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The Hutton Project: Long-Term Agricultural Impacts on Soil Loss and Carbon Dynamics in Eastern South Dakota

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THE HUTTON PROJECT:

LONG-TERM AGRICULTURAL IMPACTS ON SOIL LOSS AND CARBON DYNAMICS IN EASTERN SOUTH DAKOTA

By

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THESIS ACCEPTANCE PAGE

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This thesis is approved as a creditable and independent investigation by a candidate for the master's degree and is acceptable for meeting the thesis requirements for this degree. Acceptance of this does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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This thesis is dedicated to my grandmother, Audrey Halverson (12/3/1930-2/6/2023), who passed away during my time at SDSU. Thank you for being one of my biggest supporters.

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ABBREVIATIONS

@: at

137^{c}: Caesium 137

2HCO_3: bicarbonate ion

A horizon: topsoil horizon

a, a^{-1}: acre, per acre

AB horizon: combination horizon

Al^{3+}: aluminum ion

ANOVA: Analysis of Variance

AVG: average

BD: bulk density

Bk horizon: subsurface horizon with pedogenic carbonates

Bt horizon: subsurface horizon with accumulation of illuviated clay

Bw horizon: subsurface horizon that has weakly developed color and structure

C horizon: soil parent material

C: carbon

C°: degrees Celsius

Ca^{2+}: calcium ion

$CaCO_3$: calcium carbonate

Caw: carbon atomic weight

Cc: carbon concentration

cc: cubic centimeter

CCC: Civilian Conservation Corps

CH_4: methane

cm, cm^3: centimeter, centimeter cubed

CO_2: carbon dioxide

d_{ac}: current depth to alternative reference level

d_{ai}: initial depth to alternative reference level

Dc: current depth to subsurface feature

Do: original depth to subsurface feature

d_{pc}: current depth to selected property

d_{pi}: initial depth to selected property

e.g.: for example

eff.: effervescence

ESD: Eastern South Dakota

et. al.: and others

etc.: etcetera

g, g^{-1}: gram, per gram

H^{1+}: hydrogen ion

H2CO_3: carbonic acid

ha, ha^{-1}: hectare, per hectare

HCL: hydrochloric acid

HSD: Honest Significant Difference

IA: Iowa

IC: inorganic carbon

in: inch

kg, kg^{-1}: kilogram, per kilogram

LiDAR: Light Detection and Ranging

LSD: Least Significant Difference

m, m^{-1}, m^2: meter, per meter, meter squared

M: molarity

Mg: megagram

mm: millimeter

MN: Minnesota

N°: degrees north

Na^{1+}: sodium

NA: not available

ND: North Dakota

NE: Nebraska

NRCS: Natural Resource Conservation Service

NRI: Natural Resource Inventory

OC: organic carbon

p: p-value

RUSLE: Revised Universal Soil Loss Equation

S: stones

S^{-1}: per second

SCS: Soil Conservation Service

SD: South Dakota

SES: Soil Erosion Service

T: thickness

TC: total carbon

US: United States

USDA: United States Department of Agriculture

USLE: Universal Soil Loss Equation

vfr: very friable

WATEM: Water and Tillage Erosion Model

yr, yr^{-1}: year, per year

Δd_p: change in depth to selected soil property

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ABSTRACT

THE HUTTON PROJECT:

LONG-TERM AGRICULTURAL IMPACTS ON SOIL LOSS AND CARBON DYNAMICS IN EASTERN SOUTH DAKOTA

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2024

Long-term and intensified agricultural land management has resulted in increased rates of soil erosion and has altered much of the carbon cycle at regional and global scales. Anthropogenic degradation of soil resources is a barrier to sustainable production, soil functioning, and ecosystem services. It is difficult to quantify the scope of pedogenic changes due to the lack of legacy data and short temporal scales. This study utilized decades to century-old soil information to quantify historical soil erosion losses and changes in soil carbon pools of eastern South Dakota soils. The results show that soils in the region have been significantly truncated by the forces of erosion. The results also show that there were significant decreases in soil carbon pools, however, it also shows that soil carbon may have begun to increase in more recent decades with shifts in management. This work deepened the understanding of anthropogenic impacts on soil resources since the rapid mechanization of agriculture. The study also highlights the value and importance of utilizing and building legacy soil datasets for quantifying pedogenic change.

Chapter 1. Introduction and Literature Review

1.1 Introduction

Degradation of soil resources has plagued global societies for generations. The soils of the Northern Great Plains, including South Dakota, have undergone significant changes and losses since the dawn of the Industrial Revolution and rapid mechanization of agriculture. Soil is a finite resource with a slow natural rate of production (Montgomery, 2007) and is critical to current and future crop production as well as overall environmental and human health. To sustainably continue producing food, fiber, and fuel from agricultural lands, soil health and conservation must be prioritized. The future of South Dakota's rural communities and ecosystems relies on productivity of the region's soil resources. The integrity, stability, and ecosystem services of soil must not be diminished by the increasing demand for productivity.

Early knowledge of soil science goes back thousands of years around the world, including pre-settlement United States through Indigenous cultures. However, through westward expansion in the late 19th and early 20th century, the exhaustion of soil resources plagued many regions of the United States (Brevik and Hartemink, 2010; Brevik et al., 2015). Given the relatively newer age of soil science as a discipline, long-term soil data is finite. Limited studies have focused on human interactions with soil processes over the long term (>60years), going back on a scale of decades is rarely assessed and provides a unique opportunity to examine the human-soil relationship (Richter, 2007; Richter and Yaalon, 2012).

To understand the human-soil relationship is especially important in arable systems that have undergone intensive alterations from the soil's "natural" state (Richter and Yaalon, 2012). Over half of the world's soils have been converted for human utilization, largely for agricultural production (Richter, 2007). Human forces, particularly land management practices, have dramatically accelerated the rate of pedological change seen on global and local scales (Bajard et al., 2016). Anthropogenic driven land conversion, tillage, erosion, compaction, and changes in nutrient cycling (e.g., soil carbon loss) have influenced how soils function and contribute to greater ecosystem services (Richter and Yaalon, 2012). Agricultural land use often exploits soil, focusing on the mitigation of limiting factors and optimizing soil properties for the enhancement crop production yields (Kuzyakov and Zamanian, 2019). Agriculture has introduced new mechanisms of soil changes, driven by mechanical manipulation and synthetic inputs.

Traditionally, pedological processes (pedogenesis) are perceived to be moving at a slow rate of change, taking place over prolonged periods of time. The concept of "anthropedogenesis" is anthropogenic influence dominating many of the soil development and processes in managed lands (Richter, 2007, 2020; Richter and Yaalon, 2012). A subset of anthropogenesis is "agropedogenesis" which relates to humans and specifically agricultural practices altering soil formation, processes, properties, and increasing rates of change (Kuzyakov and Zamanian, 2019). Agricultural practices have been responsible for increased soil compaction, loss of nutrients, loss of organic matter, shallower soil depths, alterations of soil structure, as well as affecting soil water and aeration dynamics (Kuzyakov and Zamanian, 2019). Agricultural soils cover ~34% of the Earth's land area and the forces of humans and agricultural land uses have a lasting footprint on much of the soil across the globe (Kuzyakov and Zamanian, 2019). Given the extent of agricultural impacts and land mass utilized for agriculture, there is a great need to assess the anthropogenic impact on soil resources.

Agricultural lands are eroding and losing soil at rates much faster than soil development or geological erosion rates (Wilkinson and McElroy, 2007; Montgomery, 2007; Bajard et al., 2016; Vanwalleghem et al., 2017; Richter, 2020). The global average erosion rates on conventionally tilled fields can be up to 3.93mm $year^{-1}$, outpacing the average soil production rate of 0.036mm yr^{-1}(Montgomery, 2007). However, these rates vary with management context and inherent soil, water, and landscape characteristics (Montgomery, 2007). Soils are experiencing shifts in pH values from unnatural system inputs and dependency of synthetic fertilizers (Malo et al., 2005; Jones et al., 2019). Land use changes have accelerated the removal of biomass, and tillage has reduced soil organic matter and its associated organic carbon through rapid oxidation (Gregorich et al., 1998; Malo et al., 2005; Olson et al., 2014). Soils are a significant sink and pool of terrestrial carbon through organic carbon derived from organic matter and inorganic sources that have pedogenically formed. The alteration of carbon stored within soils influences climatic processes through the storage and exchange of atmospheric CO_2 (Lal, 2004).

The agricultural soils of South Dakota have undergone human induced changes and degradation within the past century. Much of South Dakota is part of the Midwestern Corn Belt, where conversion of grassland ecosystems for agriculture has been very prominent (Wright and Wimberly, 2013). Historically, across the western side of the Corn Belt (MN, SD, IA, ND, NE), it is estimated that 99% of the original pre-settlement tallgrass has been converted to other land use forms. A case study estimated 530,000 hectares (~1.3 million acres) of grassland were converted between 2006 and 2011 in the corn belt alone, South Dakota lost ~182,000 hectares of grasslands in that period (Wright and Wimberly, 2013). Much of the losses of grasslands in the region are driven by increased crop production, particularly corn (*Zea mays*) and soybeans (*Glycine max*) (Wright and Wimberly, 2013).

Given the wide extent of land use change and soil manipulation that has occurred on midwestern soils, there is a need for long-term datasets to track pedological changes within the past century of industrialized agricultural practices. The purpose of this study is to examine the century-long influence of agricultural land use on historical soil loss and changes in soil carbon pools. This study utilizes historical data collected by Dr. Joseph G. Hutton (1873-1939), a South Dakota State University (then South Dakota State College) professor of agronomy from 1911 to 1939. Dr. Hutton was known for speaking about the consequences of improper cropping practices that degraded soil health and fertility. Dr. Hutton took part in regional soil surveying and completed some of the initial soil mapping in the state. Heretofore soil descriptions and laboratory data from Dr. Hutton's fertility studies and soil surveys will be utilized as baseline data for this thesis.

Hutton's initial soil survey descriptions from 1926 in Moody County, South Dakota will be utilized to assess soil loss and profile truncation over the past century. Along with these descriptions, archived USDA-Soil Conservation Service (now Natural Resource Conservation Service) descriptions from 1955 will also be used. Additionally, Hutton began a study in 1921 comparing soil carbon (total, inorganic, and organic) in cultivated and uncultivated lands in Beadle County, South Dakota. These sites were revisited in 1996 (Malo et al., 2005) to examine 75-year changes in soil carbon. The previously visited fields were relocated and resampled in 2023 to assess century-long changes in these soil properties. My research aims to quantify the amount of soil lost as well as track changes in soil carbon in eastern South Dakota agricultural lands. With this, I have formed the following hypotheses:

Chapter 2:

H_0: A century of agricultural production has not caused significant losses and truncation of soil.

H_1: A century of agricultural production has caused significant losses and truncation of soil.

Chapter 3:

H_0: A century of agricultural production has not caused significant losses in soil carbon.

H_1: A century of agricultural production has caused significant losses in soil carbon.

To test these hypotheses, the earlier study sites were relocated, revisited, and resampled. The goal of this work is to track long-term changes in soil properties while utilizing and building upon a historical legacy dataset. The assessment and quantification of soil loss will be assessed in Chapter 2, the changes in soil carbon and its associated stocks will be addressed in Chapter 3, summarization of findings and evaluation of the impact on eastern South Dakota soils will be concluded in Chapter 4.

1.2 Assessment of Current Knowledge

1.2.1 Soil Loss and Soil Profile Truncation

1.2.1.1 Soil Erosion Processes

Erosion is a two-step process, beginning with detachment of soil particles from the initial soil mass, followed by the transport from water or wind. Once energy is not able to continue transport, deposition of the detached particles occurs (Morgan, 2005). Water erosion is the accelerated detachment and movement of soil particles via the forces of water via precipitation, ice, snowmelt, or running water (Huffman et al., 2013).

Rain splashes are the most significant source of soil detachment. In a rainfall event, raindrops have the potential to reach velocities of 800cm s^{-1} and have a diameter of 2-3mm in size, resulting in sufficient energy hitting the soil surface to break up soil aggregates (Jenny, 1980). The forces of water break up, lift, and transport soil particles. Water and the associated particles move downslope in uniform sheets through the forces of gravity, this is sheet flow. As these sheets of water flow, they follow and accumulate along paths of least resistance, creating small channels known as rills. Over time, continuous water flow through rills creates larger channels called gullies (Jenny, 1980; Morgan, 2005). Water induced erosion is often highest on lower shoulder and backslope landscape positions where the slope gradient is constant and at its maximum (Schumacher et al., 1999).

Wind erosion can dislodge and carry soil particles vast distances. Carried particles can travel thousands of miles away from their original location (Pimentel, 2006). Bare, loose, and dry soil is subject to wind erosion, influenced by the velocity of moving air near the soil surface (Morgan, 2005; FAO and ITPS, 2015). Wind erosion transports particles through suspension, creep, and saltation. Suspension is the transport of fine particles suspended in air and carried over a distance. Creep is the dislodged particles rolling across the soil surface. Saltation is the movement of particles across the surface in a series of jumps (Morgan, 2005). Resistance to wind erosion increases when particles and aggregates are >1mm in size, as well as when the soil surface has obstacles (e.g., vegetation) and roughness to break and lessen the abrasion caused by blowing wind (Morgan, 2005).

Soil erodibility relates to soil's resistance to erosional detachment, influenced by factors such as rainfall intensity, slope, vegetation community, and well as sediment catchment position. Soil factors such as structure, organic matter content, aggregation, permeability, and management can dictate the erodibility (FAO and ITPS, 2015). Finer textured (0.063-0.250mm particle size) soils such as silt, silt loam, loam, and fine sands are the most susceptible to erosion, soils formed in loess (fine wind-blown sediment) tend to be the most erosive (Jenny, 1980; Morgan, 2005). Coarse textured soils are heavier and require more energy to move, making the particles more resistant to detachment. Fine clay particles have resistance due to adhesive forces and chemical bonds that hold them together, however this is variable with inherent minerology and amount of dispersive (Na^{1+}) or flocculating ions (Ca^{2+}, Al^{3+}, H^{1+}) within the soil matrix (Morgan, 2005). If the soil is dry and the erosive intensity is high, the soil is more susceptible to aggregate slaking and dispersing (Morgan, 2005).

Intensive tillage exposes bare soil and disrupts soil aggregates, allowing forces of precipitation to directly hit unprotected soil, which causes excessive erosion. Tillage creates a condition where soil particles and associated nutrients are carried and translocated to other areas within the landscape (Lal et al., 2007). Tillage erosion occurs when soil is cultivated and turned over causing lateral translocation of surface soil material. Tillage translocation displaces a mass of soil from the cultivated layer, moved by tillage on a slope gradient (Van Oost et al., 2006). The landscape topography and tillage practice impact the severity and extent of tillage erosion. Tillage erosion is dominant on convex landforms (summit and shoulder landscape positions) where the slope gradient is curved and trending downward (Schumacher et al., 1999; Li et al., 2007).

Tillage and water induced erosion work simultaneously in the processes of soil translocation along a hillslope. Both result in deposition of soil in lower landscape positions such as the footslope and toeslope; where the slope is beginning to decrease and forms a concave to eventually flat shape (Schumacher et al., 1999). Intense tillage practices on agricultural lands have resulted in substantial amounts of lateral soil transferring and movement on slopes (Vanwalleghem et al., 2009). Tillage erosion is prevalent in the rolling and hummocky landscapes commonly found in the region. More than 75% of the land in the Northern Great Plains is classified as rolling, undulating, and hummocky (Li et al., 2007; Zilverberg et al., 2018). Eroded particles have been transported and temporarily held across fields, ditches, local waterways, and eventually to larger bodies of water such as lakes and reservoirs (Heathcote et al., 2013; Quine and Van Oost, 2020), in this region sediments may eventually end up in tributaries of the Missouri and Mississippi River systems.

1.2.1.2 Soil Erosion Extent

Soils that have been converted from natural states to cultivated cropping systems have significantly increased rates of erosion (Montgomery, 2007; Vanwalleghem et al., 2017). In the United States, soils are thinning from erosion at a rate exceeding the rate soil formation, an estimated 90 percent of cropland in the United States is losing soil faster than it is forming (Pimentel, 2006; Montgomery, 2007; Nearing et al., 2017). Based on a meta-analysis assessing global erosion rates, erosion rates on conventional croplands have been estimated to be 3.94mm yr^{-1} with a median of 1.54mm yr^{-1}, outpacing the average soil production rate of 0.06-0.08mm yr^{-1} (Montgomery, 2007). In recent years, average erosion rates have been reduced in the United States and South Dakota (USDA-NRCS, 2017) (Table 1) likely from conservation practices such as reduced tillage, residue management, as well as program incentives taking erosive land out of production (Nearing et al., 2017).

In the 1970s erosion losses for the United States were as high as 4 billion Mg soil yr^{-1}, in 1997 the losses were reduced to 2 billion Mg soil yr^{-1} (Huffman et al., 2013). The Corn Belt region of the United States has had severe erosional losses on its landscapes. An estimated 35-11% of soils have had up to 50% surface horizon (A horizon) removal (Figure 1), and most of the removal has happened on convex shaped landscapes (Thaler et al., 2021). Many soils have suffered complete loss of the soil surface; equivalent to the class 4 erosional category under USDA classification and has created billions of dollars in economic loss (Thaler et al., 2021).

Table 1. NRI estimated erosion rates for US and SD (USDA-NRCS, 2017)

Area	Year	Estimated Erosion Rate (Tons/Acre/Year)	Confidence Interval
National	1982	7.12	0.06
	1987	6.74	0.05
	1992	5.67	0.06
	1997	5.00	0.06
	2002	4.81	0.09
	2007	4.59	0.08
	2012	4.63	0.08
	2017	4.63	0.09
South Dakota	1982	5.59	0.22
	1987	5.15	0.20
	1992	3.94	0.15
	1997	3.12	0.11
	2002	3.01	0.14
	2007	2.36	0.13
	2012	2.31	0.12
	2017	2.00	0.07

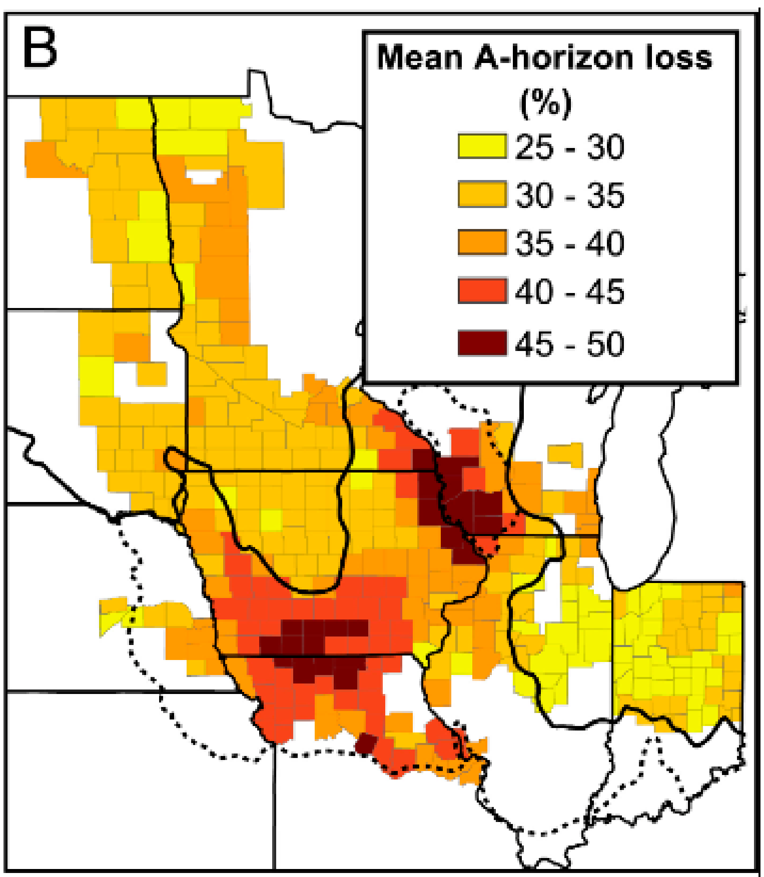

Figure 1. Estimated regional soil surface horizon loss from (Thaler et al., 2021)

1.2.1.3 Quantification of Soil Erosion

The ability to quantify the amount and scale of erosion can be difficult due to many environmental, management, and measurement factors (García-Ruiz et al., 2015). Much of the variability and uncertainty between datasets is a result of differing timelines, experiment durations, and pedological context resulting in large temporal and spatial variability (Vanwalleghem et al., 2017). Many studies regarding erosion rates are assessed on a short-term basis for three years or less and typically erosion studies use simulated experiments that undergo intervals of 10 to 30 minutes, daily, or seasonally. There are few soil erosion studies that are conducted to examine decades of change (Meyer et al., 1999; García-Ruiz et al., 2015). A meta-analysis on global soil erosion rates suggests a timeline >20 years is optimum for tracking true changes in soil thickness (García-Ruiz et al., 2015).

Predictive modeling has been used to estimate erosion rates given specific management and climate factors. Widely used models are the Universal Soil Loss Equation (USLE) and Revised Universal Soil Loss Equation (RUSLE) (Spaeth et al., 2003). The RUSLE model uses five factors: rainfall erosivity, soil erodibility, slope length and steepness, soil cover, and conservation practice management. Each factor has its own weight and variables that contribute to the model output, giving a value related to potential soil erosion rates (Spaeth et al., 2003; Borrelli et al., 2017; Ghosal and Das Bhattacharya, 2020). Soil erodibility has the largest regional variation within the model; it is based on soil texture, structure, moisture, minerology, organic matter, density, among other chemical and biological factors. No single factor within the model has proven to be the most effective predictor of estimating and assessing soil loss (Huffman et al., 2013; Ghosal and Das Bhattacharya, 2020).

The Water and Tillage Erosion Model (WATEM) relies heavily on landscape topography to evaluate the influence of hydrology and tillage practices to estimate total erosion (Schumacher et al., 2005). The model suggests that tillage is the largest driver of soil movement on convex hillslope positions, rather than movement by water or wind (Schumacher et al., 2005). As noted above, convex landscapes make up much of the region (Thaler et al., 2021), therefore, tillage is a large contributor to erosion occurring on landscapes.

The Caesium-137 ($137^{\wedge C}$) method has been used globally (Mabit et al., 2002) and in the Northern Great Plains (Li et al., 2007) to track sediment movement. Caesium-137 is a radioactive isotope deposited from nuclear sources and is distributed globally. Redistribution of the isotope in transported and deposited sediments can track erosional transport of soil. The restrictions with this method include nonuniform distribution of the isotope and lack of reference sites. This method is commonly used in European countries, compared to North America where there are lower concentrations of the isotope found in the soils (Mabit et al., 2002).

Many erosion studies utilize research plots to quantify sediment movement and runoff. The plots can be used to show differences under multiple management, cropping, geographic, and climatic scenarios (Meyer et al., 1999; Meijer et al., 2013). Many of the plots use rainfall simulators to keep the amount and velocity of water controlled and standardized. Use of plots such as this can have difficulties with the data they produce and its interpretation due to field variation in soils and topography (Meyer et al., 1999).

Remote sensing has provided insight into new methods of quantifying changes in erosion rates and soil truncation related to land management practices. Remote sensing information such as Light Detection and Ranging (LiDAR) (Meijer et al., 2013) as well as satellite imagery combined with soil spectral data (Thaler et al., 2021) can quantify erosion landscape changes on a field scale. Many of the issues with these methods reside with a lack of reference data of previous soil conditions for the fields (Meijer et al., 2013; Thaler et al., 2021).

1.2.1.4 Pedological Assessment of Soil Erosion

Comparisons have been made using cultivated and uncultivated sites to compare eroded and un-eroded soil profiles (Papiernik et al., 2005; Olson et al., 2014; Jelinski et al., 2019). However, there are few sites in the Midwest that are historically native. The establishment of benchmarks on uncultivated soils requires a similar landform, parent material, and other pedogenic variables, which proves to be a challenge (Olson et al., 2014). If proper benchmarks are established, changes in soil profile thickness can quantify historical erosion rates and truncation.

Midwestern soil erosion rates have occurred at estimated rates of 0.2-4.3mm yr^{-1} with a median value of 1.9mm yr^{-1} (Thaler et al., 2022). Prior to this estimate, Midwest measurements varied between 0.14-7.7mm yr^{-1} (Thaler et al., 2022). A study specifically in Minnesota found erosion rates of cropped land were an average of 3.09mm yr^{-1} compared to the 0.05mm yr^{-1} in the adjacent native prairie conditions (Jelinski et al., 2019). $137^{\wedge C}$ measurements in the Northern Great Plains showed an average erosion rate of ~12-22Mg ha^{-1} yr^{-1} in two separate agricultural landscapes (Li et al., 2007). Other regional modelling estimated of the mass of soil lost on erosional landscapes ranged from

46->60Mg ha^{-1} yr^{-1}, varying across slope gradients and landform positions across the studied area (Papiernik et al., 2005).

Soil morphology has been used as a benchmark for soil change in numerous studies. Many of which have occurred in the Midwest under similar climates and soil parent materials compared to eastern South Dakota. Erosional loss of surface A horizons from soils have led to shallower depths to subsurface B horizons and associated features (Phillips et al., 1999; Indorante et al., 2014; Veenstra and Burras, 2015). Soil loss and subsequent tillage mixes and incorporates subsoil materials in upper surface horizons, pushing features upward (Indorante et al., 2014). Severely eroded soils can have >50% subsoil mixed within surface soil horizons (Fenton et al., 2005). The incorporation of subsoil into topsoil can have dramatic implications on productivity (Vanwalleghem et al., 2017), as subsoil is lower in available nutrients, organic matter, and often denser. The opposite of truncation occurs in lower landscape positions, where material is deposited from upper landscape positions over preexisting soil surface (Papiernik et al., 2007). These processes and trends are commonly seen in the Midwest, where cultivation is occurring on naturally undulating topographies (Van Oost et al., 2006). Quantifying soil losses through soil morphology requires legacy data with site locations to get direct comparisons.

The truncation of soil profiles can be quantified utilizing various morphological indicators within the soil. Erosion impacted soils often have higher clay contents at shallower depths than previously, from incorporation of clay-rich subsoil (Olson and Nizeyimana, 1988; Phillips et al., 1999; Arriaga and Lowery, 2003; Indorante et al., 2014). Changes in rock fragment percentages track the movement of soil parent materials and texture modifiers (Veenstra and Burras, 2015). Soil structure is altered, with blocky and cloddy structure dominating once granular structure in the surface (Kimble et al., 2001; Meijer et al., 2013; Veenstra and Burras, 2015). Soil color, redoximorphic features, as well as redistribution of soil carbon have also been used as benchmarks to compare horizon shifting (Veenstra and Burras, 2015).

Regional studies of erosional landscapes have reported shallower depths to parent material (C horizon), calcic horizons (Bk horizon; pedogenic carbonate accumulation), and higher amounts of inorganic carbon in the topsoil from the shifting upward of calcareous material from the Bk horizon (De Alba et al., 2004; Papiernik et al., 2005, 2007). Carbonates shifting upward in the soil profile are positively correlated with increasing rates of erosion. In west central Minnesota, the average depth to Bk horizons on erosional landscapes was ~50cm, compared to ~80cm in uncultivated benchmark soils (Papiernik et al., 2005, 2007). The physical processes associated with profile truncation and shifting of carbonate material are described in detail in (De Alba et al., 2004).

1.2.2 Soil Carbon Dynamics

1.2.2.1 Soil Organic Matter and Soil Organic Carbon

Soil organic carbon (SOC) is derived from living, once living, and decomposed biomass known as soil organic matter (SOM). Organic carbon (OC) is derived from the balance of inputs from organic sources (plant matter and soil organisms) and outputs as CO_2 from decomposition and respiration of microorganisms (Jobba´gy and Jackson, 2000). Soil organic matter is an array of compounds from living and nonliving components, a fraction of compounds (~50-60%) are what eventually become soil organic carbon. Soil organic matter also has inorganic elemental components aside from carbon such as nitrogen, sulfur, phosphorus, calcium, and potassium (Bajgai et al., 2013). The richness of nutrients serves a critical role for biological populations, plant health, and ecosystem services (Dynarski et al., 2020). Soil organic carbon is much more susceptible to changes and management impacts compared to inorganic components (Stockmann et al., 2013).

Soil organic matter is split into two different pools (labile and recalcitrant) each with differing chemical reactions, composition, and decomposition status. The labile and more active pool consists of living biomass, particulate matter, readily soluble carbohydrates, enzymes, proteins, nucleic acids, and polysaccharides derived from plant material, microbial populations, and other biomass (Rovira and Vallejo, 2002; Bajgai et al., 2013; Liu et al., 2020). The labile fraction is dynamic and susceptible to changes within its ecosystem and environment. Labile carbon has fast turnover times and the oxidation of organic matter causes fluxes of CO_2 in the soil-atmosphere interface (Kalambukattu et al., 2013; Sheng et al., 2015). In an agricultural system, it is expected to have higher fluxes in CO_2 from soil following tillage events. Increased aeration and mixing from tillage give microbial communities more access to labile pools as well as increasing the temperature, accelerating decomposition of carbon sources.

The less active recalcitrant pool has slower decomposition and takes longer to reflect changes from management (Quincke et al., 2007). It is composed of organic materials and molecules that are more stable and resistant to decay (Dynarski et al., 2020). Microbial populations will often first degrade less recalcitrant forms of organic compounds, altering the balance of labile and recalcitrant portions (Sollins et al., 1996) .

There are shifting mindsets on the classical views held on organic matter and organic carbon fractionation. A meta-analysis identified twenty different methods to isolate certain pools of organic carbon considering physical associations to soil particles/aggregates/colloids, chemical extractants, and spectroscopic methods (Poeplau et al., 2018). The shift includes new insights in decomposition rates, microbial communities, and ecosystem components such as soil mineral fractions (Lehmann and Kleber, 2015). The sizes of substances, ecosystem feedback, biomass input, and management influence the proportion and production of soil organic matter and soil organic carbon. Inherent soil factors such as texture, minerology, and structure determine how carbon is associated and held on particle fractions and colloidal surfaces (Poeplau et al., 2018).

Amounts of carbon (C) within soil are often reported as concentrations (e.g., g C kg^{-1} soil) or percentages, while this is indicative of the amount of carbon in the soil, it may underrepresent the amount of carbon stored in the soil mass (Ellert and Bettany, 1995). Soil carbon is influenced by the mass, area, and volume of soil components, much of carbon storage is a function of soil thickness and bulk density. The measurement of carbon concentration per unit area (e.g., kg m^{-2}) is the soil carbon stock. Soil carbon stocks recognize the concentration of carbon relative to the physical mass of soil (Ellert and Bettany, 1995). Two identical soils may have the same carbon centration, one soil experiences a tillage event and shift in bulk density and horizon depth, resulting in differing carbon stocks between the two soils. Although the concentration of carbon has not changed, the amount of soil mass per area has. Therefore, when comparing management effects on soil carbon storage, it is valuable to not only compare carbon concentrations, but the stocks of carbon as well (Ellert and Bettany, 1995).

1.2.2.2 Soil Inorganic Carbon

In South Dakota, much of the soil is derived from carbonaceous parent material and has inherently formed inorganic carbon (IC) pedogenically (Malo et al., 2010). Inorganic carbon sources in the region are often calcium secondary carbonates ($CaCO_3$) (Malo et al., 2010). Inorganic carbon stocks are higher below the soil surface horizons, as they are a subsoil feature. Inorganic carbon can contribute to carbon sequestration deeper in the soil (Yu et al., 2020), but in general has less sequestration potential compared to organic carbon in upper soil depths (Lal, 2004).

Secondary carbonates form when soils undergo calcification, a process controlled by precipitation, temperature, pH, and air (Schaetzl and Anderson, 2005). Calcification occurs when sources of calcium carbonate exist and there are inadequate amounts of water to flush the calcium through the soil profile (Schaetzl and Anderson, 2005). The formation of secondary carbonates is derived from *in situ* dissolution and reprecipitation of calcium ions, controlled by capillary action from a wetting front such as groundwater or precipitation (Schaetzl and Anderson, 2005). Calcium carbonate reacts with carbonic acid that has formed from water and CO_2, rendering it mobile within the soil. Dry conditions cause the carbonates to precipitate and form secondary carbonates. The following reaction describe the process of carbonation (Schaetzl and Anderson, 2005):

$$CaCO_3 + H_2CO_3 \leftrightarrow Ca^{2+} + 2HCO_{-3}$$

The dissolution and precipitation of calcium carbonate forms pedogenic features such as visible and secondary carbonates. Many of the soils in the region have “Bk” horizon, indicating an accumulation of secondary carbonates (Malo et al., 2010). Over time, when carbonates accumulate to substantial amounts, the formation of “calcic” horizons occurs. Eastern South Dakota lies on the eastern edge of carbonate and calcic horizon distribution, many of the regional soils display these pedogenic features (Schaetzl and Anderson, 2005).

1.2.2.3 Soil Carbon Distribution

Tillage physically mixes organic matter in soil, increasing temperature, decreases moisture, as well as disrupts the soil structure. A tilled soil will display more evaporation in the surface and increased fluctuations in wetting, drying, and temperature cycles. Minimal forms of tillage have shown to hold more water in the surface from reduced evaporation and temperature from the surface not broken and mixed to the same extent as conventional tillage (Balesdent et al., 2000). Prolonged tillage incorporates the soil subsurface, which is much lower in organic carbon, when mixed with the topsoil it can dilute the soil carbon distribution throughout the soil (Gregorich et al., 1998).

Soil organic matter and associated organic carbon can be redistributed horizontally across a landscape through erosion and deposition, so there is large spatial variability that is management induced. The low density and high surface concentration of organic matter makes it susceptible to erosional movement. Lateral movement in organic matter decreases soil horizon thickness and contributes to losses from carbon stocks on erosional areas. The opposite of which is seen in depositional areas (Gregorich et al., 1998; Lal, 2005; Liu et al., 2013; Conforti et al., 2013; Li et al., 2017). Organic carbon distribution varies among upper, middle, and low hillslope positions vertically and horizontally. The lowest organic carbon is found in mid-slope positions where soil loss from erosion is greatest. Larger carbon stocks are in high positions with minimal erosion and more leaching of dissolved organics, as well as low landscape positions with deposition and accumulation of redistributed carbon-rich soil. (Olson et al., 2014; Li et al., 2017).

Copious amounts of soil organic carbon are distributed vertically through the soil profile as colloidal fractions, dissolved carbon, and particulate forms (Kaiser and Kalbitz, 2012; Chirinda et al., 2014). Bioturbation (soil mixing) from micro and macro-organisms as well as roots can redistribute and mix carbon. Tillage induced movement and turnover can cause burial of organic carbon rich soil, causing higher amounts of organic carbon held within the subsurface (Chirinda et al., 2014; Veenstra and Burras, 2015). Subsoil carbon is more stabilized and recalcitrant compared to the more dynamic and labile carbon held in the surface, subsoil carbon can serve as a large sink for organic carbon (Chirinda et al., 2014; Yu et al., 2020).

1.2.2.4 Status of Soil Carbon

Soil carbon varies with depth, soil type, climate, and anthropogenic alterations on the landscape, which have been dramatically altered within the past century (Lal, 2010). The spatial and temporal scale of soil carbon distribution has impeded the uniform quantification and status of the global soil carbon resources (FAO and ITPS, 2015). Evaluations of soil carbon stocks have yielded different results for decades; as different methods of measurement, technology, and held assumptions differ among scientists.

Global studies of cultivation impact on carbon storage have shown soil organic carbon decreases dramatically after the initial years of cultivation from its native state (Lal, 2004, 2010). The first five years see large shifts in the soil surface, followed by years of gradual loss after the five-year period (Liu et al., 2006). United States cropland has lost significant amounts of soil organic matter and subsequently lost soil organic carbon from our agricultural lands. By 1999, it was estimated to be ~5 billion metric tons of carbon lost (Lal et al., 1999). The large amount of organic carbon that has been lost and redistributed has affected carbon pools and ecosystems. Soil carbon that has been oxidized has contributed to greenhouse gas emissions and eroded soil organic carbon is redistributed across the landscape and can eventually be transferred out of the field to aquatic ecosystems (Lal et al., 1999; Lal, 2004).

Much research has been done to link long-term cultivation impacts on soil carbon declines. In Iowa, soil organic matter losses have ranged from 30-60 percent from the baseline level prior to cultivation (Fenton et al., 2005). Another Iowa study found significant differences in carbon vertically through the whole soil profile across a 50-year period in resampled agricultural soils (Veenstra and Burras, 2015). Soil organic carbon decreased in soil horizons in the upper 50cm and an overall increase in depths below 50cm. The changes were from physical mixing through tillage, higher decomposition, shorter crop rotations with lower carbon:nitrogen ratio crops, warmer temperatures, installation of tile drainage increasing soil aeration, as well as translocation and dissolution of soil organic matter from processes such as erosion and deposition (Veenstra and Burras, 2015).

The Midwest has experienced significant decreases in soil organic carbon percentages and subsequent stocks, with much of the loss occurring in Mollisols (grassland soils high in organic carbon) (Kimble et al., 2001; Follett et al., 2009; Veenstra and Burras, 2015). The mean loss in organic carbon concentration seen from surface horizons has ranged between 19-51% (Kimble et al., 2001). Some losses of organic carbon in regional Mollisols could be significant enough to reclassify pedons across multiple systems of taxonomic classification (Kimble et al., 2001; Veenstra and Burras, 2012).

A South Dakota study assessing 75-year changes in cultivated and uncultivated soils showed a 15 to 30% reduction in organic carbon in cultivated lands (Malo et al., 2005). Sources of inorganic carbon sources increased in cultivated sites, particularly in the 15 to 50cm depth. Increases in inorganic carbon in cultivated lands in the region have been documented in numerous studies, due to increased erosion and incorporation of calcareous subsoil from tillage (De Alba et al., 2004; Papiernik et al., 2005, 2007). Uncultivated soils in the region have more organic carbon, less erosion loss, less compaction, more microbial activity, as well as stronger weathering and deeper leaching of carbonates compared to cultivated sites (Malo et al., 2005).

Agricultural lands in eastern South Dakota have lost soil carbon due to cultivation of native grass systems and a changing climate (Malo et al., 2005; Papiernik et al., 2007; Wilkinson and McElroy, 2007; Bajard et al., 2016; O’Brien et al., 2020). A converted agricultural land had 18% less soil organic carbon when compared to a reference historically uncultivated site in Moody County, South Dakota (Olson et al., 2014). Agricultural soils of the region could continue losing carbon at a fast rate, from continued land use conversion, cultivation, and shifting climatic factors such as increasing temperature and precipitation (Olson et al., 2014).

Evidence from recent decades has shown that rates of soil carbon loss can level out and potentially increase under certain agronomic settings (McLauchlan, 2006; West et al., 2008; David et al., 2009; Tian et al., 2012; Clay et al., 2012). Attributed to increases in conservation management such as reduced tillage and grazing intensity (West et al., 2008; Clay et al., 2012). Increased yields from crop hybrids, pest management, and fertilizer use can increase biomass input within the system (Clay et al., 2012). Increases in atmospheric CO_2, allowing more photosynthetically fixed carbon to enter the soil (Van Groenigen et al., 2006; Tian et al., 2012; Lal, 2018). Legacy data of previous soil conditions can provide the opportunity to explore the potential of agricultural soil becoming carbon sinks.

1.2.3 Soil Degradation and Conservation in South Dakota

1.2.3.1 Industrial Revolution and Dust Bowl Era

Soils of the United States and South Dakota alone have undergone significant physical degradation from losses of soil and compaction, as well as chemical degradation from loss of nutrients, organic matter, organic carbon, and agricultural runoff of pollutants (Baumhardt et al., 2015; O’Brien et al., 2020). Much of the degradation has occurred since the dawn of the Industrial Revolution and rapid mechanization of agriculture (Montgomery, 2007; Baumhardt et al., 2015). Shifts to agricultural land use, changes in cropping practices, as well as a changing climate have altered ecosystem services such as nutrient, water, air, and carbon cycling of soil resources in the region (O'Brien et al., 2020).

At the turn of the 20^{th} century, settlers made their way to the Great Plains driven by cheap and fertile lands. Establishment of farming operations was incentivized by the Homestead Acts, increased regional rainfall, and spiked commodity prices from World War 1. Which led to a rapid increase in land conversion to meet national and global demands (Lee and Gill, 2015). Farm technologies and mechanized equipment, such as tractors and new plowing equipment, sped up land conversion and increased cropland production at an unprecedented rate. The use of tractors reduced the input cost from manual labor and allowed more land to be worked in shorter time (Lee and Gill, 2015). Large-scale farming rapidly increased in the 1910s-20s, giving little time for farms to learn and implement management practices that would otherwise preserve topsoil health.

The infamous Dust Bowl occurred around 1930, when continuous plowing of fields and stripping the ground of well-rooted vegetation was paired with severe drought (Hansen et al., 2004; Clay et al., 2014). The removal of native grass cover mixed with tillage altered soil structure and rapidly decreased soil organic matter, which decreased soil moisture and increased the erodibility of soil (Lee and Gill, 2015). Massive dust storms plagued the region, blowing away an average 480 tons a^{-1} of once fertile topsoil. The storms carried sediments from the Great Plains across the entire United States (Hansen et al., 2004). The drought, high winds, and loss of fertile topsoil affected the Great Plains through the reduction of soil productivity and lowering of land values, which created many social and economic issues for farms of South Dakota (Lee and Gill, 2015).

The Dust Bowl sparked increased knowledge and awareness of the importance of soil management.

The United States government acknowledged this issue and decided to intervene. As part of the New Deal in 1933, the United States Department of Agriculture granted five million dollars dedicated towards erosion prevention and control. This influenced the creation of the Soil Erosion Service (SES) (now USDA-NRCS), which began nationwide efforts to conserve soil on working lands. A new focus was created on soil erosion projects that collaborated with the landowners to provide aid, equipment, and labor from programs such as Civilian Conservation Corps (CCC) and Works Project Administration (Helms, 1991). These efforts spread rapidly in the wake of the social, economic, and ecological issues that continued to haunt the region.

1.2.3.2 Post Dust Bowl Era

After the Dust Bowl, the Great Plains began to rebound from above average rainfall, rising crop prices, and new land management practices. In 1935 the Soil Erosion Service became a federal agency and became the Soil Conservation Service (SCS). The Soil Conservation Service brought an expansion of services, demonstrations, and conservation projects to a nationwide scale. State subdivisions were formed to provide work and assistance on localized regions, creating ~2,700 Soil Conservation Service field offices ~3,000 conservation districts across the country (Helms, 1991, 2006). Today, the Soil Conservation Service is known as the Natural Resource Conservation Service (USDA-NRCS), which continues to aid landowners with assistance and incentives that facilitate much of the conservation on private lands.

Since the 1930s, there have been political actions towards soil conservation in the region. The Great Plains Conservation Program passed in 1957, providing USDA cost-share assistance for landowners to adopt conservation practices. Through the 1970s, the National Environmental Policy Act, Clean Water Act, and the Soil and Water Resources Conservation Act brought more facilitation and interest in conservation (Helms, 1985, 2006). In 1985, the Food Security Act included the Farm Bill, which included many provisions and goals for soil and water conservation. The Farm Bill is still active today and continues funding for agricultural conservation. Research on conservation practices and increasing compliance with landowners has brought progress on reducing rates of soil erosion and degradation, as well as continuing the creation of programs and financial incentives from government sources (Helms, 2006).

Through the mid-twentieth century, there were many advancements in soil science regarding the standardization of sampling, field, and laboratory methods in the United States (Brevik et al., 2015). Soil mapping efforts became widespread along with extending the interpretation of different land uses beyond agriculture (Hudson, 1999; Brevik et al., 2015). Soil surveying led to the creation of US soil taxonomy, which has become one of the most widely used classification systems in the world. Standard methods such as Munsell color, structure descriptions, as well as protocols for laboratory analysis and field collection of soil survey data were also established (Hudson, 1999; Brevik et al., 2015). Prior to the data standardization, many USDA labs across the United States had scattered data that utilized varying methods (Nettleton and Lynn, 2008). Given the recent concepts and standardization of soil science information and data, there are very few datasets that exist from the pre-1930s era.

