THE USE OF GEOMORPHOLOGICAL AND PEDOLOGICAL SOIL CHARACTERISTICS TO ASSESS PLANAR BORROWING AT A MANDAN INDIAN VILLAGE, NORTH DAKOTA

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Master of Science

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by
CRYSTAL J. FREY

Dr. Randall J. Miles, Thesis Supervisor

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The undersigned, appointed by the dean of the Graduate School, have examined the thesis entitled

THE USE OF GEOMORPHOLOGICAL AND PEDOLOGICAL SOIL CHARACTERISTICS TO ASSESS PLANAR BORROWING AT A MANDAN INDIAN VILLAGE, NORTH DAKOTA

presented by Crystal J. Frey

a candidate for the degree of Master of Science

and hereby certify that in their opinion it is worthy of acceptance.

Dr. Randall J. Miles, Thesis Supervisor

Dr. W. Raymond Wood

Dr. Fred J. Young

DEDICATION

For Gwyn, Sailor Bob and Stan,

You all saw the beginning of this project, but not the end.

ACKNOWLEDGEMENTS

This project could not have taken place without the assistance and support of several people. First among these is my committee: Drs. Randall J. Miles, W. Raymond Wood, and Fred Young. They have shown a great deal of patience and understanding of the demands of life. Dr. Miles generously provided critical funding. The employees of the State Historical Society of North Dakota, especially Ms. Fern Swenson, Mr. Paul Picha and Mr. Tim Reed, provided technical assistance at the Double Ditch State Historic Site as well as encouragement. The SHSND allowed access to the village and gave permission for obtaining soil cores for this project. The North Dakota Geological Survey came to the rescue during the second summer of field work by providing a Giddings probe. Dr. Edward C. Murphy of the NDGS offered insight on pedomorphic features beneath the Leonard Paleosol, more than three meters and 9,000 years ago. Heartfelt thanks are extended to those of the PaleoCultural Research Group: Dr. Stanley Ahler for moral support and the idea for this project. We miss you, Stan. Mr. George Crawford introduced me to the more artistic aspects of working on a dig, and taught me to knap. Dr. Mark Mitchell has been the consummate archaeologist, digging through a mound of files from the Double Ditch project for figures for this thesis. Very special thanks (899,000 of them) go out to Dr. Kenneth Kvamme and others at the Archeo-Imaging Laboratory for sharing their Digital Elevation Model data for surface micro topography, and to Bryan Mayhan of CARES (University of Missouri) for being computer wizard enough to make sense of them. Your work was essential to the goal of this project.

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Crystal J. Frey

Dr. Randall J. Miles, Thesis Supervisor

ABSTRACT

The Double Ditch State Historic Site is situated in a loess landscape immediately east of the Missouri river near Bismarck, North Dakota. The 9 ha site was occupied from ca AD 1450 to 1785 by Mandan Indians, Plains Villagers who exhibited a systematic and deliberate pattern of behavior unique to the region.

A crucial factor in developing a timeline of cultural activity during occupation is to understand the earth-moving activities relative to pattern and time. A soil-coring program was conducted with: transects both within the village and in an adjacent area of similar, relatively undisturbed soil to serve as a control; and satellite locations within the village in unique cultural features. An underlying, contiguous paleosol (Early Holocene) is used as the stratigraphic reference in concert with physical, chemical and spatial characteristics of both the Paleosol and overlying loess soil to determine the degree of earth-moving activity (planar borrowing).

The control transect, through measured depth to the paleosol, indicates the Early Holocene topography to gradually slope toward the edge of the Missouri River terrace; the modern surface rises gently with distance eastward from the Missouri River. In the Holocene-aged loess, texture is predominantly silt loam with lesser amounts of fine and very fine sand in the upper 1 m, and slightly coarser from 1 to 3 m. Subrounded sand

grains occurring below the paleosol indicate the landform was a strath terrace prior to ca 10,000 ybp. In soil cores taken within the village, it is strikingly evident that depth to the paleosol has been altered by as much as 1.5 m when compared to the control at a comparable distance from the source. This non-uniform removal or addition of soil is attributed to deliberate cultural activity of the inhabitants of Double Ditch Village. Utilization of geomorphological and pedological soil characteristics in concert variability cultural features should allow an estimate anthropogenic activity with regard to planar borrowing.

CHAPTER 1

Introduction and Literature Review

INTRODUCTION

General Description

The Double Ditch State Historic Site was home to the Mandan Indians from ca AD 1450 until about 1781. The Double Ditch Village is one of seven or more traditional Mandan villages located around the mouth of the Heart River along the Missouri River west of Bismarck. It is the most unique of the villages with its two visible fortification ditches, giving rise to the name, and the large array of mounds around and within the ditches. The 9 ha site, officially known as the Double Ditch State Historic Site (32BL8)[1], is under the auspices of the State Historical Society of North Dakota. This 9 ha (22 ac)

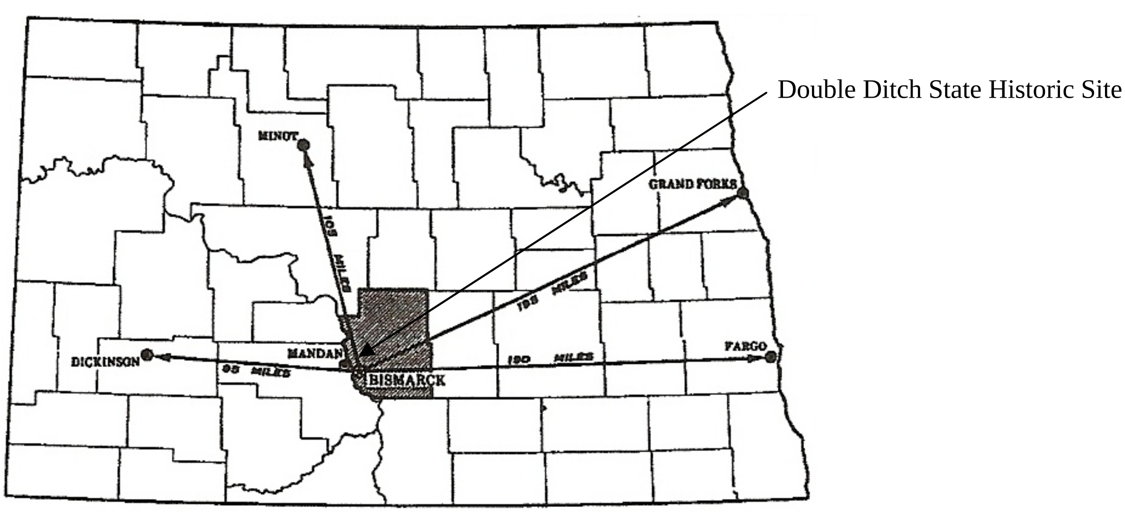

Figure 1.1 Double Ditch Village in relation to Bismarck, North Dakota.

[1] Coding for archaeological sites provides numerical rank for the state in alphabetical order, two letter code for county, and numerical number for the site as it was listed with the state (32 is North Dakota; BL is Burleigh County; Double Ditch is the 8th site recorded in that county).

site is situated in a loess landscape on a high terrace immediately east of the Missouri River about 15 km (9 mi) north of Bismarck, North Dakota (Figure 1.1).

The Mandans are Plains Villagers, the most recent of four general culture periods on the Great Plains. Paleo-Indian, Archaic, Woodland and Plains Village are distinguished by technology, subsistence, settlement patterns and some social features (Wood 1967). As Plains Villagers in the Middle Missouri tradition, the early Mandans lived in unfortified villages characterized by rectangular houses with southwest-facing entrances. Later, as settlements became larger, houses were commonly circular and villages were fortified.

The Double Ditch site is unusual in that the Mandan occupants exhibited a systematic and deliberate pattern of behavior which is not seen at any other site in the Middle Missouri Valley. The Mandans, as earthlodge dwellers, utilized earthen material as lodge covering and obtained this material from nearby areas; specific borrow areas was the norm. However, the Mandan inhabitants at Double Ditch borrowed significant amounts of earth throughout the site, in addition to four, discrete borrow areas: a behavior that is unique to earthlodge dwellers in this region (Ahler and Swenson 2001; Ahler et al. 2003).

The Double Ditch Village was fortified with a sequence of ditches and palisade fences. Sioux attacks were common, and fortifications were an important feature of the village. During the centuries of occupation, whether from attack or disease or both, the Mandan population of the village appears to have declined. The original, fourth or outermost ditch[2] was replaced by a similar structure closer to the interior of the village. This activity occurred two additional times, leaving the village with a total of four

[2] See Ahler 2005, page 13 and page 332 for the possibility that the 3rd ditch was first, followed chronologically by the fourth.

ditches; the two outermost and assumed oldest ditches were filled in, probably when replacements were constructed, and are not visible on the modern-day landscape (Figure 1.2).

A crucial factor in developing a timeline of cultural activity relative to population changes is to understand the earth-moving activities of the Mandans relative to spatial pattern and time. A soil coring program was conducted with: transects both within the village and in an adjacent area of similar, relatively undisturbed soil to serve as a control; and satellite locations within the village in unique cultural features. An underlying, contiguous paleosol formed in the Early Holocene (the Leonard Paleosol of the Oahe

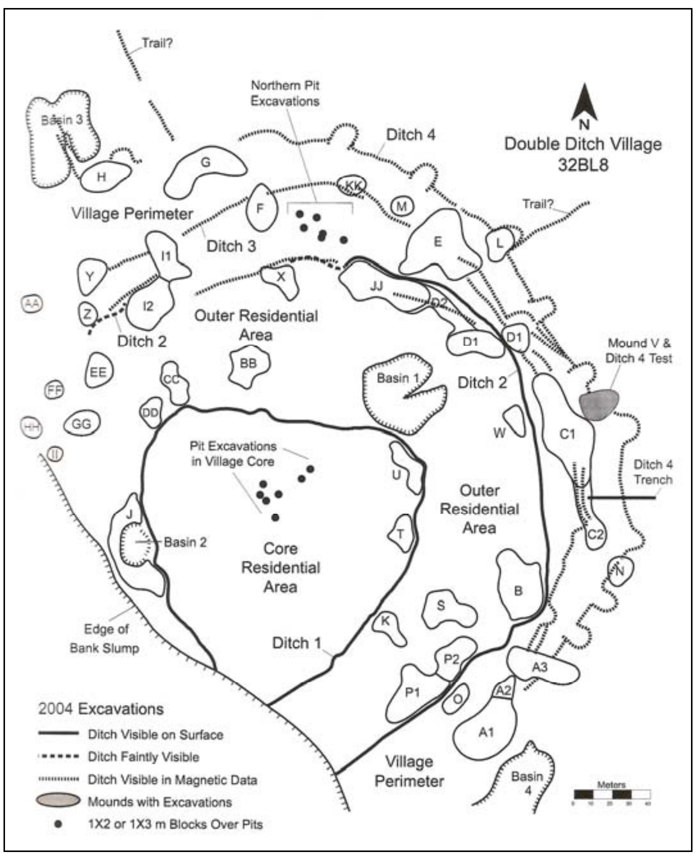

Figure 1.2 Plan map of Double Ditch Village showing major surface features and the two outer surface-invisible ditches (courtesy Ahler 2005, p. 25).

