ha,15cm)	3	5/14/04	0.0032	0.00	5.24	0.0000
SL-4A-5(1,0t/ha,15cm)	3	6/16/04	0.0085	0.03	4.82	0.0000
SL-4A-5(1,0t/ha,15cm)	3	8/18/04	0.0058	1.51	6.27	0.0013
SL-4A-5(1,0t/ha,15cm)	3	10/16/04	-0.0026	0.06	4.97	0.0276
SL-4A-5(1,0t/ha,15cm)	3	12/4/04	-0.0044	0.09	4.98	0.0385
SL-4A-5(1,0t/ha,15cm)	3	2/10/05	0.0007	0.10	4.89	0.0488
SL-4A-5(1,0t/ha,15cm)	3	4/14/05	0.0007	0.09	4.65	0.0354
SL-4A-5(1,0t/ha,15cm)	3	6/4/05	0.0089	24.03	4.82	0.0428
SL-4A-5(1,0t/ha,15cm)	3	8/11/05	0.0013	0.42	5.38	0.0009
SL-4A-5(1,0t/ha,15cm)	3	12/8/05	9.2469	3.44	5.47	0.0153
SL-4A-5(1,0t/ha,15cm)	3	2/5/06	14.7055	5.95	5.55	0.0544
SL-4A-5(1,0t/ha,15cm)	3	4/10/06	1.2736	3.36	5.91	0.0263
SL-4A-5(1,0t/ha,15cm)	3	6/16/06	18.3182	2.50	6.26	0.0201
SL-4A-5(1,0t/ha,15cm)	3	8/2/06	4.2613	1.20	5.39	0.0029
SL-4A-5(1,0t/ha,15cm)	3	12/3/06	35.2937	4.19	5.66	0.0266
SL-4A-5(1,0t/ha,15cm)	3	4/6/07	7.6346	0.07	6.9	0.0058
SL-4A-5(1,0t/ha,15cm)	3	10/1/07	10.0643	1.21	5.94	0.0103
SL-4A-6(1,0t/ha,120cm)	3	10/1/07	0.1813	98.54	7.66	0.0054
SL-4A-6(1,0t/ha,120cm)	3	12/7/07	-0.0720	172.64	6.85	0.1386
SL-4A-6(1,0t/ha,120cm)	3	2/6/08	0.6447	59.82	6.87	2.9103
SL-4A-6(1,0t/ha,120cm)	3	4/9/08	0.9327	45.64	6.63	1.0928
SL-4A-6(1,0t/ha,120cm)	3	6/2/08	0.1258	46.27	6.85	0.7784
SL-4A-6(1,0t/ha,120cm)	3	8/4/08	4.0206	53.98	6.74	1.3893
SL-4A-6(1,0t/ha,120cm)	3	1/11/09	3.3122	42.16	6.59	2.6470
SL-4A-6(1,0t/ha,120cm)	3	4/5/09	1.2219	39.13	6.58	0.7480
SL-4A-6(1,0t/ha,120cm)	3	7/1/09	1.4304	35.81	6.40	
SL-4A-6(1,0t/ha,120cm)	3	10/3/09	16.5208	20.94	6.34	
SL-4B-3(1,0t/ha,30cm)	2	11/23/03	0.1610	2.04	7.71	-0.1379
SL-4B-3(1,0t/ha,30cm)	2	12/21/03	-0.0043	2.38	7.10	0.0000
SL-4B-3(1,0t/ha,30cm)	2	1/30/04	0.0437	1.84	7.27	-0.0109
SL-4B-3(1,0t/ha,30cm)	2	2/26/04	0.0120	1.93	7.64	-0.0034
SL-4B-3(1,0t/ha,30cm)	2	3/26/04	0.0121	0.03	7.20	-0.0031
SL-4B-3(1,0t/ha,30cm)	2	4/30/04	0.0036	2.45	7.58	0.0022
SL-4B-3(1,0t/ha,30cm)	2	5/27/04	0.0145	2.63	7.09	0.0026
SL-4B-3(1,0t/ha,30cm)	2	6/30/04	0.0036	2.24	6.60	0.0028
SL-4B-3(1,0t/ha,30cm)	2	8/31/04	0.0242	8.09	7.63	0.0076
SL-4B-3(1,0t/ha,30cm)	2	10/30/04	0.0070	2.27	6.75	0.0057