Today, South Dakota remains a dominant agricultural state, much of the economy relies on agricultural goods and services. Agriculture and forestry related industries contributed $11.7 billion in revenue and close to 130,000 jobs for South Dakota (Decision Innovation Solutions, 2021). Many working lands in South Dakota face forms of degradation to this day. Improved soil health can enhance soil productivity, restore once degraded lands, and reduce soil loss. To continue production on cropped lands, more emphasis, research, and education should be placed upon the application of conservation agricultural practices (Clay et al., 2014).

1.2.3.3 Soil Conservation Management

Various management alternatives exist to improve soil health and encourage the shift to conservation agriculture. Conservation agriculture is a system that encompasses multiple land management techniques that preserve soil health and prevent degradation (Gonzalez-Sanchez et al., 2015). Core practices include minimizing or eliminating soil disturbance (e.g., tillage) (Anderson, 2015), increasing ground cover through cover crops and residues (De Baets et al., 2011; Gyssels et al., 2016), and diversifying crop rotations (Feng et al., 2021). Social and economic alternatives include enrolling producers in federal and state programs, as well as increasing education regarding conservation and research. These practices are most impactful when implemented with each other, however, committing to at least one of the practices will reduce soil degradation over the long-term. Soil properties have slow feedback and require years to reflect positive impacts of conservation practices on yield and profitability (Al-Kaisi and Lowery, 2017). There is no “one size fits all” approach, the impact of conservation practices varies with environmental, climatic, and social context.

Conservation tillage systems reduce soil disturbance by retention of crop residues and involves the reduction or elimination of tillage (i.e., no-till) (Busari et al., 2015). Reduced disturbance and increased residue enhance biological activity, increases soil organic matter, reduces erosion, and improves movement and retention of air and water within the soil through reduction of evaporation. Conservation tillage, especially no-till, works well in the drier South Dakota climate due to increased moisture retention (Anderson, 2015). Approximately 82% of South Dakota cropland is under a form of conservation tillage, ~52% of which is no-till managed (Obembe et al., 2023).

Producers can plant cover crops between crop cycles to keep continuous living roots growing within the soil. Cover crops reduce erosion and increase soil organic matter through limiting bare soil exposure, improving aggregation, increasing water infiltration, and reducing surface runoff (De Baets et al., 2011; Gyssels et al., 2016). Cover crops are not well adopted in South Dakota, with ~1.5% total cropland in participation (Wang et al., 2020). Cover crops may not work as well in drier portions of the state due to moisture limitations; water utilization by cover crops restricts moisture for the incoming cash crop if the cover crop is not terminated on time. Cover crops can also increase input cost through seeds and labor, which can impede small-scale operations (Wang et al., 2020; Obembe et al., 2023).

Another management alternative is diversifying cropping systems through crop rotations, which have been successful in South Dakota. Rotations can increase natural fertility and reduce the dependency on synthetic fertilizers, which decreases the input costs associated with them (Feng et al., 2021). Incorporation of nitrogen fixing crops such as alfalfa (*Medicago sativa*) and clover (*Trifolium*), as well as other crops like peas

(*Pisum sativum*), oats (*Avena sativa*), and winter or spring wheat (*Triticum aestivum L.*), are introduced into traditional corn-soy rotations. Diversifying rotations can be difficult, due to higher demands and subsidies for main cash crops. It is hard for producers to risk an economic loss from growing a less profitable or nonmarketable crop. Crop rotations are beneficial to producers who can afford to grow alternatives to corn or soybeans.

1.3 Conclusion

Decades of agricultural production have impacted soils across the world, United States, and South Dakota. Anthropogenic forces have impacted land resources and have become a major factor in soil functioning and processes (Richter, 2007, 2020; Richter and Yaalon, 2012; Kuzyakov and Zamanian, 2019). Agricultural lands are eroding, and soil profiles are being truncated at unsustainable rates. Erosion has occurred on landscapes faster than erosion rates under natural landscape settings, as well as outpacing the rate of soil development and production processes (Wilkinson and McElroy, 2007; Montgomery, 2007; Bajard et al., 2016; Vanwalleghem et al., 2017; Jelinski et al., 2019; Richter, 2020; Thaler et al., 2021, 2022). The global carbon cycle has been altered by changing biogeochemical processes in the soil interface (Lal, 2004). Soils have lost organic matter and subsequently undergone changes in carbon pools through management such as tillage, cropping practices, land use changes, as well as a changing climate (Gregorich et al., 1998; Fenton et al., 2005; Malo et al., 2005; Lal, 2010; Olson et al., 2014; Veenstra and Burras, 2015; Bajard et al., 2016; O'Brien et al., 2020). Conservation of soil resources through alternative management practices can reduce the rates of erosion, as well as begin to accumulate and protect stocks of soil carbon.

South Dakota has a legacy of agricultural production and soil degradation. The communities and economy of South Dakota rely on soil productivity to continue current and future production of agricultural goods and services. To encourage the further reduction of soil degradation, a combination of land management alternatives and mindset shifts must occur. Conservation agents, researchers, and producers should continue to work towards bridging knowledge gaps and creating social networks through outreach and educational resources. With a shared goal of improving attitudes held towards conservation and shifting management practices. Soil conservation takes effort, thought, and economic considerations that can be a burden for producers. A continuation of providing the tools, knowledge, and research will continue to work towards the goal of reducing soil degradation in South Dakota.

Chapter 2. Century-Long Quantification of Soil Loss in Eastern South Dakota Agricultural Fields

2.1 Abstract

Soil loss remains a barrier to long term sustainable agro-ecosystems. It is difficult to accurately quantify soil loss over multidecade time periods due to a lack of useful legacy data. Utilizing thirteen previously unseen soil survey descriptions of agricultural soils from the 1920's and 1950's in eastern South Dakota, we quantify soil loss over the last century. Although the descriptions are missing nomenclature, they include marker features such as horizon depths, depth to carbonates, texture class, and depth to parent material. By revisiting and resampling the original locations, modern soil descriptions were utilized to assess the approximate 100-year changes in soil horizon thickness and morphological differences to quantify the amount of soil lost over the period. Changes in depth to carbonates, horizon depths and boundaries, texture changes and contrast, and depth to parent material were used to quantify the range in soil loss and potential mixing of subsurface and surface soil horizons. The average amount of soil lost was 18.0cm (1926 to 2023) and 14.9cm (1955 to 2023). The annual historical rates and masses of soil loss were between 1.9-2.2mm yr^{-1} and 26.0-30.6Mg ha yr^{-1}, which is comparable to regional studies that utilized shorter timescales. This study highlights the utility of legacy soil datasets as well as the importance of tracking long-term anthropogenic impacts for pedological modeling.

2.2 Introduction

Human influences have accelerated soil erosion rates that exceed soil development, particularly in agricultural landscapes (Wilkinson and McElroy, 2007; Montgomery, 2007; Bajard et al., 2016; Vanwalleghem et al., 2017; Richter, 2020). Often, accelerated soil erosion rates on cultivated lands are higher than background rates seen by natural pedogenic or geologic erosion processes (Wilkinson and McElroy, 2007; Montgomery, 2007; FAO and ITPS, 2015; Bajard et al., 2016). A substantial portion of agricultural lands across the world have historically suffered from generations of erosion, threatening the communities and populations that depend on the productivity of its soil resources (Pimentel, 2006; Adhikari and Nadella, 2011; Vanwalleghem et al., 2017). The socioeconomic cost and burden through the loss of once fertile farmland can be severe, loss of soil productivity, quality, and fertility can cost billions of dollars (Pimentel, 2006; Panagos et al., 2018). In the Midwest alone, the loss of surface soil horizons has led to potential losses of $0.9 to $2.8 billion, which has directly impacted producers and consumers in the region (Thaler et al., 2021).

Ecosystem functioning is dramatically altered with the forces of erosion (Larson et al., 1983; Fenton et al., 2005; Vanwalleghem et al., 2017; Panagos et al., 2018). Soil erosion alters the physical, chemical, and biological properties of soil, which harms productivity and hinders crop production or fulfillment of ecosystem services (Fenton et al., 2005; Montgomery, 2007; Vanwalleghem et al., 2017). Erosion proves is a major threat to sustainable food production and resilience for future generations. A positive and sustainable plant-soil feedback is critical as we face the growing demand for crop production (Sposito, 2013).

Quantifying the amount and scale of erosion can be difficult due to environmental, management, data variability, and measurement factors (García-Ruiz et al., 2015). Variability and uncertainty between datasets are a result of differing timelines and experimental design. Studies regarding erosion rates are often on a short-term basis (e.g., for three years or less) in controlled plots, there is a large need to track erosion rates for longer periods to quantify long-term losses (García-Ruiz et al., 2015). A lack of historical data has been a barrier to tracking temporal changes in soil properties, including historical erosion rates and its impacts on the soil profile (Vanwalleghem et al., 2017).

Agricultural management not only impacts the soil surface but also the entire soil profile. Many studies address upper soil depths as they are more dynamic and susceptible to change, rarely addressing the subsoil characteristics (Veenstra and Burras, 2015). Long-term erosion truncates the soil profile and alters soil horizon depths, textures, rock fragments, as well as decreases productivity (Vanwalleghem et al., 2017). The lack of emphasis on viewing the whole soil profile pedologically is a barrier to understanding the scope of anthropogenic-induced pedological and ecological changes (Richter and Yaalon, 2012; Veenstra and Burras, 2015).

Topsoil is thinning and soil profiles are being truncated from erosion exceeding soil formation (Pimentel, 2006; Montgomery, 2007; Nearing et al., 2017; Thaler et al., 2021). Global erosion rates on conventional croplands are estimated to be an average of 3.94mm yr^{-1} with a median of 1.54mm yr^{-1}, compared to 0.01-0.02mm yr^{-1} seen under what are considered natural geological erosion losses. Agricultural erosion rates often exceed the average soil production rate of 0.06-0.08mm yr^{-1}, in result, soil erosion is occurring at unsustainable rates (Montgomery, 2007). In recent decades, soil erosion on United States cropland has been reduced due to extensive adoption of conservation practices as well as enrollment in conservation programs (USDA-NRCS, 2017; Nearing et al., 2017). According to the USDA Natural Resource Inventory (NRI), by 2017, the United States had an estimated ~35% (7.12 to 4.63 tons a^{-1} yr^{-1} or 15.96 to 10.37Mg ha^{-1} yr^{-1}) reduction in erosion rates from 1982 to 2017. In South Dakota, the soil erosion rates had an estimated reduction of ~64% (5.59 to 2.00 tons a^{-1} yr^{-1} or 12.53 to 4.48Mg ha^{-1} yr^{-1}) from 1982-2017 (USDA-NRCS, 2017). The NRI estimates only accounts for wind and water erosion, and does not consider tillage erosion, which could be attributing to substantial amounts of soil movement on cropped landscapes (Schumacher et al., 1999).

The Midwest region has been dominantly agricultural since the rapid Euro-American settlement and industrialization of agriculture. Studies have estimated erosion rates for the region, recent estimates varied between 0.2 to 4.3mm yr^{-1} (Thaler et al., 2022). A study in Minnesota found erosion rates of cropped land were an average of 3.09mm yr^{-1} compared to the 0.047mm yr^{-1} found in the adjacent native prairie conditions (Jelinski et al., 2019). Another Minnesota study estimated the masses of soil lost on an erosional landscape ranged from ~46 to >60 Mg ha^{-1} yr^{-1} (Papiernik et al., 2005). Caesium 137 ($137^{\wedge C}$) measurements in South Dakota estimated lower rates of ~12 to 22Mg ha^{-1} yr^{-1} in two separate agricultural landscapes (Li et al., 2007). Soil truncation can occur rapidly, for example, if a topsoil is 30cm thick, an erosion rate of 3mm yr^{-1} could erode the entire topsoil in within 100 years (Vanwalleghem et al., 2017). Given these rates, over a century of production could account for total removal of surface soil horizons.

Long-term erosion truncates the entire soil profile through combining topsoil loss and incorporating of subsoil. As soils erode, they lose topsoil, and the subsoil is incorporated after prolonged cultivation and deep tillage (Indorante et al., 2014). Erosional loss of surface A horizons has led to shallower depths to subsurface B horizons and its associated subsurface features, pushing pedogenic features upward as the soil profile truncates (Phillips et al., 1999; Indorante et al., 2014). The opposite of this truncation occurs in lower landscape positions, where soil material is deposited over original soil surfaces through translocation of soil materials from upper landscape positions (Phillips et al., 1999; Papiernik et al., 2007). Deposition pushes pedogenic features downward to deeper depths.

The incorporation of subsoil into topsoil has negative implications on the productivity of soils (Vanwalleghem et al., 2017). Subsoil is usually denser, has higher clay contents, lower in available nutrients, and has decreased organic matter when compared to surface soil. When subsoil is closer to the rooting depth, it will affect plant growth, water holding capacity, infiltration, among other physical, chemical, and biological properties. Incorporation of subsoil in erosional environments and pushing nutrient rich topsoil to lower environments alters landscapes over time and affects land management (De Alba et al., 2004; Papiernik et al., 2005, 2007, 2009; Indorante et al., 2014; Vanwalleghem et al., 2017). Erosional and depositional processes are common in the Midwest landscapes, where consistent cultivation is occurring on naturally undulating topographies (Van Oost et al., 2006).

Soil morphology has been used as a benchmark for tracking temporal soil profile changes in numerous studies, many of which have occurred in the Midwest under similar climates and soil parent materials compared to eastern South Dakota. Erosion causes textural changes, erosion impacted soils often have higher clay contents at shallower depths than previously (Olson and Nizeyimana, 1988; Phillips et al., 1999; Arriaga and Lowery, 2003; Indorante et al., 2014), as well as changes in rock fragment percentages (Veenstra and Burras, 2015). The soil structure changes, as blockier and cloddy structures begin dominating once more granular structure as erosion increases and exposes more subsoil (Kimble et al., 2001; Meijer et al., 2013; Veenstra and Burras, 2015). Soil color, redoximorphic features, as well as movement of soil carbon have also been benchmarks for assessing profile change (Veenstra and Burras, 2015).

Studies of erosional landscapes formed in calcareous parent materials (e.g., till and loess) have reported shallower depths to parent material (C horizon), calcic horizons (Bk horizon; pedogenic carbonate accumulation), and subsequently higher amounts of inorganic carbon in the topsoil from the incorporation and shifting upward of calcareous material from the Bk horizon (Papiernik et al., 2007). Soil carbonates shifting upward in the soil profile are correlated with increasing rates of erosion, the average depth to Bk horizon on erosional landscapes was ~50cm, compared to ~80cm in uncultivated soils in west-central Minnesota (Papiernik et al., 2005, 2007). The processes associated with profile truncation and shifting of carbonate materials are described in detail in (De Alba et al., 2004).

Erosion and subsequent truncation of soils in the region not only affect productivity (Vanwalleghem et al., 2017), but also change the classification of these soils in multiple systems and scales (Veenstra and Burras, 2012). The movement and loss of topsoil as well as changes to pedogenic features can change taxonomic classifications of soils from the previous classifications. Not only does this affect mapping efforts, but also management and land use interpretations (Mokma et al., 1996; De Alba et al., 2004; Veenstra and Burras, 2012). To understand how agricultural soils have changed within the past century relies on legacy data of past soil conditions, which is often a limitation for many studies.

Given the extensive work done on soil erosion and conservation within the Midwest, there have been few studies addressing historical erosional losses in South Dakota. In general, there are limited studies that address decades of erosion and overall changes to soil properties (Richter and Yaalon, 2012; García-Ruiz et al., 2015; Veenstra and Burras, 2015). The goal of this project is to fill a regional knowledge gap regarding historical erosion losses by utilizing legacy soil information. A century of agricultural production has likely caused significant losses and truncation of soil profiles in South Dakota.

Soil survey descriptions were conducted on eastern South Dakota agricultural fields in 1926. Along with the 1926 descriptions, soil survey descriptions from 1955 were also conducted in the same area (South Dakota Agricultural Heritage Museum, 2023). These sites were resampled, and soils were redescribed to assess the changes in soil morphology to quantify the amount of soil truncation that has occurred from the 1920s and 1950s. The age of these legacy soil descriptions provides a novel opportunity to examine nearly a century of soil morphological changes, as well as increase the historical knowledge of anthropogenic driven losses in soil.

2.3 Methods

2.3.1 Legacy Data

Soil descriptions from 1926 were conducted in Moody County, South Dakota by Dr. Joesph Hutton, a South Dakota State University (then South Dakota State College) professor of agronomy from 1911 to 1939. Hutton took part in initial soil surveying and mapping of eastern South Dakota. These descriptions include information such as horizon depths, texture, as well as depths to carbonates and parent material (South Dakota Agricultural Heritage Museum, 2023). Soil descriptions from 1955 were conducted by USDA-Soil Conservation Service (now Natural Resource Conservation Service) in Moody and Brookings Counties, South Dakota. These descriptions include information such as horizon labels, slope, parent material type, Munsell colors, texture, structure, topsoil depth, and depth to carbonates and parent material (South Dakota Agricultural Heritage Museum, 2023). Both datasets include location information and field notes for determination of the original sampling locations. In total, thirteen fields were revisited and resampled, 142 pedons were redescribed to quantify the loss and transport of soil.

2.3.2 Study Area

Moody and Brookings Counties, South Dakota reside on the Minnesota border on the geographic Coteau des Prairies region (Figure 1 and 2). The area consists of undulating topography composed of early-Wisconsin aged glacial drift and the soil parent materials are glacial deposits such as glacial till, glacial outwash, and silty drift that has been deposited then reworked by meltwater as the glaciers retreated. Many of the soils have silty loess or sandy aeolian deposits as well, particularly in central to southern portions of Moody County (USDA-NRCS, 1989; Malo et al., 2010). Mapped soils of the study areas (Figure 3, Table 2) are classified in US Soil Taxonomy as Mesic/Typic, Udic/Typic/Calcic Haplustolls, Hapludolls, and Argiustolls (Soil Survey Staff, 2024). The area has a mean average precipitation between 500-600mm and mean average air temperature of 7-9°C (Malo et al., 2010). Additional information regarding location coordinates and soil classification information is in the Appendix (Appendix A, Table 14).

Table 2. Mapped soil series of sampling locations (Soil Survey Staff, 2024)

Current Mapped Soil Series	US Soil Taxonomy Classification
Moody	Fine-silty, mixed, superactive, mesic Udic Haplustolls
Vienna	Fine-loamy, mixed, superactive, frigid Calcic Hapludolls
Estelline	Fine-silty over sandy or sandy-skeletal, mixed, superactive, frigid Calcic Hapludolls
Houdek	Fine-loamy, mixed, superactive, mesic Typic Argiustolls
Flandreau	Fine-loamy, mixed, superactive, mesic Udic Haplustolls
Kranzburg	Fine-silty, mixed, superactive, frigid Calcic Hapludolls
Egan	Fine-silty, mixed, superactive, mesic Udic Haplustolls

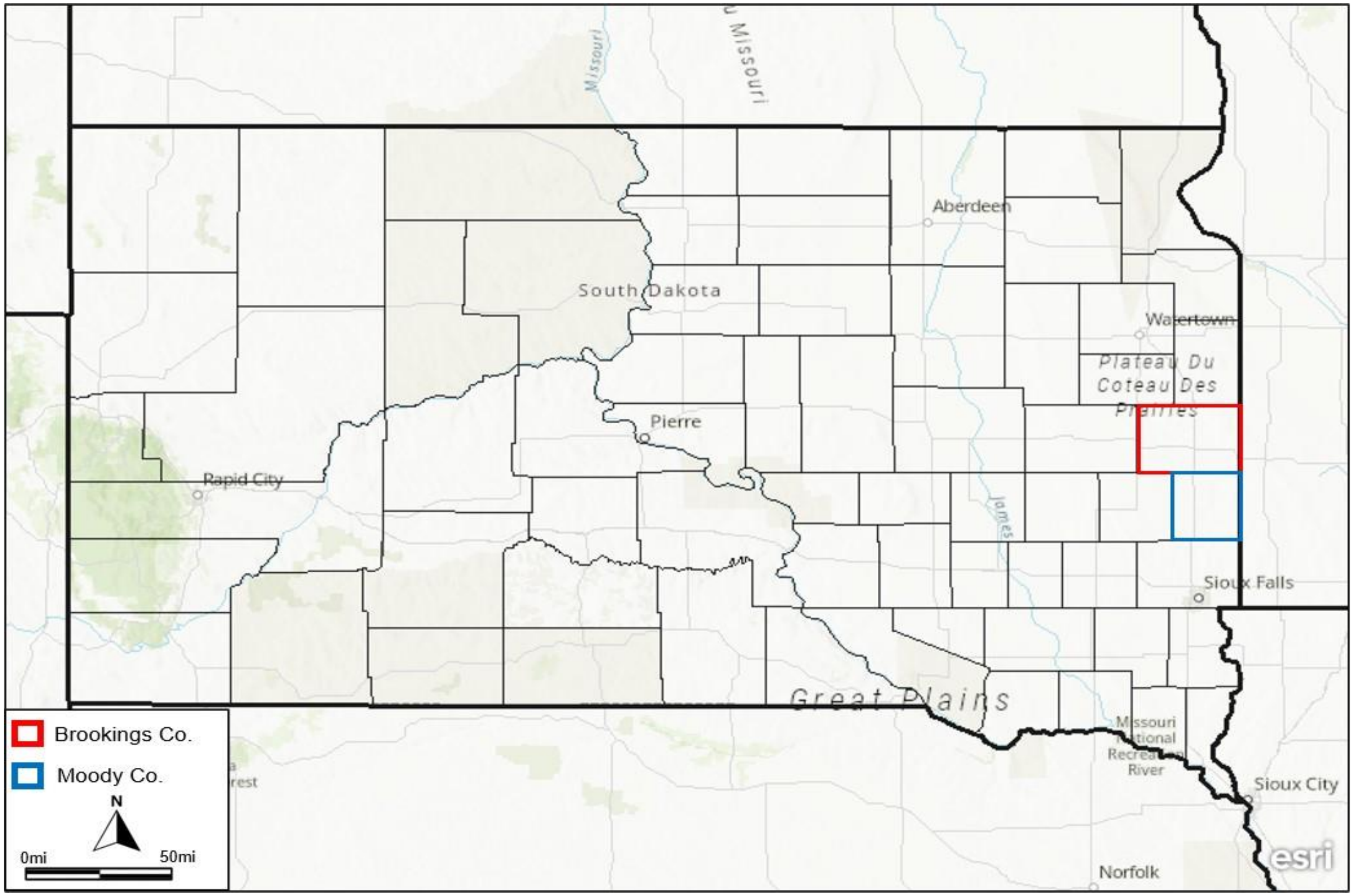

Figure 2. Map of South Dakota with Brookings and Moody Counties (ESRI Inc., 2024). Map source: Esri; U.S. Department of Commerce, Census Bureau; U.S. Department of Commerce (DOC), National Oceanic and Atmospheric Administration (NOAA), National Ocean Service (NOS), National Geodetic Survey (NGS) | Esri, USGS | South Dakota Game Fish and Parks, Esri, TomTom, Garmin, FAO, NOAA, USGS, EPA, NPS, USFWS

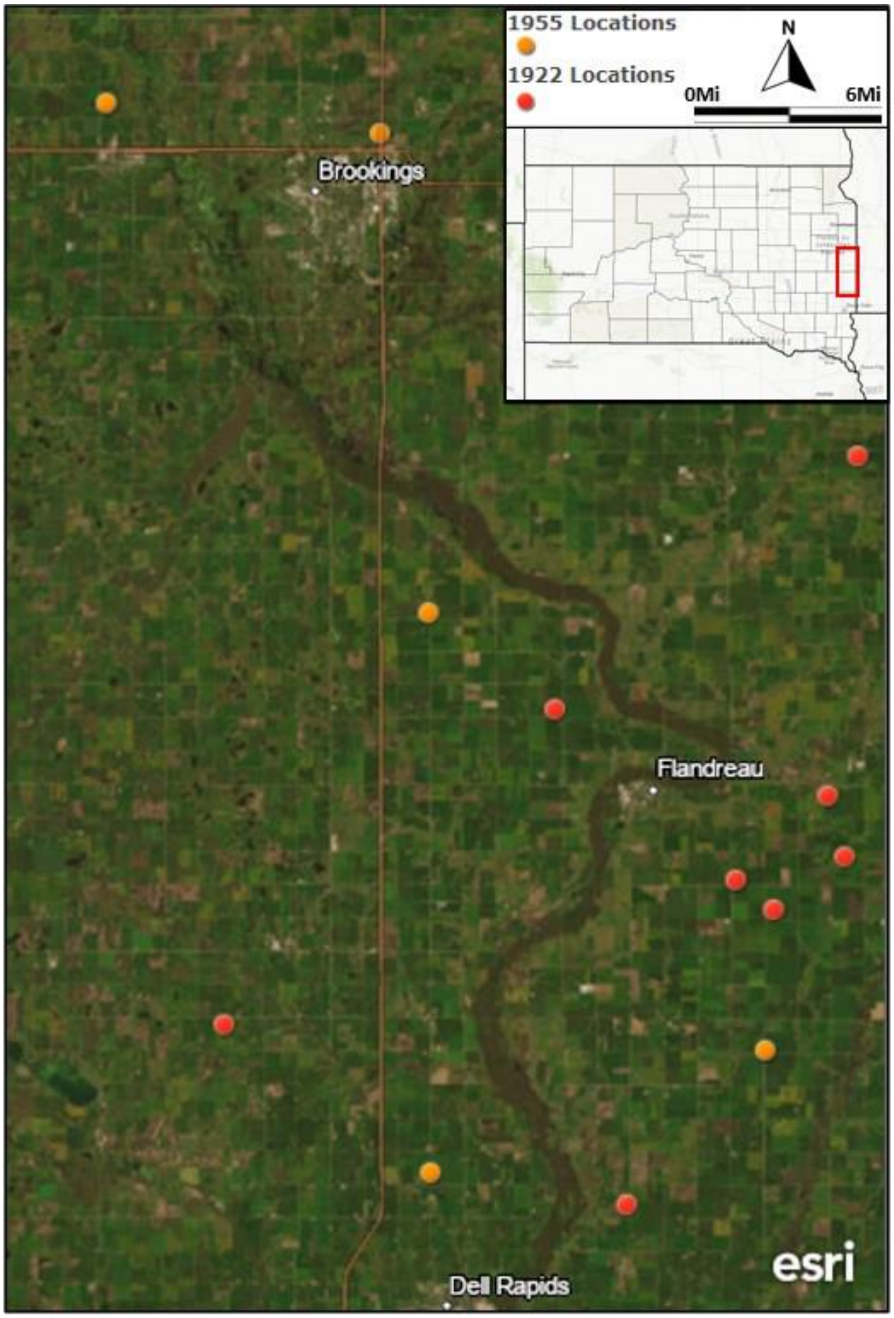

Figure 3. Study area and sampling locations (ESRI Inc., 2024). Map Source: Earthstar Geographics | South Dakota Game Fish and Parks, Esri, TomTom, Garmin, SafeGraph, METI/NASA, USGS, EPA, NPS, USDA, USFWS

2.3.3 Sampling Methods

The locations used in this study (Figure 3) were relocated using Public Land Survey System (PLSS) legal descriptions recorded from the original sampling. Field notes from the descriptions were used to add site specific context to find the original sampling location to the nearest meter. The information provided in the descriptions was interpreted and used to acquire GPS locations for navigation to each location. The relocated sites were sampled in a pattern that reflects a representative sequence across the sampled area (Figure 4). Slopes of the fields did not exceed 4% (Appendix A, Table 11) and most of the soils described in this study were considered well drained. Soil profile samples were collected by extracting 7.5cm diameter soil cores to a depth of ~150cm along the transect, at 0, 75, and 150-meter distances. Smaller 4.5cm diameter cores were collected in 15-meter increments between the large cores to account for variability of soil morphology across the sampling area (Figure 4). A total of eleven soil cores were extracted per site. The sampling was completed using a truck mounted hydraulic soil sampling probe and profiles were transferred out of the field for laboratory description, processing, and analysis.

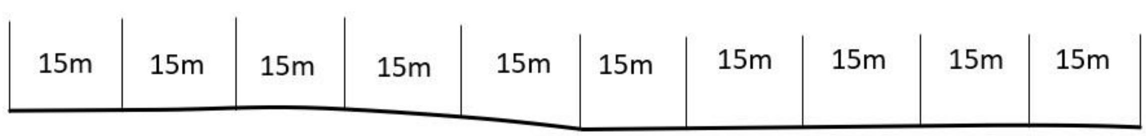

Figure 4. Example of sampling sequence (erosion study)

2.3.4 Laboratory Analyses

Soil morphology was described using current USDA-NRCS soil survey description methods (Schoeneberger et al., 2012). Munsell air-dry and moist colors, redoximorphic features (amount and size), physical states of concentrations of $CaCO_3$

visually assessed (e.g., masses, nodules, etc.), and disseminated carbonates tested with 0.1*M* HCl to assess carbonate effervescence reaction. Soil texture and particle size class of each horizon via hand texturing as well as subsets of textures analyzed utilizing a Pario particle size analysis instrument (METER Group, Inc. USA). Rock fragments and texture modifiers were evaluated using visual and sieving estimates. Soil parent material type and depths in cm as well as type were also noted. Diagnostic features, master horizon labels, horizon suffixes, and modifiers are assigned with current U.S. Soil Taxonomy nomenclature (Schoeneberger et al., 2012).

Bulk densities for fields were collected using the core method (Blake and Hartge, 1986). Samples were taken in the field at depth increments of 0-15cm and 15-30cm, weighed, placed in the oven at 105C° for 24 hours and reweighed for oven-dry weight. The dry weight of each core section is divided by the volume and depth of the sampling tube and reported as a mass of soil/volume reported in g cm $^{-3}$ (Equation 1). Bulk densities were not collected by the previous studies, measured bulk densities from 2023 will be extrapolated for all years.

Equation 1. Soil bulk density

$$\text{mass of dry soil (g) / volume of soil (cm}^{-3}\text{) = soil bulk density (g cm}^{-3}\text{)}$$

2.3.5 Statistical Analysis

Soil horizon top boundaries for depth to carbonates, texture contrast (lithologic discontinuity), as well as depth to parent material are used to quantify soil loss and truncation by shifting of subsurface features and horizons. Soil loss or gain from each pedon is calculated by the differences in depth to subsoil features from the soil surface, compared between the current and old sampling time (Equation 2).

Equation 2. Soil profile change

$$\Delta d_p = \text{present depth to feature (cm)} - \text{original depth to feature (cm)}$$

Δd_p equals the change in depth for a selected soil property (soil loss or gain). A negative number indicates the feature is higher now than it was originally and suggests that material has been lost from the surface and subsoil has shifted upwards through the soil profile. A positive value indicates the feature is lower than before, and that deposition of translocated soil has occurred on top of the original soil surface.

To quantify soil loss using soil morphological changes, the baseline or reference for comparisons must be considered. The reference level utilized in this study was the soil surface, however, the soil surface tends to be unstable through time (Veenstra and Burras, 2015). An alternative method is outlined in (Veenstra and Burras, 2015), where changes in depth to soil property were evaluated with alternative soil features as reference levels (Equation 3). Where Δd_p equals the change in depth for a selected soil property (soil loss or gain), d_{ai} is the initial depth to alternative reference, d_{pi} is the initial depth to property, d_{ac} is the current depth to alternative reference, and d_{pc} is the current depth to selected property (Equation 3). A positive Δd_p value indicates that the elected soil property is deeper than it was during its initial sampling time. A negative value indicates the property is shallower than the initial sampling period (Veenstra and Burras, 2015).

Equation 3. Soil profile change with alternative reference level from (Veenstra and Burras, 2015)

$$\Delta d_p = (d_{ai} - d_{pi}) - (d_{ac} - d_{pc})$$

To compare differing reference levels, an alternative reference approach was adapted in this study. In the legacy data utilized, the bottom of the A horizon (including combinational horizons e.g., AB) provided consistent information between datasets and utilized as an alternative reference (Equation 4). Assessing the bottom of the A horizon relative to the subsoil features gives a snapshot of subsoil movement towards the topsoil.

Equation 4. Alternative reference equation

Δd_p = (initial bottom depth of A horizon - initial depth to subsurface feature) - (current bottom depth of A – current depth to subsurface feature)

Average changes were calculated for each soil profile and site; however, this could result in misrepresentation due to certain landscape positions being naturally more susceptible to erosional losses or depositional gains. In a separate analysis, profiles in sloping landscapes were separated into two categories of depositional and non-depositional based on their landscape position or microrelief on the transect. Depositional areas were considered the concave and micro-low positions and non-depositional areas were convex and micro-high positions. Fields that were level were excluded from categorical splitting.

Erosion rates as masses (Mg ha^{-1} yr^{-1}) were calculated following Equation 5, adapted from (Veenstra, 2010). Where *D*c is current depth to subsurface feature, *D*o is original depth to feature. *BD* is measured bulk density (g cm^{-3}) of the top 30cm averaged for each field and used for both time periods.

Equation 5. Mass of soil loss (Mg ha^{-1} yr^{-1})

$$\text{Soil loss (Mg ha}^{-1}\text{ yr}^{-1}) = \frac{((Dc\text{ (cm)}*BD)) - ((Do\text{ (cm)}*BD)) * 10{,}000\text{ cm}^2/\text{m}^2 * 10{,}000\text{m}^2/\text{ha} * 1\text{ Mg}/10^6\text{g}}{\text{Years since original sampling}}$$

Statistical analysis included a paired T-tests of individual locations using RStudio v4.3.1 statistical software. The significance of $\alpha = 0.05$ was used to test for significant difference in the current depth to feature compared to the original depth to feature. Each field was statistically analyzed separately, as each field has its own unique pedological and management context, despite similarities in proximity and parent materials.

2.4 Results and Discussion

2.4.1 Historical Soil Loss Estimates

Utilizing the depth from the soil surface as a reference level (Equation 2), the average soil loss seen across all sites (142 pedons) was -16.8cm (Table 3). The sites revisited from 1926 (8 fields, 86 pedons) had an average soil loss of -18.0cm, across the 97-year period is an average loss of 1.9mm yr^{-1} (Table 3). The sites revisited from 1955 (5 Fields, 56 pedons) had an average soil loss of -14.9cm, across the 68-year period is an average loss of 2.2mm yr^{-1} (Table 3). Of the 13 sites, 9 showed statistically significant losses, one of the locations was significant $p < 0.05$ and 8 were significant at $p < 0.01$ (Figure 5, Table 3). The revisited 1926 sites had more historical erosional loss, due to a longer period between sampling with the land likely being cultivated each year between. The 1926 sites were also described in the pre-Dust Bowl era, which can account for some of the larger losses and variability seen at the sites.

Utilizing the bottom of the A horizon as an alternative reference value showed varying, yet similar amounts of soil loss compared to using the soil surface (Equation 4, Table 4). The average loss from 1926-present sites was -15.5cm (1.6mm yr^{-1}), which is .27mm yr^{-1} less than the soil surface reference values. The average loss from 1955-present sites was -20.4cm (3.0mm yr^{-1}), which is .8mm yr^{-1} greater than the soil surface reference values. Using the bottom of the A horizon as an alternative reference can have different variability compared to using the soil surface. A horizon deepness over time could be dynamic, as tillage methods (e.g., plow depth) as well as organic carbon losses/gains across the timespan can change the extent of the A horizon bottom boundary.

2.4.2 Site Variability

Wide variability of losses between sites (Figure 5) could be linked to management intensity, cropping practices, and climatic factors, the entire history and context for each field is unique and unknown. The fields differ in management history such as cropping rotations and changing of tillage practices, as well as intensity of site-specific wind/water movement and slope intensities, all contribute to temporal changes in historical erosion intensity (Vanwalleghem et al., 2009, 2017). The 1926 sites had more average losses in compared to the 1955 sites, however, the sites were more variable (Figure 5). Some fields have likely experienced extended tillage redistribution of eroded particles, dust bowl-related blowing, removal, and distribution of eroded sediment from surrounding fields, burying, or removing previous soil surfaces. One of the 1926 sites displayed an average net gain of soil across the toposequence that was sampled, this could be an example of tillage translocation (Van Oost et al., 2006; Li et al., 2007) and soil depositions from adjacent landscapes at the location.

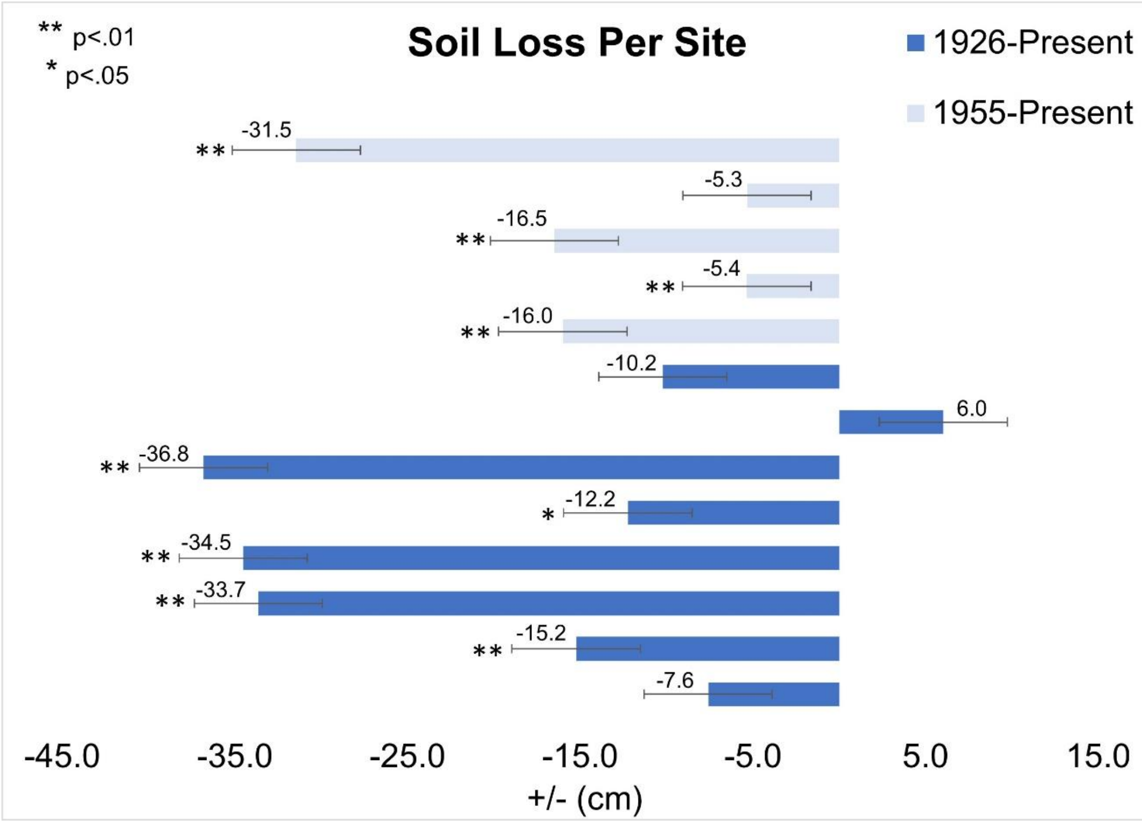

*Figure 5. Soil loss per site. Statistically significant loss per site indicated by *(α=.05) and **(α=0.01)*

*Table 3[1]. Soil loss per site in total cm, mm yr^{-1}, and Mg ha^{-1} yr^{-1}. Statistically significant loss per site indicated by *(α=.05) and **(α=0.01). BD = soil bulk density.*

Site	Avg. Loss (+/- cm)	Avg. Loss (+/- mm yr^{-1})	Avg. BD 0-30cm (g cm^{-3})	Mass of Soil Lost (+/- Mg ha^{-1} yr^{-1})
1926-2	-7.6	-0.8	1.50	-11.7
1926-10	**-15.2****	-1.6	1.31	-20.6
1926-12	**-33.7****	-3.5	1.38	-47.5
1926-13	**-34.5****	-3.6	1.41	-49.8
1926-16	**-12.2***	-1.3	1.45	-18.3
1926-17	**-36.8****	-3.8	1.40	-52.8
1926-18	6.0	0.6	1.22	7.6
1926-19	-10.2	-1.1	1.37	-14.4
1955-2	**-16.0****	-2.4	1.36	-31.6
1955-5	**-5.4****	-0.8	1.57	-12.4
1955-7	**-16.5****	-2.4	1.30	-32.0
1955-8	-5.3	-0.8	1.40	-11.0
1955-9	**-31.5****	-4.6	1.43	-66.2
1926 Avg.	-18.0	-1.9	1.38	-26.0
1955 Avg.	-14.9	-2.2	1.41	-30.6
Overall Avg.	-16.8	-2.00	1.39	-27.7

Table 4. Comparison of reference levels on soil loss estimates

Site	Avg. Loss (+/- cm) Soil Surface Reference	Avg. Loss (+/- cm) Bottom of A Horizon Reference
1926-2	-7.6	-4.3
1926-10	-15.2	-5.4
1926-12	-33.7	-24.6
1926-13	-34.3	-33.8
1926-16	-12.2	-5.2
1926-17	-36.8	-25.7
1926-18	6.0	0.2
1926-19	-10.2	-24.8
1955-2	-16.0	-17.5
1955-5	-5.4	-13.3
1955-7	-16.5	-21.4
1955-8	-5.3	-11.9
1955-9	-31.5	-37.8
1926 Avg.	-18.0	-15.5
1955 Avg.	-14.9	-20.4
Overall Avg.	-16.8	-17.4

[1] Additional information regarding location coordinates and soil classification information is in the Appendix (Appendix A, Table 14).

2.4.3 *Mass of soil loss*

To determine the historical average masses of soil lost per year, the average erosion rate and measured 0-30cm bulk density values (Table 3) are utilized. Given the variability in bulk density through the decades (Dam et al., 2005; Özdemir et al., 2022), the following numbers could be over/underestimates. The annual rate of soil mass lost from the 1926 sites is 26.0Mg ha^{-1} yr^{-1} (11.6ton a^{-1} yr^{-1}) and 30.6Mg ha^{-1} yr^{-1} (13.7ton a^{-1} yr^{-1}) for 1955 sites (Table 3). The 1955 sites were slightly more compacted with higher bulk densities, which could explain the higher mass of soil lost within the period. The average bulk densities for in the top 30cm in the was 1.38g cm^{-3} in the 1926 sites and 1.41g cm^{-3} for the 1955 sites (Table 3). Higher bulk density results in more soil particle mass per area, a higher bulk density soil surface will have less soil aggregation and reduced water infiltration, which will produce larger masses of lost soil (Zhang et al., 2007). The yearly erosion rate and bulk densities have changed throughout the period as the management intensity, equipment, cropping practices, and amount of organic matter are not static (Dam et al., 2005; Vanwalleghem et al., 2009; Özdemir et al., 2022).

2.4.4 Landscape Position Effect on Soil Loss

Due to the micro-topography features and hummocky relief of some of the landscapes, pedons were split between depositional (concave and micro-low) and non-depositional (convex, flat, and micro-high) areas. Level fields without slope (≤1%) were not split (Table 5 “NA”), however, the average loss from level fields were -17.4cm (1926-present) and -10.7cm (1955-present). There was loss seen in both depositional and non-depositional environments on the fields. The average loss was -21.2cm from non-depositional areas (62 pedons) and -7.2cm in depositional areas (16 pedons) (Table 5).

The results indicate that in areas of soil deposition, loss, and further transport of soil particles has still occurred, outpacing the rate of *in-situ* deposition. Of the sampled locations, the average slope did not exceed 4% (Appendix A, Table 11), the losses and deposition could be more dramatic in landscapes with steeper slopes. In these landscapes, much of the soil loss and translocation is derived from tillage movement (Schumacher et al., 1999; De Alba et al., 2004; Li et al., 2007).