Formation) is used as the stratigraphic reference in concert with physical, chemical and spatial characteristics of both the paleosol and the overlying loess soil to determine the degree of overall earth-moving activity by the Mandan inhabitants. This activity has been described as "planar borrowing" in contrast with earth borrowing from discrete locations (basins).

Rationale and Summary of the Problem

The Double Ditch State Historic Site is unique among the Plains Village sites in the Middle Missouri region in North Dakota. Its large size, multiple fortification ditches, and numerous, large midden mounds contribute to its status. The village is believed to have been occupied continuously from ca AD 1450 to 1785; over this period of time changing population dynamics resulted in various "occupation zones" on the site. It is important to determine a timeline of occupation and activity in order to more fully understand this important archaeological site.

One of the key components to establishing this timeline is an understanding of the earth-moving activities of the Mandan Indians occupying Double Ditch. These people exhibited a deliberate, systematic pattern of behavior not evident at any other village in the region (Ahler 2003). Midden mounds are kept almost exclusively at the perimeter of the village; earth volume is estimated to be nearly 6400 m^3 in these mounds (Ahler 2003, p. 12). Concentrated sources of earth for covering the lodges seem to have been two borrow areas (Basins 1 and 2) within the site, and two areas (Basins 3 and 4) just outside the ring of midden mounds (Figure 1.2). However, rough calculations of the volume of soil removed from the two largest of these borrow areas (Basin 1 and Basin 3) indicates less than half the 6400 m^3 amount (Ahler and Swenson 2001).

Through geophysical investigations and archaeological excavations, two aspects of village life have emerged. First is a pattern of village-wide structural earth excavation, transport, use and redeposition. Second, there is evidence of a contraction of the village associated with "progressively intensified" defensive features (ditch and palisade) spanning the approximately three centuries of occupation (Ahler et al. 2003, page 1).

These aspects of village life may be understood more fully if the pattern of excavation and redeposition of earth is investigated. A contiguous, Early Holocene paleosol (the Leonard Paleosol) is present at a depth that is but rarely affected by anthropogenic activity, and is overlain by Holocene loess deposits. The thickness of overlying loess as well as the pattern of horizons in the soil can be utilized in assessing planar borrowing and depositional activity.

The Leonard Paleosol is an easily recognized component of the Oahe Formation with its distinctive surface A horizon. Color of the A horizon is very dark brown; it is generally several centimeters thick; and nearly always characterized by copious faunal mixing (evidenced by tubular, in-filled pores approximately 4 mm in diameter which intermix soil material among the overlying C horizon, the paleo-A horizon, and underlying B horizons) (Clayton et al. 1976). The paleosol is nearly contiguous on this site, having been found in thirty eight of thirty nine cores taken.

By using the paleosol as the stratigraphic reference, it is possible to estimate the volume of overlying loess soil. The relatively undisturbed transect, located on the north perimeter of the State Historic Site property, is oriented roughly perpendicular to the

Missouri River. This transect provides baseline data on several soil properties, including depth to paleosol with distance from the river. Utilizing this information in conjunction with measured depth to paleosol throughout the village, it is then possible to calculate an approximate volume of soil overlying the paleosol; or, conversely, to estimate the volume of soil removed or added through anthropogenic activity.

Hypotheses

A crucial factor in developing a timeline of cultural activity during occupation of Double Ditch Village is to understand the earth-moving activities relative to pattern and time. By measuring the depth to paleosol in the relatively undisturbed transect, and comparing the depth to paleosol in pedons throughout the village, the amount of soil material relocated through cultural activity by the Mandan occupants of Double Ditch Village can be estimated. In areas of the village with thicker depth to the paleosol (possible areas of deposition), artifacts within the soil may indicate possible sources or timeline; the borrowed material may have been used for covering earthlodges, as fill material in the two outer ditches or in mounds, or for other uses as yet undetermined. In areas with thinner depth to paleosol, planar borrowing has likely taken place.

Patterns of earth-moving behavior relative to cultural feature and time can be used to verify occupational patterns within the village. During early stages of occupation, population numbers were greater and the village was much larger than indicated by current surface features, and it is possible that traces of earthlodges outside of the two visible ditches may be discovered through remote sensing. The two outermost ditches, filled in by occupants as village size shrunk, may have been filled with surface soil borrowed nearby.

In addition, the volume of soil removed from the four concentrated borrow areas can be estimated, and compared to the volume of material in the various mounds. It is noted by Ahler (2005, page 327) that some of the mounds, especially the large Mound B, are an "intentional construction" (purpose unknown) and as such contain very small amounts of refuse.

LITERATURE REVIEW

Soils have an important and immediate relationship with archaeology. Soils are the repository of the archaeological record, and contribute to site interpretation through their physical and chemical characteristics. Chemically, the soil may be useful as an indicator of habitation patterns, diet, and possible presence of agriculture. Physically, the soil serves to preserve the artifacts of human activity such as lithics, pottery, food or skeletal remains. In the past, archaeology has incorporated soils at the smallest level (microscopic or chemical characteristics) or at the highest level (landscape or regional patterns). A vast middle ground, that of pedological or morphological characteristics of the soil, can further understanding and interpretation of an archeological site such as Double Ditch.

The factors and processes important in pedogenesis are reviewed followed by a discussion of the anthropogenic activity of the inhabitants of Double Ditch Village and resultant effects on the soil at the study area.

♦ **FACTORS AND PROCESSES OF SOIL FORMATION**

The Role of Climate in Soil Formation

Climate is perhaps the most important force in pedogenesis (Birkeland 1999), controlling processes through inputs of energy and water (Runge 1973; Smeck et al. 1983; Daniels and Hammer 1992). Water movement into and through the soil is vital for the processes of transformation and translocation, while temperature influences rates of chemical and biological activity.

In any discussion of climate it is important to consider the matter of scale; microclimate may differ from regional climate, and the soil environment differs from the environment above ground. Thorp (1941) tied regional climatic variations to the concept of zonal soils, which he defines as soils with first order differences. At the same time, Jenny (1941) stressed the importance of the amount and annual distribution of precipitation, as well as the differences between macroclimate and microclimate. He pointed out that topography affects temperature, humidity and vegetation, but did not mention topography's affect on water movement into and through the profile.

Thornthwaite (1948) and Thornthwaite and Mather (1957) combined precipitation, temperature and vegetation to formulate the concept of potential evapotranspiration. Arkley (1963, 1967) utilized this idea, calling the concept the soil's *water balance*, useful in describing climatic attributes important to pedogenesis (Birkeland 1999, p. 269). By factoring in the water-holding capacity of the soil, Arkley (1963) was able to estimate the depth of water movement in the profile which he called the leaching index (L or L_i). And Crompton (1967) expanded on the idea when he stated that the weathering to leaching ratio can control where solutes might precipitate and be deposited in the profile. McKeague and St. Arnaud (1969) described the movement of dissolved or suspended constituents through, out of or even upward in the soil as pedotranslocation and stated that "water movement within soils is one of the most important processes leading to profile differentiation" (McKeague and St. Arnaud 1969, p. 428).

It is somewhat artificial to separate the affects of temperature and moisture when considering soil weathering. Precipitation and temperature both influence pedogenesis, but temperature alone does not have as marked an affect on soil properties as precipitation. Most radiant energy is expended in evapotranspiration or the production of organic matter (Yaalon 1983; Nikiforoff 1959; Runge 1973). However, the *rate* of many soil processes is influenced by temperature, as with any biological system. Jenny (1941) reminded us of Van't Hoff's Temperature Rule that states for every 10° C rise in temperature the rate of a chemical or biological reaction increases by a factor of 2 or 3 (Jenny 1941, p. 143). Birkeland (1999) agreed, stating "temperature influences the rate of chemical and biological processes" (p. 268), yet he observed that it is more appropriate to think in terms of seasonality of rainfall, that is, to consider the time of year of maximum precipitation in relation to temperature, rather than temperature alone. Yaalon (1983) observed that many differences in soils that are attributed to temperature are "more apparent than real" (p. 242), but not all; one exception is the increased biotic activity that accompanies an increase in temperature.

The influence of radiant energy on pedogenesis is mentioned above, but of greater importance may be the role played by radiant solar energy in large scale climatic shifts such as those seen during the glacial events of the Pleistocene and Holocene. Wright (1983) and Kutzbach (1983) made the argument that variation in the global distribution of solar energy affected the advance and retreat of glaciers in North America and elsewhere. Kutzbach (1983) suggested that during the Early Holocene changes in tilt of the earth's axis caused solar radiation to increase 7% globally compared to today. He calculated temperatures in the Northern Hemisphere were 0.7° C warmer in summer and precipitation was 7% greater, although in some places values were much greater. Wright (1983) stated that Milankovitch cycles may be correlated to gradual changes between glacial and post-glacial conditions.

The Holocene Climate in North Dakota

The massive ice sheets of the Late Paleocene influenced climate at great distances from the ice. Summers were cool because the ice reflected solar radiation, and also drier than today; in winter, cold air was trapped at the poles or was warmed adiabatically as it descended off the ice (Wright 1983). As the glaciers retreated in the Late Paleocene and Early Holocene these effects were lost and seasonality became more pronounced (Wright 1983) with warmer summers and cooler winters. Bluemle (2000) determined dates for several moraines in North Dakota and states there were several advances and retreats of ice from about 12,900 ybp to 11,900 ybp. Hoganson and Murphy (2003, p. 30) stated that North Dakota was glaciated during the Wisconsinan Age with three major glacial events (ca 70,000 to 10,000 ybp). It is generally accepted that the last glacial ice retreated from North Dakota for the final time about 12,000 ybp.