SL-4B-3(1,0t/ha,30cm)	2	12/22/04	0.0046	2.00	6.88	0.0111
SL-4B-3(1,0t/ha,30cm)	2	2/26/05	0.0180	1.41	6.99	0.0013
SL-4B-3(1,0t/ha,30cm)	2	4/29/05	0.0149	1.74	7.26	0.0192

SL-4B-3(1,0t/ha,30cm)	2	6/18/05	0.0121	1.90	7.02	0.0111
SL-4B-3(1,0t/ha,30cm)	2	8/25/05	0.0103	2.65	7.05	0.0069
SL-4B-3(1,0t/ha,30cm)	2	10/18/05	0.0087	1.60	6.58	0.0043
SL-4B-3(1,0t/ha,30cm)	2	12/21/05	15.6586	0.14	6.65	0.0163
SL-4B-3(1,0t/ha,30cm)	2	2/26/06	6.8424	0.29	7.20	0.0075
SL-4B-3(1,0t/ha,30cm)	2	4/23/06	3.1022	0.07	6.49	0.0125
SL-4B-3(1,0t/ha,30cm)	2	6/28/06	0.0713	0.11	6.50	0.0025
SL-4B-3(1,0t/ha,30cm)	2	8/16/06	1.5739	0.07	6.88	0.0097
SL-4B-3(1,0t/ha,30cm)	2	10/14/06	1.3379	0.08	6.77	0.0055
SL-4B-3(1,0t/ha,30cm)	2	12/16/06	2.6497	0.03	7.6	0.0019
SL-4B-3(1,0t/ha,30cm)	2	2/24/07	0.0117	0.16	7.47	0.0029
SL-4B-3(1,0t/ha,30cm)	2	4/20/07	0.0187	0.01	6.3	0.0014
SL-4B-3(1,0t/ha,30cm)	2	2/20/08	1.5893	0.08	6.71	0.0009
SL-4B-3(1,0t/ha,30cm)	2	4/23/08	0.5056	0.05	6.63	0.0032
SL-4B-3(1,0t/ha,30cm)	2	6/16/08	0.3271	0.07	6.48	0.0054
SL-4B-3(1,0t/ha,30cm)	2	4/18/09	0.0782	0.02	6.34	0.0000
SL-4B-4(1,0t/ha,60cm)	2	11/23/03	0.1354	7.48	7.11	-0.1377
SL-4B-4(1,0t/ha,60cm)	2	12/21/03	-0.0111	5.97	7.02	0.0000
SL-4B-4(1,0t/ha,60cm)	2	2/26/04	-0.0028	7.20	7.07	-0.0073
SL-4B-4(1,0t/ha,60cm)	2	3/26/04	0.0121	0.10	7.02	-0.0024
SL-4B-4(1,0t/ha,60cm)	2	4/30/04	0.0036	9.14	7.31	0.0022
SL-4B-4(1,0t/ha,60cm)	2	5/27/04	0.0051	10.84	7.00	0.0030
SL-4B-4(1,0t/ha,60cm)	2	6/30/04	0.0045	10.52	6.78	0.0025
SL-4B-4(1,0t/ha,60cm)	2	8/31/04	0.0025	7.85	7.35	0.0042
SL-4B-4(1,0t/ha,60cm)	2	10/30/04	0.0079	13.04	6.86	0.0074
SL-4B-4(1,0t/ha,60cm)	2	12/22/04	0.0058	9.86	6.88	0.0105
SL-4B-4(1,0t/ha,60cm)	2	2/26/05	0.0048	6.50	6.95	0.0011
SL-4B-4(1,0t/ha,60cm)	2	4/29/05	0.0145	4.56	7.66	0.0156
SL-4B-4(1,0t/ha,60cm)	2	6/18/05	0.0114	5.70	7.78	0.0162
SL-4B-4(1,0t/ha,60cm)	2	1/11/09	0.0221	0.05	6.61	0.0000
SL-4B-5(1,0t/ha,15cm)	2	11/23/03	0.1418	0.94	6.28	-0.1181
SL-4B-5(1,0t/ha,15cm)	2	12/21/03	0.0031	0.96	6.02	0.0000
SL-4B-5(1,0t/ha,15cm)	2	2/26/04	0.0224	0.74	5.84	-0.0079
SL-4B-5(1,0t/ha,15cm)	2	3/26/04	0.0354	0.04	5.88	-0.0042