Table 5. Soil loss by non-depositional vs. depositional. Level fields with negligible slope were excluded from splitting (NA)[2]

Site	Non-depositional Loss (+/- cm)	Depositional Loss (+/- cm)
1926-2	NA	NA
1926-10	NA	NA
1926-12	-36.1	-27.2
1926-13	NA	NA
1926-16	NA	NA
1926-17	-34.5	-47.2
1926-18	-3.2	47.6
1926-19	-16.1	5.5
1955-2	NA	NA
1955-5	NA	NA
1955-7	-20.5	1.4
1955-8	-5.2	-6.0
1955-9	-32.9	-24.8
1926 Avg.	-22.5	-5.3
1955 Avg.	-19.5	-9.8
Overall Avg.	-21.2	-7.2

[2] Additional information regarding location coordinates and soil classification information is in the Appendix (Appendix A, Table 14).

2.4.5 Depth to Pedogenic Carbonates

The depth to calcium carbonate accumulation is variable with inherent climatic (rainfall) and pedogenic context (texture, drainage, parent material, etc.) (Schaetzl and Anderson, 2005). Carbonates can reflect the climate and soil features of a previous time before rapid western settlement (Jelinski et al., 2019). In erosion effected landscapes, higher depths and incorporation of carbonate bearing subsoil (Bk horizons) has been documented (De Alba et al., 2004; Papiernik et al., 2005, 2007). Of the original locations with visible carbonates, the average original depth to carbonates was 68.7cm, the new average depth in 2023 was 55.6cm, an upward shift of 13.1cm.

It is often rare for pedogenic carbonates to naturally shift upward at this rate, as carbonates are thought to migrate downward with leaching and weathering (Zamanian et al., 2016). Upward migration can occur due to, constant raising wetting front, higher temperatures, and higher CO_2 in the topsoil from organism respiration processes (Zamanian et al., 2016). It is possible that these processes may be occurring in the studied soils, and the rate of carbonate nodule formation is thought to occur on a decade-long basis (Zamanian et al., 2016). The shift upwards of 13.1cm indicates that within the past decade, carbonates in the studied soils are shifting upwards from truncation exceeding carbonate weathering, potentially outpacing what is considered natural pedogenic processes.

2.4.6 Depth of Mollic Colors

Soil color is related to organic matter/organic carbon and dark soil colors (low Munsell value/chroma) are correlated with organic matter accumulation (Konen et al., 2003). In the Midwest and Northern Great Plains, it is common to have deep upper soil layers known as mollic epipedons. The mollic epipedon is the defining characteristic of the Mollisol soil order of US Soil Taxonomy. Mollic colors in the region can often extend past the soil surface into B (e.g., AB, Bw, Bt) horizons as well. To meet mollic epipedon criteria for the Mollisol soil order the color criteria for a mollic epipedon requires a matrix (dominant) soil color of a value ≤3 (moist) or ≤5 (dry) and chroma ≤3 moist. Munsell soil color is a key morphological property utilized to understand soil genesis, organic carbon accumulation, and chemical properties such as redoximorphic features, etc..

A comparison of the change in depth of mollic colors can indicate loss of soil that has outpaced deep organic matter and organic carbon accumulation. The soil descriptions from 1955 contained Munsell soil colors recorded for each horizon. The average maximum depth of mollic colors from the original 1955 descriptions was 46.2cm, in 2023 the average depth is 36.1cm. Through the 68-year period, there has been a ~10cm or 21.8% reduction of the mollic epipedon thickness (Figure 6). Which is comparable to results found in (Kimble et al., 2001). The changes in depth of mollic colors in these soils indicates that erosion has not only outpaced topsoil maintenance, but also organic carbon accumulation (Kimble et al., 2001). Tillage influences organic matter accumulation, it homogenizes and redistributes topsoil, but it can also bury organic matter deeper in the soil (Veenstra and Burras, 2015). Tillage also aerates and heats the soil, altering the oxidation and often increasing decomposition of organic materials (Balesdent et al., 2000; Veenstra and Burras, 2015). Shifts in cropping practices across the period can change rooting depths and biomass accumulation as well.

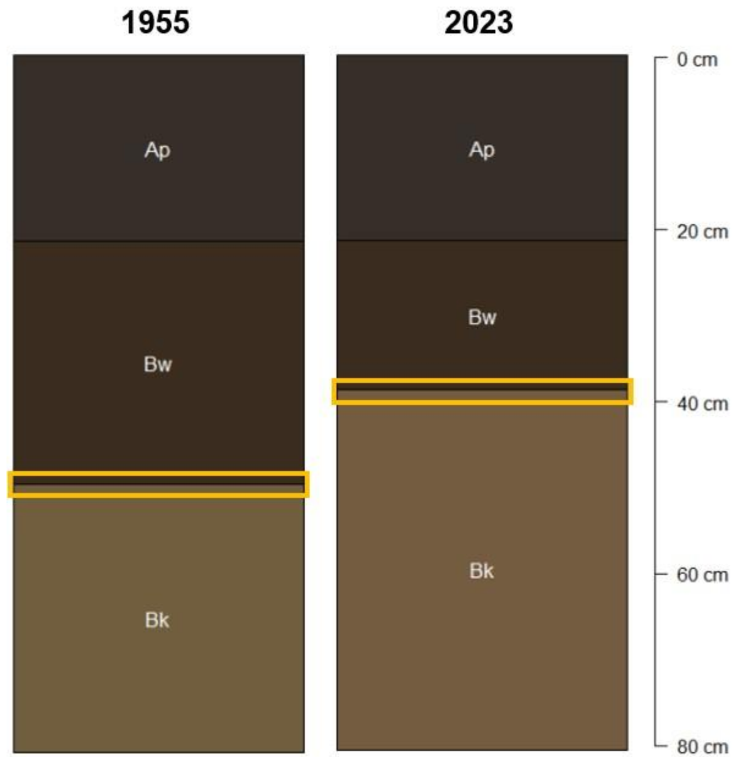

Figure 6. Change in depth of mollic colors 1955 to present

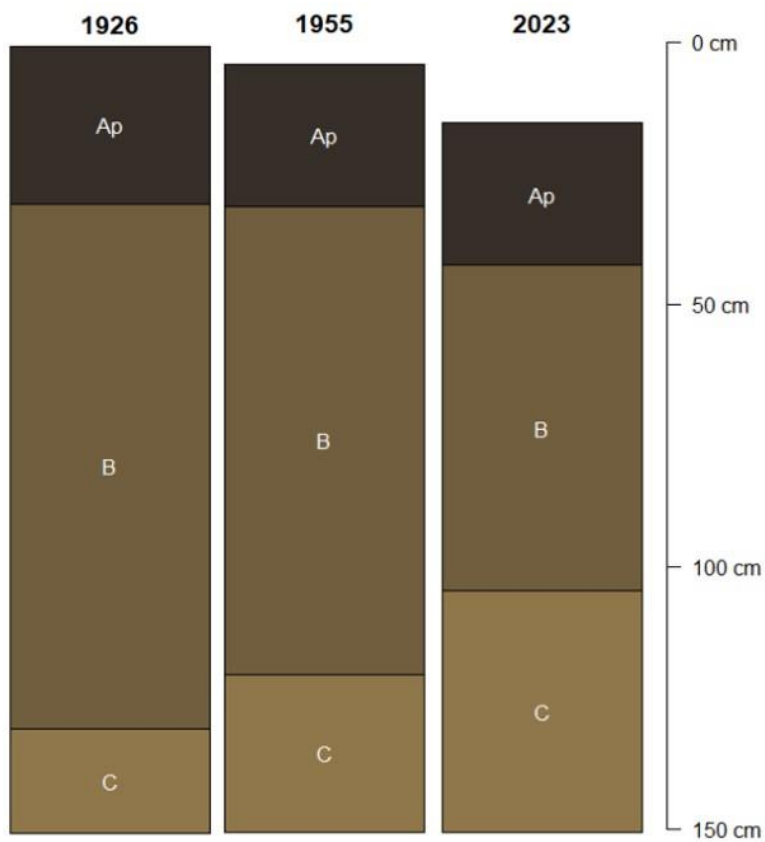

Figure 7. Soil profile truncation

2.5 Summary and Conclusion

Soils in the region have undergone losses, translocations, and overall truncation since the 1920s and 1950s (Figure 7). Depths to subsurface pedogenic features and parent material has changed significantly throughout the century. Based on depths of mollic colors, the soils of this study have lost organic carbon throughout the period as well. The erosion seen in these landscapes is due to water and wind removal paired with tillage translocation. Erosion rate estimates from this study could be overestimates for today's standards, as South Dakota has increased adoption of conservation practices such as no-till and increased crop residue retainment (Clay et al., 2012) which can greatly reduce the rate of erosion (Montgomery, 2007; Nearing et al., 2017). However, the erosion rates and annual masses of soil loss calculated in this study align within other global and regional estimates of croplands (Papiernik et al., 2005; Li et al., 2007; Montgomery, 2007; Veenstra and Burras, 2015; Jelinski et al., 2019; Thaler et al., 2022).

Soils in this study have lost soil in erosional and depositional sites (Table 5). Losses were quite variable across toposequences, and eroded soil may never leave the field. Sediment movement is dynamic across landscapes, eroded particles have been transported and temporarily held across fields, ditches, local waterways, and eventually to larger bodies of water such as lakes and reservoirs (Heathcote et al., 2013; Quine and Van Oost, 2020). Other fields not studied in the region, in particular ones with steeper slopes and more extreme convex landscape positions, have seen greater losses and profile truncations compared to the soils of this study.

Due to the large timespan covered, there may have been both periods of high intensity and low intensity erosion events happening intermittently in each field at various times, which can cause large temporal variability between fields and sampling periods (Vanwalleghem et al., 2009). A large limitation to this study is a lack of knowledge regarding the full management context, site specific hydrology, and micro-climatic variables of the studied lands. The historical erosion rates and profile truncation from this study are averaged and may limit reflections of true temporal patterns. Future work should couple data and knowledge from this study with further erosional modelling to account for higher resolution spatial, temporal, climatic, and management patterns (Vanwalleghem et al., 2017).

Truncation of the soil profile can have negative consequences such as lower fertility, increased rock fragments, or higher density from subsoil shifting further into the rooting depth or plow layer (Veenstra and Burras, 2015; Vanwalleghem et al., 2017). Aside from agronomic impacts, the changes in soil properties can have effects on soil taxonomic classifications such as depth of mollic colors, family particle size class, horizon thickness, land capability, depth to diagnostic horizons, etc. Changes in these properties affects a pedon at the series to order level, further expanding the complexity of the anthropogenic impacts on soil resources (Mokma et al., 1996; Veenstra and Burras, 2012). Landscapes experiencing long-term erosion and profile truncation is an example of "regressive pedogenesis" where active degradation and removal of soil is accelerated beyond soil production (the development and deepening of pedogenic horizons), in this instance, being accelerated by anthropogenic forces (Sommer et al., 2008; Bajard et al., 2016). The anthropogenic role in soil and landscape processes is extensive, and it is happening in real time. Agricultural resilience depends on practices to keep soil in place and prevent the further truncation of soil profiles.

Chapter 3. Century-Long Soil Carbon Dynamics in Eastern South Dakota

3.1 Abstract

Soil carbon stocks change with land management, but few long-term datasets exist. Many modern estimates of soil carbon loss are limited to recent decades and do not capture the full impact of human land use changes. A 1921 study comparing non-cultivated and cultivated lands that had been converted from native grasslands took place in Beadle County, South Dakota. That study examined various chemical properties including soil carbon. After 75 years, a follow up study on soil carbon change found significant losses in carbon across cultivated and uncultivated sites. Our study aimed to revisit these sites again to examine the 102-year and 27-year changes in total, organic, and inorganic soil carbon. Our objective was to understand how long-term and current trends in agricultural management are affecting soil carbon pools. Data from this study showed that pools of soil carbon have varied greatly throughout the sampling period. There were significant losses in carbon seen in both cultivated and uncultivated lands from 1921 to 1996 followed by insignificant increases in carbon from 1996 to 2023. Overall, our data shows that modern conservation practices, increased yields/biomass, and/or shifts in management intensities may have slowed the loss of soil carbon and potentially have begun to increase soil carbon in some systems.

3.2 Introduction

Anthropogenic forces have severely degraded the global carbon cycle through imbalanced inputs of atmospheric gases (CO_2 and CH_4) and long-term degradation of soil resources (e.g., erosion). Much of the degradation is due to the removal of vegetation biomass, losses of soil organic matter, and accelerated combustion of fossil fuels since the industrial revolution (Paustian et al., 2000; Lal, 2010; Yang et al., 2020). As a result, atmospheric concentrations of carbon-based gases have increased at exponentially higher rates than what would be naturally occurring (Lal, 2010). Pools of soil carbon have been altered and depleted in many cases by anthropogenic forces through the ages of agricultural intensification, industrial advancements, and shifts in land use management (Lal, 2004, 2010; Sanderman et al., 2017). The depletion of soil carbon across the globe has created a net carbon debt within the terrestrial zone at the hands of humankind (Sanderman et al., 2017). To enact policies and management regarding restoration and protection efforts of soil carbon, quantitative measures, modeling, as well the utilization and establishment of legacy soil carbon datasets must be prioritized (Sanderman et al., 2017).

Depletion of soil carbon has dramatic environmental consequences, such as loss of soil productivity, degraded soil quality parameters, water quality impacts, increases in greenhouse gas emissions, among other negative ecosystem influences (Lal, 2004). All of which impact the sustainability, resilience, and food security of communities that depend on soil resources (Lal, 2004, 2010). Soil can be a sink for a massive portion of terrestrial carbon. However, the full potential of carbon storage within soil varies through inherent climate, soil properties, land management, and ecosystem characteristics across the globe

(Paustian et al., 2000; Lal, 2004, 2010). To understand the potential of protecting and sequestering soil carbon, it is important to evaluate the resiliency and extent of human impacts within soil carbon fractions (Sanderman et al., 2017).

Reliable legacy data regarding the status of soil carbon needed to understand the extent of temporal carbon losses or additions (Sanderman et al., 2017), especially in dominantly agricultural states such as South Dakota (Olson et al., 2014). Legacy data provides insight on previous soil conditions and can be utilized to track long-term impacts and trends of land use management (Olson et al., 2014; Sanderman et al., 2017). Agricultural management alterations of soil carbon are derived from tillage mixing, higher decomposition from shorter crop rotations with lower carbon:nitrogen ratio crops, warmer temperatures, installation of tile drainage increasing soil aeration and altering soil moisture, dissolution and translocation of soil organic matter through the soil profile, as well as redistribution across the landscape from processes such as erosion and deposition (Veenstra and Burras, 2015).

Cropland across the United States has lost significant amounts of soil organic matter and subsequently soil organic carbon from agricultural lands due to long-term cultivation (Lal et al., 1999; Malo et al., 2005; David et al., 2009; Zilverberg et al., 2018). Grasslands were once dominant natural ecosystems across the Northern Great Plains and Midwestern region, resulting in the formation of fertile soils inherently high in soil organic carbon (Mollisols). Euro-American settlement, rapid industrialization of agriculture, and long-term cultivation within the past century has decreased carbon concentrations significantly in the region’s soils (Tiessen et al., 1982; Cambell and

Souster, 1982; Reeder et al., 1998; Papiernik et al., 2005; Malo et al., 2005; Olson et al., 2014; Zilverberg et al., 2018).

Research across the region has been done to link long-term cultivation impacts on soil carbon and organic matter declines in Mollisol soils (Papiernik et al., 2005; Fenton et al., 2005; Malo et al., 2005; David et al., 2009; Olson et al., 2014; Veenstra and Burras, 2015; Zilverberg et al., 2018). In Iowa, soil organic matter losses have ranged from 30 to 60 percent (Fenton et al., 2005). Most of the decreases in soil organic carbon have occurred in soil horizons within the upper 50cm (Veenstra and Burras, 2015). Paired comparisons of native and long-term cultivated pedons in Illinois showed that cultivated soils had ~30% less carbon concentration compared to the adjacent prairie with comparable soil types (David et al., 2009).

In Moody County, South Dakota (Olson et al., 2014) found agricultural lands had an 18% lower soil organic carbon stocks compared to a native prairie. Comparable results in Moody County were also found by (Zilverberg et al., 2018). An assessment of 70-year changes in cultivated and uncultivated pedons showed significant decreases in total and organic carbon in the soil profiles, with a 15-30% reduction in organic carbon in cultivated sites compared to uncultivated sites (Malo et al., 2005). Inorganic carbon concentrations are also shifting, sources of inorganic carbon such as carbonates have increased in cultivated sites, attributed to increased erosion rates and subsoil incorporation from tillage. A shift upward of inorganic carbon in cultivated lands in the region has been documented in numerous studies (De Alba et al., 2004; Papiernik et al., 2005, 2007; Malo et al., 2005). Agricultural soils of the region could potentially continue to lose carbon, due to continued land use conversion and shifting climatic factors such as increasing temperature and precipitation (Olson et al., 2014).

Evidence from recent decades has shown that rates of soil carbon loss can level out and potentially increase in some agronomic systems (McLauchlan, 2006; West et al., 2008; David et al., 2009; Tian et al., 2012; Clay et al., 2012). Legacy data provides the opportunity to explore the potential of agricultural soils becoming carbon sinks over time. However, very limited work has been done utilizing century old legacy data as a benchmark for tracking changes. This study will examine the century-long changes in soil carbon pools, with the goal of evaluating if the selected soils have begun to store carbon relative to the initial losses.

A soil fertility study was conducted in Beadle County, South Dakota in 1921 by Dr. Joesph Hutton, a South Dakota State University (then South Dakota State College) professor of agronomy from 1911 to 1939. In this unpublished study, Hutton compared soil carbon pools of non-cultivated and cultivated lands (South Dakota Agricultural Heritage Museum, 2023). The locations and data were revisited in 1996 (Malo et al., 2005) to examine the 75-year changes, in which found significant differences between cultivated and uncultivated soils. For this study, sites were visited once again to examine the 27 and 102-year trends in soil carbon. Soil data of this age, to a depth of 100cm is rather unique. The dataset utilized in this study provides a novel opportunity to track century-long changes in soil properties and carbon pools across cultivated and uncultivated lands.

3.3 Methods

3.3.1 Study Area

The revisited study sites (Figure 9) reside in Beadle County, South Dakota (Figure 8). Beadle County resides in the James River Basin of eastern South Dakota. Much of the county resides within the James River Lowland, a near level and undulating glacial drift plain. The dominant parent materials are late-Wisconsin aged glacial till, outwash, stratified loamy glacial drift, and alluvial materials. Smaller portions of parent materials include glaciolacustrine, local alluvium, and aeolian materials (USDA-NRCS, 1979; Malo et al., 2010). The soils of the county are primarily classified as Mesic/Typic/Calcic Haplustolls and Argiustolls (Malo et al., 2010) (Appendix A, Table 15). Beadle County has a mean average precipitation of ~500mm and mean average air temperature between 7-9°C (Malo et al., 2010). Additional information regarding location coordinates and soil classification information is in the Appendix (Appendix A, Table 15).

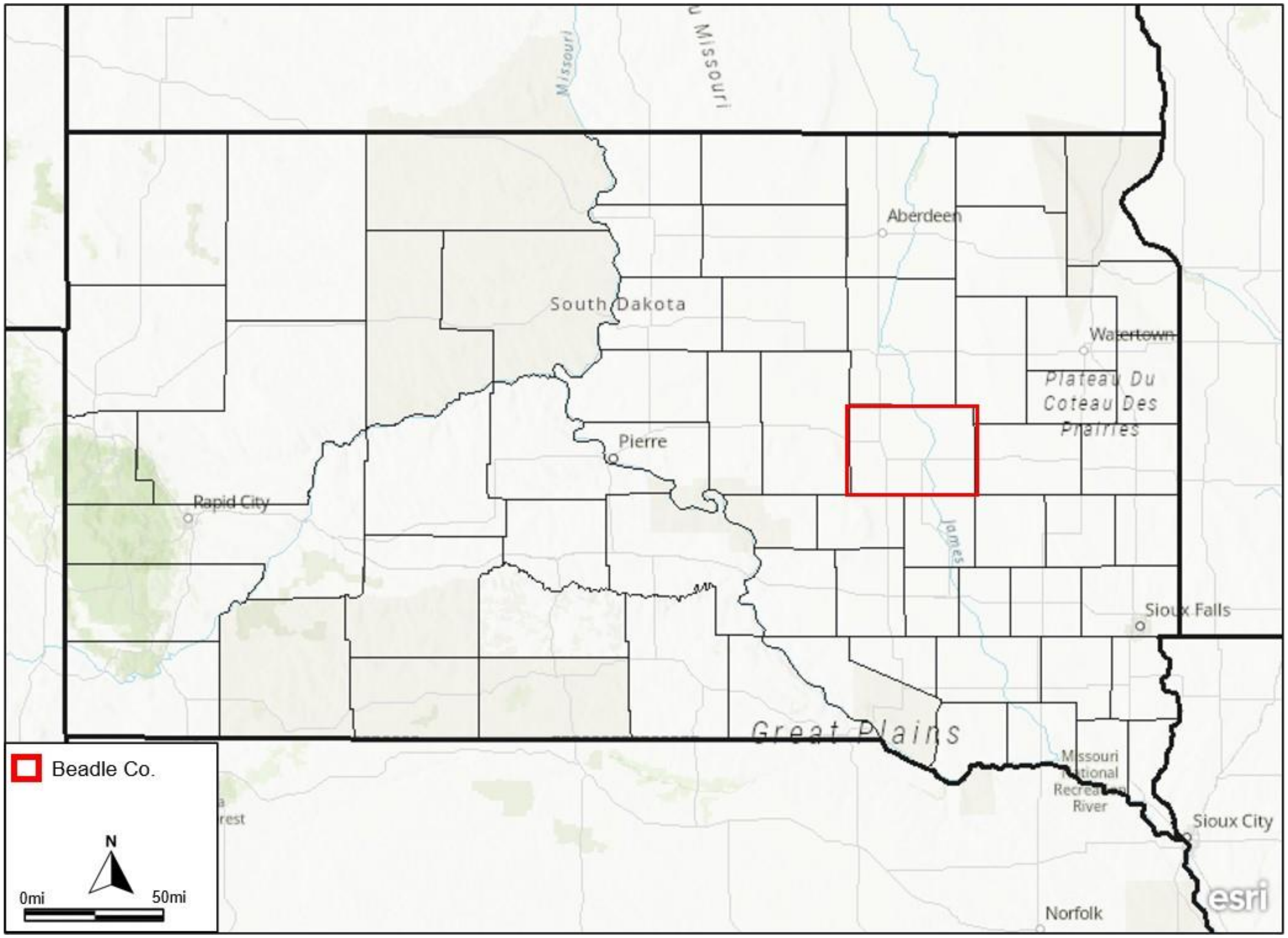

Figure 8. Map of South Dakota and Beadle County (ESRI Inc., 2024). Map source: Esri; U.S. Department of Commerce, Census Bureau; U.S. Department of Commerce (DOC), National Oceanic and Atmospheric Administration (NOAA), National Ocean Service (NOS), National Ge Geodetic Survey (NGS) | Esri, USGS | South Dakota Game Fish and Parks, Esri, TomTom, Garmin, FAO, NOAA, USGS, EPA, NPS, USFWS

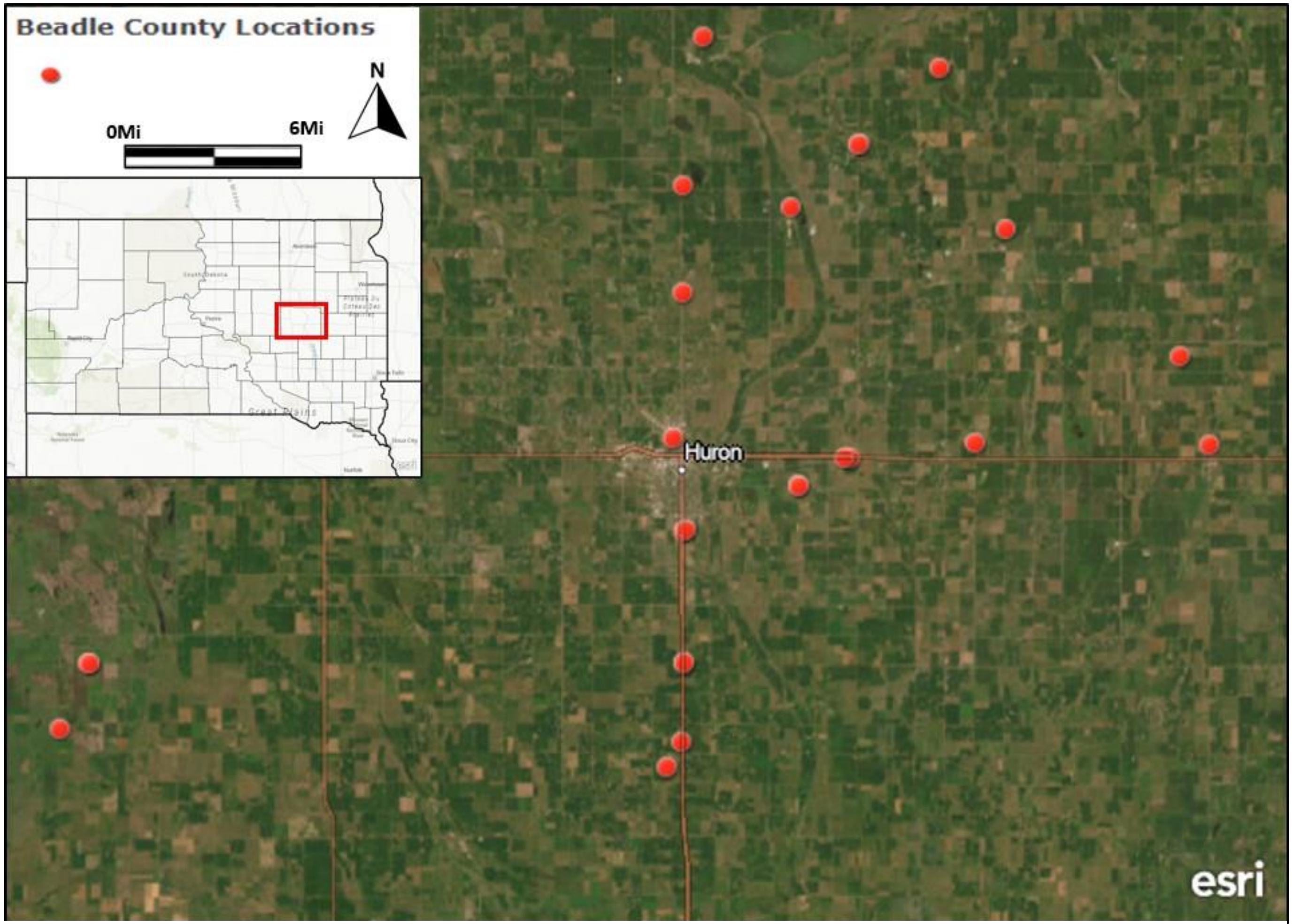

Figure 9. Study area and sampling locations (ESRI Inc., 2024). Map Source: Earthstar Geographics | South Dakota Game Fish and Parks, Esri, TomTom, Garmin, SafeGraph, METI/NASA, USGS, EPA, NPS, USDA, USFWS

3.3.2 Sampling Methods

The resampled locations (Figure 9) were relocated using Public Land Survey System (PLSS) legal descriptions recorded from the original sampling times as well as detailed field notes (distance to the nearest meter) to add site specific context. The detailed location information was interpreted and used to acquire GPS locations. Soils were sampled at fixed depth increments using a truck mounted hydraulic soil sampling probe. Analysis increments were split to 0 to 5, 5 to 15, 15 to 30, 30 to 50, 50 to 75, 75 to 100cm. To maintain homogeneity of procedures used previously, depth increments were analyzed separately and weighted averaged to depths of 0 to 15, 15 to 50, and 50 to 100cm for comparisons. At each location, clusters of five cores, 4.5cm in diameter, three meters apart, were taken at each site (Figure 10). Samples were taken from well-drained landscape positions where wind/water erosion potential and slope intensity considered minimal (Malo et al., 2005).

The data from 1921 was taken from 13 cultivated fields and 13 uncultivated fields (26 fields total). The data utilized from 1996 (Malo et al., 2005) is from 15 cultivated fields and 11 uncultivated fields (26 fields total) that were revisited. Lastly, during the 2023 field season, 14 cultivated lands and 6 uncultivated lands were resampled (20 fields total). All fields were sampled in the spring and fall of 2023. Limitations due to time, weather, and landowner permissions inhibited sampling of the remaining 6 fields. In 1996 and 2023, the cultivated lands outnumbered uncultivated lands. As expected, a portion of uncultivated lands were converted for crop production at unknown dates. Land conversion for row crop production in the region has increased in recent decades, largely due to high commodity demand and growth of the biofuel industry (Wright and Wimberly, 2013).

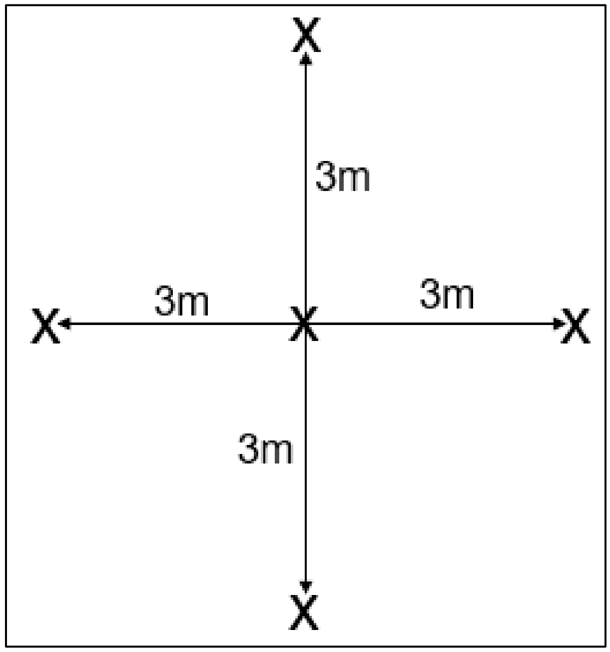

Figure 10. Example of sampling sequence (carbon study)

3.3.3 Laboratory Analyses

Soil carbon analysis is kept in accordance with the methods in Malo (2005); total, inorganic, organic carbon, and pH were measured with the addition of bulk density (Table 6). Samples were air-dried, sieved to 2mm size fraction, then ground with a mortar and pestle. The method utilized for total carbon measurement in 1921 was by measuring CO_2 evolution (Chatterjee et al., 2009). Total carbon in 1996 and 2023 was measured using a Mass Spectrometer (Nelson and Sommers, 1983). Inorganic carbon was measured using titration (Equation 7) (Bundy and Bremner, 1972; Loeppert and Suarez, 1996). Organic carbon is based off the difference between total and inorganic carbon (Equation

6) (Malo et al., 2005). A comparison of laboratory methods through the sampling periods can be found in (Table 6).

Equation 6. Soil organic carbon percentage

(total carbon % – inorganic carbon % = organic carbon %)

The inorganic carbon titration procedure (Bundy and Bremner, 1972):

Reaction equations:

$$CaCO_3 + 2HCl = CaCl_2 + H_2O + CO_2$$

$$KOH + CO_2 = KHCO_3$$

$$KHCO_3 + HCl = KCl + CO_2 + H_2O$$

Weighed out .5-1 grams of soil with an unknown amount of inorganic carbon in a stoppered glass bottle. The glass bottle contains a vial which has 2*M* KOH elevated above the soil. With a syringe, air is taken out of the vial and 20cc of 2*M* HCl is added to the soil sample. The sample then digests for ~24 hours. During digestion, CO_2 is released and captured in the KOH solution. The KOH solution is then titrated to endpoint using 0.1*M* HCl. The amount of acid necessary to reach the endpoint is indicative to the amount of CO_2 released and subsequently the amount of inorganic carbon in the sample.

Equation 7. %CaCO3 in soil sample (Bundy & Bremmer, 1972)

$$\frac{0.1\ (M \text{ of HCl}) * (\text{ml HCl to endpoint - ml HCl for blank endpoint}) * 12\ (\text{Caw})}{(\text{Soil weight (mg)}) * 100}$$

Soil pH was measured with a 1:1 soil-water solution (Thomas, 1996). Bulk density was calculated for each fixed depth, using the core method (Blake and Hartge, 1986). Soil cores were cut at the specified depth increments, weighed, placed in the oven at 105C° for 24 hours and reweighed for oven dry weight. Rock fragments were sieved out of dried samples for a rock fragment correction. The dry weight of each core section is divided by the volume and depth of the sampling tube and reported as a mass of soil/volume reported in g cm $^{-3}$ (Equation 8). Bulk densities were not collected by either previous study and measured bulk densities from 2023 were extrapolated for all years. However, the bulk densities have likely changed slightly throughout the sampling periods as it is a dynamic property.

Equation 8. Soil bulk density

$$\text{mass of dry soil (g) / volume of soil (cm}^{-3}\text{) = soil bulk density (g cm}^{-3}\text{)}$$

Carbon stocks were calculated for each site for each period (Equation 9), stocks were calculated at each depth and summed to the depth of meter (Rovira et al., 2022). Where bulk density (BD, g cm^{-3}), carbon concentration (Cc), thickness of depth (T, cm), correction for volume of stones (S, between 0-1), calculate the carbon stock of each layer utilizing the following equation:

Equation 9. Soil carbon stock equation

$$\text{Carbon stock (kg}^{-1}\text{ m}^{-2}\text{) = BD * Cc * (100*100*T) * (1-S) * (1/1000)}$$

Table 6. Comparison of laboratory methods

Laboratory Methods					
Year	Total Carbon	Inorganic Carbon	Organic Carbon	pH	Bulk Density
1921	CO_2 Evolution	Titration	Total-Inorganic	Not collected	Not collected
1996	Mass Spectrometer	Titration	Total-Inorganic	1:1 soil:water	Not collected
2023	Mass Spectrometer	Titration	Total-Inorganic	1:1 soil:water	Core method

3.3.4 Statistical Analysis

Comparisons were made for each depth and management separately, to compare carbon across three years under each management and fixed depth treatment. Statistical tests were conducted utilizing RStudio (v.4.3.1). The Analysis of Variance (ANOVA) test was used to determine significant differences between treatment means. Due to some sample sizes being unequal, the ANOVA was unbalanced (Driscoll, 1996; Ott-Lyman and Longnecker, 2015). However, the data met assumptions of ANOVA due to being normally distributed with equal variances. If the ANOVA resulted in a significant p-value (<.05), the analysis was proceeded by a post-hoc test for pairwise comparisons between groups.

The Tukey-Kramer Honest Significant Difference (HSD) ($\alpha = 0.05$) post hoc test was performed to check for significance between groups. The Tukey-Kramer test was utilized rather than the standard Tukey test, due to the unbalanced sample sizes. The Tukey-Kramer test also controls the experiment wise Type 1 error (null hypothesis being improperly rejected), compared to other post hoc tests such as the Fishers LSD (Driscoll, 1996; Ott-Lyman and Longnecker, 2015; Lee and Lee, 2018). The inorganic carbon data from uncultivated lands in the 0-15cm depth was the only dataset with unequal variance, in this case, the Games-Howell post hoc test was utilized. Two sample T-tests ($\alpha = 0.05$) were also utilized to test for significant difference between cultivated and uncultivated lands for each year (Ott-Lyman and Longnecker, 2015). All statistical analyses were conducted at the 95% confidence interval.

3.4 Results and Discussion

3.4.1 Total carbon

Total carbon in cultivated lands decreased from 1921 to 1996 at each depth, with significant loss occurring above 15cm. At the 0 to 15cm depth, there was a significant decrease from 1921 to 1996 and total carbon increased insignificantly from 1996 to 2023 (Table 7A). At the 15 to 50cm and 50 to 100cm depths, there was a loss in total carbon from 1921 to 1996 and increase from 1996 to 2023, however, the changes were insignificant (Table 7A). Total carbon in uncultivated lands also decreased from 1921 to 1996 at each depth. At all depths for uncultivated lands, the loss in total carbon was insignificant from 1921 to 1996 and the total carbon increase was insignificant from 1996 to 2023 (Table 7A). In 1996 and 2023, total carbon in cultivated lands were statistically different from uncultivated lands in the 0 to 15cm depth (Table 7A). The summed total carbon (0 to 100cm) in cultivated lands decreased by 26.8% from 1921 to 1996 and increased by 13.5% from 1996 to 2023. The summed total carbon (0 to 100cm) in uncultivated lands decreased by 20.7% from 1921 to 1996 and increased by 19.6% from 1996 to 2023.

High concentrations of total carbon in the 0 to 15cm depth (Table 7A) can be attributed to higher organic carbon concentrations. Most organic carbon is held in the surface horizons with low concentrations of pedogenic carbonates. In uncultivated lands, surface total carbon was higher than cultivated lands, due to the land not being cultivated and more organic matter has accumulated. Grasses are the dominant plant type in the uncultivated fields, grasses grow seasonally, have high belowground root biomass, and the lands are not tilled, which facilitates accumulation and higher levels of organic matter in the soil (Yu et al., 2020). High total carbon concentration in the subsoil under both settings can be attributed to inorganic carbonates held deeper in the profile (Malo et al., 2005; Yu et al., 2020), carbonates contribute to much of the amounts of total carbon >50cm (Table 7A). There could also be prolonged downward translocation of organic carbon components through tillage and water movement (Reeder et al., 1998; David et al., 2009; Veenstra and Burras, 2015; Yu et al., 2020).

3.4.2 Organic carbon

Organic carbon in cultivated lands decreased from 1921 to 1996 at each depth. At all depths, the loss in organic carbon was significant from 1921 to 1996 (Table 7B). Above 50cm, there was an increase in organic carbon from 1996 to 2023, however, the changes were insignificant (Table 7B). Organic carbon in uncultivated lands decreased from 1921 to 1996 at each depth, the loss was significant below 15cm and insignificant above 15cm. At all depths in uncultivated lands, there was an increase in organic carbon from 1996 to 2023, these changes were insignificant (Table 7B). In 1996 and 2023, organic carbon in cultivated lands were statistically different from uncultivated lands in the 0 to 15cm depth (Table 7B). The summed organic carbon (0 to 100cm) in cultivated lands decreased by 30.2% from 1921 to 1996 and increased by 11.9% from 1996 to 2023. The summed total carbon (0 to 100cm) in uncultivated lands decreased by 19.9% from 1921 to 1996 and increased by 24.5% from 1996 to 2023.

The 0 to 15cm depths were the most variable between years and land use, likely due to management impacts such as increased erosion, mixing, changes in oxidation and decomposition, removal of organic matter, increased temperatures, biomass removal, etc. (Veenstra and Burras, 2015). Tillage accounts for much of the surface losses of organic carbon in cultivated lands, tillage also mixes organic matter in to the subsurface which can facilitate vertical accumulations deeper than the topsoil (Reeder et al., 1998; Veenstra and Burras, 2015). The changes in organic carbon in these fields reflect comparable results found in (David et al., 2009), where there is a significant loss from the early 20th century followed by a leveling period and potential increase in organic carbon as time progresses. The leveling and increase of organic carbon could begin in the era of increased fertilizer use, increasing yields, and no-till adoption (David et al., 2009; Clay et al., 2012), as well as further downward translocations of organic carbon deeper in the soil profile through time (Veenstra and Burras, 2015). Such was reflected in the results of this study, by increases in organic carbon in the surface as well as subsurface depths over the sampling period (Table 7B).

The increases in organic carbon from 1996 to 2023 could be attributed to increased conservation practices, which have gained popularity in the Midwest and South Dakota in recent decades (West et al., 2008; Clay et al., 2012). Increases could also be due to increases in crop yields, in particular yields of high carbon biomass crops such as corn (*Zea mays*). Since the 1930s, corn yields have increased and tillage intensity has decreased in South Dakota, resulting in more non-harvested biomass left in the field (Clay et al., 2012). Yields have been exponentially increasing in South Dakota at an annual rate due to new crop hybrids, increased fertilizer use, and improved pest management (Clay et al., 2012). Another mechanism of carbon storage is elevated atmospheric CO_2, when paired with large nitrogen additions, elevated CO_2 can result in more photosynthetically fixed carbon via plants (Van Groenigen et al., 2006; Tian et al., 2012; Lal, 2018). In this study, the higher yields, increased biomass, changes in CO_2, nitrogen additions, organic amendments, and adoption of conservation practices has likely contributed to higher organic carbon returned to the soil in recent decades (Van Groenigen et al., 2006; McLauchlan, 2006; West et al., 2008; Tian et al., 2012; Clay et al., 2012; Lal, 2018). The changes in organic carbon in uncultivated lands could be a result of shifting grazing intensities, periodic burning, shifting in plant communities, or movement of carbon-enriched topsoil to other positions on the landscape (Olson et al., 2014).

3.4.3 Inorganic carbon

Inorganic carbon in cultivated lands decreased in all depths from 1921 to 1996. There was a decrease in inorganic carbon above 50cm from 1996 to 2023, with an increase below 50cm, attributed to leaching of carbonates (Table 7C). Inorganic carbon in uncultivated lands increased in the 0 to 15 and 50 to 100cm depth from 1921 to 1996 and in the 15 to 50cm depth from 1996 to 2023. Inorganic carbon decreased in the 15 to 50cm depth from 1921 to 1996 as well as the 0 to 15, and 0 to 100cm depth from 1996 to 2023. The changes in inorganic carbon were insignificant at all depths under both managements (Table 7C). Inorganic carbon in cultivated lands had higher concentrations overall compared to uncultivated lands.

Much of the inorganic carbon was concentrated lower in the soil profile (>50cm), which is expected as most inorganic carbon is in the form of pedogenic carbonates that have formed in the subsoil. Cultivated lands had higher concentrations of inorganic carbon at higher soil depths, potentially because of long-term erosion and tillage mixing of carbonate horizons higher in the soil profile (De Alba et al., 2004). The uncultivated soils had more organic carbon (Table 7B), less compaction (Table 8), and had less erosion, which could have resulted in deeper leaching of pedogenic carbonates through the profile with higher rates of infiltration (Malo et al., 2005). The summed inorganic carbon (0 to 100cm) in cultivated lands decreased by 21.1% from 1921 to 1996 and increased by 16.2% from 1996 to 2023. The summed inorganic carbon (0 to 100cm) in uncultivated lands increased by 11.9% from 1921 to 1996 and increased by 9.1% from 1996 to 2023.

*Table 7[3]. Summary table of total (A), organic (B), and inorganic (C) carbon. Lower case letters are associated with the pairwise comparisons of each depth and management, numbers not connected by the same letter are statistically significant (α = .05). Significant T-tests between land management per year are indicated by * (α = .05) and ** (α = .01)*

Total Carbon g kg^{-1} (7A)			
Depth (cm)	Year	Cultivated Land	Uncultivated land
0-15	1921	**24.65a**	30.83a
	1996*	**17.87b**	24.33a
	2023**	**20.61ab**	30.44a
15-50	1921	21.13a	18.78a
	1996	14.38a	12.40a
	2023	15.44a	17.08a
50-100	1921	24.92a	24.55a
	1996	19.50a	22.07a
	2023	22.52a	22.83a
0-100	1921	70.70a	74.16a
	1996	51.75a	58.80a
	2023	58.57a	70.35a
Organic Carbon g kg^{-1} (7B)			
Depth (cm)	Year	Cultivated Land	Uncultivated land
0-15	1921	**24.05a**	29.17a
	1996*	**17.44b**	24.16a
	2023**	**20.35ab**	30.29a
15-50	1921	**14.09a**	**16.14a**
	1996	**9.47b**	**10.69b**
	2023	**10.44ab**	**12.73ab**
50-100	1921	**7.15a**	**9.91a**
	1996	**4.66b**	**5.36b**
	2023	**4.56b**	**7.05ab**
0-100	1921	**45.29a**	**55.22a**
	1996	**31.58b**	**40.21b**
	2023	**35.35ab**	**50.07ab**
Inorganic Carbon g kg^{-1} (7C)			
Depth (cm)	Year	Cultivated Land	Uncultivated land
0-15	1921	0.61a	0.00a
	1996	0.46a	0.17a
	2023	0.26a	0.15a
15-50	1921	7.34a	2.63a
	1996	5.65a	1.71a
	2023	5.00a	4.35a
50-100	1921	17.37a	13.98a
	1996	13.89a	16.70a
	2023	17.96a	15.78a
0-100	1921	25.32a	16.62a
	1996	19.99a	18.59a
	2023	23.23a	20.28a

[3] Additional information regarding location coordinates and soil classification information is in the Appendix (Appendix A, Table 15).