At this time, the climate was cool and moist, supporting boreal forest species such as spruce, aspen and fir. Fossilized white spruce wood taken from Devils Lake, North Dakota (about 100 mi from the study area) has been dated to about 11,500 ybp (Bluemle 2000). Pollen samples from the sediment in Wordworth Pond in Stutsman County indicate a cool climate with boreal spruce forest until 10,500 ybp (Bluemle 2000). From that time to about 9,000 ybp the climate warmed resulting in the disappearance of spruce, tamarack, poplar and black ash from the pollen record; birch, elm, ironwood, oak and hazel remained. Over the next 1,000 years the climate gradually warmed and became much drier (Bluemle 2000).

During a period known as the Hypsithermal (8500 to 4500 ybp), the climate in North Dakota was like much of the Great Plains. As noted by Holliday (1985) and Haynes (1968) in the Southern Plains, and Mandel (1995) and Reider (1980) among others in the Central Plains, the Hypsithermal was warmer and much drier than climate before or after. In North Dakota average temperatures were up to 2° C warmer than today, and the boreal forests in North Dakota disappeared and were replaced by sage and short grass prairie and savanna vegetation (Bluemle 2000). With less effective vegetative cover, wind erosion was prevalent, carrying silts and fine sands from river valleys toward the southeast and depositing them on adjacent uplands east of the floodplains.

By around 4000 ybp, climate patterns approximated what they are today. After the Hypsithermal, climate became much more variable, with frequent episodes of warm dry climate alternating with cooler and drier (Clayton et al. 1976). Warmer and drier periods resulted in increased slopewash erosion on steep slopes and eolian deposition on gentler slopes (Clayton et al. 1976, p. 11). Precipitation increased slightly from the Hypsithermal, allowing some tree species to occupy moister, more favorable sites (Bluemle 2000).

Parent Material and Time

Hans Jenny (1941) stated that parent material is transformed into soil over time under variable external conditions including climate, topography and biotic factors. The parent material undergoes continuous change until it reaches equilibrium with its environment, at which point it may be described as a mature soil (Jenny 1941). Simonson (1959) proposed that soil genesis consists of two steps, the accumulation of parent material and the differentiation of soil horizons. These are not distinct steps and may certainly overlap, nor do they necessarily tend in only one direction (i.e., differentiation or haploidization, discussed in much greater detail by Johnson and Watson-Stegner 1987).

While Simonson (1959) focused on horizon differentiation and the processes responsible, he does not cover the parent material aspect of soil formation in much detail. Crompton (1967), however, focused almost exclusively on parent material characteristics; of greatest importance are the weathering of parent material and the translocation of the products of weathering. Weathering releases minerals into the soil solution where they may be translocated or leached from the profile. He introduced the term *richness of weathering* which embodies the concept of the amount and variety of minerals inherent in the parent material, combined with the factors of temperature, topography and vegetation which bring those minerals into solution. He contrasted this with the *intensity of leaching* involving both the water balance of the soil (rainfall and evapotranspiration) and soil permeability.

Eolian parent materials have been the subject of numerous studies, partially due to their great extent (Daniels and Hammer 1992) and the fact that they commonly contain weatherable minerals to great depths (Cady 1960). Eolian materials are commonly very fine sands or silts, but may range in size from coarse sand to clay (Daniels and Hammer 1992). Because finer-sized particles travel greater distances than heavier, coarser particles, eolian deposits composed of silt, called loess, may mantle a large area; very fine sands and coarser remain closer to the source. Daniels and Hammer (1992) noted that silt may be transported from 400 to 4000 km, while very fine sand may only travel 46 to 460 m.

Thick deposits of loess have uniform texture both vertically and horizontally. Mineralogy varies according to the source, and has been noted to change with distance from the source (Daniels and Hammer 1992). Many authors have noted that loess thins with distance from the source (Daniels and Hammer 1992; Ruhe 1969a; Birkeland 1974; and others). Birkeland (1974, 1999) discusses a study by Smith (1942) who observed that loess deposits are both thicker and coarser nearest the source (and thinner and finer-grained with increasing distance). Smith (1942) stated that this affects development of argillic horizons in the loess, with more well-developed B horizons with increasing distance from the source. Another factor, according to Smith (1942) may also be the rate of accumulation of new surficial material, with more frequent and rapid accumulation of loess closer to the source. Ruhe (1969a, b; 1973) pointed out that age of loess deposits cannot necessarily be inferred by degree of development in the soil; loess deposits further from the source had stronger-developed B horizons yet were apparently younger.

<u>Parent Materials in North Dakota</u>

North Dakota includes portions of the Great Plains and Central Lowlands physiographic provinces; the boundary between these two provinces may be considered to be the western margin of the Missouri Coteau, a hummocky glaciated plain formed with the collapse of superglacial sediment (Bluemle 1977, p. 4), which approximates the course of the Missouri River. The Great Plains province lies to the west of this divide; the eastern side of the Missouri River, rising up toward the Missouri Coteau, is the Coteau Slope. The site is founded in postglacial sediment known as the Oahe Formation (Clayton et al. 1976, 1980). Originally defined to describe unconsolidated eolian silt deposits on uplands, the concept was expanded to include all sediment above the late Wisconsinan Cole Harbor Group (Clayton and Moran 1979; Artz 1995), including eolian, pond and river sediments. Not all lithofacies are found at any given location, and at Double Ditch Village the Oahe Formation is primarily eolian.

The Oahe Formation (Figure 1.3), with a total thickness of as much as 6 m, is Late Wisconsinan and Holocene in age. In south-central North Dakota it is primarily silt loam

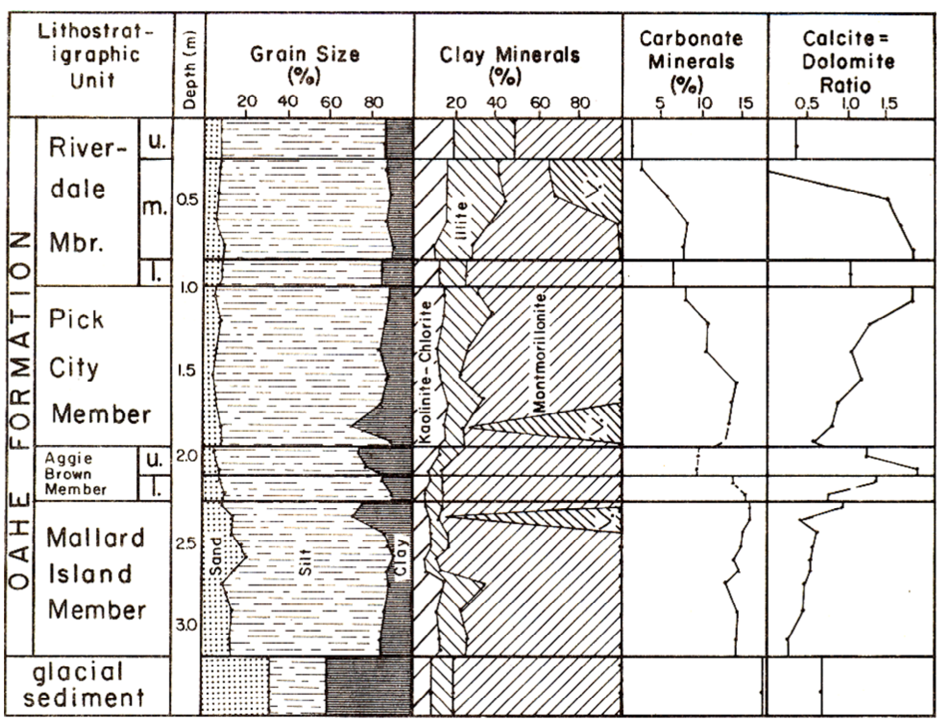

Figure 1.3 The Oahe Formation (courtesy Clayton et al. 1976, p. 5).

in texture; vertical bluffs exhibit vertical jointing which gives columns 0.1 m in width or greater (Clayton et al. 1976). The silt is generally unbedded; or it may have diffuse beds at least 0.1 m thick which are slightly different in color, and may have minor variations in grain size distribution.

As described at the type location[3], the Oahe Formation consists of four members: the Riverdale Member, the Pick City Member, the Aggie Brown Member, and the Mallard Island Member. The Mallard Island is Late Wisconsinan or perhaps Early Holocene in age. Temperatures were warming after the last glacial episode and precipitation was abundant. Thickness on the downwind side of the Missouri River may be 1 to 2 m. Clay mineralogy can be very great in smectitic clays with some vermiculite in the surface, and the soil is usually pale brown (10YR 7/3) (Clayton et al. 1976).

The Aggie Brown Member is divided into two submembers of roughly equal thickness (Clayton et al. 1976, p. 5). The lower submember, formed perhaps during the Late Wisconsinan or Early Holocene, is redder (7.5YR colors) than any other part of the Oahe Formation. Like the underlying Mallard Island, this soil possesses great quantities of smectitic clays. Although texture can be variable, it has less sand than the Mallard Island Member. The upper submember has a larger calcite to dolomite ratio than almost any other portion of the Oahe Formation. The upper submember, dating to the Early Holocene, formed during gradual climatic warming with slightly drier conditions, though still humid and moist, probably similar to today's climate in North Dakota (Clayton et al. 1976). The spruce and aspen vegetation from the Late Wisconsinan was giving way to prairie species, and this is reflected in the distinct and striking A horizon in the Aggie

[3] Type location is the Riverdale Section in a vertical bluff on the shore of Lake Sakakawea, near the center of section 22, T147N, R84W in McLean County, North Dakota.

Brown. The Leonard Paleosol (so named by W. B. Bickley 1972) in the upper submember possesses a distinctive A horizon with very dark colors. It is characterized by evidence of faunal turbation, probably earthworm activity, into the underlying B horizon as well as the C horizon above the paleosol.

Immediately above the Aggie Brown is the Pick City Member. It is less sandy with more silt than the lower parts of the Oahe Formation and up to 1 m thick along the Missouri River. It is usually very light in color (light gray, 2.5Y 7/3) and formed during the warmer and drier portion of the Middle Holocene (the Hypsithermal). Data from the type location seem to indicate a clay bulge at the base of the Pick City, immediately above the A horizon of the Leonard Paleosol of the Aggie Brown (Clayton et al. 1976).

The most recent, Riverdale Member is subdivided into three submembers that in some locations are approximately equal in thickness. The middle submember is slightly lighter in color than the upper and lower submembers, and is described as being darker than any other part of the Oahe Formation except the upper submember of the Aggie Brown. It is similar in texture to the Pick City Member, but clay mineralogy is different. The lower submember is primarily smectitic clays as found throughout the lowest members of the formation. The middle submember of the Riverdale has increasing percentages of both illite and vermiculite, and the upper submember is about half smectite and the remainder evenly divided between kaolinite/chlorite and illite. The lower part of the Riverdale Member is considered to be an A horizon, and has been named the Thompson Paleosol (Clayton et al. 1976, p. 7). It is similar to the modern day surface horizon, suggesting that it formed under similar climatic conditions.