SL-4B-5(1,0t/ha,15cm)	2	4/30/04	0.0000	0.47	6.23	0.0000
SL-4B-5(1,0t/ha,15cm)	2	5/27/04	0.0036	0.66	5.98	0.0032
SL-4B-5(1,0t/ha,15cm)	2	6/30/04	0.0055	0.56	5.90	0.0025
SL-4B-5(1,0t/ha,15cm)	2	8/31/04	0.0049	5.68	6.95	0.0000
SL-4B-5(1,0t/ha,15cm)	2	10/30/04	0.0061	1.40	6.13	0.0085
SL-4B-5(1,0t/ha,15cm)	2	12/22/04	0.0070	1.32	6.21	0.0107
SL-4B-5(1,0t/ha,15cm)	2	2/26/05	0.0054	0.78	6.19	0.0016

SL-4B-5(1,0t/ha,15cm)	2	4/29/05	0.0085	1.62	6.51	0.0104
SL-4B-5(1,0t/ha,15cm)	2	6/18/05	0.0063	2.15	6.23	0.0059
SL-4B-5(1,0t/ha,15cm)	2	10/18/05	0.0055	0.11	6.08	0.0035
SL-4B-5(1,0t/ha,15cm)	2	12/21/05	3.6190	0.15	5.92	0.0391
SL-4B-5(1,0t/ha,15cm)	2	2/26/06	0.9065	0.11	5.94	0.0115
SL-4B-5(1,0t/ha,15cm)	2	4/23/06	0.0055	0.05	5.53	0.0005
SL-4B-5(1,0t/ha,15cm)	2	6/28/06	0.1698	0.45	5.57	0.0028
SL-4B-5(1,0t/ha,15cm)	2	8/16/06	0.5340	0.24	6.16	0.0070
SL-4B-5(1,0t/ha,15cm)	2	10/14/06	0.1789	0.18	5.44	0.0018
SL-4B-5(1,0t/ha,15cm)	2	12/16/06	1.4515	0.08	5.73	0.0019
SL-4B-5(1,0t/ha,15cm)	2	2/24/07	0.8084	0.00	5.92	0.0028
SL-4B-5(1,0t/ha,15cm)	2	12/19/07	0.0313	0.04	5.67	0.0028
SL-4B-5(1,0t/ha,15cm)	2	2/20/08	0.1017	0.26	5.71	0.0045
SL-4B-5(1,0t/ha,15cm)	2	4/23/08	0.0614	0.14	5.51	0.0041
SL-4B-5(1,0t/ha,15cm)	2	10/5/08	0.0328	0.06	5.27	0.0035
SL-4B-5(1,0t/ha,15cm)	2	1/11/09	0.3622	0.03	5.39	0.0156
SL-4B-5(1,0t/ha,15cm)	2	4/18/09	0.0691	0.07	5.64	0.0033
SL-4B-5(1,0t/ha,15cm)	2	10/18/09	3.1330	0.17	5.10	
SL-4B-6(1,0t/ha,120cm)	2	12/19/07	0.2724	55.20	6.6	0.0042
SL-4B-6(1,0t/ha,120cm)	2	2/20/08	0.0514	87.66	6.25	0.0014
SL-4B-6(1,0t/ha,120cm)	2	4/23/08	0.0123	40.94	6.25	0.0033
SL-4B-6(1,0t/ha,120cm)	2	6/16/08	0.0980	43.81	6.22	0.0262
SL-4B-6(1,0t/ha,120cm)	2	8/17/08	0.0278	49.14	6.2	0.0081
SL-4B-6(1,0t/ha,120cm)	2	10/5/08	0.0228	58.66	6.23	0.0023
SL-4B-6(1,0t/ha,120cm)	2	1/11/09	0.0193	52.41	6.27	0.0035
SL-4B-6(1,0t/ha,120cm)	2	4/18/09	0.0040	48.47	6.38	0.0015
SL-4B-6(1,0t/ha,120cm)	2	7/16/09	0.0064	41.20	6.24	
SL-4B-6(1,0t/ha,120cm)	2	10/18/09	0.0131	46.68	6.21	
SL-4C-1(1,0t/ha,30cm)	1	12/8/03	-0.0265	1.62	7.50	0.0047
SL-4C-1(1,0t/ha,30cm)	1	1/12/04	-0.0010	0.64	7.64	-0.0114