3.4.4 Soil bulk density

Bulk density values in 2023 were higher above 30cm in cultivated lands compared to uncultivated lands, bulk density values were statistically different in the 0 to 5, 5 to 15, and 15 to 30cm depths between the two managements (Figure 11, Table 8). Bulk density values below 30cm were comparable in both cultivated and uncultivated and insignificantly different (Table 8). Higher bulk density values in the subsoil are due to less root alteration, smaller micro and macro pore spaces, and lower organic matter content (Özdemir et al., 2022). The increased surface density in cultivated landscapes can be attributed to increased disturbance and subsequent compaction from annual crop production, as well as having less organic matter compared to uncultivated lands (Özdemir et al., 2022). Cultivated lands also have more erosion, which incorporates denser, less aggregated, or clay-enriched subsoil horizons into surface horizons, resulting in overall denser soil surfaces (Indorante et al., 2014; Özdemir et al., 2022).

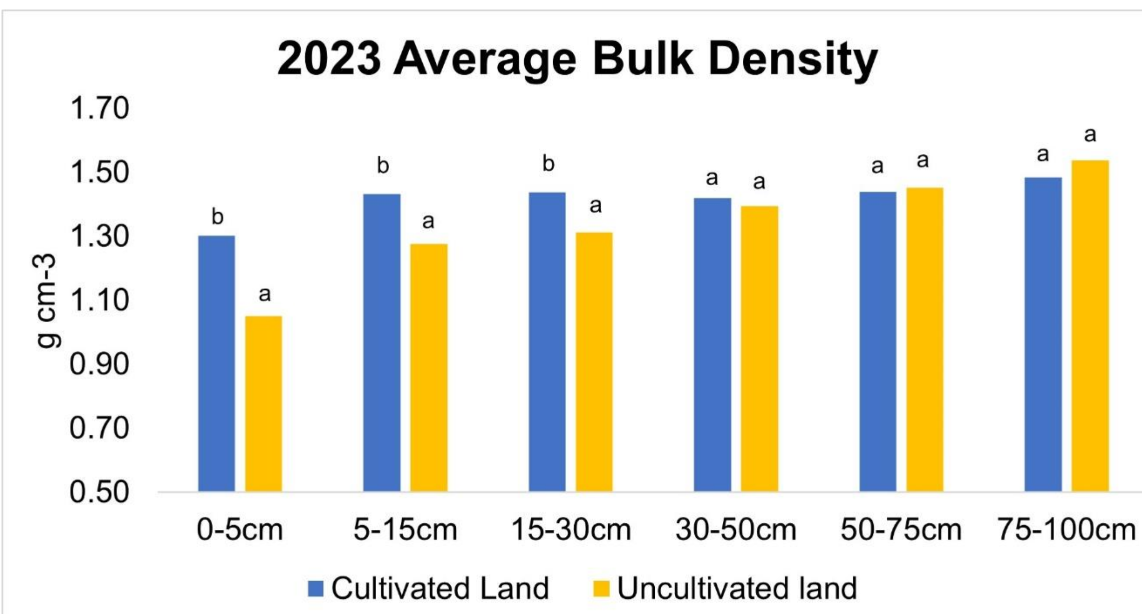

Figure 11. 2023 measured bulk densities

Table 8. 2023 bulk density values. Statically significant bulk densities between land use are indicated by lowercase letters at each depth (α = .05)

Bulk Density (g cm^{-3})		
Depth (cm)	Cultivated	Uncultivated
0-5	**1.31b**	1.05a
5-15	**1.43b**	1.27a
15-30	**1.44b**	1.31a
30-50	1.42a	1.39a
50-75	1.44a	1.45a
75-100	1.48a	1.54a

3.4.5 Soil pH

Soil pH values were lowered from 1996 to 2023 across both land managements in the 0 to 15cm depth (Figure 12, Table 9). At all depths in 2023 and above 15cm in 1996, pH values were lower in cultivated lands, due to continued or increased use of nitrogen fertilizers, which can increase soil acidity through nitrification processes (Tarkalson et al., 2006; Reeves and Liebig, 2016). Differences in acidification can also be attributed to cropping practice, as no-till retains more moisture and decreases the temperature, which changes nitrogen movement and nutrient cycling compared to a tilled soil. Tillage also redistributes and incorporates fertilizer throughout the soil surface (Tarkalson et al., 2006). Soil pH increased with depth (Figure 12, Table 9), due to increases in carbonates within the soil profile. All the changes seen in soil pH across the depths, years, and management were statistically insignificant.

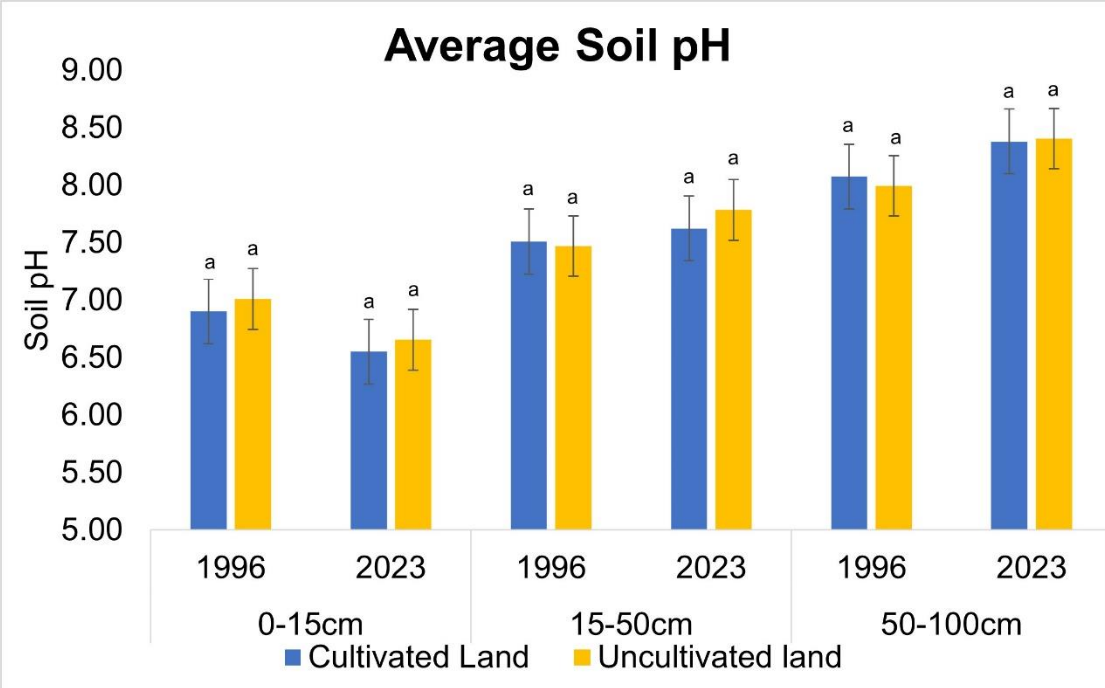

Figure 12. 1996 and 2023 soil 1:1 pH

Table 9. 1996 and 2023 soil pH values

Soil pH 1:1				
Depth (cm)	Cultivated		Uncultivated	
	1996	2023	1996	2023a
0-15	6.90a	6.55a	7.01a	6.66a
15-50	7.51a	7.62a	7.47a	7.78a
50-100	8.08a	8.38a	7.99a	8.41a

3.4.6 Carbon Stocks

When extrapolating the measured bulk density values across the sampling periods, total carbon stocks of cultivated lands insignificantly decreased from 1921 to 1996 and increased insignificantly from 1996 to 2023 (Table 10). Total carbon stocks were higher in uncultivated lands compared to cultivated lands in 1996 and 2023 (Table 10). Uncultivated total carbon stocks decreased insignificantly from 1921 to 1996 and increased insignificantly from 1996 to 2023 (Figure 13, Table 10). Approximately half of the carbon stocks were derived from organic carbon sources; organic carbon accounted for ~47 to 62% of total carbon stocks across both land uses (Figure 13, Table 10).

Organic carbon stocks of cultivated lands decreased significantly by 31.9% from 1921 to 1996 and increased insignificantly by 6.6% from 1996 to 2023 (Figure 13, Table 10). Uncultivated organic carbon stocks decreased significantly by 33.9% from 1921 to 1996 and increased insignificantly by 20.8% from 1996 to 2023 (Figure 13, Table 10). Organic carbon stocks were ~14 to 29% higher in uncultivated lands compared to cultivated lands across all years. The cultivated lands had higher stocks of inorganic carbon, due to the higher concentrations. Changes in inorganic carbon stocks were insignificant across all years and land uses (Figure 13, Table 10). Comparisons of carbon stocks between management per year were insignificant, as the carbon stock values in cultivated and uncultivated lands were similar (Table 10). Cultivated lands had less total and organic carbon, and the soils had higher bulk densities above 30cm (Figure 11, Table 8). The elevated bulk densities result in higher carbon stocks due to more soil mass per area holding carbon components (Ellert and Bettany, 1995).

Bulk density values are dynamic and have changed throughout the period from management and changes in organic carbon (Dam et al., 2005; Özdemir et al., 2022). The carbon stock values in 1921 and 1996 may be over/underestimated due to a lack of bulk density data for previous years. The bulk density values in 2023 (Table 8) were utilized and considered representative of each field and land management. Bulk density values per depth can be estimated utilizing pedotransfer functions utilizing organic carbon data (Manrique and Jones, 1991; Benites et al., 2007). After computing a bulk density/organic carbon pedotransfer function (Equation 10) derived from (Manrique and Jones, 1991) on the soils of this study, followed by a comparison to the lab measured values, the bulk density values were comparable with an average difference of +/-0.04 g cm^{-3}. Therefore, the lab measured bulk density values from 2023 were utilized and extrapolated for the previous periods.

Equation 10. Bulk Density pedotransfer function (Manrique & Jones, 1991)

$$\text{Estimated Bulk Density g cm}^{-3} = 1.660 - 0.318\ (\text{OC\%})^{1/2}$$

Table 10. Soil carbon stock values. Lower case letters are associated with the pairwise comparisons of each depth and management, numbers not connected by the same letter are statistically significant (α = .05)

Carbon Stocks kg m^{-2}					
Land Use	Year	Total	Organic	Inorganic	Organic % of Stock
Cultivated	1921	33.94a	**17.30a**	16.64a	50.1
	1996	24.86a	**11.78b**	13.08a	47.4
	2023	27.77a	**12.56b**	15.21a	45.2
Uncultivated	1921	32.83a	**20.33a**	12.50a	61.9
	1996	26.77a	**13.44b**	13.33a	50.2
	2023	29.57a	**16.24ab**	13.33a	54.9

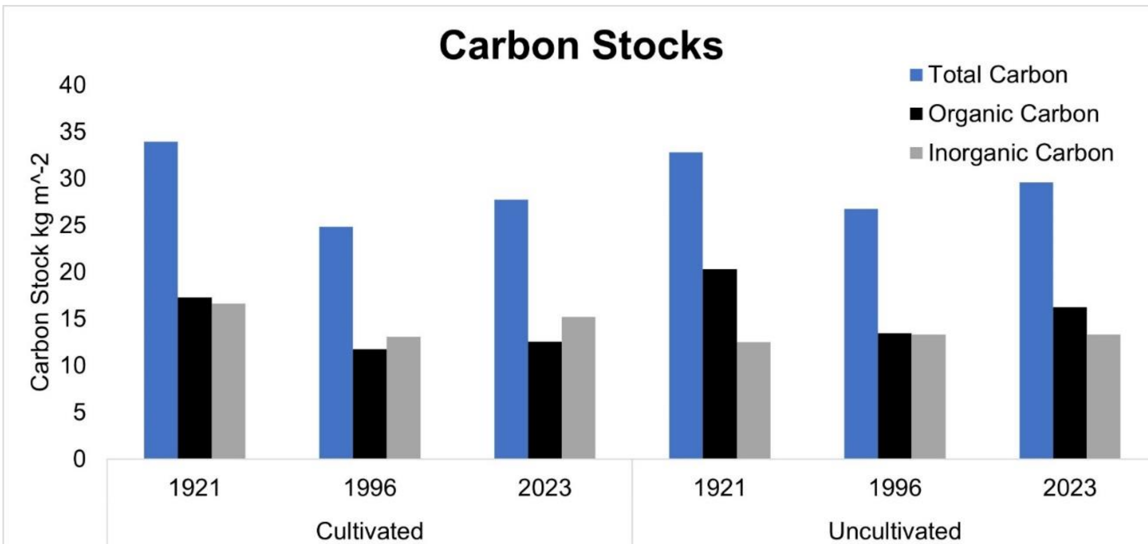

Figure 13. Total, organic, and inorganic carbon stocks

3.5 Summary and Conclusion

Pools of soil carbon have changed significantly since the 1920s. Organic carbon was higher in uncultivated lands across all years. There were losses in organic carbon seen in both cultivated and uncultivated lands from the 1920s to the 1990s. Tillage, erosion, shifting of plant communities, shifting of climates, and management intensities all may have contributed to these changes. There were increases of organic carbon from the 1990s to present under both land uses, from higher yields, increased biomass inputs, nitrogen additions, CO_2 dynamics, organic amendments, as well as conservation practices adoption such as reduced tillage and grazing intensities. Inorganic carbon was higher in cultivated lands, presumably from increased carbonate-bearing subsoil incorporated higher in the profile from erosion and tillage mixing events. Cultivated lands in 2023 were denser compared to uncultivated lands due to compaction from heavy equipment. Lastly, cultivated soils were also more acidic on the surface, due to long-term nitrogen fertilization. The trends of increasing soil carbon within the studied lands indicate that soils of some agricultural systems within South Dakota could potentially become a sink of carbon, rather than a source.

Much of the variability in this study results from the lack of land use history and management context. There have been large shifts in tillage equipment, cropping, and pasturing practices over the years. Land management can change year to year, soil properties such as carbon, pH, and bulk density are dynamic and reflect shifts in management practices. There is spatial and temporal variability between sampling locations, time periods, and land management that has not been captured by the results of this study. Other variability can reside in the sampling, the previous sampling depths of 0 to 15, 15 to 50, and 50 to 100cm is not standard by today's methods and potentially misrepresented the carbon distribution. On top of this, the lack of bulk density from the previous period could miss important context regarding management history and change carbon stock interpretations. Future work could incorporate more knowledge of land use and management intensity paired with modeling to further understand the land use impacts on the pools of carbon and dynamic soil properties.

Studies such as this highlight the utility of legacy data and the importance of tracking long-term temporal changes in soil carbon fractions (Sanderman et al., 2017). Soil carbon proves to be critical for soil productivity, ecosystems services, and contributes to human well-being and sustainable development goals (Lal, 2004, 2010). It is becoming increasingly important to track anthropogenic impacts on carbon reservoirs, studies such as this highlight regional contexts for future management and identification of potential carbon sinks. With growing populations and increasing demands for production, land managers should focus on holistic approaches to reduce biomass removal and carbon emissions, while increasing inputs, restoring, sequestering, and protecting soil carbon components within their systems (Lal, 2018).

Chapter 4. Conclusion

The soils of eastern South Dakota have undergone dramatic changes from agricultural intensification within the century. Soil erosion has truncated soils of Moody and Brookings counties, landscapes are changing within a decadal timescale. Soil profiles in the studied landscapes have historically lost soil at an average rate of 1.9mm yr^{-1} (26.0Mg ha^{-1} yr^{-1}) to 2.2mm yr^{-1} (30.6Mg ha^{-1} yr^{-1}). The soil losses are greater on steeper slopes and more convex landscapes and less in minor slope and concave landscapes. Eroded sediment does not always leave the field, as there are large depositions and translocations to lower and adjacent landscape positions. Soil erosion is a dynamic process that occurs on a landscape and site-specific scale, often changing with temporal, spatial, climatic, and management induced factors. Further work could expand into new landscapes of other counties or states within the region. An effort to visit more sites varying in landforms, parent materials, and land uses across a broader area can widen the scope of region-wide variability in soil loss and profile truncation within the century.

The pools of soil carbon in Beadle County have undergone losses and additions within the century. Soils in long-term cultivated and pastured lands lost significant portions of organic carbon from 1921 to 1996, spanning to depths of 100cm. There is evidence of the studied soils accumulating carbon in the surface and subsurface since 1996, although the changes were insignificant. Increases in carbon are due to shifting management practices such as conservation tillage and reduced grazing pressures. Gaining organic carbon can also be attributed to the exponential increase in commodity crop yields, which have steadily been increasing throughout the past century (Clay et al., 2012). The amount of land utilized for crop production in South Dakota has grown rapidly, resulting in considerable amounts of biomass produced on agricultural lands. As the amount of acres under cultivation increases, an understanding of management impacts on soil is critical. The dataset utilized for this study could continue to be built upon, as many locations were not resampled. Work could be done to increase the historical knowledge of temporal changes in land management to understand the context of long or short-term agricultural changes in soil properties.

A lack of knowledge regarding full management histories and pedological context within each year is a limit to understanding the full temporal scale of soil loss and carbon dynamics on the landscapes studied. There are many limitations that come from working with legacy datasets. First, there are long time gaps, there can be large temporal uncertainty and many unknown variables regarding natural and anthropogenic forces between sample periods. Which makes it quite difficult to understand the full scale of changes occurring within the soil system. Another limitation is the lack of truly exact location information, getting close to the nearest meter can be accurate to an extent, but soils (especially in glaciated landscapes) can be heterogenous. Creating the potential for spatial variability between old and new sampling points.

Changes in data collection and interpretations vary as well. Using soil profile descriptions from three separate people across a span of 100 years can be noisy, as standards regarding description methods and nomenclature have changed within the past century. Soil profile descriptions have an inherent personal bias, as each person varies in how they describe soil and interpret pedological concepts. For example, viewing color, structure, horizon breaks, as well as interpreting parent material boundaries are just some of the interpretations that can vary from person to person. Other sampling variability is working with large, fixed depth increments. In the carbon study, previous sampling used depths of 0 to 15, 15 to 50, and 50 to 100cm. The old depths have the potential to miss much of the vertical distribution of soil carbon. Along with sampling depths, the lack of previous bulk density data can under or overestimate carbon stocks and soil loss estimates.

Truncation of soil profiles and losses of soil carbon has large implications on present and future crop production and ecosystem functions (Lal, 2005; Vanwalleghem et al., 2017). Soil loss reduces fertility, transports carbon, and irreversibly alters landscapes. Erosion occurring in tiny amounts (e.g., ~1mm yr^{-1}) can seem minuscule, however, over a century can result in full removal of preexisting soil horizons (Vanwalleghem et al., 2017). Losses of soil carbon reduces fertility, water holding capacity, and affects the carbon cycle in terms of holding physical carbon components and sequestering atmospheric CO_2 (Lal, 2010). The physical, chemical, and biological soil changes occurring on agricultural landscapes have large implications on soil taxonomic classification, mapping efforts, and land use interpretations. Future work should continue to collaborate with producers, policy makers, and scientists to effectively reduce erosion, monitor and manage pools of soil carbon, and seek to increase conservation-minded land management practices regionally, nationally, and globally.

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APPENDIX A. SUPPLEMENTAL DATA

Table 11. Slopes of fields (erosion study)

Site	Slope
1926-2	1% near level
1926-10	1% near level
1926-12	1-2% near to gently level
1926-13	1% near level
1926-16	0% flat
1926-17	1-2% near to gently level
1926-18	1-4% near level to gently sloping
1926-19	1-3% near level to gently sloping
1955-2	0-1% flat to near level
1955-5	1% near level
1955-7	0-4% flat to gently sloping
1955-8	1-2% near to gently level
1955-9	1-2% near to gently level

Table 12. Average depth of topsoil, parent material, and carbonates (erosion study, 1926 sites)

1926			
Site	Depth of topsoil (cm)	Depth to PM (cm)	Depth to Vis. Carb (cm)
2	30.5	NA	66.0
10	43.2	NA	55.9
12	45.7	NA	76.2
13	20.3	188.0	42.0
16	22.9	68.6	NA
17	27.9	167.6	76.2
18	20.3	167.6	58.4
19	NA	121.9	63.5
AVG.	30.1	142.8	62.6

Table 13. Average depth of topsoil, parent material, and carbonates (erosion study, 1955 sites)

1955			
Site	Depth of Topsoil (cm)	Depth to PM (cm)	Depth to Vis. Carb (cm)
2	20.3	137.2	81.3
5	20.3	101.6	45.7
7	30.3	121.9	101.6
8	43.2	142.2	63.5
9	22.9	101.6	83.8
AVG.	27.4	120.9	75.2

Table 14. GPS locations and mapped soils (erosion study)

Site	Latitude °N	Longitude °W	Previously Mapped Series	Currently Mapped Series (WSS)	US Soil Taxonomic Classification
1926-2	43.86792	-96.60988	Barnes	Houdek	Fine-loamy, mixed, superactive, mesic Typic Argiustolls
1926-10	44.01953	-96.47798	Marshall	Moody	Fine-silty, mixed, superactive, mesic Udic Haplustolls
1926-12	44.00943	-96.54383	Marshall	Moody	Fine-silty, mixed, superactive, mesic Udic Haplustolls
1926-13	44.04601	-96.48819	NA	Flandreau	Fine-loamy, mixed, superactive, mesic Udic Haplustolls
1926-16	44.19353	-96.47004	NA	Estelline	Fine-silty over sandy or sandy-skeletal, mixed, superactive, frigid Calcic Hapludolls
1926-17	44.08361	-96.6534	NA	Kranzburg	Fine-silty, mixed, superactive, frigid Calcic Hapludolls
1926-18	43.94641	-96.8537	NA	Egan	Fine-silty, mixed, superactive, mesic Udic Haplustolls
1926-19	43.99645	-96.52094	NA	Moody	Fine-silty, mixed, superactive, mesic Udic Haplustolls
1955-2	44.346456	-96.924899	Estelline	Estelline	Fine-silty over sandy or sandy-skeletal, mixed, superactive, frigid Calcic Hapludolls
1955-5	44.333241	-96.759243	Barnes	Vienna	Fine-loamy, mixed, superactive, frigid Calcic Hapludolls
1955-7	43.881854	-96.728673	Moody	Moody	Fine-silty, mixed, superactive, mesic Udic Haplustolls
1955-8	43.93521	-96.526012	Trent	Moody	Fine-silty, mixed, superactive, mesic Udic Haplustolls
1955-9	44.125494	-96.729758	Moody	Moody	Fine-silty, mixed, superactive, mesic Udic Haplustolls

Table 15. GPS locations and mapped soils (carbon study)

Sample ID	Latitude °N	Longitude °W	Currently Mapped Series (WSS)	US Soil Taxonomic Classification
1	44.41901	-97.87382	Beadle	Fine, smectitic, mesic, Typic Argiustolls
2	44.37576	-97.85356	Beadle	Fine, smectitic, mesic, Typic Argiustolls
3	44.37674	-98.01378	Houdek	Fine-loamy, mixed, superactive, mesic Typic Argiustolls
4	44.333466	-98.213122	Shue	Sandy over loamy, mixed, superactive, mesic Typic Endoaquolls
5	44.334268	-98.211529	Shue	Sandy over loamy, mixed, superactive, mesic Typic Endoaquolls
8	44.48104	-97.99272	Beadle	Fine, smectitic, mesic, Typic Argiustolls
10	44.45015	-98.2136	Hoven	Fine, smectitic, mesic Vertic Natraquolls
13	44.574802	-98.199678	Houdek	Fine-loamy, mixed, superactive, mesic Typic Argiustolls
14	44.369368	-98.099197	Houdek	Fine-loamy, mixed, superactive, mesic Typic Argiustolls
15	44.369475	-98.103146	Houdek	Fine-loamy, mixed, superactive, mesic Typic Argiustolls
16	44.230572	-98.214518	Carthage	Coarse-loamy, mixed, superactive, mesic Pachic Haplustolls
17	44.218255	-98.224506	Blendon	Coarse-loamy, mixed, superactive, mesic Pachic Haplustolls
18	44.356224	-98.134376	Houdek	Fine-loamy, mixed, superactive, mesic Typic Argiustolls
19	44.355643	-98.134156	Houdek	Fine-loamy, mixed, superactive, mesic Typic Argiustolls
21	44.26899	-98.620097	Houdek	Fine-loamy, mixed, superactive, mesic Typic Argiustolls
22	44.269015	-98.618978	Houdek	Fine-loamy, mixed, superactive, mesic Typic Argiustolls
23	44.268833	-98.21272	Blendon	Coarse-loamy, mixed, superactive, mesic Pachic Haplustolls
24	44.269524	-98.212758	Blendon	Coarse-loamy, mixed, superactive, mesic Pachic Haplustolls
26	44.502309	-98.213335	Beadle	Fine, smectitic, mesic, Typic Argiustolls
27	44.491748	-98.139745	Bend	Fine-silty, mixed, superactive, mesic Typic Haplustolls

Table 16. Change in depth to pedogenic features for each site (erosion study)

1926-2				
Site 2	Pedon	Depth to Visible Carbonates (in)	Depth to Visible Carbonates (cm)	Pedon Change (cm)
	Original	26.00	66.0	
	1	17.32	44.00	-22.04
	2	24.41	62.00	-4.04
	3	16.54	42.00	-24.04
	4	24.41	62.00	-4.04
	5	16.54	42.00	-24.04
	6	20.87	53.00	-13.04
	7	16.14	41.00	-25.04
	8	43.31	110.00	43.96
	9	34.65	88.00	21.96
	10	11.02	28.00	-38.04
	11	27.95	71.00	4.96
	New Avg.	23.01	58.45	
	Upland Avg.		60.89	
	Avg. change	-2.99	-7.59	
	Soil Loss (Mg/ha/yr)	-11.73008435		

1926-10				
Site 10	Pedon	Depth to Visible Carbonates (in)	Depth to Visible Carbonates (cm)	Pedon Change (cm)
	Original	22.00	55.9	
	1	16.93	43.00	-12.88
	2	14.96	38.00	-17.88
	3	14.96	38.00	-17.88
	4	22.44	57.00	1.12
	5	12.60	32.00	-23.88
	6	16.54	42.00	-13.88
	7	18.50	47.00	-8.88
	8	12.99	33.00	-22.88
	9	13.39	34.00	-21.88
	10	16.54	42.00	-13.88
	11	16.14	41.00	-14.88
	New Avg.	16.00	40.64	n=11
	Avg. change	-6.00	-15.24	
	Soil Loss (Mg/ha/yr)	-20.58676664		

1926-12				
Site 12	Pedon	Depth to Visible Carbonates (in)	Depth to Visible Carbonates (cm)	Pedon Change (cm)
	Original	30.00	76.2	
	1	19.29	49.00	-27.20
	2	15.75	40.00	-36.20
	3	17.32	44.00	-32.20
	4	12.60	32.00	-44.20
	5	23.23	59.00	-17.20
	6	17.72	45.00	-31.20
	7	16.93	43.00	-33.20
	9	18.90	48.00	-28.20
	10	12.99	33.00	-43.20
	11	14.17	36.00	-40.20
	12	15.35	39.00	-37.20
	New Avg.	16.75	42.55	n=11
	Upland Avg.	15.80	40.13	n=8
	Lowland Avg.	19.29	49.00	n=3
	Avg. change	-13.25	-33.65	
	Upland change	-14.20	-36.08	
	Lowland change	-10.71	-27.20	
	Soil Loss (Mg/ha/yr)	-47.53270853		

1926-13				
Site 13	Pedon	Depth to texture change (in)	Depth to texture change (cm)	Pedon Change (cm)
	Original	36.00	91.4	
	1	24.02	61.00	-30.44
	2	34.65	88.00	-3.44
	3	27.56	70.00	-21.44
	4	20.47	52.00	-39.44
	5	20.47	52.00	-39.44
	6	18.11	46.00	-45.44
	7	20.87	53.00	-38.44
	8	18.90	48.00	-43.44
	9	21.65	55.00	-36.44
	10	16.14	41.00	-50.44
	11	23.62	60.00	-31.44
	New Avg.	22.41	56.91	n=11
	Avg. change	-13.59	-34.53	
	Soil Loss (Mg/ha/yr)	-49.83842549		

1926-16				
Site 16	Pedon	Depth to parent material (in)	Depth to parent material (cm)	Pedon Change (cm)
	Original	27.00	68.6	
	1	25.98	66.00	-2.58
	2	14.96	38.00	-30.58
	3	16.93	43.00	-25.58
	4	20.87	53.00	-15.58
	5	NA		
	6	32.28	82.00	13.42
	7	18.11	46.00	-22.58
	8	23.23	59.00	-9.58
	9	30.31	77.00	8.42
	10	16.93	43.00	-25.58
	11	NA		
	New avg.	22.18	56.33	n=9
	Change	-4.82	-12.25	
	Soil Loss (Mg/ha/yr)	-18.30687285		

1926-17				
Site 17	Pedon	Depth to Visible Carbonates (in)	Depth to Visible Carbonates (cm)	Pedon Change (cm)
	Original	30.00	76.2	
	1	7.48	19.00	-57.20
	2	15.35	39.00	-37.20
	3	12.99	33.00	-43.20
	4	18.90	48.00	-28.20
	5	15.75	40.00	-36.20
	6	16.54	42.00	-34.20
	7	22.44	57.00	-19.20
	8	16.14	41.00	-35.20
	9	14.96	38.00	-38.20
	10	11.02	28.00	-48.20
	11	18.90	48.00	-28.20
	New Avg.	15.50	39.36	n=11
	Upland Avg.		41.67	n=9
	Lowland Avg.		29.00	n=2
	Avg. change	-14.50	-36.84	
	Upland change		-34.53	
	Lowland change		-47.20	
	Soil Loss (Mg/ha/yr)	-52.78612933		

1926-18				
Site 18	Pedon	Depth to Visible Carbonates (in)	Depth to Visible Carbonates (cm)	Pedon Change (cm)
	Original	23.00	58.4	
	1	7.48	19.00	-39.42
	2	35.43	90.00	31.58
	3	44.49	113.00	54.58
	4	18.11	46.00	-12.42
	5	44.49	113.00	54.58
	6	26.77	68.00	9.58
	7	6.69	17.00	-41.42
	8	19.69	50.00	-8.42
	9	12.99	33.00	-25.42
	10	24.02	61.00	2.58
	11	38.98	99.00	40.58
	New Avg.	25.38	64.45	n=11
	Upland Avg.	21.74	55.22	n=9
	Lowland Avg.	41.73	106.00	n=2
	Avg. change	2.38	6.03	
	Upland change	-1.26	-3.20	
	Lowland change	18.73	47.58	
	Soil Loss (Mg/ha/yr)	7.589840675		

1926-19				
Site 19	Pedon	Depth to Visible Carbonates (in)	Depth to Visible Carbonates (cm)	Pedon Change (cm)
	Original	25.00	63.5	
	1	11.81	30.00	-33.50
	2	10.63	27.00	-36.50
	3	27.95	71.00	7.50
	4	16.93	43.00	-20.50
	5	16.93	43.00	-20.50
	6	16.93	43.00	-20.50
	7	33.46	85.00	21.50
	8	31.10	79.00	15.50
	9	22.83	58.00	-5.50
	10	24.80	63.00	-0.50
	11	17.32	44.00	-19.50
	New Avg.	20.97	53.27	n=11
	Upland Avg.	18.65	47.38	n=8
	Lowland Avg.	27.17	69.00	n=3
	Avg. change	-4.03	-10.23	
	Upland change	-6.35	-16.13	
	Lowland change	2.17	5.50	
	Soil Loss (Mg/ha/yr)	-14.44470478		

1955-2				
55(2)	Pedon	Depth to discontinuity (in)	Depth to discontinuity (cm)	Pedon Change (cm)
	Original	48	121.9	
	1	42.12598425	107	-14.92
	2	39.37007874	100	-21.92
	3	37.4015748	95	-26.92
	4	40.5511811	103	-18.92
	5	39.37007874	100	-21.92
	6	42.51968504	108	-13.92
	7	44.88188976	114	-7.92
	8	44.48818898	113	-8.92
	9	45.66929134	116	-5.92
	10	42.91338583	109	-12.92
	11	39.37007874	100	-21.92
	New Avg.	41.92913386	105.9090909	
	avg. change	-6.070866142	-16.01090909	
	Soil Loss (Mg/ha/yr)	-32.02181818		

1955-5				
55(5)	Pedon	Depth to carbonate (in)	Depth to carbonate (cm)	Pedon Change (cm)
	Original	18.00	45.7	
	1	12.99	33.00	40.59
	2	16.93	43.00	50.59
	3	15.75	40.00	47.59
	4	15.35	39.00	46.59
	5	15.75	40.00	47.59
	6	15.75	40.00	47.59
	7	14.17	36.00	43.59
	8	16.54	42.00	49.59
	9	19.69	50.00	57.59
	10	15.75	40.00	47.59
	11	16.14	41.00	48.59
	New Avg.	15.89	40.36	
	avg. change	-2.11	-5.36	
	Soil Loss (Mg/ha/yr)	-12.3668984		

1955-7				
55(7)	Pedon	Depth to Visible Carbonates (in)	Depth to Visible Carbonates (cm)	Pedon Change (cm)
	Original	40.00	101.6	
	1	27.95	71.00	-30.60
	2	29.13	74.00	-27.60
	3	33.07	84.00	-17.60
	4	38.98	99.00	-2.60
	5	35.04	89.00	-12.60
	6	29.13	74.00	-27.60
	7	30.71	78.00	-23.60
	8	32.28	82.00	-19.60
	9	31.10	79.00	-22.60
	10	35.04	89.00	-12.60
	11	46.06	117.00	15.40
	New Avg.	33.50	85.09	n=11
	Upland Avg.	31.93	81.11	n=9
	Lowland Avg.	40.55	103.00	n=2
	Avg. change	-6.50	-16.51	-16.51
	Upland change	-8.07	-20.49	
	Lowland change	0.55	1.40	
	Soil Loss (Mg/ha/yr)	-31.56149733		

1955-8				
55(8)	Pedon	Depth to Visible Carbonates (in)	Depth to Visible Carbonates (cm)	Pedon Change (cm)
	Original	25.00	63.5	
	1	24.41	62.00	-1.50
	2	22.05	56.00	-7.50
	3	22.83	58.00	-5.50
	4	33.07	84.00	20.50
	5	23.23	59.00	-4.50
	6	22.05	56.00	-7.50
	7	23.62	60.00	-3.50
	8	20.08	51.00	-12.50
	9	17.72	45.00	-18.50
	10	20.47	52.00	-11.50
	11	23.62	60.00	-3.50
	12	21.65	55.00	-8.50
	New Avg.	22.90	58.17	
	Upland Avg.		58.30	
	Lowland Avg.		57.50	
	Avg. change		-5.33	
	Upland change		-5.20	
	Lowland change		-6.00	
	Soil Loss (Mg/ha/yr)	-10.98039216		

1955-9				
55(9)	Pedon	Depth to Visible Carbonates (in)	Depth to Visible Carbonates (cm)	Pedon Change (cm)
	Original	33.00	83.8	
	1	22.05	56.00	-27.82
	2	17.72	45.00	-38.82
	3	19.69	50.00	-33.82
	4	20.08	51.00	-32.82
	5	23.23	59.00	-24.82
	6	18.11	46.00	-37.82
	7	21.65	55.00	-28.82
	8	19.69	50.00	-33.82
	9	18.11	46.00	-37.82
	10	21.26	54.00	-29.82
	11	25.20	64.00	-19.82
	New Avg.	20.62	52.36	n=11
	Upland Avg.	20.03	50.88888889	n=9
	Lowland Avg.	23.23	59	n=2
	Avg. change	-12.38	-31.46	
	Upland change	-12.97	-32.93	
	Lowland change	-9.77	-24.82	
	Soil Loss (Mg/ha/yr)	-66.15088235		

APPENDIX B. CARBON DATA

Table 17. Beadle County carbon data (1921)

County	Sample	Depth (in)	Depth (in)	Land use	Bulk Density	TC (%)	IC (%)	OC (%)	TC g/kg	OCg/kg	ICg/kg	SOC kg/m2	TC kg/m2	OCStock	TCStock
Beadle	1	0	7	C	1.39	2.94	0.00	2.94	29.40	29.40	0.00	6.14	6.14		
Beadle	1	7	20	C	1.43	1.58	0.26	1.32	15.80	13.20	2.60	6.59	7.89		
Beadle	1	20	40	C	1.46	2.94	1.74	1.20	29.40	12.00	17.40	8.78	21.51	21.52	35.55
Beadle	2	0	7	U	1.20	3.91	0.00	2.91	39.10	29.10	0.00	5.24	7.04		
Beadle	2	7	20	U	1.36	2.09	0.00	2.09	20.90	20.90	0.00	9.94	9.94		
Beadle	2	20	40	U	1.50	2.38	1.27	1.11	23.80	11.10	12.70	8.30	17.79	23.48	34.77
Beadle	3	0	7	U	1.20	2.77	0.00	2.77	27.70	27.70	0.00	4.99	4.99		
Beadle	3	7	20	U	1.36	1.84	0.00	1.84	18.40	18.40	0.00	8.75	8.75		
Beadle	3	20	40	U	1.50	2.84	1.46	1.38	28.40	13.80	14.60	10.32	21.23	24.05	34.97
Beadle	4	0	7	C	1.39	1.56	0.00	1.56	15.60	15.60	0.00	3.26	3.26		
Beadle	4	7	20	C	1.43	0.77	0.00	0.77	7.70	7.70	0.00	3.85	3.85		
Beadle	4	20	40	C	1.46	1.06	0.24	0.82	10.60	8.20	2.40	6.00	7.76	13.11	14.86
Beadle	5	0	7	U	1.20	1.29	0.00	1.29	12.90	12.90	0.00	2.32	2.32		
Beadle	5	7	20	U	1.36	0.90	0.00	0.90	9.00	9.00	0.00	4.28	4.28		
Beadle	5	20	40	U	1.50	0.66	0.00	0.66	6.60	6.60	0.00	4.93	4.93	11.54	11.54
Beadle	6	0	7	C	1.39	2.59	0.00	2.59	25.90	25.90	0.00	5.41	5.41		
Beadle	6	7	20	C	1.43	1.08	0.00	1.08	10.80	10.80	0.00	5.39	5.39		
Beadle	6	20	40	C	1.46	1.11	0.50	0.61	11.10	6.10	5.00	4.46	8.12	15.27	18.93
Beadle	7	0	7	U	1.20	3.14	0.00	3.14	31.40	31.40	0.00	5.65	5.65		
Beadle	7	7	20	U	1.36	1.52	0.22	1.30	15.20	13.00	2.20	6.18	7.23		
Beadle	7	20	40	U	1.50	1.34	0.73	0.61	13.40	6.10	7.30	4.56	10.02	16.40	22.90
Beadle	8	0	7	C	1.39	2.25	0.00	2.25	22.50	22.50	0.00	4.70	4.70		
Beadle	8	7	20	C	1.43	2.39	0.00	2.39	23.90	23.90	0.00	11.94	11.94		
Beadle	8	20	40	C	1.46	2.89	2.27	0.62	28.90	6.20	22.70	4.54	21.15	21.17	37.79
Beadle	9	0	7	U	1.20	3.77	0.00	3.77	37.70	37.70	0.00	6.79	6.79		
Beadle	9	7	20	U	1.36	2.83	1.18	1.65	28.30	16.50	11.80	7.85	13.46		
Beadle	9	20	40	U	1.50	3.62	2.62	1.00	36.20	10.00	26.20	7.48	27.06	22.11	47.31
Beadle	10	0	7	U	1.20	2.55	0.00	2.55	25.50	25.50	0.00	4.59	4.59		
Beadle	10	7	20	U	1.36	1.65	0.00	1.65	16.50	16.50	0.00	7.85	7.85		
Beadle	10	20	40	U	1.50	1.91	1.02	0.89	19.10	8.90	10.20	6.65	14.28	19.09	26.72
Beadle	11	0	7	U	1.20	4.52	0.00	4.52	45.20	45.20	0.00	8.14	8.14		
Beadle	11	7	20	U	1.36	2.37	0.00	2.37	23.70	23.70	0.00	11.27	11.27		
Beadle	11	20	40	U	1.50	2.82	1.71	1.11	28.20	11.10	17.10	8.30	21.08	27.71	40.49
Beadle	13	0	7	U	1.20	3.79	0.00	3.79	37.90	37.90	0.00	6.82	6.82		
Beadle	13	7	20	U	1.36	1.69	0.00	1.69	16.90	16.90	0.00	8.04	8.04		
Beadle	13	20	40	U	1.50	2.94	2.37	0.57	29.40	5.70	23.70	4.26	21.98	19.12	36.84
Beadle	14	0	7	C	1.39	3.19	0.00	3.19	31.90	31.90	0.00	6.66	6.66		

Beadle	14	7	20	C	1.43	4.16	2.64	1.52	41.60	15.20	26.40	7.59	20.78		
Beadle	14	20	40	C	1.46	2.91	2.47	0.44	29.10	4.40	24.70	3.22	21.29	17.48	48.74
Beadle	15	0	7	C	1.39	2.64	0.00	2.64	26.40	26.40	0.00	5.51	5.51		
Beadle	15	7	20	C	1.43	3.54	2.12	1.42	35.40	14.20	21.20	7.09	17.68		
Beadle	15	20	40	C	1.46	3.29	2.27	1.02	32.90	10.20	22.70	7.46	24.08	20.07	47.27
Beadle	16	0	7	C	1.39	1.92	0.00	1.92	19.20	19.20	0.00	4.01	4.01		
Beadle	16	7	20	C	1.43	1.14	0.00	1.14	11.40	11.40	0.00	5.69	5.69		
Beadle	16	20	40	C	1.46	2.49	1.70	0.79	24.90	7.90	17.00	5.78	18.22	15.49	27.93
Beadle	17	0	7	U	1.20	2.53	0.00	2.53	25.30	25.30	0.00	4.55	4.55		
Beadle	17	7	20	U	1.36	1.35	0.00	1.35	13.50	13.50	0.00	6.42	6.42		
Beadle	17	20	40	U	1.50	3.32	2.25	1.07	33.20	10.70	22.50	8.00	24.82	18.97	35.79
Beadle	18	0	7	C	1.39	2.98	0.00	2.98	29.80	29.80	0.00	6.23	6.23		
Beadle	18	7	20	C	1.43	2.97	0.70	2.27	29.70	22.70	7.00	11.34	14.83		
Beadle	18	20	40	C	1.46	3.52	2.77	0.65	35.20	6.50	27.70	4.76	25.76	22.32	46.82
Beadle	19	0	7	U	1.20	3.22	0.00	2.22	32.20	22.20	0.02	4.00	5.80		
Beadle	19	7	20	U	1.36	3.04	1.18	1.86	30.40	18.60	11.80	8.85	14.46		
Beadle	19	20	40	U	1.50	3.13	1.82	1.31	31.30	13.10	18.20	9.79	23.40	22.64	43.65
Beadle	20	0	7	C	1.39	3.45	0.67	2.78	34.50	27.80	6.70	5.81	7.21		
Beadle	20	7	20	C	1.43	3.41	2.02	1.39	34.10	13.90	20.20	6.94	17.03		
Beadle	20	20	40	C	1.46	3.13	2.63	0.50	31.30	5.00	26.30	3.66	22.90	16.41	47.14
Beadle	21	0	7	C	1.39	2.21	0.00	2.21	22.10	22.10	0.00	4.62	4.62		
Beadle	21	7	20	C	1.43	1.30	0.00	1.30	13.00	13.00	0.00	6.49	6.49		
Beadle	21	20	40	C	1.46	3.16	2.52	0.64	31.60	6.40	25.20	4.68	23.12	15.79	34.23
Beadle	22	0	7	U	1.20	3.21	0.00	3.21	32.10	32.10	0.00	5.78	5.78		
Beadle	22	7	20	U	1.36	2.12	0.58	1.54	21.20	15.40	5.80	7.33	10.08		
Beadle	22	20	40	U	1.50	3.58	2.10	1.48	35.80	14.80	21.00	11.06	26.76	24.17	42.62
Beadle	23	0	7	C	1.39	1.39	0.00	1.39	13.90	13.90	0.00	2.90	2.90		
Beadle	23	7	20	C	1.43	0.90	0.00	0.90	9.00	9.00	0.00	4.50	4.50		
Beadle	23	20	40	C	1.46	0.91	0.33	0.58	9.10	5.80	3.30	4.24	6.66	11.64	14.06
Beadle	24	0	7	U	1.20	2.30	0.00	2.30	23.00	23.00	0.00	4.14	4.14		
Beadle	24	7	20	U	1.36	1.13	0.00	1.13	11.30	11.30	0.00	5.37	5.37		
Beadle	24	20	40	U	1.50	0.92	0.22	0.70	9.20	7.00	2.20	5.23	6.88	14.75	16.39
Beadle	25	0	7	U	1.20		0.00		0.00	0.00	0.00				
Beadle	25	7	20	U	1.36		0.00		0.00	0.00	0.00				
Beadle	25	20	40	U	1.50		0.61		0.00	0.00	6.06				
Beadle	26	0	7	C	1.39		0.00		0.00	0.00	0.00				
Beadle	26	7	20	C	1.43		0.00		0.00	0.00	0.00				
Beadle	26	20	40	C	1.46		1.91		0.00	0.00	19.10				
Beadle	27	0	7	C	1.39		0.00		0.00	0.00	0.00				
Beadle	27	7	20	C	1.43		0.75		0.00	0.00	7.47				
Beadle	27	20	40	C	1.46		0.38		0.00	0.00	3.80				