Paleosols and Past Climate

Paleosols are defined as soils formed under an environment different from that of the present day. Yaalon (1971, 1983) specified that paleosols formed on a landscape of the past, and offers two scenarios. A paleosol may be a relict soil found on the present-day surface if it formed under different climatic or environmental conditions; or it may be a buried soil, but should be considered a paleosol only if the past environment was different. Hall (1983) provided a third condition: that of an exhumed soil previously buried and subsequently exposed. In Johnson and Hole (1994) we are presented with a detailed review of historical definitions and terms in paleopedology.

Several studies in the last four decades have focused on aspects of paleosols which contribute to paleoenvironmental reconstruction. Fenwick (1968) reviewed pollen records and observed that while minor changes in the soil (e.g. color or texture) are probably not significant to archaeology, buried profiles are important. In a review of the literature, Holliday (1990) and Mandel and Bettis (2001) stated that paleoenvironmental information can be obtained by soil characteristics such as overall morphology, organic matter and carbonate content, depth to leaching, or depth to the top of a Bk horizon or salt accumulation. In arid and semi-arid climates, carbonates may be an important component in the soil. Fedoroff et al. (1990) looked at micromorphologic analysis of carbonates and clays, West et al. (1988) differentiated between pedogenic and lithogenic carbonates, and Gile et al. (1966) defined stages of carbonate development with some climatic interpretations.

Artz (1995) identified the Leonard Paleosol at several locations in the Northern Plains as a mantle on Wisconsinan-age terraces along the Missouri River. According to Artz

(1995) soluble humates in the horizon give a radiocarbon age of 10,000 to 8,000 ybp at a site in Dunn County, North Dakota, west of the study site. The paleosol would have formed during a period of relative stability with climatic conditions somewhat more moist than present day, as evidenced by the A horizon of the Leonard Paleosol, which is strikingly dark and distinctive. Of note are the characteristic in-filled insect or earthworm burrows which are "conspicuous" (Clayton et al. 1976, p. 7) and further indicate an environment different from today with different biotic activity.

Topography

Topography, that is slope shape and steepness, may influence soil development through water relations, and also when considering surface stability relative to erosion or deposition. Aspect plays a role in pedogenesis through evapotranspiration, and type and density of vegetation. Jenny (1941) believed that aspect is the most important factor in creating differences in the soil because it affects vegetation. Birkeland (1999) agreed, stating that slope aspect as well as slope shape affect soil moisture. He further stated that characteristics such as soil moisture, organic matter thickness and A horizon thickness are affected by micro-climate and vegetation; in colder climates, where significant precipitation may come in the form of snow the windward-facing slopes may receive less effective precipitation because of snow drift. At the same time as Jenny, Thorp (1941) pointed out that micro- and macro-relief both affect moisture in the soil. He observed that with increasing steepness of slope there is decreasing water content. Shape of the slope directly influences surface runoff characteristics: a simple slope (linear or uniform) induces sheet flow; on convex slopes the runoff rate will increase downhill, while on concave slopes the flow velocity decreases downhill.

Daniels and Hammer (1992) believe that hydrology is the most important contributor to pedogenesis, and topography greatly influences the behavior of water in the system. Several soil properties “vary systematically” (Daniels and Hammer 1992, p. 1) with topography, and the hydrology of soil solum is “predictable” in reference to topography and parent material. They observed that it is not only the shape of the land surface that influences water movement, but also differences in local elevation. Relief determines the hydraulic head, and when considered along with distance to the outlet, controls rates of subsurface flow (Daniels and Hammer 1992). Yaalon (1975) reviewed several studies relating landscape variables with soil properties. Soil properties including particle size, organic matter content, depth to carbonates, or thickness of soil horizons or solum have been evaluated with landscape factors such as slope, distance from the summit, or aspect. Hole and Campbell (1985) also reviewed literature on relief, landscape position and water movement. Richardson and Daniels (1993) determined that soil color is influenced by the vertical sequence of parent material, moisture regime and flow characteristics, and by relief and topographic position. Looking at chroma or redoximorphic features in various locations and parent materials, they observed brighter chroma in the Bt horizon on the shoulder position of a slope; redoximorphic features were common on the interior of flat divides while closer to the backslope colors were redder.

Much of the research concerning water movement in the landscape focuses on definition of a soil landscape. Ruhe and Walker (1968) proposed a model for open and closed systems which included five landscape positions (summit, shoulder, backslope, footslope and toeslope); water and eroded sediment can exit in an open system but are contained in a closed one. Conacher and Dalrymple (1977) expanded on this model with a more detailed nine-unit model based on process and response. Yet these types of landscape models are primarily two dimensional. Recognizing a need, Huggett (1975) created a model for a three dimensional soil landscape. He proposed using an open system defined by the soil surface, the depth of weathering, and the geographical limits of a valley basin or watershed, such that water flows into, through, and out of the system under conditions set by topography.

Gerrard (1990) considered variation in soils on three landscapes in England. While he did find evidence of a general relationship between soils and landform, he disputed the idea of a catena where soils are welded together through geomorphic processes. Gerrard seemed to agree with Kachanoski (1988), who observed that the relationship between soils and topography are "well-documented" (p. 156) but there was too much variability to be able to quantify the relationship. Birkeland (1999) defines a catena as a toposequence, where soil properties are related to position on the slope. He responded to Gerrard (1990) that catena studies should more strictly limit the number of variables and have "tighter factorial control" (p. 231) in research design. In this statement he sides with O'Loughlin (1990), who agreed with the concept of a catena when scale and location in the landscape are determined by the particular process being investigated. In other words, sampling must be determined by processes which influence subsurface flow.

Catena studies involving calcic or gypsic soils have been characterized by lateral translocation of the most soluble salts, for example, chlorides (Birkeland 1999). Honeycutt et al. (1990a, b) looked at soils in eastern Colorado and discovered that $CaCO_3$

had accumulated in all soils in the catena, but was at a greater depth at the footslope which receives more water. Similarly, clay distribution showed a slight bulge at the moister footslope position, although they admit this may be partially attributable to clay migration down slope.

While a large part of the literature focuses on water relations and the landscape, it is important to recognize the role of topography on the processes of erosion and deposition. Butler (1959, 1982) introduced the concept of the K-cycle, or the time necessary for the formation of a new soil surface. Butler dealt with soil formation through the framework of stable and unstable phases in hillslope processes and the resultant erosion and deposition of sediment. This may be a continuous and slow process, or may proceed rapidly at periodic intervals in time; if continuous and slow, there is a steady state or equilibrium of losses of nutrients balancing gains by new additions of soil or parent material. If, however, it is a rapid but occasional event then during each period of erosion or deposition the soil is not in equilibrium and is altered from its "original state" (Butler 1959, p. 5). Butler (1982) pointed to buried soils as proof that these periodic phenomena occur. There may be many different K-cycles coexisting on a given landscape, and each point to new stable or unstable sequences.

Biological Factors

Starting with fresh, unweathered parent material, the accumulation of surficial organic matter is one of the first visible signs of pedogenesis (Daniels and Hammer 1992). Following this process, and to a certain extent dependant on it, other processes are able to proceed.

All living organisms are active participants in carbon and nitrogen cycling. Ugolini and Edmonds (1983) classified these organisms as producers, consumers or decomposers, and discuss ecosystems in terms of amount of vegetative biomass produced and decomposed. In a review of literature, they determined that grasslands produce more biomass than other ecosystems, but forests have greater above-ground biomass (p. 198, Table 7.2). Because grasslands produce more biomass, they also have greater decomposition rates (p. 200) with microbial biomass on the order of one-fifth that of vegetative biomass; in forested ecosystems microbial biomass may only be 1% of the total biomass and decomposition rates are correspondingly smaller.

Soil properties related to biological factors, for example organic matter, nitrogen, pH and certain types of structure can be quickly altered if inputs are changed (Ugolini and Edmonds 1983), sometimes in 1000 yr or less (Yaalon 1971). While vegetation may certainly vary with time for climatic or other reasons, process-response rates may be slow. Alteration of the soil due to animal influence may be more dramatic.

Hole (1961) discussed the role of pedoturbation in soil formation and classifies various factors and processes as propedanisotropic (profile differentiation) or propedisotropic (those which disturb soil horizons or retard their formation) and notes that plants and animals may be part of either process. In the late 1800s in a series of publications, Charles Darwin documented effects of earthworms in the soil, estimating they digest more than 10 tons $ac^{-1}yr^{-1}$ of soil (Darwin 1896) and transport much of it to the surface.

The effects of earthworms, both progressive and regressive, have been documented by several authors. Stein (1983) discussed beneficial effects, stating that wormcasts have great amounts of calcium humates; are more stable and hold more water than surrounding soil; and bacteria in the casts improve soil structure with bacterial glues. Stein also noted affects on soil aeration in part because of decreased bulk densities with improved structure; worm burrows are important as well, branching near the surface but becoming nearly vertical with depth. These vertical burrows may reach depths of 6 m as earthworms search for favorable environments during very dry, hot or cold seasons (Stein 1983). Ugolini and Edmonds (1983) observed that wormcasts left on and near the soil surface have near-neutral pH and are greater than the surrounding soil in organic matter, exchangeable cations, calcite, sesquioxides, phosphates, silt and clay, and certain microbes. Earthworms in ustolls may be active to a depth of two feet and may impact the structure of the B horizon and carry $CaCO_3$ to the surface (Buol et al. 1997).

Earthworms also contribute to homogenization or haploidization of soil material. In terms of pedogenesis this may be a positive factor, for example creation of the characteristic A horizon of Mollisols, but on archaeological sites faunal turbation can affect interpretation of cultural assemblages (Wood and Johnson 1978). Termites and ants (reviewed in detail in Ugolini and Edmonds 1983) also bring finer sediments to the surface, often in noticeable but localized quantity (Wood and Johnson 1978).

The effects of rodents, in particular pocket gophers, are even more localized. They can turn over large volumes of soil and may burrow a few meters in depth, creating krotovinas and burrows filled with surficial materials and mixing A and B horizons. Displacement of artifacts on archaeological sites may be significant. Near the surface pocket gopher burrows may extend horizontally from 60 m up to 150 m and artifacts may be transported out of cultural context; transport of an artifact may occur more than once, and direction may be reversed (Bocek 1986).