SL-4C-1(1,0t/ha,30cm)	1	2/18/04	-0.0015	2.39	7.83	0.0000
SL-4C-1(1,0t/ha,30cm)	1	4/23/04	0.0082	2.53	7.30	0.0000
SL-4C-1(1,0t/ha,30cm)	1	5/21/04	0.0041	1.26	7.43	0.0000
SL-4C-1(1,0t/ha,30cm)	1	6/23/04	0.0053	3.25	7.16	0.0024
SL-4C-1(1,0t/ha,30cm)	1	8/25/04	0.0187	1.27	7.02	0.0095
SL-4C-1(1,0t/ha,30cm)	1	10/23/04	0.0181	1.80	7.98	0.0252
SL-4C-1(1,0t/ha,30cm)	1	12/13/04	0.0076	0.86	7.00	0.0052
SL-4C-1(1,0t/ha,30cm)	1	2/19/05	0.0026	2.09	6.88	0.0045
SL-4C-1(1,0t/ha,30cm)	1	4/22/05	0.0045	1.74	7.42	0.0047
SL-4C-1(1,0t/ha,30cm)	1	12/17/05	16.7270	0.19	6.86	0.0151
SL-4C-1(1,0t/ha,30cm)	1	2/20/06	0.1078	0.84	6.87	0.0020

SL-4C-1(1,0t/ha,30cm)	1	4/14/06	14.3415	0.04	7.37	0.0046
SL-4C-1(1,0t/ha,30cm)	1	8/11/06	2.6539	0.34	6.67	0.0040
SL-4C-1(1,0t/ha,30cm)	1	10/9/06	1.6190	2.04	6.75	0.0120
SL-4C-1(1,0t/ha,30cm)	1	12/10/06	0.0522	0.10	6.83	0.0064
SL-4C-1(1,0t/ha,30cm)	1	12/14/07	41.2486	0.05	7.31	0.0054
SL-4C-1(1,0t/ha,30cm)	1	2/15/08	16.8830	0.17	6.59	0.0276
SL-4C-1(1,0t/ha,30cm)	1	4/16/08	1.6257	0.03	6.48	0.0089
SL-4C-1(1,0t/ha,30cm)	1	6/11/08	0.0300	0.06	6.49	0.0013
SL-4C-1(1,0t/ha,30cm)	1	10/5/08	19.1049	0.24		0.0084
SL-4C-1(1,0t/ha,30cm)	1	4/8/09	65.1918	0.35	6.56	0.0048
SL-4C-1(1,0t/ha,30cm)	1	7/8/09	4.9743	0.02	6.82	
SL-4C-1(1,0t/ha,30cm)	1	10/9/09	1.0445	0.02	6.44	
SL-4C-2(1,0t/ha,15cm)	1	11/18/03	-0.0256	2.03	8.00	0.0149
SL-4C-2(1,0t/ha,15cm)	1	12/8/03	-0.0187	1.89	7.50	0.0032
SL-4C-2(1,0t/ha,15cm)	1	1/12/04	-0.0059	1.74	7.68	-0.0102
SL-4C-2(1,0t/ha,15cm)	1	2/18/04	-0.0106	3.03	7.43	-0.0001
SL-4C-2(1,0t/ha,15cm)	1	3/19/04	-0.0303	2.43	7.46	-0.0003
SL-4C-2(1,0t/ha,15cm)	1	4/23/04	0.0093	3.82	7.57	0.0015
SL-4C-2(1,0t/ha,15cm)	1	5/21/04	0.0077	3.11	7.45	0.0033
SL-4C-2(1,0t/ha,15cm)	1	6/23/04	0.0094	2.45	7.52	0.0057
SL-4C-2(1,0t/ha,15cm)	1	8/25/04	2.0968	0.36	6.93	0.0112
SL-4C-2(1,0t/ha,15cm)	1	10/23/04	0.0202	2.20	7.84	0.0224
SL-4C-2(1,0t/ha,15cm)	1	12/13/04	0.0067	2.46	6.95	0.0059
SL-4C-2(1,0t/ha,15cm)	1	2/19/05	0.0033	2.71	6.87	0.0023
SL-4C-2(1,0t/ha,15cm)	1	4/22/05	0.0038	2.74	7.31	0.0023