Table 18. Beadle County carbon data (1996)

County	Sample	Depth (in)	Depth (in)	Land Use	pH	Bulk Density	TC (%)	IC (%)	OC (%)	TC g/kg	OCg/kg	ICg/kg	SOC kg/m2	TC kg/m2	OCStock	TCStock
Beadle	1	0	7	C	6.45	1.39	2.18	0.00	2.18	21.80	21.80	0.00	4.55	4.55		
Beadle	1	7	20	C	7.68	1.43	2.09	1.05	1.04	20.93	10.41	10.52	5.20	10.45		
Beadle	1	20	40	C	8.09	1.46	2.84	2.42	0.42	28.43	4.19	24.24	3.07	20.80	12.82	35.81
Beadle	2	0	7	U	7.47	1.20	1.75	0.01	1.74	17.48	17.35	0.13	3.12	3.15		
Beadle	2	7	20	U	8.28	1.36	0.99	0.06	0.93	9.87	9.31	0.56	4.43	4.69		
Beadle	2	20	40	U	8.22	1.50	2.03	1.58	0.45	20.26	4.47	15.79	3.34	15.14	10.89	22.99
Beadle	3	0	7	U	6.24	1.20	1.74	0.00	1.74	17.44	17.44	0.00	3.14	3.14		
Beadle	3	7	20	U	7.68	1.36	1.32	0.40	0.92	13.23	9.22	4.01	4.39	6.29		
Beadle	3	20	40	U	8.31	1.50	2.15	1.52	0.63	21.50	6.28	15.22	4.69	16.07	12.22	25.50
Beadle	4	0	7	C	7.89	1.39	1.54	0.19	1.35	15.35	13.47	1.88	2.81	3.21		
Beadle	4	7	20	C	7.77	1.43	3.41	2.81	0.60	34.10	6.04	28.06	3.02	17.03		
Beadle	4	20	40	C	7.84	1.46	3.31	2.82	0.49	33.06	4.87	28.19	3.56	24.19	9.39	44.43
Beadle	5	0	7	U	7.61	1.20	2.56	0.03	2.53	25.59	25.34	0.25	4.56	4.61		
Beadle	5	7	20	U	8.03	1.36	0.60	0.08	0.53	6.02	5.27	0.75	2.51	2.86		
Beadle	5	20	40	U	7.97	1.50	3.12	2.69	0.43	31.21	4.34	26.87	3.24	23.33	10.31	30.80
Beadle	6	0	7	C	6.57	1.39	1.25	0.00	1.25	12.54	12.54	0.00	2.62	2.62		
Beadle	6	7	20	C	6.85	1.43	0.75	0.02	0.73	7.45	7.26	0.19	3.63	3.72		
Beadle	6	20	40	C	7.45	1.46	0.48	0.04	0.44	4.76	4.38	0.38	3.21	3.48	9.45	9.82
Beadle	7	0	7	U	6.97	1.20	1.93	0.00	1.93	19.33	19.33	0.00	3.48	3.48		
Beadle	7	7	20	U	6.87	1.36	0.89	0.01	0.88	8.87	8.78	0.09	4.18	4.22		
Beadle	7	20	40	U	6.50	1.50	0.24	0.00	0.24	2.44	2.44	0.00	1.82	1.82	9.48	9.52
Beadle	8	0	7	C	6.60	1.39	2.29	0.00	2.29	22.93	22.93	0.00	4.79	4.79		
Beadle	8	7	20	C	7.26	1.43	1.01	0.06	0.95	10.09	9.53	0.56	4.76	5.04		
Beadle	8	20	40	C	8.16	1.46	1.96	1.41	0.55	19.58	5.49	14.09	4.02	14.33	13.57	24.16
Beadle	9	0	7	U	6.50	1.20	3.77	0.00	3.77	37.70	37.70	0.00	6.79	6.79		
Beadle	9	7	20	U	7.25	1.36	2.83	1.18	1.65	28.30	16.50	11.80	7.85	13.46		
Beadle	9	20	40	U	8.22	1.50	3.62	2.62	1.00	36.20	10.00	26.20	7.48	27.06	22.11	47.31
Beadle	10	0	7	U	6.59	1.20	3.16	0.00	3.16	31.61	31.61	0.00	5.69	5.69		
Beadle	10	7	20	U	7.16	1.36	1.63	0.04	1.59	16.27	15.89	0.38	7.56	7.74		
Beadle	10	20	40	U	7.97	1.50	2.49	1.92	0.57	24.91	5.74	19.17	4.29	18.62	17.54	32.05
Beadle	11	0	7	C	7.08	1.39	1.75	0.03	1.72	17.48	17.20	0.28	3.59	3.65		
Beadle	11	7	20	C	8.21	1.43	2.70	1.88	0.82	27.03	8.24	18.79	4.12	13.50		
Beadle	11	20	40	C	8.69	1.46	2.25	1.71	0.54	22.50	5.40	17.10	3.95	16.47	11.66	33.62
Beadle	13	0	7	C	6.76	1.39	2.71	0.00	2.71	27.11	27.11	0.00	5.66	5.66		
Beadle	13	7	20	C	7.75	1.43	1.69	0.35	1.34	16.89	13.38	3.51	6.68	8.44		
Beadle	13	20	40	C	8.30	1.46	3.11	2.50	0.61	31.09	6.10	24.99	4.46	22.75	16.81	36.85
Beadle	14	0	7	C	7.27	1.39	2.02	0.04	1.98	20.22	19.84	0.38	4.14	4.22		

Beadle	14	7	20	C	7.94	1.43	1.58	0.30	1.28	15.84	12.83	3.01	6.41	7.91		
Beadle	14	20	40	C	7.90	1.46	1.43	1.02	0.42	14.32	4.17	10.15	3.05	10.48	13.60	22.61
Beadle	15	0	7	U	7.59	1.20	4.41	0.06	4.35	44.13	43.50	0.63	7.83	7.94		
Beadle	15	7	20	U	7.63	1.36	1.96	0.09	1.87	19.56	18.68	0.88	8.89	9.30		
Beadle	15	20	40	U	8.03	1.50	3.05	2.18	0.87	30.47	8.67	21.80	6.48	22.78	23.20	40.02
Beadle	16	0	7	C	6.81	1.39	0.74	0.00	0.74	7.42	7.42	0.00	1.55	1.55		
Beadle	16	7	20	C	7.47	1.43	0.60	0.00	0.60	5.96	5.96	0.00	2.98	2.98		
Beadle	16	20	40	C	8.07	1.46	1.00	0.70	0.30	10.01	3.00	7.01	2.20	7.33	6.72	11.85
Beadle	17	0	7	U	6.95	1.20	1.43	0.02	1.41	14.32	14.13	0.19	2.54	2.58		
Beadle	17	7	20	U	7.26	1.36	0.48	0.01	0.47	4.82	4.73	0.09	2.25	2.29		
Beadle	17	20	40	U	8.15	1.50	1.87	1.65	0.21	18.68	2.14	16.54	1.60	13.96	6.39	18.83
Beadle	18	0	7	C	7.05	1.39	1.85	0.06	1.80	18.54	17.98	0.56	3.76	3.87		
Beadle	18	7	20	C	7.11	1.43	2.30	0.03	2.27	22.95	22.67	0.28	11.32	11.46		
Beadle	18	20	40	C	8.02	1.46	2.67	2.11	0.56	26.69	5.64	21.05	4.13	19.53	19.21	34.87
Beadle	19	0	7	U	7.32	1.20	2.82	0.04	2.78	28.15	27.77	0.38	5.00	5.07		
Beadle	19	7	20	U	7.14	1.36	1.10	0.01	1.09	11.01	10.92	0.09	5.19	5.24		
Beadle	19	20	40	U	8.89	1.50	2.85	2.37	0.49	28.53	4.85	23.68	3.63	21.33	13.82	31.63
Beadle	20	0	7	C	6.69	1.39	1.24	0.00	1.24	12.43	12.43	0.00	2.60	2.60		
Beadle	20	7	20	C	7.55	1.43	0.75	0.16	0.59	7.50	5.87	1.63	2.93	3.75		
Beadle	20	20	40	C	8.36	1.46	1.70	1.45	0.25	16.97	2.50	14.47	1.83	12.42	7.36	18.76
Beadle	21	0	7	C	6.81	1.39	2.00	0.02	1.98	20.01	19.82	0.19	4.14	4.18		
Beadle	21	7	20	C	7.35	1.43	0.96	0.04	0.92	9.60	9.22	0.38	4.60	4.79		
Beadle	21	20	40	C	8.19	1.46	2.44	1.75	0.69	24.40	6.92	17.48	5.06	17.86	13.81	26.83
Beadle	22	0	7	U	7.21	1.20	1.67	0.03	1.64	16.67	16.39	0.28	2.95	3.00		
Beadle	22	7	20	U	7.68	1.36	0.80	0.00	0.80	8.00	8.00	0.00	3.81	3.81		
Beadle	22	20	40	U	8.01	1.50	2.43	1.79	0.64	24.29	6.44	17.85	4.81	18.16	11.57	24.96
Beadle	23	0	7	C	6.10	1.39	0.87	0.00	0.87	8.66	8.66	0.00	1.81	1.81		
Beadle	23	7	20	C	6.98	1.43	0.56	0.05	0.51	5.57	5.10	0.47	2.55	2.78		
Beadle	23	20	40	C	8.00	1.46	0.71	0.28	0.43	7.09	4.27	2.82	3.12	5.19	7.48	9.78
Beadle	24	0	7	U	6.67	1.20	1.52	0.00	1.52	15.17	15.17	0.00	2.73	2.73		
Beadle	24	7	20	U	7.20	1.36	1.05	0.02	1.03	10.46	10.27	0.19	4.88	4.98		
Beadle	24	20	40	U	7.67	1.50	0.43	0.06	0.36	4.26	3.63	0.63	2.71	3.18	10.33	10.89
Beadle	25	0	7	C	6.92	1.39	2.28	0.00	2.28	22.77	22.77	0.00	4.76	4.76		
Beadle	25	7	20	C	7.11	1.43	0.64	0.00	0.64	6.39	6.39	0.00	3.19	3.19		
Beadle	25	20	40	C	7.56	1.46	0.35	0.04	0.31	3.50	3.12	0.38	2.28	2.56	10.23	10.51
Beadle	26	0	7	C	7.03	1.39	1.55	0.04	1.52	15.53	15.15	0.38	3.16	3.24		
Beadle	26	7	20	C	7.78	1.43	2.21	1.28	0.93	22.06	9.28	12.78	4.63	11.02		
Beadle	26	20	40	C	8.42	1.46	2.05	1.67	0.38	20.49	3.77	16.72	2.76	14.99	10.56	29.26
Beadle	27	0	7	C	7.50	1.39	2.53	0.33	2.21	25.33	22.07	3.26	4.61	5.29		
Beadle	27	7	20	C	7.83	1.43	1.44	0.45	0.99	14.42	9.91	4.51	4.95	7.20		
Beadle	27	20	40	C	8.09	1.46	1.54	0.92	0.62	15.36	6.15	9.21	4.50	11.24	14.06	23.73

Table 19. Beadle County carbon data (2023)

Sample	Depth(cm)	Depth(cm)	Land use	Bulk Density	Rock %	pH	TC (%)	IC (%)	OC (%)	TC g/kg	OCg/kg	ICg/kg	TC stock kg/m-2	SOC Stock kg/m-2
21-1	0	5	Cultivated	1.41	0.01	6.82	1.76	0.06	1.70	17.63	17.03	0.60	1.23	1.19
21-2	5	15	Cultivated	1.58	0.00	6.78	1.48	0.06	1.42	14.77	14.17	0.60	2.32	2.23
	0-15			1.52	0.01	6.79	1.57	0.06	1.51	15.72	15.12	0.60		
21-3	15	30	Cultivated	1.44	0.00	7.31	0.97	0.05	0.92	9.68	9.20	0.48	2.08	1.98
21-4	30	50	Cultivated	1.37	0.00	8.70	1.90	1.39	0.51	19.02	5.10	13.92	5.21	1.40
	15-50			1.40	0.00	8.10	1.50	0.82	0.69	15.02	6.86	8.16		
21-5	50	75	Cultivated	1.54	0.01	8.97	3.01	2.74	0.27	30.07	2.71	27.36	11.46	1.03
21-6	75	100	Cultivated	1.45	0.00	8.40	2.40	2.21	0.19	24.00	1.92	22.08	8.66	0.69
	50-100			1.49	0.01	8.69	2.70	2.47	0.23	27.04	2.32	24.72		
	Total												30.96	8.52
22-1	0	5	Cultivated	1.71	0.00	5.81	2.79	0.00	2.79	27.91	27.91	0.00	2.38	2.38
22-2	5	15	Cultivated	1.47	0.01	6.48	1.73	0.00	1.73	17.30	17.30	0.00	2.53	2.53
	0-15			1.55	0.01	6.26	2.08	0.00	2.08	20.84	20.84	0.00		
22-3	15	30	Cultivated	1.54	0.01	7.22	1.02	0.07	0.95	10.23	9.51	0.72	2.34	2.18
22-4	30	50	Cultivated	1.47	0.01	8.40	2.10	1.18	0.92	20.98	9.22	11.76	6.11	2.69
	15-50			1.50	0.01	7.89	1.64	0.70	0.93	16.37	9.34	7.03		
22-5	50	75	Cultivated	1.55	0.03	8.26	3.13	2.76	0.37	31.25	3.65	27.60	11.68	1.37
22-6	75	100	Cultivated	1.35	0.00	8.58	2.48	2.21	0.27	24.81	2.73	22.08	8.36	0.92
	50-100			1.45	0.02	8.42	2.80	2.48	0.32	28.03	3.19	24.84		
	Total												33.41	12.06
4-1	0	5	Cultivated	1.23	0.00	6.74	2.08	0.01	2.07	20.78	20.66	0.12	1.28	1.27
4-2	5	15	Cultivated	1.45	0.01	7.30	2.06	0.02	2.04	20.58	20.42	0.16	2.97	2.94
	0-15			1.38	0.00	7.11	2.06	0.01	2.05	20.64	20.50	0.15		
4-3	15	30	Cultivated	1.26	0.02	7.83	2.36	0.07	2.28	23.56	22.84	0.72	4.33	4.19
4-4	30	50	Cultivated	1.20	0.01	7.88	2.49	0.10	2.39	24.90	23.94	0.96	5.88	5.65
	15-50			1.22	0.02	7.86	2.43	0.09	2.35	24.33	23.47	0.86		
4-5	50	75	Cultivated	1.34	0.02	8.13	3.65	3.10	0.55	36.50	5.54	30.96	11.97	1.82
4-6	75	100	Cultivated	1.47	0.07	7.91	2.04	1.80	0.24	20.40	2.40	18.00	6.91	0.81
	50-100			1.40	0.05	8.02	2.85	2.45	0.40	28.45	3.97	24.48		
	Total												33.34	16.70
5-1	0	5	Cultivated	1.53	0.00	5.71	2.01	0.00	2.01	20.13	20.13	0.00	1.54	1.54
5-2	5	15	Cultivated	1.52	0.00	6.78	0.97	0.03	0.94	9.75	9.43	0.32	1.48	1.43
	0-15			1.52	0.00	6.42	1.32	0.02	1.30	13.21	12.99	0.21		
5-3	15	30	Cultivated	1.56	0.00	7.23	0.42	0.03	0.39	4.20	3.88	0.32	0.98	0.90
5-4	30	50	Cultivated	1.49	0.00	7.56	0.40	0.03	0.37	4.02	3.70	0.32	1.20	1.10
	15-50			1.52	0.00	7.42	0.41	0.03	0.38	4.10	3.78	0.32		
5-5	50	75	Cultivated	1.53	0.01	7.60	0.30	0.02	0.28	3.00	2.84	0.16	1.13	1.07
5-6	75	100	Cultivated	1.57	0.07	8.08	1.57	0.91	0.66	15.70	6.58	9.12	5.72	2.40

	50-100			1.55	0.04	7.84	0.94	0.46	0.47	9.35	4.71	4.64		
	Total												12.05	8.45
23-1	0	5	Cultivated	1.64	0.00	6.24	1.20	0.00	1.20	12.05	12.05	0.00	0.99	0.99
23-2	5	15	Cultivated	1.58	0.00	4.95	0.96	0.00	0.96	9.57	9.57	0.00	1.51	1.51
	0-15			1.60	0.00	5.38	1.04	0.00	1.04	10.40	10.40	0.00		
23-3	15	30	Cultivated	1.60	0.00	6.05	0.82	0.00	0.82	8.23	8.23	0.00	1.98	1.98
23-4	30	50	Cultivated	1.53	0.00	6.66	0.61	0.00	0.61	6.08	6.08	0.00	1.85	1.85
	15-50			1.56	0.00	6.40	0.70	0.00	0.70	7.00	7.00	0.00		
23-5	50	75	Cultivated	1.33	0.01	7.96	0.52	0.05	0.48	5.24	4.76	0.48	1.73	1.57
23-6	75	100	Cultivated	1.39	0.04	8.18	1.54	1.10	0.43	15.37	4.33	11.04	5.12	1.44
	50-100			1.36	0.03	8.07	1.03	0.58	0.45	10.31	4.55	5.76		
	Total												13.17	9.34
19-1	0	5	Pasture	1.21	0.00	6.97	4.18	0.11	4.07	41.81	40.73	1.08	2.53	2.46
19-2	5	15	Pasture	1.21	0.01	7.21	2.96	0.01	2.95	29.57	29.45	0.12	3.56	3.54
	0-15			1.21	0.00	7.13	3.37	0.04	3.32	33.65	33.21	0.44		
19-3	15	30	Pasture	1.15	0.01	7.87	2.09	0.34	1.75	20.90	17.54	3.36	3.59	3.01
19-4	30	50	Pasture	1.21	0.02	8.31	3.40	2.26	1.14	33.96	11.40	22.56	8.05	2.70
	15-50			1.19	0.02	8.12	2.84	1.43	1.40	28.36	14.03	14.33		
19-5	50	75	Pasture	1.38	0.05	8.61	3.19	2.64	0.55	31.87	5.47	26.40	10.46	1.80
19-6	75	100	Pasture	1.35	0.05	8.32	2.49	1.99	0.50	24.90	4.98	19.92	7.99	1.60
	50-100			1.37	0.05	8.47	2.84	2.32	0.52	28.38	5.22	23.16		
	Total												36.18	15.11
17-1	0	5	Pasture	0.93	0.00	5.66	6.16	0.00	6.16	61.61	61.61	0.00	2.87	2.87
17-2	5	15	Pasture	1.40	0.00	6.19	1.22	0.00	1.22	12.24	12.24	0.00	1.71	1.71
	0-15			1.24	0.00	6.01	2.87	0.00	2.87	28.70	28.70	0.00		
17-3	15	30	Pasture	1.57	0.00	6.84	0.66	0.01	0.65	6.62	6.50	0.12	1.56	1.53
17-4	30	50	Pasture	1.55	0.00	7.22	0.40	0.04	0.37	4.05	3.69	0.36	1.25	1.14
	15-50			1.56	0.00	7.06	0.52	0.03	0.49	5.15	4.89	0.26		
17-5	50	75	Pasture	1.52	0.00	7.82	0.28	0.05	0.23	2.78	2.30	0.48	1.05	0.87
17-6	75	100	Pasture	1.80	0.03	7.62	1.90	1.42	0.49	19.02	4.86	14.16	8.30	2.12
	50-100			1.66	0.02	7.72	1.09	0.73	0.36	10.90	3.58	7.32		
	Total												16.75	10.25
24-1	0	5	Cultivated	1.18	0.00	6.45	2.04	0.00	2.04	20.37	20.37	0.00	1.21	1.21
24-2	5	15	Cultivated	1.50	0.00	5.96	1.51	0.00	1.51	15.13	15.13	0.00	2.26	2.26
	0-15			1.39	0.00	6.12	1.69	0.00	1.69	16.87	16.87	0.00		
24-3	15	30	Cultivated	1.46	0.00	6.59	1.06	0.00	1.06	10.55	10.55	0.00	2.31	2.31
24-4	30	50	Cultivated	1.51	0.00	6.98	0.75	0.04	0.71	7.45	7.09	0.36	2.24	2.13
	15-50			1.49	0.00	6.81	0.88	0.02	0.86	8.78	8.58	0.21		
24-5	50	75	Cultivated	1.48	0.00	7.29	0.43	0.02	0.40	4.28	4.04	0.24	1.58	1.49
24-6	75	100	Cultivated	1.49	0.00	8.26	0.65	0.58	0.07	6.46	0.70	5.76	2.40	0.26
	50-100			1.48	0.00	7.78	0.54	0.30	0.24	5.37	2.37	3.00		
	Total												12.00	9.66
16-1	0	5	Cultivated	1.49	0.01	7.64	1.67	0.05	1.62	16.68	16.20	0.48	1.23	1.20

16-2	5	15	Cultivated	1.52	0.01	8.14	1.58	0.19	1.39	15.85	13.93	1.92	2.39	2.10
	0-15			1.51	0.01	7.97	1.61	0.14	1.47	16.12	14.68	1.44		
16-3	15	30	Cultivated	1.45	0.00	8.25	2.32	1.15	1.17	23.22	11.70	11.52	5.05	2.54
16-4	30	50	Cultivated	1.22	0.00	8.53	3.55	3.00	0.55	35.51	5.51	30.00	8.67	1.34
	15-50			1.32	0.00	8.41	3.02	2.21	0.82	30.24	8.16	22.08		
16-5	50	75	Cultivated	1.17	0.00	8.55	2.82	2.54	0.27	28.19	2.75	25.44	8.25	0.80
16-6	75	100	Cultivated	1.38	0.02	8.65	2.60	2.06	0.54	26.01	5.37	20.64	8.83	1.82
	50-100			1.28	0.01	8.60	2.71	2.30	0.41	27.10	4.06	23.04		
	Total												34.42	9.81
26-1	0	5	Cultivated	1.45	0.00	6.50	3.31	0.00	3.31	33.11	33.11	0.00	2.40	2.40
26-2	5	15	Cultivated	1.31	0.01	5.94	2.17	0.00	2.17	21.72	21.72	0.00	2.82	2.82
	0-15			1.36	0.01	6.13	2.55	0.00	2.55	25.52	25.52	0.00		
26-3	15	30	Cultivated	1.43	0.00	7.23	1.19	0.01	1.18	11.92	11.80	0.12	2.56	2.53
26-4	30	50	Cultivated	1.42	0.00	8.48	2.22	0.94	1.28	22.20	12.84	9.36	6.28	3.63
	15-50			1.43	0.00	7.94	1.78	0.54	1.24	17.79	12.39	5.40		
26-5	50	75	Cultivated	1.55	0.02	8.69	3.14	2.52	0.62	31.39	6.19	25.20	11.98	2.36
26-6	75	100	Cultivated	1.65	0.01	8.87	2.52	1.97	0.55	25.18	5.50	19.68	10.23	2.24
	50-100			1.60	0.01	8.78	2.83	2.24	0.58	28.29	5.85	22.44		
	Total												36.26	15.97
18-1	0	5	Cultivated	0.98	0.00	7.09	1.85	0.11	1.74	18.52	17.44	1.08	0.91	0.85
18-2	5	15	Cultivated	1.56	0.01	6.35	1.53	0.00	1.53	15.29	15.29	0.00	2.36	2.36
	0-15			1.36	0.01	6.60	1.64	0.04	1.60	16.37	16.01	0.36		
18-3	15	30	Cultivated	1.50	0.01	6.72	1.03	0.05	0.98	10.30	9.82	0.48	2.31	2.20
18-4	30	50	Cultivated	1.39	0.01	8.19	1.35	0.72	0.63	13.46	6.26	7.20	3.71	1.72
	15-50			1.44	0.01	7.56	1.21	0.43	0.78	12.11	7.79	4.32		
18-5	50	75	Cultivated	1.39	0.02	8.57	2.63	2.47	0.16	26.29	1.57	24.72	8.93	0.53
18-6	75	100	Cultivated	1.51	0.04	8.72	2.33	2.04	0.29	23.27	2.87	20.40	8.49	1.05
	50-100			1.45	0.03	8.65	2.48	2.26	0.22	24.78	2.22	22.56		
	Total												26.69	8.71
3-1	0	5	Pasture	1.29	0.00	6.52	3.69	0.00	3.69	36.89	36.89	0.00	2.39	2.39
3-2	5	15	Pasture	1.31	0.01	6.85	1.77	0.01	1.76	17.74	17.62	0.12	2.30	2.29
	0-15			1.30	0.01	6.74	2.41	0.01	2.40	24.12	24.04	0.08		
3-3	15	30	Pasture	1.36	0.00	6.99	1.38	0.02	1.36	13.80	13.56	0.24	2.82	2.77
3-4	30	50	Pasture	1.53	0.01	8.22	1.82	0.12	1.70	18.24	17.04	1.20	5.54	5.17
	15-50			1.46	0.01	7.69	1.63	0.08	1.55	16.34	15.55	0.79		
3-5	50	75	Pasture	1.40	0.02	8.57	2.48	1.61	0.87	24.80	8.72	16.08	8.49	2.98
3-6	75	100	Pasture	1.61	0.01	8.66	1.56	0.22	1.34	15.60	13.44	2.16	6.17	5.32
	50-100			1.50	0.02	8.62	2.02	0.91	1.11	20.20	11.08	9.12		
	Total												27.70	20.91
2-1	0	5	Pasture	0.97	0.00	6.92	5.02	0.01	5.01	50.18	50.06	0.12	2.42	2.42
2-2	5	15	Pasture	1.25	0.00	7.12	2.38	0.03	2.35	23.84	23.52	0.32	2.97	2.93
	0-15			1.15	0.00	7.05	3.26	0.03	3.24	32.62	32.37	0.25		
2-3	15	30	Pasture	1.28	0.00	8.31	1.98	0.12	1.86	19.81	18.61	1.20	3.81	3.58

2-4	30	50	Pasture	1.33	0.00	8.49	1.88	0.26	1.62	18.80	16.16	2.64	4.98	4.28
	15-50			1.31	0.00	8.41	1.92	0.20	1.72	19.23	17.21	2.02		
2-5	50	75	Pasture	1.46	0.00	8.79	2.94	2.11	0.83	29.40	8.28	21.12	10.72	3.02
2-6	75	100	Pasture	1.36	0.00	8.91	2.61	1.94	0.67	26.10	6.66	19.44	8.87	2.26
	50-100			1.41	0.00	8.85	2.78	2.03	0.75	27.75	7.47	20.28		
	Total												33.77	18.49
14-1	0	5	Cultivated	1.15	0.00	7.87	2.97	0.08	2.89	29.75	28.95	0.80	1.71	1.66
14-2	5	15	Cultivated	1.51	0.01	8.22	2.51	0.10	2.42	25.15	24.19	0.96	3.77	3.62
	0-15			1.39	0.01	8.10	2.67	0.09	2.58	26.68	25.78	0.91		
14-3	15	30	Cultivated	1.55	0.04	8.43	1.89	0.17	1.72	18.92	17.24	1.68	4.21	3.84
14-4	30	50	Cultivated	1.69	0.06	8.40	1.63	0.19	1.44	16.33	14.41	1.92	5.22	4.61
	15-50			1.63	0.05	8.41	1.74	0.18	1.56	17.44	15.62	1.82		
14-5	50	75	Cultivated	1.50	0.02	8.44	1.68	1.25	0.44	16.84	4.36	12.48	6.17	1.60
14-6	75	100	Cultivated	1.66	0.03	8.58	1.89	1.06	0.84	18.94	8.38	10.56	7.67	3.40
	50-100			1.58	0.02	8.51	1.79	1.15	0.64	17.89	6.37	11.52		
	Total												28.75	18.72
15-1	0	5	Pasture	0.89	0.00	6.83	4.43	0.01	4.42	44.29	44.17	0.12	1.98	1.97
15-2	5	15	Pasture	1.08	0.00	7.02	3.20	0.01	3.18	31.95	31.83	0.12	3.44	3.43
	0-15			1.02	0.00	6.96	3.61	0.01	3.59	36.06	35.94	0.12		
15-3	15	30	Pasture	1.13	0.00	7.31	1.73	0.06	1.67	17.30	16.66	0.64	2.93	2.82
15-4	30	50	Pasture	1.38	0.01	8.40	2.61	1.39	1.22	26.11	12.19	13.92	7.16	3.34
	15-50			1.27	0.01	7.93	2.23	0.82	1.41	22.33	14.10	8.23		
15-5	50	75	Pasture	1.49	0.02	8.57	3.62	2.42	1.19	36.18	11.94	24.24	13.21	4.36
15-6	75	100	Pasture	1.52	0.03	8.61	2.56	1.82	0.74	25.60	7.36	18.24	9.48	2.72
	50-100			1.51	0.02	8.59	3.09	2.12	0.96	30.89	9.65	21.24		
	Total												38.20	18.65
10-1	0	5	Pasture	1.01	0.00	6.37	4.14	0.00	4.14	41.40	41.40	0.00	2.08	2.08
10-2	5	15	Pasture	1.40	0.00	5.87	2.05	0.00	2.05	20.50	20.50	0.00	2.88	2.88
	0-15			1.27	0.00	6.04	2.75	0.00	2.75	27.47	27.47	0.00		
10-3	15	30	Pasture	1.37	0.00	6.78	1.21	0.01	1.20	12.10	11.98	0.12	2.49	2.46
10-4	30	50	Pasture	1.36	0.00	8.02	1.03	0.07	0.96	10.30	9.58	0.72	2.80	2.60
	15-50			1.36	0.00	7.49	1.11	0.05	1.06	11.07	10.61	0.46		
10-5	50	75	Pasture	1.47	0.00	8.04	1.09	0.50	0.59	10.90	5.86	5.04	4.01	2.16
10-6	75	100	Pasture	1.58	0.00	8.35	2.68	2.21	0.47	26.80	4.72	22.08	10.59	1.86
	50-100			1.53	0.00	8.20	1.89	1.36	0.53	18.85	5.29	13.56		
	Total												24.85	14.05
13-1	0	5	Cultivated	1.16	0.00	5.82	4.43	0.00	4.43	44.30	44.30	0.00	2.58	2.58
13-2	5	15	Cultivated	1.32	0.00	6.35	2.95	0.00	2.95	29.50	29.50	0.00	3.89	3.89
	0-15			1.27	0.00	6.17	3.44	0.00	3.44	34.43	34.43	0.00		
13-3	15	30	Cultivated	1.35	0.00	6.48	1.49	0.00	1.49	14.90	14.90	0.00	3.01	3.01
13-4	30	50	Cultivated	1.53	0.00	7.17	0.84	0.04	0.80	8.40	8.04	0.36	2.58	2.46
	15-50			1.45	0.00	6.87	1.12	0.02	1.10	11.19	10.98	0.21		
13-5	50	75	Cultivated	1.64	0.00	8.37	2.78	1.18	1.60	27.80	16.04	11.76	11.38	6.56

13-6	75	100	Cultivated	1.55	0.00	8.47	2.78	1.97	0.81	27.80	8.12	19.68	10.77	3.15
	50-100			1.59	0.00	8.42	2.78	1.57	1.21	27.80	12.08	15.72		
	Total												34.21	21.66
27-1	0	5	Cultivated	1.02	0.00	7.12	2.58	0.01	2.57	25.80	25.68	0.12	1.31	1.31
27-2	5	15	Cultivated	1.13	0.00	7.42	1.89	0.00	1.89	18.90	18.90	0.00	2.13	2.13
	0-15			1.09	0.00	7.32	2.12	0.00	2.12	21.20	21.16	0.04		
27-3	15	30	Cultivated	1.28	0.00	8.07	1.19	0.10	1.09	11.90	10.94	0.96	2.29	2.11
27-4	30	50	Cultivated	1.32	0.00	8.48	3.28	2.35	0.93	32.80	9.28	23.52	8.66	2.45
	15-50			1.30	0.00	8.30	2.38	1.39	1.00	23.84	9.99	13.85		
27-5	50	75	Cultivated	1.22	0.00	8.45	3.93	2.81	1.12	39.30	11.22	28.08	11.96	3.41
27-6	75	100	Cultivated	1.41	0.00	8.43	2.05	2.02	0.03	20.50	0.34	20.16	7.21	0.12
	50-100			1.31	0.00	8.44	2.99	2.41	0.58	29.90	5.78	24.12		
	Total												33.56	11.53
8-1	0	5	Cultivated	1.24	0.00	5.79	2.97	0.00	2.97	29.70	29.70	0.00	1.85	1.85
8-2	5	15	Cultivated	1.24	0.00	5.34	2.16	0.00	2.16	21.60	21.60	0.00	2.69	2.69
	0-15			1.24	0.00	5.49	2.43	0.00	2.43	24.30	24.30	0.00		
8-3	15	30	Cultivated	1.35	0.00	6.67	1.26	0.00	1.26	12.60	12.60	0.00	2.55	2.55
8-4	30	50	Cultivated	1.35	0.00	7.87	0.93	0.14	0.79	9.30	7.86	1.44	2.52	2.13
	15-50			1.35	0.00	7.36	1.07	0.08	0.99	10.71	9.89	0.82		
8-5	50	75	Cultivated	1.41	0.00	8.29	2.51	2.02	0.49	25.10	4.94	20.16	8.82	1.74
8-6	75	100	Cultivated	1.40	0.00	8.51	2.66	2.35	0.31	26.60	3.08	23.52	9.29	1.08
	50-100			1.40	0.00	8.40	2.59	2.18	0.40	25.85	4.01	21.84		
	Total												27.70	12.02
1-1	0	5	Cultivated	1.18	0.00	5.62	3.28	0.00	3.28	32.80	32.80	0.00	1.94	1.94
1-2	5	15	Cultivated	1.36	0.00	5.97	2.30	0.00	2.30	23.00	23.00	0.00	3.12	3.12
	0-15			1.30	0.00	5.85	2.63	0.00	2.63	26.27	26.27	0.00		
1-3	15	30	Cultivated	1.36	0.00	6.91	1.50	0.01	1.49	15.00	14.88	0.12	3.06	3.04
1-4	30	50	Cultivated	1.37	0.00	7.70	1.89	0.85	1.04	18.90	10.42	8.48	5.18	2.86
	15-50			1.37	0.00	7.36	1.72	0.49	1.23	17.23	12.33	4.90		
1-5	50	75	Cultivated	1.51	0.00	8.68	2.73	2.57	0.16	27.30	1.62	25.68	10.29	0.61
1-6	75	100	Cultivated	1.51	0.00	8.76	2.30	1.99	0.31	23.00	3.08	19.92	8.66	1.16
	50-100			1.51	0.00	8.72	2.52	2.28	0.24	25.15	2.35	22.80		
	Total												32.26	12.73

APPENDIX C. SOIL DESCRIPTIONS

Soil Description Abbreviations

Boundary

A: abrupt

C: clear

D: diffuse

G: gradual

Redoximorphic features

C: common

F: few

M: many

Ped/void features and carbonates

CAM: carbonate masses

CAN: carbonate nodules

CLF: clay films

FDC: finely disseminated carbonates

NE: not effervescent

OSF: organic staining

ST: strongly effervescent

VE: violently effervescent

Structure

ABK: angular blocky

FI: firm

FR: friable

GR: granular

MA: massive

PL: platy

SBK: sub-angular blocky

VFI: very firm

VFR: very friable

<u>Texture</u>

C: clay

fs: fine sand

fsl: fine sandy loam

L: loam

LS: loamy sand

S: sand

Scl: sandy clay loam

Si: silt

Sic: silty clay

Sicl: silty clay loam

Sil: silt loam

SL: sandy loam

Table 20. Soil descriptions from 1926

Horizon depth (IN)	Texture	Color	Structure	Notes/Additional Info
1926-2				
0 to 12	FSL			surface 14-16" aeolian
12 to 20		lighter brown		Transitional, pebbles pick up around 16"
20 to 26				Typical Barnes subsoil, Till w/ occasional pebbles/gravel
26+				accum of CaCO3
1926-10				
0 to 17	SiL	dark brown		
17 to 22 or 23	SiL "heavier"	lighter brown		faint dark brown mottling
23 to 40		yellow		CaCO3 @ 22 to 30
1926-12				
0 to 18	SiL	dark brown		Low ground, gentle slope
18 to 26	not heavier than above or below	brown		slightly mottled w/gray/dark, accum of gypsum,
26 to 40	Si	yellowish subsoil		CaCO3 @30
1926-13				
0 to 8	SiL	brown		
8 to 20		light brown		
20 to 36		yellowish		
36 to 50	SL	yellowish brown		eff. @42
50 to 72	SiL	mottled gray,yellow,red (hematite), green		Visible CaCO3 not present
72+				Till
1926-16				
0 to 9	L/SiL	dark brown		
9 to 12		lighter brown		transitional?
12 to 20	SL	yellowish brown		eff @63.5cm
20 to 27				pebbles and sand mixed
27+				gravel? Sand?
1926-17				
0 to 1 1/2	SiL	brown		dust/mulch blown from field
1 1/2 to 4	SiL	brown	structureless	
4 to 11	SiL	brown	coarse granular	
11 to 22	Si w/ FS	light brown	granular, larger than above	transitional
22 to 30	SiL w/FS	light brown		darker material in vertical, no Eff.
30 to 57	SiL w/FS	yellowish gray	no structure	
57 to 66	gravel, sand , pebbles			till

1926-18				
0 to 2 1/2	SL or SiL w/FS	dark brown		
2 1/2 to 8	SiL "slightly heavier"	darker brown		
8 to 23	SiL "slightly heavier than overlying"	brown		occasional gravel
23 to 47	L w/ clay	yellowish gray		layer of CaCO3
47 to 66	SIC	yellowish		no CaCO3
1926-19				
0 to 2				sod
2 to 8				
8 to 14				
14 to 20				
20 to 26				CaCO3 @25
26 to 32				
32 to 48				

Table 21. Soil descriptions from 1955

1955-2								
Horizon	Upper Depth (in)	Lower Depth (in)	Dry color	Moist color	Texture	Structure	Consistence	Reaction
A1	0	8	10YR 4/1.5	10YR 2/1		cloddy		0
B21	8	18	10YR 4/1.5	10YR 2/2		2b11 > 2bt		0
B22	18	32	2.5Y 6/2.5	1Y 4/2		2b11 > 2bt		0
Cca	32	48	2.5Y 7/2.5	2.5Y 5/2.5		Ma		3 X 2
C-D	48	54	2.5Y 7/2.5	2.5Y 5/2.5		Ma - Sq		3 x 1
D1	54	60	10YR 5/3		Sand/gravel	Sq		3

1955-5								
Horizon	Upper Depth (in)	Lower Depth (in)	Dry color	Moist color	Texture	Structure	Consistence	Reaction
A1p	0	8	10YR 3/1	10YR 2/1		cloddy	fr	0
B21	8	13	10YR 3/1, 2.5Y 5/2	1Y 2/0, 2.5Y 4/3		v1b11 > 2bt		0
B22	13	18	2.5Y 5/2.5	2.5Y 4/3		v1b11 > 2bt		0
Cca	18	40	2.5Y 7/3	2.5Y 5/3		v1b11 > Ma		3x2
C	40	60	2.5Y 6/3 7/0, 10YR 5/8	2.5Y 5/2.5 6/0, 10YR 5/8		Ma		2x1

1955-7								
Horizon	Upper Depth (in)	Lower Depth (in)	Dry color	Moist color	Texture	Structure	Consistence	Reaction
A1p	0	5	10YR 4/1.5	10YR 3/1	SiCL	Cloddy	Fri	0
A1 B21	5	8		10YR 3/2	SiCL	11b2		0
B22	8	19		10YR 3/3	SiCL	11b2 > 1b2		0
B23	19	40		10YR 4/3	SiL/SiCL	11C1>C1>11b1>b1		0
Cca	40	48	10YR 6/4	2.5YR 5/4	SiL	11C1/4 Ma		
C	48	60			Si	Ma		1 X 1 + 3

1955-8								
Horizon	Upper Depth (in)	Lower Depth (in)	Dry color	Moist color	Texture	Structure	Consistence	Reaction
A1	0	6	10YR 4/1.5	10YR 2.5/2	SiCL	Cloddy	Fri	0
A1B2	6	17	10YR 4/2	10YR 2/2	SiCL	ab2		0
B2	17	25		10YR 4/2	SiCL	11b1		0
Cca	25	56		10YR 4/3	SiCL	Ma		3 X 2
D	56							

1955-9								
Horizon	Upper Depth (in)	Lower Depth (in)	Dry color	Moist color	Texture	Structure	Consistence	Reaction
A1p	0	6	10YR 4.5/2	10YR 2/2	SiCL	cloddy	Fri	0
A1p B2	6	9	10YR 3/1.5	10YR 2.5/2	SiCL	cloddy + ab12		0
B21 A1	9	16		10YR 3/2	SiCL	11b12 > ab12		0
B22	16	24		10YR 3/3	SiCL	11b21 > ab21		0
B23	24	33		10YR 3.5/3	SiCL	11b12 > b1		0
Cca	33	40		10YR 4.5/3	SiL	Ma		3 X 1
C	40	60		1Y 5/3	SiL	Ma		

Table 22. Soil descriptions from 2023

Site	Location	Position	Map unit	Notes												
2-1	Moody															
Horizon	Depth	Boundry	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	15CM			4D	1D											
Ap1	6IN	A	10YR	3M	1M	SBK-1	VFR	SiL	30	15	0				NE	
	28CM			3D	1D											
Ap2	11IN	A	10YR	2M	1M	SBK-2/PL-2	FR	SiL	22	16	0				NE	platy at boundary
	44cm			5D	2D											
Bw	17.5in	C	10YR	4M	2M	SBK-2	FR	SiL	23	18	0	F1			NE	
	57cm			5D	3D											
Btk1	22.5in	C	10YR	4M	3M	SBK-2	FR	SIL	25	24	3	F2	F2	CAM, FDC,CLF	ST	stones increase
	86cm			5D	3D											
Btk2	34in	C	10YR	4M	3M	PR-2	FI	SICL	18	29	5	C2	F2	CAM, CLF	VE	
	107cm			5D	4D											
Btk3	42in	C	10YR	5M	4M	SBK-1	FI	SICL	15	31	8	C3	C3	CAM, CLF	ST	
	107+cm			5D	4D											
BC	42+in		10YR	5M	3M	MA	VFI	SICL	15	31	5	M3	M3	FDC	ST	