The role played by humans as a biological factor deserves special mention, and is discussed below with regard to archaeological sites.

Soil-forming Processes

The five factors previously discussed set the conditions for the four processes of soil formation, namely additions to and losses from the soil, and translocations and transformations within the soil. First proposed by R. W. Simonson (1959), the process theory modified the then-current factorial theory of soil genesis to better fit the idea of soils as a continuum with properties in common, and initiated a decades-long series of process oriented models (Hole 1961; Crompton 1967; Yaalon 1971; Runge 1973; Johnson et al. 1990 to name a few). Simonson proposed that soil genesis consists of two steps, the accumulation of parent material and the differentiation of soil horizons. These are not distinct steps and may certainly overlap, nor do they necessarily tend in only one direction (i.e., differentiation or horizonation, discussed in much greater detail by Johnson and Watson-Stegner 1987).

Focusing on horizon differentiation, Simonson stated that there are “four basic kinds of changes” (Simonson 1959, p. 153) responsible for differentiation of all horizons in any soil, namely, additions, removals, transfers (or translocations) and transformations. Each of the four changes, or processes, affects many of the substances which make up the soil, including organic matter, silicate clay minerals, carbonates, soluble salts and sesquioxides. He postulated that these four basic processes act on the same constituents in “most if not all soils” (Simonson 1959, p. 155) regardless of the classification of the soil. For example, there would be transformation and translocation of sesquioxides in Spodosols (Podzols, which might also include Alfisols and Ultisols) as well as Oxisols (Latosols), Mollisols (Chernozems) and Aridisols (Desert soils), but the degree of the process would vary; silicate clays and organic matter would undergo similar processes in the above soils, but again to different degrees. In addition, the “relative importance” of each process is “not uniform” for all soils (Simonson 1959, p. 155), and the relative importance of the several processes at work accounts for the differences among soils. Simonson stated that the balance among combinations of processes, and shifts that occur in that balance, “are responsible for soil differences rather than the operation of markedly different genetic processes” (Simonson 1959, p. 155). The processes occur simultaneously, but the rates may differ from soil to soil (Smeck et al. 1983). There is an important distinction between these four processes and the five factors in the functional-formation theory of Jenny. According to Birkeland (1999), the processes are what *form* the soil, while the factors define the *conditions* under which the soil forms.

Yaalon (1971) discussed the idea of steady state in relation to the soil-forming process model as outlined by Simonson (1959), which explains the variety of different soils but does not address how the soil will develop over time (Yaalon 1971). He proposed two classifications: Those processes which approach a state of dynamic equilibrium, at either a fast initial rate (rapidly adjusting soil features) or at a slower initial rate (features which develop at a slower rate but are more enduring); and irreversible or self-terminating processes where the balance of inputs and outputs is not maintained. For systems which approach a state of dynamic equilibrium, inputs (I) of material and energy are balanced by outputs (E). Yaalon (1983) noted that adjustment to change is continual (although there is a lag period); however it does not proceed so quickly that the dynamic equilibrium is affected. Johnson and Watson-Stegner (1987) observed that developed soil characteristics can reach a threshold level and create feedback processes which then direct pedogenesis in an alternate direction, including propedanisotropic (progressive) or propedisotropic (regressive). This redirection may arise solely from internal conditions in the soil, independent of external environmental factors.

Yaalon defined a feedback system as the "complex response of soils to the governing driving forces" of radiant energy, precipitation, gravity and biological activity (Yaalon 1983, p. 244), and differentiated between negative or self-regulating feedbacks and positive or self-enhancing feedbacks. Negative feedbacks (processes that do not tend toward a steady state, that is, where the balance between inputs and outputs is not maintained) are those that moderate the effects of a process, such as H^+ concentration affecting the fixation of phosphorus. Positive feedback systems amplify a change in the soil, usually until some threshold or limit is reached which halts the process (Yaalon 1983, p. 244), for example clay eluviation/illuviation will often exceed the rate of weathering of secondary minerals.

Smeck et al. (1983) offered a thorough discussion on soil dynamics and development of pedogenetic models, beginning with thermodynamics and energy fluxes (for example, Runge 1973, who modified the functional-factorial approach of Jenny with an emphasis on inputs of energy[4]) to demonstrate the complex nature of the soil system. They made a convincing argument for the soil to achieve a steady state, but never to be at equilibrium

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[4] Runge (1973) proposed that the soil, S, is a function of organic matter produced by radiant energy (o), water available for leaching (w), and time (t). $S = f\,(o, w, t)$.

because the soil is an open system. *Steady state* implies that soil properties remain unchanged over time, and like most biological systems, soils import energy and matter during developmental phases and lose energy with degradation of the profile. At "steady state," additions of energy and matter are just enough to maintain properties of the soil (Smeck et al. 1983, p. 64) and soil properties do not develop, intensify or degrade. *Equilibrium*, on the other hand, is the "static and time-invariant state of a system" where free energy is at a minimum and no irreversible processes occur (Smeck et al. 1983, p. 61), and is an unachievable state for the soil in terms of thermodynamics; soil development may actually result in the system "moving away from equilibrium" (Smeck et al. 1983, p. 62). They agreed that it is tempting to employ the term "equilibrium" as it is used in chemistry, in order to simplify a complex system with many variables and facilitate understanding; but this is inappropriate because the soil is an open system.

Smeck et al. (1983) suggested instead the use of the landscape approach taken by Huggett (1975), who introduced Patten's (1971) terminology to soils; others (Kachanoski 1988; O'Loughlin 1990; Glazovskaya 1968; and others) agreed that the drainage basin is the most logical unit of study. *Isomorphic* models study individuals (i.e., the pedon), while *homomorphic* models study a collection of similar individuals (i.e., the landscape) as a single integrated (and simplified) system. Huggett's landscape model allows many individuals to be analyzed through a drainage basin system, defined by the drainage divides, the land surface, and the weathering front at the base of the soil profile. This has several advantages, among which are clearly defined system parameters, functionally defined boundaries, and the transport and conservation of mass and energy throughout the system, enhancing the concept of integration of all components in the landscape

(Huggett, 1975). While they acknowledged it is a dynamic system model, Smeck et al. (1983) offered two disadvantages to Huggett's model: First, the model primarily deals with material balances rather than energy balances and transformations in the soil; and second, the model does not further an understanding of processes at work within the system, nor does it detail the inputs and outputs which affect the system (Smeck et al. 1983, p. 75).

Johnson and Watson-Stegner (1987) proposed an evolution model which overcomes many limitations in previous pedogenetic models. They observed that process models evolved when limitations in the functional-factorial approach were recognized, and reflect the dynamic nature of interactions in the soil. The processes of haploidization and renewal (rejuvenation), and a concept of profile organizing versus retarding processes have been subsequently proposed. It has been recognized that certain soil characteristics can reach threshold levels such that feedback processes result and alter the pathway of pedogenesis.

Johnson and Watson-Stegner (1987) recapitulated that soil thickening and soil mixing can each be developmental or regressive. Their evolution model is designed to incorporate all these concepts and recognize the polygenetic character of soils. Two vectors, horizonation and haploidization incorporate the thermodynamic concepts of entropy and energy. They work in combination with four processes of deepening, removal, developmental upbuilding and retardant upbuilding. The authors provided several examples from various taxonomic subgroups to illustrate possible combinations of vectors and four processes (Johnson and Watson-Stegner 1987, Fig. 3, 4, 7 and 8), and illustrated the processes for a hypothetical soil with possible alterations in the environment (i.e., stability alternating with gradual uplift and gradual downwearing) (Johnson and Watson-Stegner 1987, Fig. 5).

Johnson et al. (1990) contended that polygenesis is the norm, rather than monogenesis. The two concepts have been based on climatic variables (stability or instability), and data are now available from sources such as deep-sea cores and ice cores that were not available when monogenesis and polygenesis were first considered. These data indicate the climate is in continual fluctuation on several time scales, and even without such data, the authors contend, the "concept of climate as the exclusive determinant of polygenesis is far too limiting because…it carries the implication that climatic changes will be morphologically imprinted" in a lasting form in the soil (Johnson et al. 1990, p. 308). Climate is but one of many exogenous/endogenous vectors at work, most of which may leave morphological characteristics in the soil. Energy and mass fluctuations, wet and dry cycles, organisms and pedoturbation are given as vectors which are active in dynamic pedogenesis; passive factors are those such as parent material, chemistry and stable land surfaces. The dynamic rate model proposed is the dynamic and passive vectors plus the changes in those vectors over time.

♦ ANTHROPOGENIC INFLUENCE ON SOIL FORMATION

Soil and Archaeology

Soils have been recognized for many years as being an integral part of archaeological interpretation (Fenwick 1968; Ahler 1973; Haynes 1976; Foss 1977; Griffith 1980a, 1980b; Holliday 1985; Holliday 1990; Artz 1995; Ferring 1995; Mandel 1995; Mandel and Bettis 2001; Kvamme 2002 and many others). Physical, chemical and biological characteristics of the soil can aid understanding of an archaeological site, and contribute to paleoclimate reconstruction. However, turbation processes may negatively impact site context.

Human occupation of a site can have a profound affect, especially evident with regard to chemical characteristics of the soil. Organic matter is most rapidly influenced (Eidt 1985), but some chemical constituents, especially phosphorus, that are important in determining occupation patterns in archaeological sites can remain in the soil for hundreds or thousands of years (Ahler 1973; Foss 1977; Griffith 1980a, b). Phosphorus has often been used to indicate past human activity (Ahler 1973; Griffith 1980b; Rapp and Hill 1998) owing to its great concentrations in animal waste and human refuse; the fact that it remains relatively stable in the soil over long periods of time; and normally has low background levels (Courty et al. 1989). Ahler (1973) found phosphorus analysis to be useful for determination of site location and boundaries as well as investigation of stratigraphy in anthropogenic mounds. At sites in Oregon, McDowell (1988) found phosphorus and calcium to be of use in defining site boundaries. Griffith (1980) compared prehistoric settlements to comparable undisturbed areas in Ontario, Canada and found accumulations of exchangeable magnesium and of organic and inorganic phosphorus in occupation zones. There were slightly greater concentrations of exchangeable calcium and organic carbon off-site, but pH, sodium, potassium and carbonates were not useful in distinguishing between undisturbed areas and those of previous occupation.

The use of paleosols as stratigraphic markers can be useful in determination of potential archaeological sites (Holliday 1994; Artz 1995; Mandel 1995; Mandel and Bettis 2001). The presence of a paleosol indicates a period of landscape stability and may allow correlation among soil stratigraphy, climate and archaeological chronologies (Artz 1995). Mandel (1995) offered a thorough discussion of the use of paleosols in the Central Plains to predict possible locations of archaeological sites.