SL-4C-2(1,0t/ha,15cm)	1	12/17/05	23.3819	0.07	6.82	0.0122
SL-4C-2(1,0t/ha,15cm)	1	2/20/06	2.9936	0.09	6.88	0.0248
SL-4C-2(1,0t/ha,15cm)	1	4/14/06	10.3151	0.04	7.68	0.0034
SL-4C-2(1,0t/ha,15cm)	1	8/11/06	2.8865	0.07	7.01	0.0019
SL-4C-2(1,0t/ha,15cm)	1	10/9/06	6.6896	0.06	6.82	0.0107
SL-4C-2(1,0t/ha,15cm)	1	12/10/06	1.4042	0.09	6.99	0.0035
SL-4C-2(1,0t/ha,15cm)	1	12/14/07	151.1137	0.03	6.96	0.0089
SL-4C-2(1,0t/ha,15cm)	1	2/15/08	5.8857	0.05	6.61	0.1244
SL-4C-2(1,0t/ha,15cm)	1	4/16/08	0.0274	0.02	6.55	0.0022
SL-4C-2(1,0t/ha,15cm)	1	6/11/08	0.0672	0.05	6.47	0.0053
SL-4C-2(1,0t/ha,15cm)	1	1/11/09	38.5052	0.01	6.46	0.0030
SL-4C-2(1,0t/ha,15cm)	1	4/8/09	37.9939	0.02	6.35	0.0040
SL-4C-2(1,0t/ha,15cm)	1	10/9/09	9.4388	0.01	6.52	
SL-4C-5(1,0t/ha60cm)	1	11/18/03	0.0102	7.50	8.00	0.0421
SL-4C-5(1,0t/ha60cm)	1	2/18/04	0.0078	4.87	6.81	0.0026
SL-4C-5(1,0t/ha60cm)	1	3/19/04	-0.0192	4.63	6.80	0.0002

SL-4C-5(1,0t/ha60cm)	1	4/23/04	0.0055	6.10	7.40	0.0014
SL-4C-5(1,0t/ha60cm)	1	5/21/04	0.0052	2.60	7.15	0.0000
SL-4C-5(1,0t/ha60cm)	1	6/23/04	0.0068	6.33	6.96	0.0036
SL-4C-5(1,0t/ha60cm)	1	8/25/04	0.0036	1.30	6.11	0.0048
SL-4C-5(1,0t/ha60cm)	1	10/23/04	0.0120	6.01	7.42	0.0143
SL-4C-5(1,0t/ha60cm)	1	12/13/04	0.0058	6.88	6.61	0.0087
SL-4C-5(1,0t/ha60cm)	1	2/19/05	0.0020	5.43	6.50	0.0045
SL-4C-5(1,0t/ha60cm)	1	4/22/05	0.0054	5.64	7.07	0.0017
SL-4C-5(1,0t/ha60cm)	1	6/11/05	0.0058	7.39	6.83	0.0067
SL-4C-5(1,0t/ha60cm)	1	10/13/05	0.3230	0.45	6.49	0.0058
SL-4C-5(1,0t/ha60cm)	1	12/17/05	0.1168	2.99	6.57	0.0694
SL-4C-5(1,0t/ha60cm)	1	2/20/06	0.0014	3.99	6.59	0.0064
SL-4C-5(1,0t/ha60cm)	1	4/14/06	0.0606	4.93	6.55	0.0611
SL-4C-5(1,0t/ha60cm)	1	6/21/06	23.3295	1.31	5.98	0.0000
SL-4C-5(1,0t/ha60cm)	1	12/10/06	0.2288	3.97	6.23	0.0047
SL-4C-5(1,0t/ha60cm)	1	4/13/07	0.2300	9.46	6.2	0.0209
SL-4C-5(1,0t/ha60cm)	1	6/13/07	61.4308	1.59	6.71	0.0710
SL-4C-5(1,0t/ha60cm)	1	10/10/07	15.5999	0.50	6.89	0.0131
SL-4C-5(1,0t/ha60cm)	1	12/14/07	0.6745	4.09	6.45	0.0248
SL-4C-5(1,0t/ha60cm)	1	2/15/08	10.5604	2.54	6.20	0.0124
SL-4C-5(1,0t/ha60cm)	1	4/16/08	3.5936	4.17	6.33	0.0224
SL-4C-5(1,0t/ha60cm)	1	6/11/08	0.5770	5.61	6.43	0.0110