Site	Location	Position	Map unit	Notes												
2-2	Moody															
Horizon	Depth	Boundry	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	11cm			4D	2D											
Ap1	4.5in	C	10YR	2M	2M	SBK-1	VFR	L	37	15	0				NE	
	26cm			3D	1D											
Ap2	10in	A	10YR	2M	1M	SBK-2/PL-2	FR	SIL	30	18	0				NE	
	46cm			4D	2D											
Bw	18in	C	10YR	3M	2M	SBK-2	FR	SIL	25	21	3	F1			NE	
	62cm			5D	2D											
Btk1	24.5in	C	10YR	4M	3M	SBK-2	VFR	SICL	18	29	2	F1	F2	FDC,CLF	SL	
	81cm			5D	2D											
Btk2	32in	C	10YR	5M	3M	PR-2	FR	SICL	18	32	2	C1	C1	CLF,CAM	VE	
	105cm			5D	2D											
Btk3	41in	C	10YR	5M	4M	SBK-2	FI	SICL	17	33	3	C2	C2	CAM,CLF	VE	
	137cm			6D	4D											
Btk4	54in	C	10YR	5M	4M	SBK-2	FI	CL	22	35	7	C2	C2	CAM,CLF	ST	
	137+cm			6D	3D											
BC	54+in		10YR	6M	4M	MA	FI	CL	21	36	6	M2	M2	CAM,CLF	SL	

Site	Location	Position	Map unit	Notes												
2-3	Moody															
Horizon	Depth	Boundry	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	12cm			3D	1D											
Ap1	4.75in	C	10YR	2M	1M	SBK-1	VFR	L	35	17	0				NE	
	29cm			3D	1D											
Ap2	11.5in	A	10YR	2M	1M	SBK-2	FR	SIL	28	18	0				NE	
	42cm			4D	2D											
Bw	16.2in	C	10YR	3M	2M	SBK-2	VFR	SIL	25	21	1	F1	F1		NE	
	60cm			5D	2D											
Btk1	24in	C	10YR	4M	2M	SBK-2	VFR	SICL	15	28	10	C1	F1	CAM,CLF	ST	CLAY FILMS FAINT
	97cm			5D	4D											
Btk2	38in	C	10YR	4M	4M	SBK-2	FR	SICL	18	31	2	C2	C3	CLF,CAM	VE	
	121cm			5D	6D											
Btk3	48in	C	10YR	5M	6M	SBK-2	FR	CL	40	30	3	C2	C2	CLF,CAM	ST	POCKETS OF SAND
	121+cm			6D	3D											
C	48+in		10YR	5M	3M	MA	VFI	CL	25	35	5	C3	C3	FDC	SL	
	cm			D	D											
	in			M	M											

Site	Location	Position	Map unit	Notes												
2-4	Moody															
Horizon	Depth	Boundry	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	10cm			3D	2D											
Ap1	4in	C	10YR	3M	1M	SBK-1	VFR	SIL	30	16					NE	
	30cm			3D	1D											
Ap2	11.5in	A	10YR	2M	1M	SBK-2/PL-1	FR	SIL	25	18		F1	F1		NE	
	41cm			5D	2D											
Bw	16in	C	10YR	4M	2M	SBK-2	VFR	SIL	27	21		F1	F1		NE	
	62cm			5D	3D											
2Btk1	24.5in	G	10YR	5M	2M	SBK-2	VFR	CL	25	32		F1	F1	FDC,CLF	ST	
	102cm			6D	4D											
2Btk2	40in	G	10YR	5M	4M	SBK-2	FI	SICL	18	29		C2	C2	CAM,CLF	VE	
	102+cm			6D	4D											
2Btk3	40+in		10YR	5M	4M	SBK-2	VFI	CL	21	30		M3	M3	CLF,CAM	ST	

Site	Location	Position	Map unit	Notes												
2-5	Moody															
Horizon	Depth	Boundry	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	26cm			3D	1D											
Ap	10in	A	10YR	2M	1M	SBK-1/PL-1	VFR	SIL	30	15					NE	MIXING AT BOUNDARY
	42cm			5D	2D											
Bw	16.5in	C	10YR	4M	2M	SBK-2	VFR	SIL	25	17		F1	F1	FDC	ST	
	63cm			5D	3D											
Btk1	26in	C	10YR	4M	3M	SBK-2	FR	SICL	15	29	1	C2	C2	CAM,CLF	VE	
	73cm			6D	2D											
Btk2	29in	C	2.5Y	5M	2M	SBK-2	FI	CL	35	31	1	RMX?		FDC, CLF?	SL	GLEYED? Btkg?
	100cm			6D	3D											
Btk3	39.5in	G	10YR	5M	3M	SBK-1/PR-1	FR	SICL	18	30	3	C2	C2	CLF,CAM	ST	
	100+cm			6D	4D											
Btk4	39.5+in		10YR	5M	4M	SBK-2	FI	CL	23	32	6	C2	C2	CAM,CLF	ST	

Site	Location	Position	Map unit	Notes												
2-6	Moody															
Horizon	Depth	Boundry	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	15cm			3D	2D											
Ap1	6in	A	10YR	2M	1M	SBK-1	VFR	L	40	15	0				NE	
	31cm			3D	1D											
Ap2	12.5in	A	10YR	2M	1M	PL-2	FR	SIL	34	16	0				NE	
	53cm			4D	2D											
Btk	21in	C	10YR	3M	2M	SBK-2	FR	L	45	22	2	F1		FDC,CLF	SL	
	78cm			5D	2D											
2Btk	30.5in	C	10YR	4M	2M	SBK-1	VFR	SL	65	15	3	F1	F1	FDC/CAM,BRF	VE	SAND TEXTURE CHANGE
	91cm			5D	3D											
3Btk1	36in	C	10YR	5M	2M	SBK-2	FR	CL	30	33	5	C2	C2	CLF,CAM	VE	
	91+cm			5D	4D											
3Btk2	36+in		10YR	5M	4M	SBK-2	FI	CL	27	35	5	M2	M2	CLF,CAM	ST	

Site	Location	Position	Map unit	Notes												
2-7	Moody															
Horizon	Depth	Boundry	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	22cm			3D	1D											
Ap	8.5in	A	10YR	2M	1M	SBK-2/PL-1	VFR	SIL	28	17	3				NE	
	41cm			4D	2D											
Bw	16in	C	10YR	3M	2M	SBK-2	VFR	L	35	20	2	F1	F1		NE	
	59cm			5D	3D											
Btk1	22.5in	C	10YR	4M	3M	SBK-2	VFR	CL	25	30	2	C2	C2	CAM/FDC, CLF	ST	MASSES AT 49CM
	102cm			6D	3D											
Btk2	40in	C	10YR	5M	3M	SBK-2	FR	CL	23	33	4	C2	C2	CAM,CLF	VE	
	128cm			6D	4D											
2Btk	50.5in	C	10YR	5M	4M	SBK-2	VFR	SCL	50	25	0	F1	F1	CLF,FDC	ST	SANDY POCKET
	128+cm			6D	4D											
3Bk	50.5+in		10YR	5M	4M	SBK-1	FR	CL	35	28	0	F1	C2	FDC	ST	

Site	Location	Position	Map unit	Notes												
2-8	Moody															
Horizon	Depth	Boundry	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	23cm			4D	1D											
Ap	9in	A	10YR	2M	1M	SBK-2/PL-1	FR	L	35	18	2				NE	
	46cm			5D	3D											
Bw	18in	G	10YR	4M	3M	SBK-2	VFR	L	45	17	0	F1			NE	
	84cm			6D	3D											
Bk	33in	C	10YR	5M	3M	SBK-2	VFR	L	48	18	2	C2	C2	FDC	ST	
	110cm			6D	4D											
2Btk1	43in	C	10YR	5M	4M	SBK-2	VFR	SCL	55	24	0	C3	C3	BRF,FDC	ST	
	121cm			5D	3D											
2Btk2	47.5in	C	10YR	4M	4M	SBK-1	VFR	FSL	60	17	1	C1	C1	CAM,BRF,CLF	VE	
	121+cm			6D	3D											
2Btk3	47.5+in		10YR	5M	4M	SBK-1	VFR	FLS	80	9	0	C3	C3	FDC,BRF	ST	

Site	Location	Position	Map unit	Notes												
2-9	Moody															
Horizon	Depth	Boundry	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	12cm			4D	1D											
Ap1	5in	A	10YR	3M	1M	SBK-1/GR-1	VFR	L	35	18	0				NE	
	29cm			3D	1D											
Ap2	11.5in	A	10YR	2M	1M	SBK-1/PL-1	FR	SIL	30	18	0				NE	
	40cm			4D	3D											
Bw1	16in	C	10YR	4M	2M	SBK-2	VFR	SIL	34	17	1	F1	F1		NE	
	50cm			5D	3D											
Bw2	19.5in	C	10YR	4M	3M	SBK-2	VFR	L	40	15	2	F1	F1		NE	
	88cm			5D	4D											
2Bk	34.5in	C	10YR	5M	3M	SBK-1	VFR	LS	80	10	3	F1	F1	FDC	ST	HUGE SAND INCREASE
	88+cm			5D	4D											
3C	34.5+in		2.5Y	6M	4M	MA	VFI	CL	30	38	7	C2	C3	CAM	VE	DENSE CLAY

Site	Location	Position	Map unit	Notes
2-10	Moody			

Horizon	Depth	Boundry	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	17cm			3D	1D											
Ap	6.5in	A	10YR	2M	2M	SBK-1/PL-1	VFR	L	40	15	0				NE	
	38cm			4D	3D											
Bw	15in	C	10YR	4M	2M	SBK-2	VFR	L	45	16	0			OSF	NE	
	74cm			5D	3D											
Btk1	29in	C	10YR	5M	3M	SBK-2	FR	SICL	18	28	2	F1		FDC/CAM,CLF	VE	CAM AT 41CM, CLAY INCREASE, SAND DECREASE
	95cm			6D	3D											
Btk2	37.5in	C	10YR	5M	4M	SBK-2	FI	CL	28	33	4	C2	C2	CAM,CLF	VE	INCREASE IN REDOX, SAND POCKETS
	119cm			6D	4D											
Btk3	47in	C	10YR	5M	4M	SBK-2	FI	CL	24	32	2	C2	C3	CAM,CLF	VE	INCREASE REDOX/CAM
	119+cm			5D	4D											
C	47in		2.5Y	5M	4M	MA	FI	CL	25	34	3	C2	C3	CAM	ST	DECREASE CAM

Site	Location	Position	Map unit	Notes
2-11	Moody			

Horizon	Depth	Boundry	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	15cm			3D	2D											
Ap1	6in	A	10YR	2M	2M	SBK-1	VFR	L	35	18	0				NE	
	33cm			3D	1D											
Ap2	13in	A	10YR	2M	1M	SBK-2/PL-1	VFR	SIL	33	15	0				NE	
	55cm			4D	2D											
Bt	22in	C	10YR	3M	2M	SBK-2	FR	L	45	20	1	F1		CLF,BRF	NE	
	71cm			4D	3D											
2Btk1	28in	C	10YR	3M	3M	SBK-2	VFR	COSL	60	17	2	F1		CLF,BRF,FDC	SL	
	106cm			5D	3D											
2Btk2	41.5in	C	10YR	4M	4M	SBK-2	FR	SL	55	19	3	F1	F1	CLF,BRF,FDC,CAM	VE	
	106+cm			6D	4D											
2C	41.5+in		10YR	5M	4M	SBK-1	VFR	LS	80	8	0	F1	F1		SL	

Site	Location	Position	Map unit	Notes												
12-1																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	19cm			3D	1D											
Ap	7.5in	A	10YR	2M	1M	SBK-2 F/PL-2M	FR	SICL	8	31	0				NE	
	30cm			4D	1D											
Bw	12in	G	10YR	3M	1M	SBK-2 M	VFR	SICL	7	30	0	F1	F1		NE	
	49cm			5D	2D											
Bk1	19.5in	G	10YR	4M	2M	SBK-2 M	FR	SICL	10	28	0	F1	F1	FDC, OSF	SL	
	86cm			6D	3D											
Bk2	34in	C	10YR	5M	3M	SBK-2 M	VFR	SIL	15	22	1	F1	F1	CAM	ST	
	86+cm			6D	4D											
Bk3	34+in		10YR	5M	4M	SBK-2 M	VFR	SIL	20	16	1	C2	C2	FDC	ST	

Site	Location	Position	Map unit	Notes												
12-2																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	25cm			3D	1D											
Ap	10in	C	10YR	2M	1M	SBK-2 M/F	FR	SICL	6	32	0				NE	
	40cm			4D	1D											
BA	16in	G	10YR	3M	1M	SBK-2 M	FR	SICL	7	30	0	F1	F1		NE	
	58cm			5D	2D											
Bk1	23in	C	10YR	4M	2M	SBK-2 M	VFR	SICL	8	28	1	F1	F1	CAM, OSF	SL	
	77cm			6D	2D											
Bk2	30.5in	C	10YR	5M	2M	SBK-2 M	FR	SICL	8	28	1	F2	F2	CAM	ST	
	120cm			6D	4D											
Bk3	47in	G	2.5Y	5M	4M	SBK-2 M	VFR	SIL	15	22	1	C1	C1	CAM	ST	
	120+cm			5D	6D											
BC	47+in		2.5Y	5M	6M	SBK-1M	VFR	SIL	20	15	0	C3	C3	FDC	ST	

Site	Location	Position	Map unit	Notes												
12-6																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	27cm			3D	1D											
Ap	10.5in	A	10YR	2M	1M	SBK-3 M	FR	SICL	8	34	0				NE	
	45cm			4D	1D											
BA	17.5in	C	10YR	3M	1M	SBK-2	VFR	SICL	9	32	0	F1	F1	FDC	ST	
	59cm			4D	1D											
Bk1	23.5in	C	2.5Y/10YR	3M	2M	SBK-2 M	VFR	SICL	14	28	1	C1	C1	CAM	ST	
	76cm			5D	3D											
Bk2	30in	C	2.5Y	4M	3M	SBK-2 M	VFR	SIL	15	24	1	C1	C2	CAM	VE	
	100cm			6D	3D											
Bk3	39.5in	G	2.5Y	5M	3M	SBK-2 M	VFR	SIL	15	20	1	C2	C2	CAM	ST	LESS CAM
	100+cm			6D	4D											
BC	39.5+in		2.5Y	5M	4M	SBK-1 M	VFR	SIL	17	18	0	M3	M3	FDC	ST	VERY FEW CAM

Site	Location	Position	Map unit	Notes												
12-4																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	21cm			3D	1D											
Ap	8.5in	A	10YR	2M	1M	PL-2 M/SBK-1 M	FR	SICL	8	29	1	F1	F1	FDC	VS	
	32cm			4D	1D											
BA	12.5in	C	10YR	3M	1M	SBK-2 M	VFR	SICL	10	30	1	F1	F1	FDC	SL	
	47cm			3D	2D											
Bk1	18.5in	A	10YR	3M	2M	SBK-2 M	VFR	SICL	12	28	0	C1	C3	CAM	SL	
	66cm			6D	2D											
Bk2	26in	C	2.5Y	5M	3M	SBK-2 M	VFR	SIL	13	22	0	C1	F1	CAM	ST	
	104cm			6D	3D											
Bk3	41in	G	2.5Y	5M	4M	SBK-2 M	VFR	SIL	15	20	1	F1	F1	CAM, FDC	ST	MUCH FEWER, ALMOST NO CAM
	104+cm			6D	4D											
C	41+in		2.5Y	5M	4M	MA	VFR	SIL	16	17	0	M3	M3	FDC	ST	

Site	Location	Position	Map unit	Notes												
12-3																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	28cm			3D	1D											
Ap	11in	C	10YR	2M	1M	SBK-2 M/ PL-1 M	FR	SICL	8	32	0				NE	
	44cm			4D	1D											
BA	17.5in	G	10YR	3M	1M	SBK-2 M	FR	SICL	11	33	0	F1	F1	FDC	ST	
	59cm			4D	2D											
Bk1	23.5in	G	10YR	4M	2M	SBK-2 M	VFR	SICL	12	29	0	F1	F1	FDC,CAM	ST	SMALL/ FEW MASSES
	109cm			6D	3D											
Bk2	43in	C	2.5y	5M	3M	SBK-2 CO	FR	SIL	14	22	1	F1	F1	CLF, CAM	ST	NOT SURE IF IT WAS CLAY FILMS OR NOT, SILT COAT?
	109+cm			6D	4D											
BC	43+in		2.5Y	5M	4M	MA	VFR	SIL	20	16	0	C2	C2	FDC	ST	

Site	Location	Position	Map unit	Notes												
12-5																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	18cm			3D	1D											
Ap	7in	A	10YR	2M	1M	SBK-2 F	VFR	SICL	7	30	0				NE	
	44cm			3D	1D											
A	17.5in	C	10YR	2M	1M	SBK-2 M	VFR	SICL	7	32	0	F1	F1		NE	
	59cm			4D	1D											
BA	23in	C	10YR	3M	1M	SBK-2 M/F	VFR	SICL	8	30	0	F1	F1	FDC	SL	SOME MIXING
	76cm			5D	3D											
Bk1	30in	C	2.5Y	4M	3M	SBK-2 M	VFR	SIL	13	21	1	M2	M3	CAM	ST	
	96cm			5D	4D											
Bk2	38in	G	2.5Y	4M	4M	SBK-2 M	VFR	SIL	14	20	1	M2	M2	FDC	SL	
	96+cm			5D	3D											
BC	38+in		2.5Y	5M	3M	SBK-1 M	VFR	SIL	20	18	0	M3	M3	FDC	SL	

Site	Location	Position	Map unit	Notes												
12-11																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	18cm			3D	1D											
Ap	7in	A	10YR	2M	1M	SBK-3 M/F	FR	SICL	6	30	0				NE	
	36cm			4D	1D											
BA	14in	C	10YR	3M	1M	SBK-2	VFR	SICL	7	29	0	F1			NE	
	49cm			4D	2D											
Bk1	19in	C	10YR	3M	2M	SBK-2 M	VFR	SICL	7	28	1	F1		CAM	ST	
	65cm			5D	3D											
Bk2	25.5in	C	2.5Y	4M	3M	SBK-2 M	VFR	SICL	8	28	1	F1		CAM	ST	
	85cm			5D	4D											
Bk3	33.5in	G	2.5Y	4M	4M	SBK-2 CO	VFR	SIL	12	21	1	C1	F1	CAM	VE	
	115cm			6D	4D											
Bk4	45.5in	G	2.5Y	5M	4M	SBK-2 M	VFR	SIL	12	17	1	C2	C2	CAM	ST	
	115+cm			6D	3D											
Bk5	45.5+in		2.5Y	5M	3M	SBK-2 M/F	VFR	SIL	14	17	0	C3	C3	CAM	ST	

Site	Location	Position	Map unit	Notes												
12-7																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	15cm			3D	1D											
Ap	6in	A	10YR	2M	1M	SBK-3 F	FR	SICL	6	34	0	F1	F1		NE	
	27cm			3D	1D											
A	10.5in	G	10YR	2M	1M	SBK-2 M	FR	SICL	6	31	0	F1	F1		NE	
	43cm			4D	1D											
BA	17in	G	10YR	3M	1M	SBK-2 M	VFR	SICL	8	29	0	F1	F1	FDC	SL	
	73cm			4D	2D											
Bk1	29in	C	2.5Y	3M	2M	SBK-2 M	VFR	SICL	10	30	1	F1	F3	CAM	ST	
	86cm			5D	3D											
Bk2	34in	C	2.5Y	4M	3M	SBK-2 M	VFR	SIL	14	25	2	F2	F2	CAM	ST	
	117cm			6D	2D											
Bk3	46in	G	2.5Y	5M	3M	SBK-2 M	VFR	SIL	16	20	0	C2	C2	CAM	ST	
	117+cm			6D	3D											
Bk4	46+in		2.5Y	5M	4M	SBK-2 M/F	VFR	SIL	16	17	1	M3	M3	CAM	VE	

Site	Location	Position	Map unit	Notes												
12-9																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	20cm			3D	1D											
Ap	8in	A	10YR	2M	1M	SBK-2 F	FR	SICL	8	29	0				NE	
	34cm			3D	1D											
AB	13.5in	C	10YR	2M	2M	SBK-2 M	VFR	SICL	6	31	1	F1			NE	
	48cm			4D	1D											
Bw	19in	C	10YR	3M	2M	SBK-2	VFR	SICL	8	27	1	F1	F1	FDC	SL	
	71cm			5D	2D											
Bk1	28in	G	2.5Y	4M	2M	SBK-2M	VFR	SIL	12	22	2	F1	F1	CAM	ST	
	91cm			5D	2D											
Bk2	36in	C	2.5Y	4M	4M	SBK-2	VFR	SIL	13	21	1	C1	C1	CAM	VE	
	112cm			6D	4D											
Bk3	44in	G	2.5Y	5M	4M	SBK-2 M	VFR	SIL	16	18	3	C2	C2	CAM	VE	
	112+cm			6D	4D											
Bk4	44+in		2.5Y	5M	6M	SBK-2 CO	VFR	SIL	15	17	0	M2	M2	CAM/FDC		FEW MASSES

Site	Location	Position	Map unit	Notes												
12-10																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	19cm			3D	1D											
Ap	7.5in	A	10YR	2M	1M	SBK-2 M/GR-1 M	VFR	SICL	7	29	0				NE	SLIGHT MIXING
	33cm			3D	2D											
BA	13in	C	10YR	3M	1M	SBK-2 M	FR	SICL	8	32	1	F1	F1	FDC	SL	
	46cm			4D	2D											
Bk1	18in	C	10YR	3M	2M	SBK-2 M	VFR	SICL	12	28	0	F1	F1	CAM	ST	SMALL MASSES
	69cm			5D	2D											
Bk2	27in	C	10YR	4M	2M	SBK-2 M	VFR	SIL	11	22	0	F1	F1	CAM	ST	DARK MIXING: MN? OLD PLOW LAYER?
	100cm			5D	4D											
Bk3	39.5in	G	2.5Y	4M	4M	SBK-2 M	VFR	SIL	16	17	0	F1	F1	CAM	ST	FEW MASSES
	100+cm			5D	4D											
Bk4	39+in		2.5y	4M	4M	SBK-2 M	VFR	SIL	20	18	0	C2	C2	CAM, FSD	ST	MASSES BARELY VISIBLE

Site	Location	Position	Map unit	Notes												
12-12																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	19cm			3D	1D											
Ap	7.5in	A	10YR	2M	1M	SBK-3 M	FR	SICL	6	28	0				NE	
	39cm			4D	2D											
Bw	15.5in	A	10YR	4M	2M	SBK-2 M	VFR	SICL	8	28	0			OSF	NE	
	58cm			5D	3D											
Bk1	23in	C	10YR	4M	3M	SBK-2 M	FR	SIL	8	26	1	F1		CAM	ST	
	82cm			5D	4D											
Bk2	32.5in	C	2.5Y	4M	4M	SBK-2 M	VFR	SIL	10	20	1	F1		CAM	VE	
	112cm			6D	4D											
Bk3	44in	G	2.5Y	4M	4M	SBK-2 M	VFR	SIL	15	17	0	C1	F1	FDC	ST	
	112+cm			6D	4D											
Bk4	44+in		2.5Y	5M	4M	SBK-2 M	VFR	SIL	15	16	0	C2	C2	FDC	ST	

Site	Location	Position	Map unit	Notes												
13-1																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	19cm			4D	2D											
Ap	7.5in	A	10YR	2M	2M	PL-2 TK	FI	L	32	21	0				NE	
	43cm			4D	4D											
Bt1	17in	G	10YR	3M	3M	SBK-2 M	FR	CL	30	28	0			CLF	NE	
	61cm			5D	4D											
Bt2	24in	C	10YR	4M	4M	SBK-2 CO	FR	SCL	45	27	0	F1	F1	CLF	NE	
	89cm			5D	6D											
2Bw	35in	C	10YR	4M	4M	SBK-2 M	VFR	SOCL	65	10	0	F1	F1		NE	
	129cm			6D	6D											
2Bt	51in	C	2.5Y	5M	6M	SBK-2 CO	FR	SL	55	18	0	F3	F3	CLF	NE	
	129+cm			5D	4D											
3BC	51+in		2.5Y	4M	4M	SBK-1 M	FR	SIL	25	24	2	M3	M3	CAM	ST	

Site	Location	Position	Map unit	Notes												
13-2																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	21cm			3D	2D											
Ap	8.5in	A	10YR	2M	2M	SBK-2 F	FR	L	30	22	0				NE	
	30cm			4D	3D											
Bt	12in	C	10YR	3M	3M	SBK-2 M	FR	CL	35	28	0			CLF	NE	
	59cm			5D	3D											
Bt2	23in	G	10YR	4M	3M	SBK-2 M	FR	CL	37	30	0	F1		CLF	NE	
	88cm			4D	4D											
2Bt3	34.5in	C	10YR	3M	4M	SBK-2 M	VFR	SCL	50	25	0	F2	F1	CLF	NE	
	112cm			6D	6D											
2BC	44in	C	2.5Y	6M	4M	SBK-1 M	VFR	COSL	70	10	0	F3	F1		NE	
	112+cm			6D	4D											
3C	44+in		2.5Y	5M	4M	MA	FR	SIL	20	20	2	M3	M3	CAM	VE	

Site	Location	Position	Map unit	Notes												
13-3																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	21cm			3D	2D											
Ap	8.5in	A	10YR	2M	2M	SBK-2 M/PL-1 M	FR	L	38	22	0				NE	
	33cm			4D	2D											
Bt1	13in	C	10YR	3M	2M	SBK-2 M	FR	L	38	25	0			CLF	NE	
	50cm			4D	3D											
Bt2	19.5in	C	10YR	3M	3M	SBK-2 M	FR	CL	40	28	0	F1		CLF	NE	
	70cm			5D	3D											
Bt3	27.5in	G	10YR	4M	3M	SBK-2 M	FR	CL	40	30	0	F1		CLF	NE	
	98cm			5D	4D											
2Bw	38.5in	C	10YR	4M	4M	SBK-2 M	VFR	SL	65	12	0	F3	F1		NE	
	116cm			5D	6D											
2BC1	45.5in	C	2.5Y	5M	4M	SBK-1 M	VFR	LS	80	6	0	F3	F1	FDC	ST	
	116+cm			5D	6D											
3BC2	45.5in		2.5Y	5M	4M	SBK-1 M	FR	L	40	21	0	F3	F3	CAM	VE	

Site	Location	Position	Map unit	Notes												
13-4																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	23cm			3D	3D											
Ap	9in	A	10YR	2M	2M	SBK-2 F	FR	L	30	25	0				NE	
	38cm			4D	3D											
Bt1	15in	C	10YR	3M	3M	SBK-2 M	FR	CL	33	29	0			CLF	NE	
	52cm			5D	3D											
Bt2	20.5in	G	10YR	4M	3M	SBK-2 M	FR	CL	32	28	0	F1		CLF	NE	
	84cm			5D	4D											
2Bt3	33in	G	10YR	4M	4M	SBK-2 M	FR	SCL	55	21	0	F1	F1	CLF	NE	
	103cm			5D	4D											
2Bw	40.5in	C	10YR	4M	4M	SBK-1 M	VFR	SL	60	18	0	F1	F1		NE	
	119cm			6D	6D											
2BC1	47in	C	2.5Y	5M	6M	SBK-1 M	VFR	LS	80	10	0	F3	F3		NE	
	119+cm			6D	3D											
3BC2	47+in		2.5Y	5M	4M	SBK-1 M	VFR	L	50	15	0	F3	F3		ST	

Site	Location	Position	Map unit	Notes
13-5				

Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	17cm			3D	2D											
Ap	7in	A	10YR	2M	2M	SBK-2 F/M	FR	L	40	25	0				NE	
	35cm			5D	3D											
Bt1	13.5in	C	10YR	4M	3M	SBK-2 M	FR	CL	40	29	0	F1		CLF	NE	
	52cm			5D	4D											
Bt2	20.5in	G	10YR	4M	4M	SBK-2 M	VFR	SCL	50	26	0	F1		CLF	NE	
	71cm			5D	4D											
2Bw1	28in	G	10YR	4M	4M	SBK-2 M	VFR	SL	60	14	0	F1	F1		NE	
	92cm			6D	4D											
2Bw2	36.5in	C	2.5Y	5M	4M	SBK-1 F	VFR	COSL	80	7	0	F1	F1		SL	
	92+cm			5D	4D											
3BC	36.5+in		2.5Y	4M	4M	SBK-1 F	VFR	L	35	22	2	C3	C3	CAM	VE	

Site	Location	Position	Map unit	Notes
13-6				

Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	17cm			3D	2D											
Ap	6.5in	A	10YR	2M	2M	PL-2 TK	FR	L	30	24	0				NE	
	46cm			5D	3D											
Bt	18in	C	10YR	4M	3M	SBK-2 M	FR	SCL	42	28	0	F1		CLF	NE	
	66cm			5D	4D											
2Bw	26in	C	10YR	4M	4M	SBK-2 CO	FR	SL	60	15	0	F1	F1		NE	
	95cm			6D	4D											
3Bk	37.5in	G	2.5Y	5M	4M	SBK-2 CO	FR	L	48	24	0	C2	C1	CAM	VE	
	128cm			6D	4D											
3Bk2	50.5in	G	2.5Y	5M	4M	SBK-2 CO/M, PL-1 TK	FR	SIL	25	26	2	C3	C3	CAM	VE	
	128+cm			6D	6D											
3BC	50.5+in		2.5Y	5M	6M	SBK-1 M	VFR	SIL	20	20	3	C3	C3	CAM	VE	

Site	Location	Position	Map unit	Notes
13-7				

Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	18cm			3D	2D											
Ap	7in	A	10YR	2M	2M	SBK-2 F/M	FR	L	30	25	0				NE	
	28cm			3D	3D											
Bt1	11in	C	10YR	3M	2M	SBK-2 M	FR	CL	32	29	0			CLF	NE	
	53cm			4D	3D											
Bt2	21in	G	10YR	3M	3M	SBK-2 M	FR	CL	42	28	0	F1		CLF	NE	
	80cm			5D	4D											
2Bw1	31.5in	G	10YR	4M	4M	SBK-2 M	VFR	SL	60	16	0	F1	F1		NE	
	104cm			5D	4D											
3Bk	41in	C	2.5Y	4M	4M	SBK-2 M	VFR	SIL	20	21	1	C3	F3	CAM	VE	
	104+cm			6D	6D											
3BC	41+in		2.5Y	5M	6M	SBK-1 M	VFR	SIL	20	22	3	C3	C3	CAM	VE	

Site	Location	Position	Map unit	Notes
13-8				

Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	18cm			3D	2D											
Ap	7in	A	10YR	2M	2M	SBK-1 M	FR	L	30	24	0				NE	
	35cm			4D	3D											
Bt1	13.5in	C	10YR	3M	3M	SBK-2 M	FR	CL	35	27	0			CLF	NE	MIXING
	48cm			5D	4D											
2Bt2	19in	G	10YR	4M	4M	SBK-2 M	VFR	SCL	55	22	0	F1		CLF	NE	
	70cm			5D	4D											
2Bw	27.5in	C	2.5Y	4M	4M	SBK-2 M	VFR	SL	60	17	0	F2	F2		NE	
	94cm			6D	4D											
3Bk1	37in	C	2.5Y	5M	4M	SBK-2 M	FR	SIL	20	21	1	C3	C3	CAM	VE	
	113cm			6D	6D											
3Bk2	44.5in	A	2.5Y	5M	6M	SBK-1 F	FR	SIL	22	19	1	C2	C2	CAM	VE	
	113+cm			5D	4D											
4C	44.5in		2.5Y	4M	4M	MA	FI	CL	25	35	5	C3	C3	CAM	ST	

Site	Location	Position	Map unit	Notes
13-9				

Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	21cm			3D	2D											
Ap	8.5in	A	10YR	3M	2M	SBK-2 M/PL-1 M	FR	L	30	23	0				NE	
	42cm			4D	3D											
Bw	16in	C	10YR	3M	3M	SBK-2 M	FR	L	30	25	0	F1			NE	
	55cm			5D	3D											
Bk1	21.5in	C	10YR	4M	3M	SBK-2 M	VFR	L	35	20	0	F1	F1	FDC	SL	
	86cm			5D	4D											
2Bk1	34in	G	2.5Y	4M	4M	SBK-2 M	VFR	SIL	16	20	1	C1	C1	CAM	VE	
	86+cm			6D	6D											
2BC	34+in		2.5Y	5M	6M	SBK-1 M	VFR	SIL	18	19	3	C3	C2	CAM	VE	

Site	Location	Position	Map unit	Notes												
13-10																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	23cm			3D	2D											
Ap	9in	A	10YR	2M	2M	PL-2 M	FR	CL	30	28	0				NE	
	41cm			4D	3D											
Bw1	16in	C	10YR	3M	3M	SBK-2 M	FR	CL	34	30	0	F1			NE	
	59cm			5D	4D											
2Bw2	23.5in	G	10YR	4M	4M	SBK-2 M	VFR	L	50	20	0	F1			NE	
	78cm			5D	3D											
2Bw3	30.5in	C	10YR	4M	3M	SBK-2 M	VFR	L	50	22	0	F1	F1		NE	
	99cm			5D	4D											
3Bk	39in	C	2.5Y	4M	4M	SBK-2 M	FR	SIL	20	20	1	F3	F3	CAM	VE	
	125cm			6D	6D											
3BC	49in	C	2.5Y	5M	6M	SBK-1 M	FR	SIL	22	20	3	C3	C3	CAM	VE	
	125+cm			5D	3D											
4C	49+in		2.5Y	4M	3M	MA	FI	CL	20	36	3	C3	C3	CAM	ST	

Site	Location	Position	Map unit	Notes												
13-11																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	17cm			4D	2D											
Ap	7in	A	10YR	2M	2M	ABK-3 F	FI	L	30	24	1				NE	
	29cm			4D	2D											
Bw1	11.5in	C	10YR	3M	2M	SBK-2 M/ PL-1 TK	FR	SIL	25	26	0	F1			NE	
	60cm			5D	3D											
Bw2	23.5in	G	10YR	4M	3M	SBK-2 CO	FR	SIL	28	22	0	F2	F1		NE	
	80cm			5D	4D											
2Bw3	31.5in	C	2.5Y	4M	4M	SBK-2 CO	VFR	SL	55	18	0	F2	F1		NE	
	105cm			6D	4D											
3Bk	41.5in	C	2.5Y	5M	4M	SBK-2 CO	FR	SIL	26	20	1	C1	C1	CAM	VE	
	105+cm			6D	4D											
3BC	41.5+in		2.5Y	5M	4M	SBK-1 M	FR	CL	30	28	1	C2	C2	CAM	VE	

Site	Location	Position	Map unit	Notes												
16-1																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	15cm			3D	2D											
Ap	6in	A	10YR	2M	2M	PL-2 TK	FI	L	40	21	0				NE	
	32cm			4D	2D											
Bw1	12.5in	C	10YR	3M	2M	SBK-2 M	FI	L	44	20	0				NE	
	50cm			5D	3D											
Bw2	19.5in	C	10YR	4M	3M	SBK-2 CO	FR	L	44	24	5	F1	F1		NE	
	66cm			5D	4D											
BC	26in	C	10YR	4M	4M	SBK-2 M	FR	SL	60	18	10	F1	F1		NE	
	66+cm			6D	4D											
2C	26+in		10YR	5M	4M	SGR	LO	VGR COSL	75	10	50			FDC	VE	

Site	Location	Position	Map unit	Notes												
16-2																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	15cm			3D	2D											
Ap	6in	A	10YR	2M	2M	SBK-2 M/F	FR	L	44	20	0				NE	
	22cm			4D	2D											
Bw	8.5in	C	10YR	3M	2M	SBK-2 M	FR	L	45	22	0	F1			NE	
	33cm			4D	4D											
Bt	13in	C	10YR	4M	3M	SBK-2 M	FR	L	50	25	2	F1		CLF	NE	
	38cm			4D	3D											
2Bk	15in	A	2.5Y	3M	3M	SBK-2 M	FR	COSL	70	18	10	F3		CAM	VE	
	38+cm			5D	6D											
2C	15+in		10YR	4M	6M	SGR	LO	VGR COSL	75	8	50 VGR			CAM,FDC	VE	

Site	Location	Position	Map unit	Notes
16-3				

Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	17cm			3D	1D											
Ap	6.5in	A	10YR	2M	1M	SBK-2 M/F	FR	L	45	19	0				NE	
	28cm			4D	2D											
Bt1	11in	C	10YR	3M	2M	SBK-2 M	FR	L	42	24	1	F1		CLF	NE	
	36cm			5D	3D											
Bt2	14in	C	10YR	4M	3M	SBK-2 M	FI	SCL	50	25	8	F3		CLF	NE	
	43cm			5D	4D											
2BC	17in	C	10YR	3M	4M	SBK-1 M	FR	GR SL	65	18	25 GR	F3			N3	
	43cm			4D	6D											
2C	17+in		10YR	3M	6M	SGR	LO	GR COSL	80	8	45 VGR			FDC	ST	

Site	Location	Position	Map unit	Notes
16-4				

Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	17cm			3D	2D											
Ap	7in	A	10YR	2M	2M	PL-2 M/SBK-2 F	FR	L	42	21	0				NE	
	28cm			4D	2D											
Bt1	11in	C	10YR	3M	2M	SBK-2 M	FR	L	42	25	0	F1		CLF	NE	
	32cm			5D	2D											
Bt2	14.5in	C	10YR	4M	2M	SBK-2 M	FI	CL	40	29	0	F1		CLF	NE	
	46cm			5D	3D											
2Bw	18in	C	10YR	4M	3M	SBK-2 M	FR	COSL	60	15	8	F1			NE	
	53cm			5D	4D											
2BC	21in	A	10YR	4M	4M	SBK-1 M	VFR	VGR COSL	65	12	40 VGR	F1			NE	
	53+cm			4D	6D											
2C	21+in		10YR	3M	6M	SGR	LO	VGR COSL	75	8	60 VGR			FDC	ST	

Site	Location	Position	Map unit	Notes
16-5				

Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	16cm			3D	2D											
Ap	6in	A	10YR	2M	2M	SBK-2 M	FR	L	42	20	0				NE	
	24cm			4D	2D											
Bt1	9.5in	C	10YR	3M	2M	SBK-2 M	FR	L	45	25	1	F1		CLF	NE	
	37cm			5D	3D											
Bt2	14.5in	A	10YR	4M	2M	SBK-2 M	FR	CL	42	29	1	F1		CLF	NE	
	37+cm			5D	4D											
2BC	14.5+in		10YR	4M	4M	SBK-1 M	VFR	COLS	75	8	6	F1			NE	

Site	Location	Position	Map unit	Notes
16-6				

Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	16cm			3D	2D											
Ap	6.5in	A	10YR	2M	2M	SBK-2 F	FR	L	45	20	0				NE	
	36cm			4D	3D											
Bt	14in	C	10YR	3M	3M	SBK-2 CO	FR	L	45	23	1			CLF	NE	
	50cm			5D	4D											
Bw1	19.5in	C	10YR	4M	4M	SBK-2 M	FR	L	50	20	1	F1			NE	
	70cm			4D	6D											
Bw2	27.5in	C	10YR	3M	6M	SBK-1 M	FR	COSL	60	17	8	F1			NE	
	82cm			4D	4D											
Bk	32in	C	10YR	3M	4M	SBK-1 M	VFR	COSL	65	15	10	F1		CAM	SL	
	82+cm			5D	6D											
C	32+in		10YR	4M	6M	SGR	L	VGR COSL	75	8	40			FDC	VE	

Site	Location	Position	Map unit	Notes
16-7				

Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	15cm			3D	2D											
Ap	6in	A	10YR	2M	2M	SBK-2 M/F	FR	L	40	20	1				NE	
	24cm			4D	2D											
Bt1	9.5in	C	10YR	3M	2M	SBK-2 M	FR	L	42	25	0	F1		CLF	NE	
	36cm			5D	3D											
Bt2	14in	C	10YR	4M	2M	SBK-2 M	FI	CL	40	30	5	F1		CLF	NE	
	46cm			5D	4D											
2BC	18in	C	10YR	4M	3M	SBK-1 M	FR	GR COSL	65	14	20 GR	F1			NE	
	46+cm			5D	4D											
2C	18+in		10YR	4M	4M	SGR	LO	GR COSL	75	8	30 GR					

Site	Location	Position	Map unit	Notes												
16-8																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	16cm			3D	1D											
Ap	6in	A	10YR	2M	1M	SBK-2 M/F	FR	L	45	20	1				NE	
	29cm			4D	2D											
Bt1	11.5in	C	10YR	3M	2M	SBK-2 M	FR	L	45	26	1	F1		CLF	NE	
	40cm			5D	3D											
Bt2	15.5in	C	10YR	4M	2M	SBK-2 M	FR	CL	44	29	2	F1		CLF	NE	
	59cm			5D	4D											
2BC	23.5in	C	10YR	4M	4M	SBK-1	VFR	COSL	70	10	10	F1			NE	
	59+cm			4D	6D											
2C	23.5+in		10YR	3M	6M	SGR	LO	VGR COLS	75	7	55				ST	

Site	Location	Position	Map unit	Notes												
16-9																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	15cm			3D	2D											
Ap	6in	A	10YR	2M	1M	SBK-2 M/F	FR	L	42	21	0				NE	
	30cm			4D	2D											
Bt1	12in	C	10YR	3M	2M	SBK-2 M	FR	L	46	25	0	F1		CLF	NE	
	41cm			5D	3D											
Bt2	16in	C	10YR	4M	2M	SBK-2 M	FI	CL	40	30	2	F1		CLF	NE	
	53cm			4D	3D											
2BC1	21in	C	10YR	3M	3M	SBK-1 M	VFR	COSL	65	15	13	F3			NE	
	77cm			5D	4D											
2BC2	30in	A	10YR	4M	4M	SBK-1 M	VFR	COSL	80	8	10	F1	F1		NE	
	77+cm			4D	6D											
2C	30+in		10YR	3M	6M	SGR	LO	VGR COSL	75	10	40 VGR	F1			NE	

Site	Location	Position	Map unit	Notes												
16-10																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	16cm			3D	2D											
Ap	16.5in	A	10YR	2M	2M	SBK-2 M/F	FR	L	44	20	0				NE	
	27cm			4D	2D											
Bt1	10.5in	C	10YR	3M	2M	SBK-2 M	FR	L	40	25	1	F1		CLF	NE	
	36cm			5D	3D											
Bt2	14in	A	10YR	4M	3M	SBK-2 M	FR	CL	40	30	3	F1		CLF	NE	
	43cm			4D	4D											
2BC	17in	C	10YR	3M	4M	SBK-1 M	VFR	GR COSL	65	14	15 GR	F1		FDC	SL	
	43+cm			4D	6D											
2C	17+in		10YR	3M	6M	SGR	LO	VGR COLS	85	6	50 VGR			FDC	VE	

Site	Location	Position	Map unit	Notes												
16-11																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	18cm			3D	2D											
Ap	7in	A	10YR	2M	1M	SBK-2 M/F	FR	L	35	20	1				NE	
	31cm			4D	2D											
Bt1	12in	C	10YR	3M	2M	SBK-2 CO	FR	L	35	25	0	F1		CLF	NE	
	46cm			5D	3D											
Bt2	18in	G	10YR	4M	3M	SBK-2 CO/M	FR	CL	36	28	2	F1		CLF	NE	
	59cm			5D	4D											
2Bw	23in	C	10YR	4M	4M	SBK-1 CO	VFR	SL	60	18	5	F1			NE	
	59+cm			5D	4D											
2Bk	23+in		10YR	4M	4M	SBK-1 M	VFR	GR COSL	75	11	30	F2		CAM	SL	