An increasingly important contribution of soil to archaeology is the use of soil or paleosols in determination of paleoclimate (Holliday 1990). He stated that "climatic change is the dominant factor producing differences in the morphologies of Early and Middle Holocene soils" at the Lubbock Lake site (Holliday 1990, p. 534), and noted that Reider (1980) found similar climatic trends in Wyoming. Several studies in the last several decades have focused on soil geomorphology and paleoclimate (Haynes 1976; Holliday 1990, 1994; Ferring 1995; Mandel 1995; Mandel and Bettis 2001). Retallack (1994) related depth to calcic horizon in paleosols and mean annual precipitation, and offered an extensive list of studies which link climatic variables to pedogenic features in paleosols. In the Southern Alberta Rocky Mountains, Reeves and Dormaar (1972) determined that buried soils dating back to ca 9000 ybp developed under environmental conditions different than those of the present. Three buried A horizons indicate long periods of stability, and the infra-red spectra of humic acids in these horizons indicate the two younger buried soils formed under grass vegetation while the oldest formed under open-canopy forest. Reider (1980) investigated Late Paleocene and Holocene soils at the Carter/Kerr-McGee site in eastern Wyoming where cultural artifacts date back over 11,000 ybp. A series of soils found in three profiles provide a sequential climatic record since Late Paleocene times. The oldest soils, associated with Clovis, Folsom, Agate Basin, Hell Gap and Cody cultural levels, formed in a cool, humid climate under grass and sedge vegetation; these merge into sandier soils upslope with good drainage.

Directly above these soils is a calcareous soil which formed under drier conditions during the Hypsithermal (around 8,000 ybp at this location); analysis of carbon in the A horizons indicates a succession of cool- to warm-season grasses. These soils were truncated by erosional activity at the close of the Hypsithermal; soils formed in resultant colluvial parent material in the paleo-arroyo are weakly developed under arid climatic conditions.

Archaeological sites are sensitive to disturbances which affect context and location of artifacts. In an early paper on disturbance processes, Wood and Johnson (1978) detailed several processes by which the soil and archaeological site may be altered. Biological agents of pedoturbation include earthworms, ants and termites, and rodents. Earthworms can blur the outlines of human-made features in the soil, such as pits (Wood and Johnson 1978; Stein 1983) or can bury surficial artifacts under wormcasts and excavated sediment in a matter of a few decades (Wood and Johnson, 1978). Vertical burrows created by earthworms may go to depths of approximately 1m, and deeply buried artifacts can be brought to the surface (Wood and Johnson 1978); however, once an artifact is transported vertically the direction is usually not reversed (Bocek 1986). Similar studies on rodents have shown that small artifacts (<3.5 cm) may be transported to the surface and artifacts larger than about 5 cm are displaced downward (Bocek 1986); Johnson (1989) pointed out that objects as large as 6 or 7 cm cannot be transported due to the diameter of the burrow.

Humans can affect all factors and processes in positive or negative ways (Bidwell and Hole 1965). Yaalon and Yaron (1966) agreed with Bidwell and Hole (1965), and observed that human-influenced changes proceed at a more rapid rate. Using a process-response model they demonstrated that human management or exploitation causes a chain reaction of interrelated changes in the soil. They suggested use of the term "metapedogenesis" to describe when human-induced changes act on a developed soil resulting in a new set of responses and feedback loops (Yaalon and Yaron 1966, p. 273) and provided several examples of affected processes and probable results. Eidt (1985) suggested classifying soils altered by human activity as Anthrosols, and divided them into intentionally and unintentionally altered.

<u>The Human Factor: Anthropogenesis and Double Ditch Cultural Features</u>

The visible surface (and invisible subsurface) features of Double Ditch Village make it unique among Terminal Middle Missouri variant villages, and provide clues to the timeline and pattern of occupation. There are two visible ditches (1 and 2) and two outer ditches (3 and 4) not visible on the surface, and over 30 mounds varying in height and volume; inside the perimeters of Ditch 2 and Ditch 1 are visible the remains of several earthlodges, looking like rims of bowls (Figure 1.4). Through analysis and dating of artifacts by comparison with those found in similar Middle Missouri villages, as well as by radiocarbon dating, a timeline of various mounds and ditches has been obtained.

Results of the extensive archaeological investigation (a cooperative effort between the State Historical Society of North Dakota, the PaleoCultural Research Group, and the Archeo-Imaging Laboratory) provide significant information concerning possible history of Double Ditch Village proper (Ahler 2003, Ahler 2004, Ahler 2005, and Ahler et al. 2005 among others). Type and density of artifacts in the soil are germane to determination of a timeline of occupation and activity. Based on extensive analysis of the artifacts, a working timeline was offered:

Period 0	AD 1725-1785
Period 1	AD 1675-1725
Period 2	AD 1650-1700
Period 3	AD 1600-1650
Period 4	AD 1490-1600

These dates were based on ceramics, lithics and trade artifact densities relative to other sites in the Middle Missouri Valley, especially those at Knife River Indian Villages, as well as changes in trade artifact types (Ahler 2005, pp. 329-330).

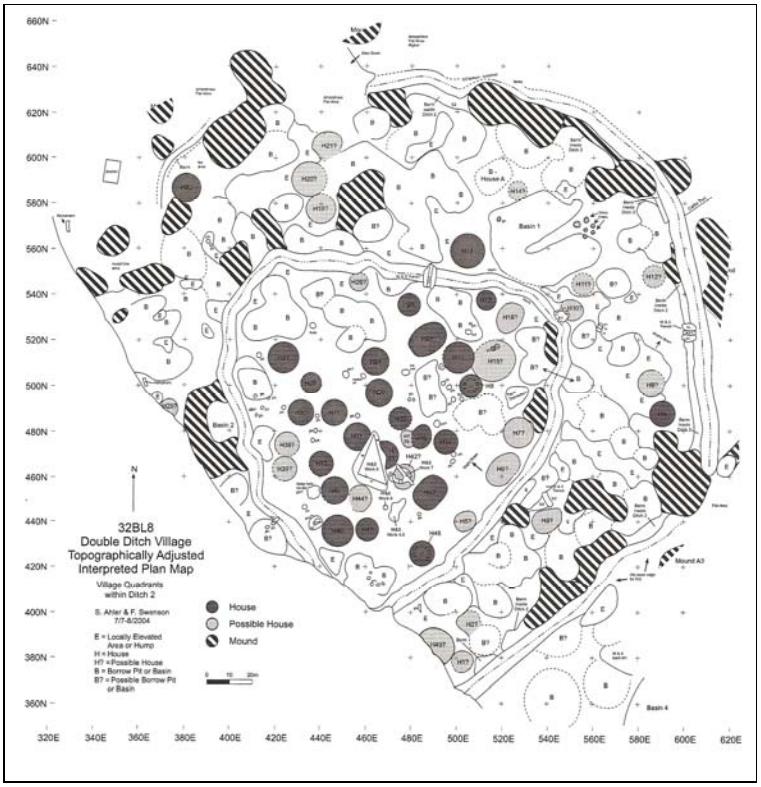


Figure 1.4 Interpreted and topographically adjusted plan map showing mounds, house sites and possible house sites (courtesy Ahler 2005, p. 52).

Pottery at Double Ditch may have been generated from local clay sources, and was tempered with heat-treated granite from nearby glacial erratics that was then broken into small grains. Pots were manufactured from a lump of clay that was shaped and beaten with a paddle and anvil. Over the time of occupation, several styles of pottery are found, many of which are tied to time periods at this site and others. Styles are primarily differentiated based on rim and body styles, and also on decorative patterns. Early rim styles (from Periods 3 and 4, or prior to AD 1650) include Classic, Recurved and High Rim varieties of Le Beau S-rim, with lesser amounts of Knife River ware, and sparse numbers of Sanger S-rim. In general, check-stamping is more common in the earlier pottery, and check-stamped body sherds may date to the AD 1300s to mid-1400s although some radiocarbon dates do not agree (Ahler 2005, p. 334). Later time periods offer simpler, plainer finishes.

A later set of ceramics, probably dating to around AD 1650-1700, is comprised of all the previously-mentioned early styles, but also includes a distinctive Sperry variety of Le Beau S-rim, Transitional ware, and larger quantities of Knife River ware. The rather abrupt introduction of the Sperry Le Beau and Transition ware into the archaeological record implies possible increased contact between the inhabitants of Double Ditch and a new social group (Ahler 2005, pp. 181-220 and p. 334).

According to Ahler (2004), Periods 4 and 3 are not that different, except for the greater quantity of check-stamping in Period 4. However, the earlier period is characterized by a few “unusual pottery vessels” leading to the conclusion that the original inhabitants of Double Ditch may have come from one or two major, and several minor, pottery traditions, and that the founders of the village may have come from several different social groups (Ahler 2004, p. 316).

Analysis of the lithic record shows a definite change over time in sources for stone. Initially, Tongue River Silicified Sediment (TRSS) was the primary raw material (Ahler 2004 named the source for TRSS as the Cannonball River area). In the more recent time periods, TRSS was replaced by Knife River Flint and “exotic” chalcedony and petrified wood from west and southwest of the village (Ahler 2003, p. 264; Ahler 2004 p. 14). Some of the same changes have been noted at other nearby Mandan and Hidatsa villages, On-a-Slant Village and Scattered Village, and Ahler (2003, p. 264) suggested this indicates an overall change in territory or “social contacts.” Some flint knapping was of high quality, while the remainder was “haphazard” in preparation (heat-treating) and execution, perhaps indicating a hierarchy of skilled workers and those who were unskilled or beginners (Ahler 2003, p. 264). Bone and antler tools exhibited a similar pattern, opening the way for speculation of specialists or “village-specific roles” regarding tool manufacture (Ahler 2005, p. 328).

Radiocarbon dates give the mid-AD 1400s as the earliest reliable date for occupation (Ahler et al. 2004). Regarding fortifications, it has been determined that the most likely scenario is that the outermost ditch, Ditch 4, is the original defensive feature and was constructed shortly after the village was founded (Ahler 2005, p. 332). The bastions along this ditch are regularly spaced and are comparable with those of the Shermer site, a Terminal Middle Missouri community that probably dates to the AD 1300s to early 1400s (Sperry 1968), and also with Huff, a village dated between Shermer and Double Ditch, around AD 1450 (Wood 1967). It would seem that by the late AD 1500s, both outer ditches had been abandoned and filled in and several mounds of earthy fill had been constructed over them (Ahler et al. 2004), possibly for defensive purposes, although that purpose may have changed over time (Ahler 2004, p. 32).