SL-4C-5(1,0t/ha60cm)	1	1/11/09	11.2183	1.19	6.1	0.0498
SL-4C-5(1,0t/ha60cm)	1	10/9/09	6.5076	2.44	5.39	
SL-4C-6(1,0t/ha,120cm)	1	10/10/07	0.0702	208.43	7.69	0.0025
SL-4C-6(1,0t/ha,120cm)	1	12/14/07	0.0184	227.10	7.7	0.0078
SL-4C-6(1,0t/ha,120cm)	1	2/15/08	0.0325	226.93	6.94	0.0009
SL-4C-6(1,0t/ha,120cm)	1	4/16/08	0.0287	222.17	7.63	0.0052
SL-4C-6(1,0t/ha,120cm)	1	8/11/08	0.0369	216.32	7.34	0.0119
SL-4C-6(1,0t/ha,120cm)	1	10/5/08	0.0386	169.57	7.38	0.0074
SL-4C-6(1,0t/ha,120cm)	1	1/11/09	0.0572	190.23	7.58	0.0051
SL-4C-6(1,0t/ha,120cm)	1	4/8/09	0.0123	156.45	6.75	0.0064
SL-4C-6(1,0t/ha,120cm)	1	7/8/09	0.0083	155.69	7.36	
SL-4C-6(1,0t/ha,120cm)	1	10/9/09	0.0450	79.33	7.25	

Abbreviations and Acronyms

Blue Plains	Wastewater treatment plant for Washington, DC, Maryland, and Virginia, located in Washington DC and operated by DC Water
C	Carbon
CEC	Cation Exchange Capacity
DC WASA	District of Columbia Water and Sewer Authority, also known as DC Water
EPA	United States Environmental Protection Agency
ERCO	Environmental Reclamation Company, Inc. Also used as the location of the study in Brandywine, MD.
MCL	Maximum Contaminant Level set by United States Environmental Protection Agency (EPA)
MDE	Maryland Department of Environment
N	Nitrogen
NO_2	Nitrite
NO_2-N	Nitrite-nitrogen - Nitrate measured as nitrogen. EPA MCL in drinking water is 1 mg/L or 1 ppm
NO_2+NO_3	Nitrite-Nitrate- combined concentrations of Nitrite (NO_2^-) and Nitrate (NO_3^-)
NO_3^-	Nitrate
NO_3-N	Nitrate-nitrogen - Nitrate measured as nitrogen. EPA MCL in drinking water is 10 mg/L or 10 ppm
OC	Organic Carbon
P	Phosphorus
ppm	Parts per million
TAN	Total Ammoniacal Nitrogen- combined ammonium (NH_4^+) and ammonia (NH_3) concentrations (Jeong and Kim, 2001)
TKN	Total Kjeldahl Nitrogen – summation of organic nitrogen, ammonia (NH_3), and ammonium (NH_4^+)
TN	Total Nitrogen- sum of Total Kjeldahl Nitrogen (TKN), Nitrate-Nitrogen (NO_3-N), and Nitrite-Nitrogen (NO_2-N)
TP	Total Phosphorus
WWTP	Wastewater Treatment Plant

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