Site	Location	Position	Map unit	Notes											
17-1															
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	19cm			3D	1D											
Ap	7.5in	A	10YR	2M	1M	ABK-3 M	FR	SICL	5	29	0				NE	
	37cm			4D	2D											
Btk1	14.5in	C	10YR	3M	2M	SBK-2 M	FI	SICL	8	32	0	F1		FDC,CLF,CAM	SL	FINE MASSES
	55cm			5D	3D											
Btk2	21.5in	C	10YR	4M	2M	SBK-2 M	FI	SICL	10	34	0	F1		CAM,CLF	ST	
	84cm			6D	3D											
Bk	33in	C	2.5Y	5M	3M	SBK-2 M	FR	SICL	10	28	0	F1	F1	CAM	VE	
	97cm			6D	6D											
BC	38in	C	2.5Y	5M	6M	SBK-2 M	FR	GR SIL	20	25	20 GR	C2	C2	FDC,CAM	ST	POCKET OF ROCKS
	97+cm			6D	6D											
C	38+in		2.5Y	5M	6M	PL-1 M	FR	SIL	20	22		C2	F2	FDC	ST	

Site	Location	Position	Map unit	Notes												
17-2																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	18cm			4D	1D											
Ap	7in	A	10YR	2M	1M	PL-2/SBK-2 M	FR	SICL	6	28	0				NE	
	39cm			4D	2D											
Bw	15.5in	G	10YR	3M	2M	SBK-2 M	FR	SICL	6	28	0				NE	MIXING
	50cm			5D	3D											
Bk1	19.5in	C	10YR	4M	3M	SBK-2 M	FR	SICL	10	30	0	F1		CAM,FDC	SL	
	67cm			5D	4D											
Bk2	27.5in	C	2.5Y	4M	4M	SBK-2 M	FR	SIL	14	25	0	F2	F1	CAM	VE	
	89cm			5D	6D											
Bk3	35in	C	2.5Y	5M	4M	SBK-2 M	FR	SIL	16	23	0	C2	F2	CAM,FDC	VE	MOSTLY FDC
	89+cm			6D	6D											
BC	35+in		2.5Y	5M	6M	SBK-1 M	FI	CL	25	38	2	C2	F2	CAM	ST	

Site	Location	Position	Map unit	Notes												
17-3																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	19cm			3D	2D											
Ap	17.5in	A	10YR	2M	1M	ABK-3/ PL-1 M	FR	SICL	7	28	0				NE	
	33cm			4D	2D											
Bw	13in	C	10YR	3M	2M	SBK-2 M	FR	SICL	6	30	0			OSF	NE	
	45cm			4D	3D											
Btk	17.5in	C	10YR	3M	3M	SBK-2 M	FR	SICL	6	32	0	F1		CAM,FDC,CLF	SL	
	67cm			5D	4D											
Bk1	26.5in	G	2.5Y	4M	4M	SBK-2 M	FR	SICL	12	30	2	F2	F1	CAM	VE	
	81cm			6D	4D											
Bk2	32in	C	2.5Y	5M	4M	SBK-2 M	VFR	SIL	25	22	3	C2	F1	CAM	VE	
	113cm			6D	6D											
2BC1	44.5in	C	2.5Y	5M	6M	SBK-2 M	FR	SCL	50	28	6	C2	F1	CAM	ST	
	136cm			6D	4D											
2BC2	53.5in	A	2.5Y	5M	4M	SBK-1 M	FI	CL	38	35	8	C3	F1	CAM	ST	2CM POCKET OF SAND AT BDY
	136+cm			6D	4D											
2C	53.5+in		2.5Y	5M	4M	MA	FI	CL	30	38	3	C3	C3	FDC	ST	

Site	Location	Position	Map unit	Notes												
17-4																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	19cm			3D	2D											
Ap	7.5in	A	10YR	2M	2M	SBK-2 F	FR	SICL	6	29	0				NE	
	30cm			4D	2D											
Bw	12in	C	10YR	3M	2M	SBK-2 M	FR	SICL	7	28	0				NE	
	48cm			4D	3D											
Bt	19in	C	10YR	3M	3M	SBK-2 M	FR	SICL	7	32	0	F1		CLF	NE	
	68cm			5D	4D											
Bk1	27in	G	2.5Y	4M	4M	SBK-2 M/F	FR	SIL	12	25	0	F1	F1	CAM	VE	
	84cm			6D	4D											
Bk2	33in	C	2.5Y	5M	4M	SBK-2 M	FR	SIL	15	23	1	F3	F2	CAM	VE	
	101cm			6D	6D											
2BC1	40in	C	2.5Y	5M	6M	SBK-2 M	FI	CL	43	32	5	C3	F2	CAM	VE	
	119cm			6D	6D											
2BC2	47in	C	2.5Y	5M	6M	SBK-1 M	FI	CL	30	38	4	C3	F3	CAM	ST	
	134cm			6D	6D											
2C1	53in	C	2.5Y	5M	6M	SBK-1 M	VFR	SCL	55	30	2	C3	F3	FDC	ST	
	134+cm			6D	6D											
2C2	53+in		2.5Y	5M	6M	MA	FI	CL	30	38	2	C3	C3	CAM	ST	

Site	Location	Position	Map unit	Notes												
17-5																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	14cm			2D	2D											
Ap	5.5in	A	10YR	2M	1M	ABK-2 F/PL-1 M	FR	SICL	8	28	0				NE	
	40cm			4D	3D											
Bw	16in	C	10YR	4M	2M	PL-1 M/SBK-2 M	FR	SICL	11	31	0	F2		OSF	VS	
	54cm			5D	4D											
Bk1	21in	C	2.5Y	4M	4M	SBK-2 M	FR	SIL	15	26	1	F2	F2	CAM	VE	
	70cm			6D	4D											
Bk2	27.5in	C	2.5Y	5M	4M	SBK-2 M	FR	SIL	15	24	1	F2	F2	CAM	VE	
	113cm			6D	6D											
2BC	44.5in	C	2.5Y	5M	6M	SBK-1 M	FI	CL	30	38	5	C3	C3	CAM	ST	
	113+cm			6D	6D											
2C	44.5+in		2.5Y	5M	6M	MA	FI	CL	40	35	4	C3	C3	FDC	ST	

Site	Location	Position	Map unit	Notes												
17-6																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	18cm			3D	1D											
Ap	7in	A	10YR	2M	1M	SBK/ABK-2 M	FI	SICL	7	32	0				NE	
	42cm			5D	3D											
Bw	16.5in	C	10YR	4M	3M	PL-2 M	FI	SICL	6	31	0				NE	
	64cm			6D	4D											
Bk	25in	C	2.5Y	5M	4M	SBK-2 M/CO	FR	SICL	14	28	0	F1	F1	CAM	VE	
	96cm			5D	4D											
Btk	38in	C	10YR	4M	4M	SBK-2 M	FI	CL	35	37	2	F3	F3	CLF, CAM	VE	
	120cm			6D	6D											
BC	47in	A	2.5Y	5M	6M	SBK-1 M	FR	SCL	55	22	3	F1	F1	FDC	VE	POCKET OF SAND
	120+cm			5D	4D											
C	47+in		2.5Y	4M	4M	MA	FI	CL	25	42	2	F3	F3	CAM	ST	

Site	Location	Position	Map unit	Notes												
17-7																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	18cm			3D	2D											
Ap	7in	A	10YR	2M	2M	ABK-2 F	FR	SICL	6	32					NE	
	32cm			4D	2D											
Bw	12.5in	C	10YR	3M	2M	SBK-2 M	FR	SICL	8	33					NE	
	57cm			4D	3D											
Bt	22.5in	C	10YR	3M	3M	SBK-2 M	FR	SICL	8	35		F1		CLF	NE	
	76cm			6D	4D											
Bk	30in	C	2.5Y	5M	4M	SBK-2 M	FR	SIL	15	25	1	C2	F1	CAM	VE	
	101cm			6D	6D											
2BC	40in	C	2.5Y	5M	6M	SBK-1 M	FR	CL	40	36	4	C3	C2	CAM	ST	
	101cm			6D	6D											
2C	40+in		2.5Y	5M	6M	MA	FI	C	35	42	5	M3	M3	CAM	ST	MOSTLY DISSEMINATED

Site	Location	Position	Map unit	Notes												
17-8																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	17cm			3D	2D											
Ap	6.5in	A	10YR	2M	1M	SBK-2 M	FR	SICL	5	30					NE	
	28cm			4D	2D											
AB	11in	C	10YR	3M	2M	PL-2 M	FR	SICL	7	29	0			OSF	NE	
	41cm			5D	3D											
Bw	16in	C	10YR	4M	3M	SBK-2 M	FR	SIL	8	26	0	F1		FDC	SL	
	65cm			5D	4D											
Bk1	25.5in	C	2.5Y	4M	4M	SBK-2 M	FR	SIL	15	24	0	F2	F1	CAM	VE	
	99cm			6D	4D											
2Bk2	39in	G	2.5Y	5M	4M	SBK-2 M	FR	CL	30	34	3	C2	C2	CAM	ST	
	117cm			6D	6D											
2BC	46in	G	2.5Y	5M	6M	SBK-1 M	FI	CL	35	38	3	C3	C3	CAM	ST	
	117+cm			6D	6D											
2C	46+in		2.5Y	5M	6M	MA	FI	CL	35	39	4	M3	M3	CAM	ST	

Site	Location	Position	Map unit	Notes												
17-9																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	17cm			3D	2D											
Ap	6.5in	A	10YR	2M	2M	PL-2M/SBK-2 F	FR	SICL	7	30	0				NE	PLATY AT BDY
	38cm			4D	2D											
Bw	15in	C	10YR	4M	2M	SBK-2 M	FR	SICL	15	31	1	F1			NE	
	57cm			6D	4D											
Bk1	22.5in	G	2.5Y	5M	4M	SBK-2 M	FR	CL	35	32	4	C1	F1	CAM	VE	
	73cm			6D	8D											
Bk2	28.5in	C	2.5Y	5M	6M	SBK-2 M	FR	SCL	47	28	6	C3	F1	CAM	VE	
	107cm			6D	6D											
Bk3	42in	G	2.5Y	5M	6M	SBK-2 M	FR	CL	35	36	6	C3	C3	CAM	ST	
	107+cm			6D	6D											
BC	42+in		2.5Y	5M	6M	SBK-1 M	FI	CL	35	35	7	C3	C3	CAM	ST	FEWER CARBONATES

Site	Location	Position	Map unit	Notes												
17-10									CLAY FILMS NOT PEDOGENIC?							
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	13cm			3D	1D											
Ap	5in	A	10YR	2M	1M	PL-2 M/ABK-2 F	FR	SICL	7	30	0				NE	
	28cm			4D	2D											
Bw	11in	C	10YR	3M	2M	SBK-2 M	FR	SICL	10	30	0			FDC	VS	
	46cm			5D	3D											
Bk1	18in	G	10YR	4M	3M	SBK-2 M	FR	SIL	15	26	0	F1		CAM	VE	
	70cm			5D	3D											
Bk2	27.5in	C	2.5Y	4M	3M	SBK-2 M	FR	CL	34	32	5	C1	C1	CAM, CLF?	ST	
	93cm			5D	4D											
BC1	36.5in	G	2.5Y	4M	4M	SBK-1 M	FI	CL	30	36	4	C3	C3	CAM	ST	
	110cm			D	D											
BC2	43in	C	2.5Y	M	M	SBK-1 M	FI	CL	28	38	3	M3	M3	CAM	ST	
	110+cm			D	D											
C	43+in		2.5Y	M	M	MA	FI	CL	28	38	3	C3	C3	CAM	ST	LESS REDOX

Site	Location	Position	Map unit	Notes												
17-11																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	16cm			3D	1D											
Ap	6.5in	A	10YR	2M	1M	ABK-3 M/F	FR	SICL	5	30					NE	
	29cm			4D	2D											
Bw	11.5in	C	10YR	3M	2M	SBK-2 M/PL-1 M	FR	SICL	6	28					VS	MIXING
	48cm			5D	3D											
Bk1	19in	G	2.5Y	4M	3M	SBK-2 M	FR	SIL	10	25		F1	F1	FDC	ST	
	62cm			6D	3D											
Bk2	24.5in	C	2.5Y	5M	3M	SBK-2 M	FR	SIL	13	26		F2	F2	CAM	VE	
	79cm			6D	6D											
Bk2	31in	C	2.5Y	5M	6M	SBK-2 M	FR	CL	38	30	6	F3	F3	CAM	ST	
	96cm			6D	4D											
BC	38in	C	2.5Y	5M	4M	SBK-1 M	FI	CL	30	36	2	C3	C3	CAM	ST	
	96+cm			5D	4D											
C	38+in		2.5Y	4M	4M	MA	FI	CL	30	39	2	M2	M2	FDC,CAM	ST	MOSTLY DISSEMINATED

Site	Location	Position	Map unit	Notes												
18-1																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	19cm			3D	2D											
Ap	7.5in	A	10YR	2M	2M	SBK-2 F/PL-1 TN	FR	L	30	25	1				NE	PLATY AT BOUNDARY
	53cm			5D	3D											
Bk1	21in	C	2.5Y	4M	3M	SBK-2 M	FR	L	45	22	2	F1	F1	CAM/FDC	ST	
	73cm			5D	3D											
Bk2	29in	C	2.5Y	4M	4M	SBK-2 M	FR	L	47	20	2	F1	F1	CAM	VE	CARBS INCREASE
	107cm			6D	3D											
Bk3	42in	C	2.5Y	5M	4M	SBK-2 F	FI	SIL	28	22	2	C2	C2	CAM	VE	CARBS/REDOX INCREASE, SAND DECREASE
	107+cm			6D	4D											
BC	42+in		2.5Y	6M	3M	SBK-2 F	VFI	CL	22	29	1	C3	C3	CAM	VE	LESS CARBS, MORE CLAY

Site	Location	Position	Map unit	Notes												
18-2																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	29cm			3D	2D											
Ap	11.5in	C	10YR	2M	1M	SBK-2 F	VFR	SIL	15	20	0				NE	
	43cm			4D	2D											
Bt1	17in	C	10YR	3M	2M	SBK-2 M	VFR	SIL	10	26	0			CLF	NE	
	66cm			5D	3D											
Bt2	26in	C	10YR	4M	3M	SBK-3 M	FR	SICL	10	29	0	F1		CLF	NE	
	90cm			5D	3D											
Bt3	35.5in	G	10YR	5M	3M	SBK-2 M	FR	SIL	10	25	0	F1	F1	CLF	NE	
	119cm			6D	4D											
Bk	47in	C	2.5Y	5M	4M	SBK-2 M	FR	CL	25	29	5	C2	C2	CAM	VE	
	119+cm			6D	6D											
BC	47+in		2.5Y	5M	6M	SBK-1 M	FR	CL	35	31	3	M3	M3	FDC	VE	

Site	Location	Position	Map unit	Notes												
18-3																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	21cm			3D	1D											
Ap	8.5in	A	10YR	2M	1M	SBK-1 M/GR-2 M	VFR	SIL	15	19	0				NE	
	38cm			3D	2D											
Bw	15in	C	10YR	2M	2M	SBK-2 M	VFR	SIL	15	23	0				NE	
	70cm			5D	3D											
Bt1	27.5in	G	10YR	4M	3M	SBK-2 M	FR	SICL	15	30	0	F1	F1	CLF	NE	
	113cm			5D	4D											
Bt2	44.5in	C	2.5Y	4M	4M	SBK-2M	FR	SICL	19	28	0	C2	C2	CLF	NE	
	113+cm			6D	2D											
Bk	44.5+in		2.5Y	5M	3M	SBK-2	VFR	CL	30	30	5	C2	C3	FDC, CAM	VE	

Site	Location	Position	Map unit	Notes												
18-4																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	17cm			3D	1D											
Ap	6.5in	C	10YR	2M	1M	SBK-2 F	VFR	SIL	12	18	3				NE	MIXING @BDY
	46cm			4D	2D											
Bt	18in	C	10YR	4M	2M	SBK-2 M	VFR	SICL	18	28	0	F1		CLF, OSF	NE	
	69cm			5D	2D											
Btk1	27in	C	10YR	4M	3M	SBK-2 M	FR	CL	22	30	2	F1	F1	CAM,CLF	ST	
	87cm			6D	2D											
Btk2	34in	C	10YR	5M	3M	SBK-2 M	FR	CL	25	30	2	C2	C2	CAM,CLF	VE	
	114cm			6D	3D											
Bk1	45in	A	2.5Y	4M	4M	SBK-2 M	FR	CL	20	34	2	C3	C3	CAM	VE	
	127cm			6D	4D											
2Bk2	50in	C	2.5Y	5M	4M	SBK-1M	VFR	SL	65	12	8	C1	C1	FDC	ST	SANDY POCKET
	127+cm			6D	4D											
3BC	50+in		2.5Y	5M	3M	MA	FR	CL	35	30	2	C2	C2	FDC	ST	

Site	Location	Position	Map unit	Notes												
18-5																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	26cm			3D	1D											
Ap	10in	A	10YR	2M	1M	SBK-2 M/PL-1 M	VFR	SIL	15	19	0				NE	PLATU @BDY
	56cm			3D	2D											
A	22in	G	10YR	2M	2M	SBK-2 M	VFR	SIL	17	22	0	F1			NE	
	72cm			4D	2D											
BA	28.5in	C	10YR	3M	2M	SBK-2 M	FR	SIL	14	26	0	F1	F1		NE	
	91cm			5D	2D											
Bt1	36in	C	10YR	4M	2M	SBK-2	FR	SICL	12	30	0	F1	F1	CLF	NE	
	113cm			6D	3D											
Bt2	44.5in	G	2.5Y	5M	3M	SBK-2 CO	FR	SICL	18	28	5	C3	C2	CLF	NE	
	113+cm			6D	2D											
Bkg	44.5+in		2.5Y	5M	2M	SBK-2 M	FR	CL	25	28	8	C3	RMX	CAM	VE	

Site	Location	Position	Map unit	Notes												
18-6																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	20cm			3D	1D											
Ap	8in	A	10YR	2M	1M	GR-2 M/SBK-1 F	VFR	SIL	20	22	1				NE	
	31cm			4D	2D											
Bw	12.5in	C	10YR	3M	2M	PL-2 TK, SBK-1 M	FR	SIL	25	25	0	F1		OSF	NE	
	53cm			4D	3D											
Bt1	21in	C	10YR	3M	3M	PR-2 M/SBK-2 M	FI	CL	30	33	3	F1		CLF	NE	
	68cm			5D	3D											
Bt2	27in	C	10YR	4M	3M	PR-2 M	FI	CL	28	30	1	C1		CLF	NE	
	101cm			6D	3D											
Bk	40in	G	2.5Y	5M	4M	SBK-2 M	VFI	SIL	20	26	2	C3	C2	CAM	VE	
	101+cm			6D	4D											
BC	40+in		2.5Y	6M	4M	SBK-1 M	VFI	SIL	22	24	2	C3	C3	CAM	ST	

Site	Location	Position	Map unit	Notes												
18-7																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	17cm			4D	2D											
Ap	6.5in	A	10YR	3M	2M	SBK-1 M	VFR	SIL	25	22	1				ST	
	37cm			5D	3D											
Bk1	14.5in	C	10YR	4M	3M	SBK-2 M	VFR	SIL	23	22	5	F1		CAM	VE	
	58cm			6D	3D											
Bk2	23in	C	10YR	5M	3M	SBK-2 F	FR	SIL	25	23	3	C1		CAM	VE	
	89cm			6D	2D											
Bk3	35in	C	2.5Y	5M	3M	SBK-2 M	FI	SIL	30	23	5	C3	F1	CAM	VE	
	113cm			6D	3D											
Bk4	44.5in	C	2.5Y	4M	4M	SBK-2	FR	SIL	33	21	3	C3	C3	FDC	ST	
	113+cm			5D	3D											
BC	44.5+in		2.5Y	5M	4M	SBK-1 M	FI	CL	27	28	4	M3	M3	FDC	SL	

Site	Location	Position	Map unit	Notes												
18-8																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	17cm			4D	1D											
Ap	6.5in	A	10YR	3M	1M	SBK-2 M/ PL-1M	VFR	SIL	20	20	1				NE	
	50cm			5D	2D											
Bt	19.5in	C	10YR	4M	2M	SBK-2 M	VFR	SIL	26	25	2	F1		CLF	NE	
	67cm			6D	3D											
Bk1	26.5in	C	10YR	5M	3M	SBK-2 M	VFR	SIL	18	19	2	C2	F1	CAM	ST	
	89cm			6D	4D											
Bk2	35in	C	2.5Y	5M	4M	SBK-2 M	FR	SIL	25	18	2	M3	C3	CAM	VE	
	119cm			6D	3D											
Bk3	47in	C	2.5Y	4M	3M	SBK-2 M	FR	SIL	32	18	3	M2	M3	CAM	ST	
	119+cm			5D	3D											
C	47+in		2.5Y	5M	2M	MA	FR	SIL	25	24	1	M3	M3	FDC, CAM	ST	VERY FEW MASSES

Site	Location	Position	Map unit	Notes												
18-9																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	19cm			3D	1D											
Ap	7.5in	A	10YR	2M	1M	SBK-1 M	VFR	SIL	25	21	1				NE	
	33cm			5D	3D											
Bk1	13in	C	10YR	4M	3M	SBK-2 M/F	VFR	L	30	22	5	F1		OSF, FDC	ST	
	56cm			6D	3D											
Bk2	22in	C	2.5Y	4M	4M	SBK-2 M	VFR	L	33	18	2	F1	F1	CAM	VE	
	84cm			6D	3D											
Bk3	33in	C	2.5Y	5M	3M	SBK-2 M	FR	L	35	19	8	C2	C1	CAM	VE	
	122cm			6D	4D											
Bk4	48in	G	2.5Y	5M	4M	SBK-2 M	FR	L	38	18	3	C3	C3	FDC	ST	
	122+cm			6D	4D											
BC	48+in		2.5Y	5M	6M	SBK-1M	FR	L	40	18	8	C2	C2	FDC	ST	

Site	Location	Position	Map unit	Notes												
18-10																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	20cm			3D	1D											
Ap	8in	C	10YR	2M	1M	SBK-2 F	VFR	SIL	20	18	1				NE	MIXING @ BDY
	50cm			4D	2D											
Bt	19.5in	C	10YR	4M	3M	SBK-2 M	FR	SICL	18	28	1	F1		CLF	NE	
	61cm			6D	3D											
Bk1	24in	C	10YR	5M	3M	SBK-2 F	FR	SIL	18	22	0	F1		FDC	VE	
	79cm			6D	4D											
Bk2	31in	G	2.5Y	4M	4M	SBK-2 M	VFR	SIL	21	20	1	F2	F1	CAM	VE	
	93cm			6D	3D											
Bk3	36.5in	C	2.5Y	5M	4M	SBK-2 M	FR	SIL	21	18	2	C2	C3	CAM	VE	
	93+cm			6D	3D											
Bk4	36.5+in		2.5Y	5M	3M	SBK-2 M	FR	SIL	25	20	2	M3	M3	FDC	ST	

Site	Location	Position	Map unit	Notes												
18-11																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	26cm			3D	1D											
Ap	10.5in	C	10YR	2M	1M	SBK-1 M	VFR	SIL	16	18	0				NE	
	53cm			3D	2D											
A	21in	G	10YR	3M	1M	SBK-2 M	FR	SIL	16	20	4	F1			NE	
	71cm			4D	1D											
BA	28in	C	10YR	3M	2M	SBK-2 M	FR	SICL	12	27	1	F1	F1	OAF	NE	
	91cm			5D	2D											
Bt	36in	C	10YR	4M	2M	PR-2 M	FI	SICL	10	33	7	C1	C1	CLF	NE	
	99cm			6D	2D											
Btk	39in	C	10YR	5M	2M	SBK-2 M	VFI	SICL	14	31	2	C2	C2	CLF, FDC	ST	
	99+cm			6D	2D											
Bk	39+in		2.5Y	5M	2M	SBK-2 M	VFI	SIL	18	23	1	M3	M3	CAM	VE	

Site	Location	Position	Map unit	Notes												
19-1																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	15cm			4D	1D											
Ap1	6in	A	10YR	3M	1M	SBK-2 M/F	FR	SICL	5	30	0				NE	
	30cm			3D	2D											
Ap2	12in	A	10YR	2M	2M	SBK-2 M/PL-1 M	FI	SICL	6	33	1	F1			NE	SLIGHT MIXING
	51cm			5D	2D											
Btk	20in	C	10YR	4M	2M	SBK-2	FR	SICL	8	35	1	F1	F1	CLF,CAM	VE	
	85cm			6D	3D											
Bk1	33.5in	G	2.5Y	5M	3M	SBK-2 CO	FR	SICL	14	30	1	C1	C1	CAM	VE	
	109cm			6D	4D											
Bk2	43in	G	2.5Y	5M	4M	SBK-2 M	VFR	SIL	17	25	1	C3	C3	CAM	ST	
	109+cm			6D	4D											
C	43+in		2.5Y	4M	4M	MA	VFR	SIL	20	22	0	M3	M3	CAM	ST	

Site	Location	Position	Map unit	Notes												
19-2																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	27cm			4D	1D											
Ap	10.5in	A	10YR	2M	1M	SBK-2 M/F	FR	SICL	6	32	0				NE	
	43cm			4D	1D											
Btk	17in	C	10YR	3M	2M	SBK-2 M	FR	SICL	6	35	0	F1	F1	CAM,FDC,CLF	SL	CARBONATE MIXING
	61cm			5D	2D											
Bk1	24in	G	10YR	4M	2M	SBK-2 M	VFR	SICL	9	31	0	F1	F1	CAM	ST	
	87cm			6D	2D											
Bk2	34.5in	G	2.5Y	5M	3M	SBK-2 M	VFR	SICL	14	27	1	F3	F3	CAM	VE	
	107cm			6D	3D											
Bk3	42in	G	2.5Y	5M	4M	SBK-2 M	VFR	SIL	18	24	0	C2	C2	CAM	ST	
	107+cm			6D	3D											
C	42+in		2.5Y	5M	4M	MA	VFR	SIL	20	21	0	C3	C3	FDC	ST	

Site	Location	Position	Map unit	Notes												
19-3																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	24cm			3D	1D											
Ap	9.5in	C	10YR	2M	1M	SBK-2 F	FR	SICL	5	33	0				NE	
	39cm			4D	1D											
A	15.5in	C	10YR	3M	1M	SBK-2 M	FR	SICL	7	30	0	F1	F1		NE	
	71cm			4D	2D											
Bw	28in	C	10YR	2M	2M	SBK-2 M	VFR	SICL	9	35	0	F1	F1	FDC	ST	
	102cm			4D	2D											
Btk	40in	C	10YR	3M	2M	SBK-2 M	VFR	SICL	8	38	1	C1	C1	CAM,CLF	VE	
	126cm			6D	2D											
Bk	49.5in	G	2.5Y	5M	3M	SBK-2 M	VFR	SICL	14	30	1	C3	C3	CAM	VE	
	126+cm			6D	3D											
C	49.5+in		2.5Y	5M	3M	MA	VFR	SIL	15	26	0	M3	M3	CAM,FDC	ST	

Site	Location	Position	Map unit	Notes												
19-4																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	23cm			3D	1D											
Ap	19in	C	10YR	2M	1M	SBK-2 M/F	FR	SICL	4	31	0				NE	
	43cm			4D	1D											
Bw	17in	C	10YR	3M	2M	SBK-2 M	FR	SICL	6	32	0	F1	F1		NE	
	60cm			5D	2D											
Bk1	23.5in	C	10YR	4M	2M	SBK-2 M	VFR	SICL	9	30	0	F1	F1	CAM	ST	
	83cm			5D	3D											
Bk2	32.5in	G	2.5Y	4M	3M	SBK-2 M	VFR	SICL	15	28	0	C2	C2	CAM	VE	
	106cm			6D	3D											
BC	42in	G	2.5Y	5M	3M	SBK-1 M	VFR	SIL	18	26	0	C3	C3	CAM	ST	
	106+cm			6D	4D											
C	42+in		2.5Y	5M	4M	MA	VFR	SIL	25	20	0	M3	M3	FDC	ST	

Site	Location	Position	Map unit	Notes
19-5				

Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	15cm			3D	1D											
Ap	6in	A	10YR	2M	1M	SBK-2 F	FR	SICL	7	34	0				NE	
	43cm			4D	1D											
A	17in	C	10YR	3M	1M	SBK-2 M/F	VFR	SICL	7	36	0				NE	
	67cm			4D	2D											
Btk	26.5in	C	10YR	3M	2M	SBK-2 M	VFR	SICL	11	30	0	F1		CAM,CLF	ST	
	89cm			5D	3D											
Bk	35in	G	2.5Y	4M	3M	SBK-2 M	VFR	SIL	15	25	0	F3	F3	CAM	VE	
	104cm			6D	3D											
BC	41in	G	2.5Y	5M	4M	SBK-1 M	VFR	SIL	18	21	1	C3	C3	CAM	VE	
	104+cm			6D	4D											
C	41+in		2.5Y	5M	4M	MA	VFR	SIL	20	20	0	M3	M3	FDC	ST	MOSTLY DISSEMINATED

Site	Location	Position	Map unit	Notes
19-6				

Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	14cm			3D	1D											
Ap	5.5in	A	10YR	2M	1M	SBK-2 M/F	FR	SICL	5	32	0				NE	
	29cm			4D	1D											
A	11.5in	G	10YR	3M	1M	SBK-2 CO	FR	SICL	5	35	0	F1			NE	
	43cm			4D	2D											
Bt	17in	C	10YR	3M	2M	SBK-2 M	FR	SICL	8	38	0	F1	F1	CLF	NE	LOTS OF MIXING
	64cm			5D	3D											
Bk1	25in	G	2.5Y	4M	3M	SBK-2 M	VFR	SICL	13	30	1	F2	F1	CAM	ST	
	76cm			6D	3D											
Bk2	30in	C	2.5Y	5M	3M	SBK-2 M	VFR	SICL	12	27	1	C2	C2	CAM	VE	
	76+cm			6D	4D											
BC	30+in		2.5Y	5M	4M	SBK-1 M	VFR	SIL	16	23	0	M3	M3	FDC	ST	

Site	Location	Position	Map unit	Notes
19-7				

Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	15cm			3D	1D											
Ap	6in	A	10YR	2M	1M	SBK-2 F	VFR	SICL	6	33	0				NE	
	33cm			3D	1D											
A	13in	C	10YR	2M	1M	SBK-2 M	FR	SICL	6	35	0	F1			NE	
	50cm			5D	2D											
Bw	49.5in	C	10YR	4M	2M	SBK-2 M	VFR	SICL	7	36	0	F3	F3		NE	
	85cm			5D	3D											
Bt	33.5in	G	2.5Y	4M	3M	SBK-2 M	FR	SICL	10	38	0	C2	C2	CLF	NE	
	102cm			6D	3D											
Bk	40in	G	2.5Y	5M	3M	SBK-2 M	VFR	SIL	14	26	1	C3	C3	CAM	VE	
	117cm			6D	4D											
BC	46in	G	2.5Y	5M	4M	SBK-1	VFR	SIL	16	24	0	M3	C3	CAM/FDC	ST	DECREASE IN CARBONATES
	117+cm			6D	4D											
C	46+in		2.5Y	5M	4M	MA	VFR	SIL	20	22	0	M3	M3	FDC	ST	

Site	Location	Position	Map unit	Notes
19-8				

Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	11cm			3D	1D											
Ap	4.5in	A	10YR	2M	1M	SBK-2 F	VFR	SICL	5	34	0				NE	
	27cm			3D	1D											
A	10.5in	C	10YR	2M	1M	SBK-2 M/ PL-1 M	FR	SICL	5	33	0				NE	
	42cm			4D	1D											
AB	16.5in	G	10YR	3M	1M	SBK-2 M	FR	SICL	6	35	0	F1			NE	
	57cm			4D	2D											
Bt1	22.5in	C	10YR	3M	2M	SBK-2 M	VFR	SICL	5	36	0	F1	F1	CLF	NE	
	79cm			5D	2D											
Bt2	31in	C	10YR	4M	2M	SBK-2 M	VFR	SICL	8	36	0	F3	F3	CLF	NE	
	95cm			5D	3D											
Bk	37.5in	C	2.5Y	4M	3M	SBK-2 M	VFR	SICL	14	28	1	C3	C3	CAM	VE	
	95+cm			6D	3D											
BC	37.5+in		2.5Y	5M	4M	SBK-1 M	VFR	SIL	18	23	1	M3	C3	CAM,FDC	ST	MOSTLY DISSEMINATED

Site	Location	Position	Map unit	Notes
19-9				

Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	11cm			3D	1D											
Ap	4.5in	A	10YR	2M	1M	SBK-2 F	VFR	SICL	5	36	0				NE	
	39cm			3D	1D											
A	15.5in	C	10YR	2M	1M	SBK-2 M/PL-1 M	FR	SICL	7	33	0	F1			NE	
	58cm			5D	2D											
Bw	23in	C	10YR	4M	2M	SBK-2 M	VFR	SICL	7	35	0	F1	F1		NE	
	76cm			5D	3D											
Btk	30in	C	2.5Y	4M	3M	SBK-2 M	VFR	SICL	10	36	1	C1	C1	CAM,CLF	SL	
	109cm			6D	3D											
Bk	43in	G	2.5Y	5M	3M	SBK-2 M	VFR	SICL	12	30	1	C3	C3	CAM	VE	
	109+cm			6D	4D											
C	43+in		2.5Y	5M	4M	MA	VFR	SIL	20	21	0	M3	M3	FDC	ST	

Site	Location	Position	Map unit	Notes												
19-10																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	27cm			3D	1D											
Ap	10.5in	C	10YR	2M	1M	SBK-2 M/F	FR	SICL	5	35	0				NE	
	49cm			4D	1D											
A	19.5in	C	10YR	3M	1M	SBK-2 M	FR	SICL	5	36	0	F1	F1		NE	
	63cm			5D	2D											
Bw	25in	C	10YR	3M	2M	SBK-2 M	FR	SICL	6	38	0	F3	F3		NE	
	81cm			5D	3D											
Btk	32in	C	2.5Y	4M	3M	SBK-2 M	FR	SICL	10	36	0	C2	C2	CAM,CLF	ST	
	103cm			6D	3D											
Bk	40.5in	G	2.5Y	5M	3M	SBK-2 M	VFR	SICL	15	30	1	C2	C2	CAM	VE	
	103+cm			6D	3D											
BC	40.5+in		2.5Y	5M	4M	SBK-1 M	VFR	SICL	18	28	2	C3	C3	CAM	VE	

Site	Location	Position	Map unit	Notes												
19-11																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	15cm			4D	1D											
Ap1	6in	A	10YR	2M	1M	SBK-3 M/F	FR	SICL	6	33	0				NE	
	30cm			4D	1D											
Ap2	12in	A	10YR	2M	1M	SBK-2 CO/ PL-2 TK	FR	SICL	7	34	0	F1			NE	
	44cm			4D	2D											
Bt	17.5in	C	10YR	3M	2M	SBK-2 M	FR	SICL	7	38	0	F1		CLF,OSF	NE	
	57cm			5D	2D											
Bk1	22.5in	C	10YR	4M	2M	SBK-2 M	VFR	SICL	11	30	0	F1	F1	CAM	ST	FEW CARBONATE MASSES
	81cm			6D	3D											
Bk2	32in	G	2.5Y	5M	3M	SBK-2 M	VFR	SICL	15	28	1	C1	C1	CAM	VE	
	81+cm			6D	3D											
BC	32+in		2.5Y	5M	4M	SBK-1	VFR	SIL	16	22	1	C3	C3	CAM	VE	

Site	Location	Position	Map unit	Notes												
552-1																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	18cm			4D	2D											
Ap	in	A	10YR	2M	2M	SBK2 F	FR	SIL	8	19	0			OSF		
	36cm			4D	2D											
Bw	in	G	10YR	3M	2M	SBK2 F	FR	SIL	11	22	0			OSF		
	61cm			5D	3D											
Bt	in	C	10YR	4M	2M	SBK2 M	FR	SICL	12	28	2			CLF		
	73cm			6D	3D											
Bk1	in	C	2.5Y	4M	4M	SBK2 M	FR	SICL	14	25	0	F1	F1	CAM	ST	
	107cm			6D	3D											
Bk2	in	A	2.5Y	5M	4M	SBK2 M	FI	SICL	16	23	0	F1	F1	CAM	ST	
	107+cm			6D	4D											
2BC	in		2.5Y	4M	4M	SBK1 F	FR	SICL	40	17	20			FDC	VE	

Site	Location	Position	Map unit	Notes												
552-2																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	23cm			4D	2D											
Ap	in	A	10YR	2M	1M	SBK2 F/M	FR	SIL	12	22	0					
	37cm			5D	2D											
Bt1	in	G	10YR	4M	2M	SBK2 M	FR	SIL	8	26	0			CLF		
	54cm			5D	3D											
Bt2	in	C	10YR	4M	3M	SBK2 M	FR	SICL	7	28	0					
	76cm			6D	3D											
Bk1	in	G	2.5Y	4M	4M	SBK2 M	FR	SIL	10	25	0	F1		CAM/N	ST	
	100cm			6D	3D											
Bk2	in	A	2.5Y	5M	4M	SBK2 F/M	FR	SIL	20	18	2	F1	F1	CAM/N	ST	CARB INCREASE
	100+cm			D	D											
2BC or C	in			M	M											

Site	Location	Position	Map unit	Notes												
552-3																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	18cm			4D	2D											
Ap	in	A	10YR	2M	1M	SBK2 F	FR	SIL	10	24	0					
	33cm			5D	2D											
Bw1	in	G	10YR	3M	2M	SBK2 M/F	FR	SIL	10	26	0					
	49cm			5D	3D											
Bw2	in	C	2.5Y	3M	3M	SBK2 M	FR	SIL	8	25	0					
	76cm			6D	3D											
Bk1	in	C	2.5Y	4M	4M	SBK2 M	FR	SIL	14	23	0	F1		CAM	ST	
	95cm			6D	3D											
Bk2	in	C	2.5Y	5M	4M	SBK2 M/F	FR	SIL	20	20	5	F1		FDC	VE	DECREASE CARB
	95+cm			D	D											
2BC or C	in			M	M											

Site	Location	Position	Map unit	Notes												
552-4																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	19cm			4D	2D											
Ap	in	A	10YR	2M	2M	SBK2 F	FR	SIL	10	24	0					
	34cm			5D	2D											
Bw1	in	G	10YR	3M	2M	SBK2 M/F	FR	SIL	7	26	0					
	50cm			5D	3D											
Bw2	in	G	10YR	4M	3M	SBK2 M	FR	SICL	7	27	0					
	70cm			5D	3D											
Bw3	in	C	2.5Y	4M	4M	SBK2 M	FR	SICL	7	33	0					
	103cm			6D	3D											
Bk	in	C	2.5y	5M	4M	SBK2 M	FR	SIL	15	22	3	F1	F2	CAM	ST	
	103+cm			D	D											
2BC or C	in			M	M											

Site	Location	Position	Map unit	Notes												
552-5																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	23cm			4D	2D											
Ap	in	C	10YR	2M	2M	SBK2 F/M	FR	SIL	20	26	0					
	36cm			5D	2D											
Bw1	in	C	10YR	3M	2M	SBK2 M/F	FR	SIL	18	27	0					
	53cm			5D	3D											
Bw2	in	G	10YR	4M	3M	SBK2 M	FR	SIL	20	26	0					
	71cm			6D	4D											
Bw3	in	C	2.5Y	4M	3M	SBK2 M	FR	SIL	18	26	0	F1				
	100cm			6D	3D											
Bk	in	A	2.5Y	4M	4M	SBK2 M	FR	SIL	20	20	3	F3	F3	CAM	VE	
	100+cm			5D	4D											
2C	in		10YR	3M	4M	SGR	LO	LS	80	5	8	F1	F1	FDC	ST	

Site	Location	Position	Map unit	Notes												
552-6																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	24cm			4D	2D											
Ap	in	D	10YR	2M	2M	SBK2 M	FI	SIL	8	23	0					
	41cm			5D	2D											
Bw	in	G	10YR	3M	2M	SBK2 F	FR	SIL	7	25	0			OSF		
	63cm			5D	3D											
Bt1	in	G	10YR	3M	4M	SBK2 M	FR	SICL	7	28	0	F1		CLF		
	91cm			6D	4D											
Bt2	in	C	2.5Y	4M	4M	SBK2 M	FR	SIL	10	26	0	F1	F1	CLF		
	108cm			6D	3D											
Bk	in	A	2.5Y	5M	4M	SBK2 M	FI	SIL	16	20	5	F1	F1	CAM/CAN	ST	
	108+cm			D	D											
2BC or C	in			M	M											

Site	Location	Position	Map unit	Notes												
552-7																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	18cm			4D	1D											
Ap	in	A	10YR	2M	1M	SBK2 F	VFR	SIL	10	21	0					
	30cm			4D	2D											
AB	in	C	10YR	2M	2M	SBK2 F/M	FR	SIL	10	23	0			OSF		
	51cm			5D	2D											
Bt1	in	G	10YR	4M	2M	SBK2 M	FR	SICL	8	28	0	F1		CLF		
	84cm			5D	3D											
Bt2	in	C	10YR	4M	3M	SBK2 M	FR	SICL	8	30	0	F1		CLF		
	114cm			6D	3D											
Bk	in	C	2.5y	4M	4M	SBK2 M/F	FR	SIL	20	20	2	F1	F1	CAM	VE	
	114+cm			D	D											
2BC or C	in			M	M											

Site	Location	Position	Map unit	Notes												
552-8																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	19cm			4D	1D											
Ap	in	A	10YR	2M	1M	SBK3 F	FR	SIL	10	21	0					
	29cm			4D	2D											
AB	in	G	10YR	2M	2M	SBK2 F/M	FR	SIL	11	21	0			OSF		
	57cm			5D	3D											
Bt1	in	G	10YR	4M	2M	SBK2 M	FR	SICL	10	27	0					
	86cm			6D	3D											
Bt2	in	C	10YR	5M	3M	SBK2 M	FR	SICL	10	28	0	F1		CLF		
	113cm			6D	3D											
Bk	in	C	2.5Y	4M	4M	SBK2 M	FR	SIL	18	22	2	F1	F2	CAM	VE	
	113+cm			D	D											
2BC or C	in			M	M											

Site	Location	Position	Map unit	Notes
552-9				

Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	21cm			4D	1D											
Ap	in	C	10YR	2M	1M	SBK2 F	FR	SIL	12	22	0					
	37cm			5D	2D											
Bt1	in	G	10YR	3M	2M	SBK2 M/F	FR	SICL	10	27	0			OSF, CLF		
	53cm			5D	3D											
Bt2	in	G	10YR	4M	2M	SBK2 M	FR	SICL	10	29	0			CLF		
	77cm			6D	3D											
Bt3	in	C	2.5Y	5M	3M	SBK2 M	FR	SICL	11	29	0	F1		CLF		
	106cm			6D	3D											
Bk	in	A	2.5Y	5M	4M	SBK2 M	FR	SIL	14	25	1	F2	F2	CAM	ST	
	116cm			6D	4D											
2BC	in		2.5Y	4M	4M	SBK1 F	FR	SL	55	15	10	F1	F1	FDC	VE	

Site	Location	Position	Map unit	Notes
552-10				

Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	20cm			4D	1D											
Ap	in	C	10YR	2M	1M	SBK2 M/F	FR	SIL	10	23	0					
	36cm			5D	2D											
Bw	in	G	10YR	3M	2M	SBK2 F/M	FR	SIL	10	26	0			OSF		
	60cm			5D	3D											
Bt1	in	G	10YR	4M	3M	SBK2 M	FR	SICL	8	28	0			CLF		
	80cm			6D	3D											
Bt2	in	C	10YR	5M	3M	SBK2 M	FR	SICL	6	30	0			CLF		
	101cm			6D	3D											
Bk	in	C	2.5Y	4M	4M	SBK2 M	FR	SIL	15	22	3	F1	F1	CAM	ST	
	109cm			6D	4D											
2BC	in		2.5Y	4M	4M	SBK 1 F	FR	SL	60	12	12	F1	F1	FDC	VE	