Integral to dating the outermost ditches are not only content of the ditch fill but also content of mounds associated with them. Ditch 4 encloses approximately 7.71 ha (19 ac) which would have accommodated about 160 dwellings with perhaps 1600 to 2000 inhabitants (Ahler et al. 2004). This outermost ditch sweeps in a wide curve and geophysical investigation has revealed 10 U-shaped bastions along the ditch (Ahler 2005, p. 12). Investigations revealed a few artifacts in the fill, primarily bone, rock and fire cracked rock (FCR) (Ahler 2005, p. 146). Mounds A3, L, N and V (Figure 1.5) were built over Ditch 4 either after or while it was being filled in. Investigation into Mound V revealed it lacks trade artifacts in the lower fill and only sparse amounts in the upper portion of the fill (Ahler 2004, p. 306), dating it to Period 4. An interesting feature of Mound V is that the orientation of the layers indicates that fill material was brought in

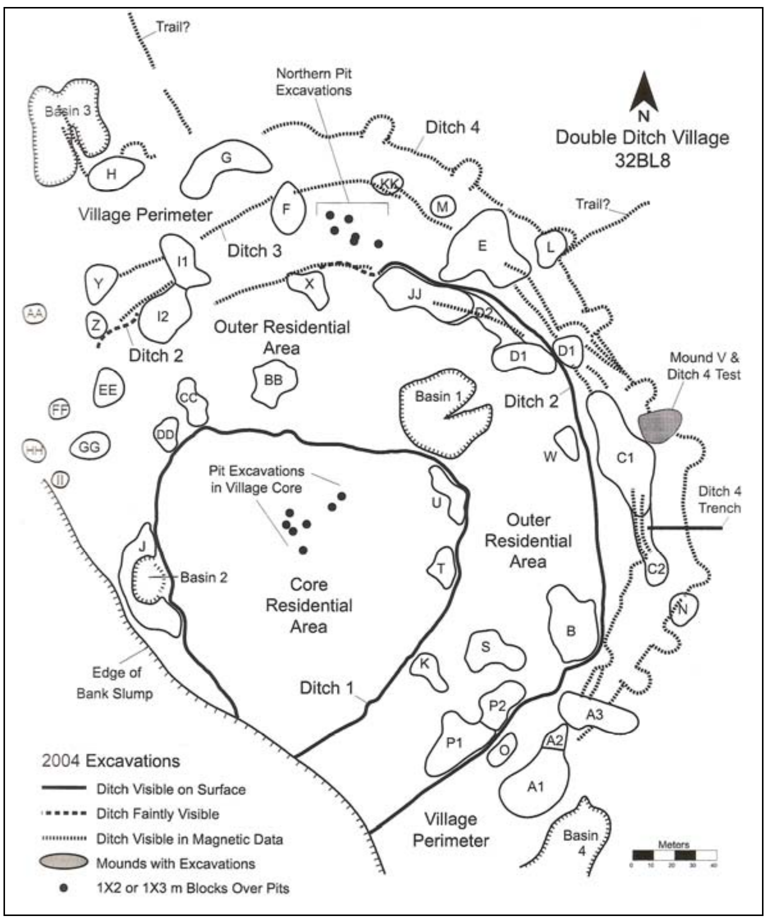


Figure 1.5 Plan map of Double Ditch Village showing major surface features (courtesy Ahler 2005, p. 25)

from the east or southeast and dumped toward the northwest; in other words, the fill was carried from outside the perimeter of Ditch 4, not from the village center (Ahler 2004, p. 145). Ditch 3 is somewhat younger in age than Ditch 4, and encloses about 6.1 ha. It is overlain by several large mounds which imply major mound-building activity around the time of abandonment of Ditch 3. Mounds D1, E and I1 post-date Ditch 3, and some material from these mounds has eroded into the ditch; Mounds A3, C1 and F are also associated with this era of activity. Mound D1 lacks trade artifacts in its lower part, and is dated to Period 4 (the late AD 1500s) along with Mounds V and F (Ahler et al. 2004). But after some break in time, the inhabitants of the village added refuse or household trash to the existing Mound D1 that contains some trade artifacts but no glass beads (Period 3). Somewhat later, as Ditch 2 was being constructed, Mound D1 was bisected by the new ditch leaving a portion of Mound D1 within the new perimeter along with Mounds D2 and JJ.

Mound E, nearby, is much larger (with a volume of about 831 m^3) and is the highest mound on the site. It consists of fairly clean earthy fill, and Ahler (2004) stated that the "deposit…appears to have been created by a massive dumping event conducted without break and probably over a short time span" and the lack of certain features suggest a time frame of "a week or two" (Ahler 2004, p. 51).

These oldest mounds (excepting JJ, constructed around the time of Ditch 2) all lie outside the perimeter of Ditch 2, are overlying Ditches 3 and 4 and date to Periods 3 and 4. Mound B, located just inside the perimeter of Ditch 2, occurred later in the village timeline, perhaps around AD 1650-1700, and just prior to construction of Ditch 2 (around AD 1700-1725). Spoil from Ditch 2 rides up over and is interlayered with the fill in the uppermost layers of Mound B (Ahler 2004, p. 309), indicating the mound was nearly completed by the time the ditch was dug. Artifacts mixed in with the fill are from a narrow window in time (Period 1; Ahler 2004, p. 309) and the mound is thought to have been deliberately constructed over a brief period of time (Crawford and Ahler 2003; Ahler 2004, pp. 31-32; Ahler et al. 2004). Mound A1, outside the perimeter of Ditch 2, is similar in this respect, although the fill in this mound is predominantly household refuse. Both mounds were constructed on a ground surface that had both pedogenic A and B horizons removed (40 to 80 cm) in an area that had undergone borrowing at some point previous to mound construction. Ahler (2004) does not speculate on the fate of the soil material borrowed prior to mound construction.

Based on artifact content, Mounds B, P1, JJ (on the east side of the village) were constructed in association with Ditch 2, having back spoil from the ditch at the base, and date to the late AD 1600s or early 1700s (Period 1). However, Mound P1 has two distinct phases of earthy fill on top of the Ditch 2 back spoil and postdates that construction. Material in all these mounds was found to have been brought from the village interior (Ahler 2004, p. 309) based on the pattern of deposits.

Ahler (2004) concluded that the majority of mound construction occurred after the two outermost ditches were abandoned. Mound construction appeared to have been ongoing throughout Periods 3, 2 and 1, and mirrored the migration of the defensive ditches toward the interior of the village. Many of the mounds are aligned with the Ditch 3 feature, and it is probable there was major mound building activity at the time this ditch was abandoned and filled.

The present-day surface inside the perimeter of Ditch 2 is irregular with many shallow depressions and mounds. At the beginning of the archaeological investigation it was thought that these were the remnants of earthlodges (house depressions), but investigations showed no evidence of hearths or other features associated with lodges in many of these depressions. Ahler et al. (2004, p. 2) proposed that a large portion of the area within Ditches 1 and 2 had been subjected to repeated and extensive borrowing with 30 to 50 cm of overburden removed. The A and B horizons of the original surface soil have been removed, as seen beneath Mounds A, B, P1 and JJ and also at least four house depressions inside Ditch 1. "Many house floors do not exist" in the core and inner core residential areas, and the inner core houses late in the village timeline rest on a truncated surface about 20 to 25 cm below the present day surface (Ahler et al. 2004, p. 2) which itself had been lowered during the course of village occupation. The spoil thrown interior to Ditch 2 during its construction rests on this truncated surface as evidenced under Mound B. Ahler et al. (2004, p.2) offered a possible explanation that this behavior was an "attempt to cleanse or renew the whole village, perhaps in the aftermath of major epidemics" which occurred with increasing frequency over the years after European contact.

One of the more remarkable and puzzling features of the site is the lack of surface disturbance outside the perimeter of Ditch 2. Prior to geophysical investigations (Kvamme et al. 2002, 2004), it was not suspected that any archaeological features were hidden beneath the surface; there was no sign of ditches, houses, or borrow areas. Magnetic gradiometry investigations in 2002-2004 revealed the full historic extent of the village (Figure 1.6), raising the question of lack of surface expression such as that seen in the village interior.

An east-west trench was dug from just under Mound C1 eastward about 50 m. The trench shows the A horizon of the original surface intact beneath the mound, which

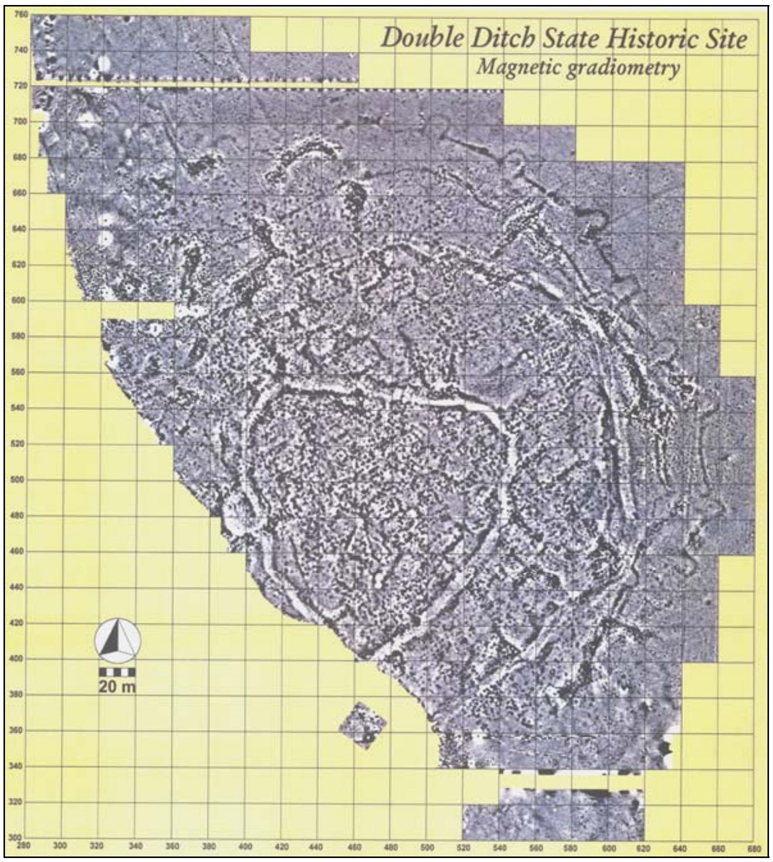


Figure 1.6 Magnetic gradiometry of Double Ditch Village (courtesy Kvamme et al. 2004).