Site	Location	Position	Map unit	Notes
552-11				

Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	15cm			4D	2D											
Ap	in	A	10YR	2M	2M	SBK2 M/F	FI	SIL	12	18	0					
	35cm			5D	2D											
Bw1	in	G	10YR	3M	3M	SBK2 M	FR	SIL	8	21	0			OSF		
	57cm			5D	3D											
Bw2	in	C	10YR	4M	3M	SBK2 M	FR	SIL	8	23	0					
	86cm			6D	3D											
Bk	in	G	2.5y	4M	4M	SBK2 M/F	FR	SIL	10	20	0	F1	F1	CAM		
	100cm			6D	3D											
BC	in	A	2.5Y	5M	4M	SBK2 M/F	FR	L	35	17	5	F1	F2	CAM, FDC	VE	FEW CARBONATES
	100+cm			D	D											
2C	in			M	M											

Site	Location	Position	Map unit	Notes
555-1				

Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	19cm			3D	1D											
Ap	in	A	10YR	2M	1M	SBK2 F/M	FR	CL	30	29	0					
	33cm			4D	2D											
AB	in	C	10YR	3M	2M	SBK2 M	FR	CL	35	28	0			OSF		MIXING
	46cm			5D	3D											
Bk1	in	C	10YR	4M	2M	SBK2 M	FR	CL	35	30	1	F1		CAM	ST	
	94cm			6D	3D											
Bk2	in	C	2.5Y	5M	4M	SBK 2 M/F	FR	CL	30	32	3	C3	C3	CAM	VE	
	113cm			6D	3D											
BC	in	C	2.5Y	5M	6M	SBK 1 M/F	FR	CL	30	33	3	M3	M3	CAM	VE	
	Ccm			6D	2D											
C	in		2.5Y	5M	3M	MA	FI	CL	35	34	5	M3	M3	CAM	ST	

Site	Location	Position	Map unit	Notes
555-2				

Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	21cm			3D	1D											
Ap	in	C	10YR	2M	1M	SBK 2 M/F	FR	L	35	26	0					
	43cm			5D	2D											
AB	in	C	10YR	4M	2M	SBK 2 M	FR	CL	36	30	2					
	61cm			6D	2D											
Bk1	in	C	10YR	5M	3M	SBK 2 M	FR	CL	35	29	2	F1		FDC CAM	SL	FEW MASSES
	102cm			6D	3D											
Bk2	in	C	2.5Y	5M	4M	SBK 2 M	FR	CL	30	29	4	C3	C3	CAM	VE	
	102+cm			6D	3D											
C	in		2.5Y	5M	6M	MA	FI	CL	33	30	5	C3	C3	CAM	ST	

Site	Location	Position	Map unit	Notes												
555-3																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	18cm			3D	1D											
Ap	in	A	10YR	2M	1M	SBK 2 F/PL 1 M	FR	CL	30	27	0					
	40cm			5D	2D											
Bw	in	C	10YR	4M	2M	SBK 2 M	FR	CL	32	28	2					
	58cm			6D	2D											
Bk1	in	G	10YR	5M	3M	SBK 2 M	FR	CL	28	25	2	F1		FDC	ST	
	101cm			6D	3D											
Bk2	in	C	2.5Y	5M	4M	SBK 2 M	FR	CL	32	29	5	C3	C3	CAM/FDC	VE	MOSTLY DISSEMINATE
	101+cm			6D	3D											
C	in		2.5Y	5M	6M	MA	FI	CL	30	30	5	C3	C3	CAM	ST	

Site	Location	Position	Map unit	Notes												
555-4																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	16cm			3D	1D											
Ap	in	A	10YR	2M	1M	SBK 2 F/M	FR	CL	30	28	0					
	39cm			5D	3D											
Bw	in	C	10YR	4M	2M	SBK 2 M	FR	CL	35	30	2				SL	MIXED
	69cm			6D	3D											
Bk1	in	G	10YR	5M	3M	SBK 2 M	FR	CL	32	27	4	F1		CAM	VE	
	98cm			6D	3D											
Bk2	in	G	2.5Y	5M	4M	SBK 2 M	FI	CL	32	28	4	C3	C3	CAM	ST	
	98+cm			6D	4D											
C	in		2.5Y	5M	6M	MA	FI	CL	32	32	6	M3	M3	CAM	ST	

Site	Location	Position	Map unit	Notes												
555-5																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	17cm			3D	1D											
Ap	in	A	10YR	2M	1M	SBK 2 F/M	FR	CL	30	29	0					
	40cm			5D	2D											
AB	in	C	10YR	3M	2M	SBK2 M/F	FR	CL	33	29	0					
	61cm			6D	3D											
Bk1	in	C	10YR	5M	4M	SBK 2 M	FR	CL	28	31	2	F1	F1	CAM		
	89cm			6D	3D											
Bk2	in	C	2.5Y	5M	4M	SBK 2 M	FR	CL	30	30	3	F3	F3			
	89+cm			6D	4D											
C	in		2.5Y	5M	6M	MA	FI	CL	30	32	4	C3	C3			

Site	Location	Position	Map unit	Notes												
555-6																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	15cm			4D	1D											
Ap	in	A	10YR	2M	1M	SBK2 M	FR	CL	35	28	1					
	40cm			5D	2D											
Bw	in	C	10YR	4M	2M	SBK2 M/F	FR	CL	30	30	0			OSF		
	78cm			6D	3D											
Bk	in	C	2.5Y	5M	4M	SBK2 M/F	FR	CL	34	32	2	F3		CAM	VE	
	78+cm			6D	4D											
C	in		2.5Y	5M	6M	MA	FI	CL	35	35	8	M3	M3	CAM	VE	

Site	Location	Position	Map unit	Notes												
7																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	16cm			3D	1D											
Ap	in	A	10YR	2M	1M	SBK2 F/M	FR	CL	35	29	0					
	36cm			5D	2D											
AB	in	C	10YR	3M	2M	SBK2 M	FR	CL	35	30	1			OSF		
	56cm			6D	3D											
Bk1	in	C	10YR	5M	3M	SBK2 M	FR	CL	32	31	1	F3	F3	CAM	ST	
	90cm			6D	3D											
Bk2	in	C	2.5Y	5M	4M	SBK2 M/F	FR	SCL	45	29	2	C3	C3	CAM	ST	CARB INCREASE
	90+cm			6D	4D											
C	in		2.5Y	5M	6M	MA	FI	CL	35	32	4	C3	C3	CAM	ST	

Site	Location	Position	Map unit	Notes												
555-8																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	16cm			3D	1D											
Ap	in	A	10YR	2M	1M	SBK 2 M/F	FR	L	30	26	0					
	28cm			4D	1D											
AB	in	G	10YR	2M	2M	SBK2 M	FR	CL	32	28	1					
	42cm			5D	2D											
Bw	in	C	10YR	4M	2M	SBK2 M	FR	CL	33	31	1					
	61cm			6D	3D											
Bk1	in	G	2.5Y	5M	3M	SBK2 M	FR	CL	30	33	1	F3	F3	CAM	ST	
	83cm			6D	3D											
Bk2	in	G	2.5Y	5M	4M	SBK2 M	FR	CL	30	30	3	C3	C3	CAM	ST	
	83+cm			6D	3D											
BC	in		2.5Y	5M	6M	SBK 1 M	FI	CL	30	28	4	C3	C3	CAM	VE	

Site	Location	Position	Map unit	Notes												
555-9																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	24cm			3D	1D											
Ap	in	A	10YR	2M	1M	SBK 2 M/F	FR	L	28	26	0					
	35cm			4D	2D											
AB	in	G	10YR	3M	2M	SBK 2 M	FR	L	30	26	0					
	50cm			5D	2D											
Bw	in	C	10YR	4M	2M	SBK 2 M	FR	L	32	26	5	F1			VS	
	69cm			6D	3D											
Bk1	in	G	10YR	5M	3M	SBK 2 M	FR	CL	33	27	2	F1	F1	CAM	ST	
	90cm			6D	3D											
Bk2	in	C	2.5Y	5M	4M	SBK 2 F	FR	CL	35	28	5	C3	C3	CAM	ST	
	90+cm			6D	3D											
BC	in		2.5Y	5M	6M	SBK 1 M	FR	CL	35	31	4	C3	C3	CAM	VE	

Site	Location	Position	Map unit	Notes												
555-10																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	18cm			3D	1D											
Ap	in	A	10YR	2M	1M	SBK 2 F/M	FR	CL	30	28	0					
	40cm			4D	2D											
AB	in	G	10YR	3M	2M	SBK2 M	FR	CL	32	29	0					
	58cm			6D	3D											
Bk1	in	C	10YR	5M	3M	SBK2 M	FR	CL	30	30	1	F1		CAM	VE	
	105cm			6D	3D											
Bk2	in	C	2.5Y	5M	4M	SBK2 F	FR	CL	35	33	3	C3	C3	CAM	ST	CARB INCREASE
	105+cm			6D	3D											
BC	in		2.5Y	5M	6M	SBK 1 M	FI	CL	33	35	4	C3	C3	CAM	ST	

Site	Location	Position	Map unit	Notes												
555-11																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	16cm			3D	1D											
Ap	in	A	10YR	2M	1M	SBK2 M/F	FR	CL	35	28	1					
	26cm			4D	2D											
AB	in	C	10YR	3M	2M	SBK2 M/F	FR	CL	32	27	0			OSF		
	41cm			5D	4D											
Bw	in	C	2.5Y	4M	4M	SBK2 M	FR	CL	30	30	2	F1		OSF/FDC	SL	
	61cm			5D	4D											
Btk1	in	G	2.5Y	4M	4M	SBK2 M	FR	CL	30	33	3	F3	F3	CLF/CAM	VE	
	100cm			6D	2D											
Btk2	in	G	2.5Y	5M	3M	SBK2 M	FR	CL	30	35	3	C3	C3	CLF/CAM	VE	
	100+cm			6D	3D											
C	in		2.5Y	5M	4M	MA	FI	CL	30	31	5	M3	M3	CAM	VE	

Site	Location	Position	Map unit	Notes												
55(7)-1																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	19cm			3D	2D											
Ap	17.5in	A	10YR	2M	2M	SBK-3 M	FR	SICL	6	29	0				NE	
	34cm			5D	2D											
Bw	13.5in	C	10YR	4M	2M	SBK-2 M	FR	SICL	6	30	0			OSF	NE	
	71cm			5D	3D											
Bt	28in	G	10YR	4M	3M	SBK-2 CO/PR-1 M	FI	SICL	7	33	1	F1	F1	CLF	NE	
	114cm			6D	3D											
Bk	45in	G	2.5Y	5M	3M	SBK-2 M	VFR	SIL	9	22	0	F2	F2	CAM	VE	
	134cm			6D	3D											
BC	53in	G	2.5Y	5M	4M	SBK-1 M	VFR	SIL	10	17	1	C2	C2	CAM	ST	
	134+cm			6D	3D											
C	53+in		2.5Y	6M	4M	MA	VFR	SIL	12	14	1	C3	C3	CAM	ST	

Site	Location	Position	Map unit	Notes												
55(7)-2																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	12cm			4D	2D											
Ap	5in	A	10YR	2M	2M	SBK-3 F	VFR	SICL	5	31	0				NE	
	37cm			5D	2D											
Bt1	14.5in	C	10YR	4M	2M	SBK-2 M/F	FR	SICL	6	35	0			CLF,OSF	NE	
	74cm			5D	3D											
Bt2	29in	C	10YR	4M	3M	SBK-2 M	FR	SICL	8	33	0	F1	F1	CLF	NE	
	125cm			6D	3D											
Bk	49in	G	2.5Y	4M	4M	SBK-2 M	FR	SIL	10	24	0	C2	F2	CAM	ST	
	125+cm			6D	4D											
BC	49+in		2.5Y	5M	4M	SBK-1 M	VFR	SIL	12	20	1	C3	C3	FDC	ST	

Site	Location	Position	Map unit	Notes												
55(7)-3																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	15cm			4D	2D											
Ap	6in	A	10YR	3M	2M	SBK-3 F	VFR	SICL	4	31	0				NE	
	39cm			5D	2D											
Bt1	15.5in	G	10YR	4M	2M	SBK-2 M	FR	SICL	5	36	0			CLF	NE	
	61cm			5D	3D											
Bt2	24in	G	10YR	4M	3M	SBK-2 M	FR	SICL	5	34	0	F1	F1	CLF	NE	
	84cm			6D	3D											
Bt3	33in	C	10YR	5M	3M	SBK-2 M	FR	SICL	5	32	0	F2	F1	CLF	NE	
	122cm			6D	3D											
Bk	48in	G	2.5Y	4M	4M	SBK-2 M	FR	SIL	10	22	0	C3	C3	CAM	ST	
	122+cm			6D	4D											
BC	48+in		2.5Y	5M	4M	SBK-1 M	VFR	SIL	10	20	1	M3	M3	CAM,FDC	ST	CARBONATES MOSTLY DISSEMINATED

Site	Location	Position	Map unit	Notes												
55(7)-4																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	17cm			4D	2D											
Ap	6.5in	A	10YR	2M	2M	SBK-2 F/M	VFR	SICL	7	32	0				NE	
	33cm			5D	2D											
Bt1	13in	C	10YR	4M	2M	SBK-2 M	VFR	SICL	7	34	0			OSF,CLF	NE	
	56cm			5D	3D											
Bt2	22in	G	10YR	4M	3M	SBK-2 M	FR	SICL	8	37	0	F1		CLF	NE	
	99cm			6D	3D											
Bt3	39in	G	10YR	5M	3M	SBK-2 M	FR	SICL	10	34	0	F1	F1	CLF	NE	
	128cm			6D	3D											
Bk	50.5in	G	2.5Y	5M	3M	SBK-2 M	FR	SIL	12	25	0	C2	F2	CAM	ST	
	128+cm			6D	3D											
BC	50.5+in		2.5Y	5M	4M	SBK-1 M	VFR	SIL	13	20	1	C3	C3	CAM	ST	

Site	Location	Position	Map unit	Notes												
55(7)-5																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	20cm			4D	2D											
Ap	8in	A	10YR	2M	2M	SBK-2 F/GR-1 M	VFR	SICL	5	30	0				NE	
	46cm			5D	2D											
Bt1	18in	G	10YR	4M	2M	SBK-2 M	FR	SICL	6	36	0			CLF	NE	
	61cm			5D	3D											
Bt2	24in	C	10YR	4M	3M	SBK-2 M	FR	SICL	5	38	0	F2	F3	CLF	NE	
	89cm			5D	3D											
Bt3	35in	C	2.5Y	4M	4M	SBK-2 M	FR	SICL	8	34	0	C3	C2	CLF	NE	
	126cm			6D	3D											
Bk	49.5in	G	2.5Y	5M	3M	SBK-2 M	FR	SIL	9	24	0	C3	C3	CAM	ST	
	126+cm			6D	3D											
BC	49.5+in		2.5Y	5M	4M	SBK-1	VFR	SIL	12	20	1	C3	C3	CAM	ST	MASSES INCREASE

Site	Location	Position	Map unit	Notes												
55(7)-6																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	20cm			4D	2D											
Ap	8in	A	10YR	2M	2M	SBK-2 F	FR	SICL	6	30	0				NE	
	42cm			5D	2D											
Bt1	16.5in	G	10YR	4M	2M	SBK-2 M	FR	SICL	5	36	0	F1		CLF,OSF	NE	
	74cm			5D	3D											
Bt2	29in	C	10YR	4M	3M	SBK-2 M	FR	SICL	6	32	0	F1	F1	CLF	NE	
	120cm			6D	3D											
Bk	47.5in	G	2.5Y	5M	3M	SBK-2 M	FR	SIL	10	22	1	C3	F3	CAM	ST	
	120+cm			6D	4D											
C	47.5+in		2.5Y	5M	4M	MA	FR	SIL	12	19	1	C3	C3	CAM	ST	

Site	Location	Position	Map unit	Notes												
55(7)-7																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	18cm			4D	2D											
Ap	7in	A	10YR	3M	2M	SBK-3 F	VFR	SICL	5	29	0				NE	
	51cm			5D	2D											
Bt1	20in	G	10YR	4M	2M	SBK-2 M	FR	SICL	5	36	0			CLF	NE	
	78cm			5D	3D											
Bt2	30.5in	C	10YR	4M	3M	SBK-2 M	VFR	SICL	8	34	0	F2	F2	CLF	NE	
	123cm			6D	3D											
Bk	48.5in	G	2.5Y	5M	3M	SBK-2 M	VFR	SIL	12	25	0	C2	C2	CAM	ST	
	123+cm			6D	3D											
BC	48.5+in		2.5Y	5M	4M	SBK-1 M	VFR	SIL	14	20	1	C2	C2	FDC	ST	

Site	Location	Position	Map unit	Notes												
55(7)-8																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	17cm			3D	2D											
Ap	34in	A	10YR	2M	2M	SBK-2 M/F	VFR	SICL	5	29	0				NE	
	34cm			5D	2D											
Bt1	13.5in	G	10YR	4M	2M	SBK-2 M	VFR	SICL	3	35	0			CLF	NE	
	61cm			5D	3D											
Bt2	24in	C	10YR	4M	3M	SBK-2 M	FR	SICL	8	34	0	F1	F1	CLF	NE	
	82cm			5D	3D											
Bt3	32in	C	2.5Y	4M	3M	SBK-2 M	VFR	SICL	10	32	0	F2	F2	CLF	NE	
	122cm			6D	3D											
Bk	48in	G	2.5Y	5M	3M	SBK-2 M	VFR	SIL	10	25	1	C2	C2	CAM	VE	
	122+cm			6D	3D											
BC	48+in		2.5Y	5M	4M	SBK-1 M	VFR	SIL	12	20	2	C3	C3	CAM	ST	

Site	Location	Position	Map unit	Notes												
55(7)-9																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	15cm			4D	2D											
Ap	6in	A	10YR	2M	2M	SBK-2 M/F	VFR	SICL	5	30	1				NE	
	30cm			5D	2D											
Bt1	12in	G	10YR	4M	2M	SBK-2 M	FR	SICL	5	35	0			CLF	NE	
	49cm			5D	3D											
Bt2	19in	G	10YR	4M	3M	SBK-2 M	FR	SICL	5	38	0	F1		CLF	NE	
	79cm			5D	3D											
Bt3	31in	C	2.5Y	4M	3M	SBK-2 M	FR	SICL	8	34	0	F1	F1	CLF	NE	
	125cm			6D	3D											
Bk	49in	G	2.5Y	5M	3M	SBK-2 M	VFR	SIL	12	25	2	C2	F2	CAM	VE	
	125+cm			6D	4D											
BC	49+in		2.5Y	5M	4M	SBK-1 M/F	VFR	SIL	12	21	1	C3	C3	CAM,FDC	ST	MOSTLY DISSEMINATED

Site	Location	Position	Map unit	Notes											
55(7)-10															
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	18cm			4D	2D											
Ap	7in	A	10YR	2M	2M	SBK-2 F	VFR	SICL	6	30	0				NE	
	35cm			4D	2D											
Bw	14in	C	10YR	3M	2M	SBK-2 M	VFR	SICL	6	32	0			OSF	NE	
	58cm			5D	3D											
Bt1	23in	G	10YR	4M	3M	SBK-2 M	FR	SICL	5	37	0	F1		CLF	NE	
	89cm			5D	3D											
Bt2	35in	C	2.5Y	4M	4M	SBK-2 M	FR	SICL	10	31	0	F1	F1	CLF	NE	
	116cm			6D	3D											
Bk	45.5in	G	2.5Y	5M	3M	SBK-2 M	FR	SIL	13	24	1	C2	C2	CAM	ST	
	116+cm			6D	4D											
BC	45.5+in		2.5Y	5M	4M	SBK-1 M	VFR	SIL	14	20	1	C2	C2	CAM	ST	

Site	Location	Position	Map unit	Notes												
55(7)-11																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	23cm			4D	2D											
Ap	9in	C	10YR	2M	2M	GR-2 M	VFR	SICL	4	32	0				NE	
	46cm			5D	2D											
Bw	18in	G	10YR	3M	2M	SBK-2 M	FR	SICL	6	30	0	F1		OSF	NE	
	94cm			5D	3D											
Bt1	37in	G	10YR	4M	3M	SBK-2 CO	FR	SICL	4	34	0	F2	F1	CLF	NE	
	117cm			6D	3D											
Bt2	46in	G	2.5Y	4M	4M	SBK-2 M	FR	SICL	8	31	0	C2	F2	CLF	NE	
	117+cm			6D	4D											
BC	46+in		2.5Y	5M	6M	SBK-1 M	VFR	SIL	12	24	1	C2	C2	CAM	ST	

Site	Location	Position	Map unit	Notes												
558-1																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	21cm			3D	1D											
Ap	in	G	10YR	2M	1M	SBK2 F	VFR	SICL	5	28	0					
	44cm			4D	1D											
Ap	in	G	10YR	2M	2M	SBK2 M/F	FR	SICL	6	30	0					
	62cm			4D	1D											
BA	in	G	10YR	3M	2M	SBK2 M	FR	SICL	5	28	0			CAM	ST	CARB MIXED, NOT PEDOGENIC
	105cm			6D	2D											
Bk	in	C	2.5Y	4M	4M	SBK2 M	FR	SIL	10	26	0	F1		CAM	ST	
	125cm			6D	3D											
BC	in	C	2.5Y	5M	3M	SBK2 M	FR	SIL	12	23	0	C3	C3	FDC	ST	
	125+cm			6D	3D											
C	in		2.5Y	5M	3M	MA	FR	SIL	14	22	0	M3	M3	FDC	ST	

Site	Location	Position	Map unit	Notes												
558-2																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	16cm			3D	1D											
Ap	in	C	10YR	2M	1M	SBK2 F	FR	SICL	6	28	0					
	33cm			3D	1D											
Ap	in	C	10YR	2M	1M	SBK2 F/M	FR	SICL	7	29	0					
	56cm			4D	1D											
AB	in	G	10YR	3M	1M	SBK2 M	FR	SICL	5	30	0			OSF		
	75cm			5D	2D											
Bk1	in	C	10YR	4M	2M	SBK2 M	FR	SIL	15	25	0	F1	F2	CAM	ST	
	105cm			6D	2D											
Bk2	in	G	2.5Y	4M	3M	SBK2 M	FR	SIL	15	23	0	C1	C1	CAM	ST	
	130cm			6D	3D											
BC	in	G	2.5Y	5M	3M	SBK2 F	VFR	SIL	20	20	0	C3	C3	CAM	ST	
	130+cm			6D	3D											
C	in		2.5Y	5M	4M	MA	FR	SIL	25	20	0	M3	M3	FDC	ST	

Site	Location	Position	Map unit	Notes												
558-3																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	29cm			4D	1D											
Ap	in	A	10YR	2M	1M	ABK 3 F/M	FR	SICL	5	30	0					
	42cm			4D	1D											
Ap	in	G	10YR	3M	1M	SBK2 M	FR	SICL	5	29	0					
	58cm			5D	2D											
Bw	in	C	10YR	4M	2M	SBK2 M	FR	SICL	8	32	0				SL	FEW NODULES @BDY
	92cm			6D	3D											
Bk1	in	G	2.5Y	4M	3M	SBK2 M	FR	SIL	15	26	0	F1		CAM	VE	
	111cm			6D	3D											
Bk2	in	G	2.5Y	5M	3M	SBK2 M/F	FR	SIL	25	24	0	C3	C3	CAM	ST	
	111+cm			6D	3D											
C	in		2.5Y	5M	3M	MA	FR	SIL	25	21	0	M3	M3	CAM	ST	MOSTLY DISSEMINATE

Site	Location	Position	Map unit	Notes												
558-4																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	28cm			4D	1D											
Ap	in	C	10YR	2M	1M	SBK2 M/F	FR	SICL	5	28	0					
	47cm			4D	1D											
A	in	C	10YR	3M	1M	SBK2 M/F	FR	SICL	5	28	0					
	67cm			5D	2D											
Bw1	in	G	10YR	4M	2M	SBK2 M	FR	SICL	6	30	0					
	84cm			5D	3D											
Bw2	in	C	2.5Y	4M	3M	SBK2 M	FR	SICL	8	27	0	F1			VS	
	105cm			6D	3D											
Bk	in	G	2.5Y	5M	3M	SBK2 M	FR	SIL	8	25	0	F3	F3	CAM	ST	
	125cm			6D	4D											
BC	in	G	2.5Y	5M	4M	SBK2 M	FR	SIL	20	24	0	C3	C3	CAM	ST	
	125+cm			6D	4D											
C	in		2.5Y	5M	4M	MA	VFR	SIL	25	20	0	M3	M3	FDC	ST	

Site	Location	Position	Map unit	Notes												
558-5																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	24cm			4D	1D											
Ap	in	C	10YR	2M	1M	ABK2 F	FR	SICL	5	30	0					
	37cm			4D	1D											
A	in	G	10YR	3M	1M	SBK2 M/F	FR	SICL	6	29	0					
	59cm			4D	2D											
Bw	in	C	10YR	3M	2M	SBK2 M	FR	SICL	6	29	0					
	78cm			6D	2D											
Bk1	in	C	10YR	4M	2M	SBK2 M	FR	SIL	15	25	0	F1	F1	CAM	SL	
	102cm			6D	2D											
Bk2	in	C	2.5Y	4M	3M	SBK2 M	FR	SIL	20	23	0	F3	F3	CAM	ST	
	116cm			6D	3D											
BC	in	G	2.5Y	5M	4M	SBK2 M	FR	SIL	25	20	0	C3	C3	FDC	ST	
	116+cm			6D	3D											
C	in		2.5Y	5M	3M	MA	FR	SIL	25	20	0	M3	M3	FDC	ST	

Site	Location	Position	Map unit	Notes												
558-6																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	19cm			3D	1D											
Ap	in	A	10YR	2M	1M	SBK2 F/M	FI	SICL	4	30	0					
	41cm			4D	1D											
AB	in	C	10YR	3M	2M	SBK2 M/F	FR	SICL	5	28	0					
	56cm			5D	2D											
Bk1	in	C	10YR	4M	2M	SBK2 M	FR	SICL	5	27	0			CAM	ST	CARB MIXED
	82cm			6D	2D											
Bk2	in	G	2.5Y	4M	4M	SBK2 M	FR	SIL	7	24	0	F1		CAM/N	VE	
	104cm			6D	3D											
Bk3	in	C	2.5Y	5M	3M	SBK2 M	FR	SIL	8	22	0	F1	C1	CAM	ST	
	125cm			6D	4D											
BC	in	C	2.5Y	5M	4M	SBK1 M	FR	SIL	15	20	0	C3	C3	CAM	ST	
	125+cm			6D	3D											
C	in		2.5Y	4M	3M	MA	FR	SIL	25	20	0	M3	M3	FDC	ST	

Site	Location	Position	Map unit	Notes												
558-7																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	23cm			3D	1D											
Ap	in	A	10YR	2M	1M	ABK2 F	FR	SICL	6	29	0					
	48cm			4D	1D											
AB	in	G	10YR	3M	1M	SBK2M	FR	SICL	8	30	0					
	60cm			5D	2D											
Bk1	in	C	10YR	4M	2M	SBK2M	FR	SICL	10	28	0			CAN	SL	NODULES MIXED IN
	90cm			6D	3D											
Bk2	in	G	10YR	5M	3M	SBK2M	FR	SIL	14	26	0	F1	F1	CAM	VE	
	117cm			6D	3D											
BC	in	C	2.5Y	5M	3M	SBK2M	FR	SIL	20	22	0	C3	C3	CAM	ST	
	117+cm			6D	3D											
C	in		2.5Y	4M	4M	MA	FR	SIL	25	19	0	M3	M3	FDC	ST	

Site	Location	Position	Map unit	Notes
558-8				

Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	21cm			3D	1D											
Ap	in	A	10YR	2M	1M	SBK2 M/F	FR	SICL	5	30	0					
	51cm			4D	1D											
AB	in	C	10YR	2M	2M	SBK2 F	FR	SICL	7	31	0					MIXING @BDY
	70cm			5D	2D											
Bk1	in	C	10YR	4M	2M	SBK2 M	FR	SICL	8	33	0			CAM	ST	
	89cm			6D	2D											
Bk2	in	G	2.5Y	5M	3M	SBK2 M	VFR	SICL	14	29	0	F1	F1	CAM	ST	
	114cm			6D	3D											
Bk3	in	G	2.5Y	4M	4M	SBK2 M	VFR	SIL	20	25	0	F3	F3	CAM	ST	
	114+cm			6D	3D											
BC	in		2.5Y	5M	4M	MA	FR	SIL	25	22	0	M3	M3	FDC/CAM	ST	IOSTLY DISSEMINATE

Site	Location	Position	Map unit	Notes
558-9				

Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	27cm			4D	1D											
Ap	in	A	10YR	2M	1M	ABK2 F	FR	SICL	8	33	0					
	45cm			5D	2D											
AB	in	C	10YR	3M	2M	SBK2 M/F	FR	SICL	10	30	0			CAM	ST	MIXED IN
	76cm			6D	2D											
Bk1	in	G	2.5Y	5M	3M	SBK2 M	FR	SIL	20	25	0	F1	F1	CAM/FDC	ST	
	100cm			6D	3D											
Bk2	in	G	2.5Y	4M	4M	SBK2 M	FR	SIL	20	22	0	C3	C3	FDC	ST	
	100+cm			6D	3D											
BC	in		2.5Y	4M	4M	SBK1 M	FR	SIL	24	20	0	M3	M3	FDC	ST	

Site	Location	Position	Map unit	Notes
558-10				

Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	19cm			3D	1D											
Ap	in	A	10YR	2M	1M	SBK2 F	FR	SICL	5	29	0					
	36cm			4D	1D											
AB	in	C	10YR	3M	1M	SBK2 M/F	FR	SICL	6	29	0			FDC	SL	MIXING
	52cm			4D	2D											
Bw	in	C	10YR	3M	2M	SBK2 M	FR	SICL	8	28	0			CAM/OSF	SL	MIXING
	87cm			6D	2D											
Bk1	in	G	2.5Y	5M	3M	SBK2 M	FR	SIL	12	25	0	F1		CAM	ST	
	101cm			6D	3D											
Bk2	in	G	2.5Y	4M	4M	SBK2 M	FR	SIL	20	20	0	C3	C3	CAM	ST	
	101+cm			6D	3D											
BC	in		2.5Y	4M	4M	SBK1 M	FR	SIL	25	20	0	M3	M3	CAM	ST	

Site	Location	Position	Map unit	Notes
558-11				

Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	17cm			3D	1D											
Ap	in	A	10YR	2M	1M	SBK2 F/M	FR	SICL	5	35	0					
	36cm			3D	1D											
A	in	A	10YR	2M	1M	ABK F/M	FR	SICL	5	35	0					
	60cm			4D	2D											
AB	in	C	10YR	3M	2M	SBK2 M	FI	SICL	6	32	0			CAM	SL	IXED, NOT PEDOGEN
	84cm			5D	3D											
Bk	in	C	2.5Y	4M	3M	SBK2 M/F	FR	SICL	8	30	0	F3	F3	CAM	SL	
	128cm			7D	1D											
Bkg	in	C	2.5Y	5M	2M	SBK2 M	FR	SIL	15	25	0	C3	RMX	CAM	SL	
	128+cm			7D	1D											
Cg	in		2.5Y	6M	1M	MA	FR	SIL	25	20	0	M3	RMX	CAM	SL	

Site	Location	Position	Map unit	Notes
558-12				

Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	29cm			3D	1D											
Ap	in	A	10YR	2M	1M	SBK2 F	FR	SICL	5	32	0					
	55cm			4D	1D											
A	in	C	10YR	3M	1M	SBK2 M	FR	SICL	5	30	0					
	72cm			4D	1D											
AB	in	C	10YR	3M	2M	SBK2 M	FR	SICL	6	30	0			CAM	ST	
	92cm			7D	1D											
Bk	in	G	2.5Y	4M	3M	SBK2 M	FR	SIL	15	24	0	F1	F1	CAM	VE	
	118cm			7D	1D											
Bg	in	G	2.5Y	5M	2M	SBK2 M/F	FR	SIL	10	26	0	MC3	RMX	FDC	ST	
	118+cm			7D	1D											
C	in		2.5Y	5M	3M	MA	FR	SIL	20	22	0	M3	M3	FDC	ST	

Site	Location	Position	Map unit	Notes
55(9)-1				

Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	19cm			3D	2D											
Ap	17.5in	A	10YR	2M	2M	SBK-2 F	FR	SICL	7	30	0				NE	
	39cm			4D	2D											
Bw1	15.5in	C	10YR	3M	2M	SBK-2 M	FR	SICL	7	28	0			OSF	NE	
	56cm			5D	2D											
Bw2	22in	C	10YR	4M	2M	SBK-2 M	VFR	SICL	7	28	0				NE	
	90cm			5D	3D											
Bk	35.5in	G	2.5Y	5M	4M	SBK-2 CO	FR	SIL	8	22	1	F1	F1	CAM	ST	
	90+cm			6D	4D											
BC	35.5+in		2.5Y	5M	6M	SBK-2 M	FR	SIL	15	20	0	C2	C2	FDC	ST	

Site	Location	Position	Map unit	Notes
55(9)-2				

Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	25cm			3D	2D											
Ap	10in	A	10YR	2M	2M	SBK-2 F/M	VFR	SICL	4	33	0				NE	
	45cm			4D	2D											
Bw	17.5in	C	10YR	4M	2M	SBK-1 M	VFR	SICL	5	32	0			OSF	NE	MIXING
	58cm			5D	3D											
Bk1	23in	C	10YR	5M	3M	SBK-2 M	VFR	SIL	8	25	1			FDC,CAM	ST	VERY FEW CAM
	100cm			6D	4D											
Bk2	39.5in	C	2.5Y	5M	4M	SBK-2 M	VFR	SIL	12	22	1	F1	F1	CAM	VE	
	125cm			6D	3D											
Bk3	49in	G	2.5Y	5M	3M	SBK-2 M	VFR	SIL	13	20	1	C2	C2	CAM	VE	
	125+cm			6D	3D											
BC	49+in		2.5Y	5M	3M	SBK-1 M	VFR	SIL	15	20	2	M2	M2	FDC	ST	

Site	Location	Position	Map unit	Notes
55(9)-3				

Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	19cm			3D	2D											
Ap	7.5in	A	10YR	2M	2M	SBK-2 M/F	FR	SICL	5	31	0				NE	
	39cm			4D	2D											
Bw1	15.5in	C	10YR	3M	2M	SBK-2 M	FR	SICL	5	30	0			OSF	NE	MIXING
	50cm			5D	2D											
Bw2	19.5in	C	10YR	5M	3M	SBK-2	VFR	SIL	7	25	0				NE	
	69cm			5D	3D											
Bk1	27in	G	2.5Y	5M	3M	SBK-2 M	VFR	SIL	14	23	0	F1	F1	CAM	VE	
	95cm			6D	4D											
Bk2	37.5in	G	2.5Y	5M	4M	SBK-2 M	VFR	SIL	14	20	1	C2	C2	CAM	VE	INCREASE IN CAM
	95+cm			6D	6D											
BC	37.5+in		2.5Y	5M	6M	SBK-1 M	VFR	SIL	15	19	1	M3	C3	FDC,CAM	ST	VERY FEW MASSES

Site	Location	Position	Map unit	Notes
55(9)-4				

Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	21cm			3D	2D											
Ap	8.5in	C	10YR	2M	2M	SBK-2 F/M	FR	SICL	4	32	0				NE	
	38cm			4D	2D											
Bw1	15in	C	10YR	3M	2M	SBK-2 M	VFR	SICL	6	30	0			OSF	NE	MIXING
	51cm			5D	2D											
Bw2	20in	G	10YR	4M	2M	SBK-2 M	VFR	SICL	6	30	0	F1		OSF	NE	
	71cm			5D	3D											
Bk1	28in	C	2.5Y	5M	4M	SBK-2 M	VFR	SICL	10	28	1	F1	F3	CAM	VE	
	109cm			6D	4D											
Bk2	43in	G	2.5Y	4M	4M	SBK-2 M	VFR	SIL	12	22	1	C3	C3	CAM	VE	FEWER MASSES
	109+cm			5D	4D											
C	43+in		2.5Y	4M	4M	MA	VFR	SIL	13	18	0	M3	M3	FDC	ST	

Site	Location	Position	Map unit	Notes												
55(9)-5																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	24cm			3D	1D											
Ap	9.5in	C	10YR	2M	1M	SBK-2 F/PL-1 M	FR	SICL	7	31	0				NE	
	41cm			3D	2D											
AB	16in	C	10YR	2M	2M	SBK-2 M	FR	SIL	7	25	0				NE	
	59cm			4D	2D											
Bw	23in	C	10YR	3M	2M	SBK-2 M	VFR	SIL	8	24	0	F1		OSF	VS	
	79cm			5D	3D											
Bk1	31in	C	2.5Y	4M	3M	SBK-2 M	VFR	SIL	10	26	0	F1	F1	FDC,CAM	ST	VERY FINE MASSES
	112cm			6D	3D											
Bk2	44in	G	2.5Y	5M	3M	SBK-2 M	VFR	SIL	14	23	1	C2	C2	CAM	VE	
	112+cm			6D	4D											
BC	44+in		2.5Y	5M	4M	SBK-1 M	VFR	SIL	15	20	0	C3	C3	FDC,CAM	ST	VERY FINE MASSES

Site	Location	Position	Map unit	Notes												
55(9)-6																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	18cm			3D	1D											
Ap	7in	A	10YR	2M	1M	SBK-2 M/ PL-1 M	FR	SICL	6	30	0				NE	
	30cm			3D	2D											
AB	12in	C	10YR	2M	2M	SBK-2 M	FR	SICL	7	29	0	F1			NE	
	46cm			4D	2D											
Bw	18in	C	10YR	4M	2M	SBK-2 M	FR	SICL	7	29	0	F1	F1		VS	MIXING, SOME FINE MASSES
	59cm			5D	3D											
Bk1	23in	C	2.5Y	4M	3M	SBK-2 M	VFR	SICL	10	28	0	F1	F1	FDC,CAM	VE	FINE MASSES, MOSTLY DISSEMINATED
	79cm			5D	3D											
Bk2	31in	G	2.5Y	5M	3M	SBK-2 CO	FR	SIL	12	26	1	C1	C1	CAM	VE	
	79+cm			6D	4D											
BC	31+in		2.5Y	5M	4M	SBK-1 M	VFR	SIL	15	22	1	C3	C3	CAM	ST	

Site	Location	Position	Map unit	Notes												
55(9)-7																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	20cm			3D	1D											
Ap	8in	C	10YR	2M	1M	SBK-3 F	FR	SICL	7	30	0				NE	
	43cm			3D	1D											
AB	17in	G	10YR	3M	1M	SBK-2 M	VFR	SICL	6	28	0	F1			NE	
	55cm			5D	2D											
Bw	21.5in	C	2.5Y	4M	2M	SBK-2 M	VFR	SICL	8	28	0	F1		FDC	VS	
	91cm			5D	3D											
Bk	36in	G	2.5Y	4M	3M	SBK-2 M	VFR	SIL	11	26	0	C1	F1	CAM	VE	
	91+cm			5D	4D											
BC	36+in		2.5Y	4M	4M	SBK-1 M	VFR	SIL	12	21	0	M3	M3	FDC, CAM	ST	FEW MASSES

Site	Location	Position	Map unit	Notes												
55(9)-8																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	18cm			3D	1D											
Ap	7in	C	10YR	2M	1M	SBK-2 F	VFR	SICL	5	30	0				NE	
	32cm			4D	1D											
AB	12.3in	G	10YR	3M	1M	SBK-2 M	VFR	SICL	6	29	0				NE	
	50cm			4D	2D											
Bw	19.5in	C	2.5Y	3M	2M	SBK-2 M	VFR	SIL	10	26	0	F1	F1	OSF,FDC,CAM	SL	MIXING
	65cm			5D	2D											
Bk1	25.3in	C	2.5Y	4M	2M	SBK-2 F/M	VFR	SIL	10	23	0	C1	C1	CAM	VE	
	93cm			5D	3D											
Bk2	36.5in	G	2.5Y	4M	4M	SBK-2 M	VFR	SIL	8	26	1	C2	C2	CAM	VE	
	121cm			6D	3D											
BC	47.5in	C	2.5Y	5M	3M	SBK-1 M	VFR	SIL	12	22	0	C3	C3	FDC	ST	
	121+cm			6D	6D											
C	47.5+in		2.5Y	5M	6M	MA	VFR	SIL	15	18	0	M3	M3	FDC	ST	

Site	Location	Position	Map unit	Notes												
55(9)-9																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	20cm			3D	1D											
Ap	8in	C	10YR	2M	1M	SBK-3 F	FR	SICL	6	32	0				NE	
	32cm			4D	1D											
AB	12.5in	G	10YR	3M	1M	SBK-2 M	VFR	SICL	7	30	0	F1			NE	
	46cm			4D	2D											
Bw	18in	C	2.5Y	3M	2M	SBK-2 M	VFR	SIL	8	24	0	F1	F1	FDC	ST	
	70cm			5D	3D											
Bk1	27.5in	G	2.5Y	5M	2M	SBK-2 M	VFR	SIL	8	24	0	C1	C1	CAM	VE	
	110cm			6D	3D											
Bk2	43.5in	G	2.5Y	5M	3M	SBK-2 M	VFR	SIL	9	23	1	C2	C2	CAM	VE	
	110+cm			6D	4D											
C	43.5+in		2.5Y	5M	4M	MA	VFR	SIL	12	19	0	M2	M3	FDC, CAM	ST	VERY FINE MASSES

Site	Location	Position	Map unit	Notes											
55(9)-10															
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	22cm			3D	1D											
Ap	8.5in	C	10YR	2M	1M	SBK-2 F	VFR	SICL	6	32	0				NE	
	54cm			4D	1D											
BA	21.5in	G	10YR	3M	1M	SBK-2 M	VFR	SICL	6	30	0	F1			NE	
	72cm			5D	2D											
Bk1	28.2in	C	2.5Y	4M	2M	SBK-2 M	VFR	SICL	8	29	0	F1	F1	CAM	ST	
	83cm			5D	3D											
Bk2	32.5in	G	2.5Y	4M	3M	SBK-2 M	VFR	SIL	10	22	1	C1	C1	CAM	ST	VERY FINE/FEW MASSES
	112cm			6D	3D											
Bk3	44in	G	2.5Y	5M	3M	SBK-2 M	VFR	SIL	10	20	0	C3	C3	CAM	ST	
	112+cm			6D	4D											
C	44+in		2.5Y	5M	4M	MA	VFR	SIL	13	18	0	M3	M3	CAM	ST	

Site	Location	Position	Map unit	Notes												
55(9)-11																
Horizon	Depth	BDY	Hue	Value	Chroma	Structure	Consis.	Text.	Sand	Clay	Frag	Con.	Depl.	Ped/void	Eff.	Notes
	20cm			3D	1D											
Ap	8in	A	10YR	2M	1M	SBK-3 F	FR	SICL	6	35	0	F1			NE	
	37cm			3D	1D											
AB	14.5in	G	10YR	3M	1M	SBK-2 CO/PL-1 TK	FR	SICL	5	33	0	F1	F1		NE	
	52cm			4D	1D											
Bw1	20.5in	C	10YR	3M	2M	SBK-2 M	VFR	SICL	8	30	1	F1	F1		NE	MIXING
	64cm			5D	2D											
Bw2	25in	C	2.5Y	4M	2M	SBK-2	VFR	SICL	9	29	1	C1	C1	FDC, OSF	VS	
	90cm			6D	3D											
Bk	35.5in	G	2.5Y	5M	3M	SBK-2 M	VFR	SIL	10	25	0	C2	C2	CAM	VE	
	90+cm			5D	4D											
BC	35.5+in		2.5Y	5M	4M	SBK-1 M	VFR	SIL	12	22	0	M2	M2	CAM	ST	