remains visible eastward for about 5 m, from 633E to about 638E, as shown in Figure 1.7 (Ahler 2005). From this location eastward, sediment eroded from the mound thins greatly, light grayish brown lenses of silt are present just beneath the surface, and the original A and B (and C?) horizons have been thoroughly mixed. The original C horizon

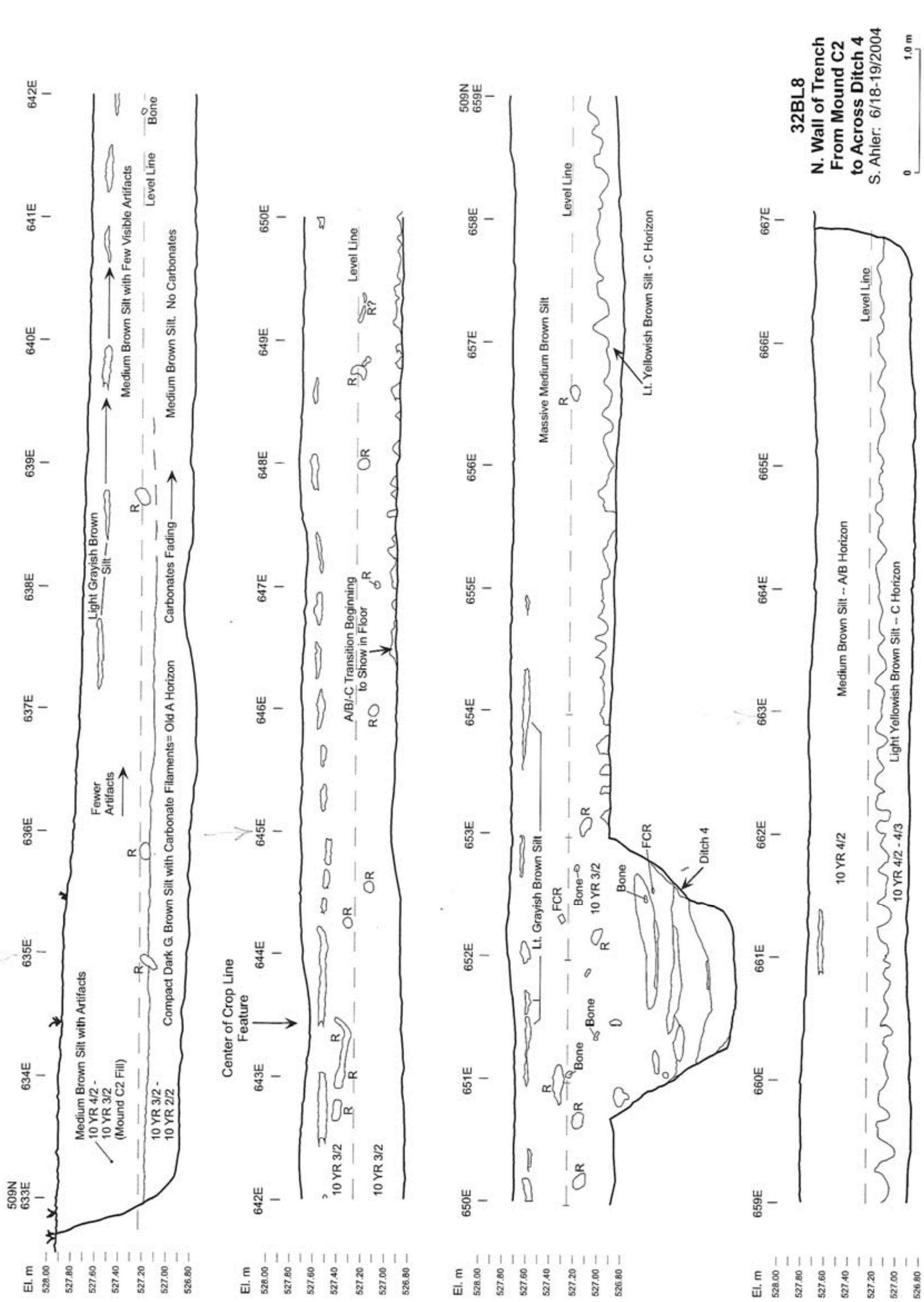


Figure 1.7 Profile drawing of the backhoe trench showing the pre-village A horizon beneath Mound C2 across Ditch 4 (courtesy Ahler 2005, p. 71).

begins to appear about 10 m from the edge of the mound and has a very irregular boundary; the C horizon increases in elevation as it continues east.

One possible theory was that historic cultivation (post-abandonment of the village) had smoothed surface irregularities and created the zone of homogenized soil. However, a partially articulated bison skeleton in association with Plains Village artifacts, was discovered in another part of the site only 15 cm beneath the present day surface. The skeleton rested on the same homogenized soil present east of Mound C1, and underneath the light grayish brown silt lens. Bison were not present in the area after about 1880, and the presence of pre-Euroamerican artifacts suggests the homogenized soil had its origin before the village was abandoned (Ahler et al. 2005, pp. 69-74).

The best explanation for this homogenized zone around the village perimeter is the inhabitants themselves, according to Ahler et al. (2005, pp. 74 and 333). By the time the village had retreated behind Ditch 2 the population was around 1000 inhabitants. It is probable that many daily activities still took place on the village perimeter (outside Ditch 2, directly over Ditches 3 and 4). Foot traffic, possible gardening, and after AD 1750 perhaps horses, all coupled with a lack of vegetation would result in compaction, puddling and a mixing of the soil to some depth.

In summation, there was earth borrowing, relocation and deposition on a massive scale. Consider Ditch 2, which was 8 m across and about 1.7 m deep; spoil piled on the interior side of the ditch gave a relative height from the floor of the ditch of almost 3 m. Ditches 3 and 4 were probably on a similar scale, and excavations of these features reveal not only were the interior berms removed but also 40 to 90 cm of the upper part of the ditches. The mounds themselves contain an estimated 6400 m^3 of material, all of which was excavated, carried and redeposited by hand.

Objectives

The objectives of the study are:

1. To describe and assess the pertinent, baseline morphological physical and chemical characteristics of the loess soil.
2. To obtain and archive necessary characterization data of the Leonard Paleosol and the Holocene loess.
3. To assess the degree of earth-moving activity by the human inhabitants, relative to spatial pattern and time and to describe the relationship of pedogenic soil features to anthropogenic site features.

This study is a detailed on-site investigation in which cores of up to 4 m in depth have been obtained. From these cores pertinent baseline morphological physical and chemical characteristics will be obtained which can be used to assess the complex depositional history at the Double Ditch State Historic Site. Among the most influential of the factors has been the parent material: Initially there are several deposits of loess from the nearby Missouri River; surface deposits may consist of anthropogenic materials excavated, homogenized and redeposited by the village inhabitants.

CHAPTER 2

Study Area

The Double Ditch State Historic Site (32BL8) sits on a high terrace east of the Missouri River, approximately 15 km north of Bismarck, North Dakota in Burleigh County. The legal location is NE ¼, section 21, T 140 N, R 81 W. Local relief across the study area is approximately 9 m (60 ft), from 534 m (1752 ft) on the northeast perimeter to 525 m (1717.5 ft) at the bluff edge (USGS 1:24000 Topographic map; detailed 25 cm-contour interval map, Kvamme pers. comm. 2005).

Age, Geologic Setting and Parent Materials

The Missouri River valley at this location is three to seven km (two to six mi) wide. The 68 km (36 mi) stretch of the river, from the Garrison dam northwest of Double Ditch to the northern terminus of Lake Oahe to the south, has remained relatively unaffected by dam construction, and is the "longest natural reach" of river in North Dakota (Hoganson and Murphy 2003, pp. 85, 96). The river behaves much as it always has done, and meanders across the valley creating and destroying sandbars sometimes within a few days; in 1804 Lewis and Clark noted this stretch of river as "a bad place" (Hoganson and Murphy 2003, p. 86) in reference to the changing sandbars.

The Double Ditch site lies within the Missouri River Basin which drains south to the Gulf of Mexico. The Missouri River Valley in this area is much younger (formed during glacial events about 25,000 ybp) and narrower than the valley south of Bismarck (Bluemle 2000, p. 61). Here, the Heart and Little Heart Rivers flowed into the Missouri River Valley and the additional influx of water created a much larger river valley. This older portion of the valley has a northeast orientation and is up to six miles wide (Hoganson and Murphy 2003, p. 79); the valley near Double Ditch State Historic Site is approximately two miles wide.

The Burleigh County Soil Survey (Natural Resource Conservation Service 1974) indicates the soil is Mandan silt loam, level, 0 to 3% slopes (*coarse-silty, mixed, superactive, frigid Pachic Haploborolls*). It is characterized by one or more episodes of loess deposition overlying an Early Holocene paleosol, assumed to be the Leonard Paleosol of the Aggie Brown Member. Below the paleosol, as seen in a few pedons, there appears to be water-worked material (rounded and subrounded sand grains interbedded with finer soil material). Calcium carbonates are present in all profiles for nearly the entire depth. A mollic epipedon is present in some of the profiles; however, intensive anthropogenic activity has eradicated the soil surface throughout much of the study area such that the mollic epipedon is not often present.

This soil formed in 4 to 6 m of Holocene age silty and very fine sandy loess overlying Late Wisconsinan loess and alluvium known as the Oahe Formation, which includes all sediment younger than the late Wisconsinan Cole Harbor group (Clayton and Moran 1979).

These loess units in turn overlie the Cannonball Formation, a Tertiary-aged mudstone and sandstone of the Fort Union group (which contains, from oldest to youngest, the Ludlow, Cannonball, Slope, Bullion Creek and Sentinel Butte Formations). The Cannonball Formation is only slightly younger than the Ludlow Formation, which sits at the Cretaceous-Tertiary boundary. The Cannonball Formation is comprised of marine shoreline and off-shore sediment deposited about 60 million years ago as the last ocean to cover North Dakota, the Cannonball Sea, receded. It is primarily olive brown sandstone, shale and mudstone and is 120 to 150 m (400 to 500 ft) thick. Fossils indicate that many extinct Cretaceous marine reptiles were present. The non-marine Bullion Creek Formation is visible in many places in bluffs along the Missouri River. It may be up to 200 m (650 ft) thick and consists of a variety of materials ranging from silt- and mudstone, sandstone, lignite, and even volcanic ash (which has sometimes weathered to high shrink-swell clays like bentonite). Fossils in the Bullion Creek Formation show that a variety of reptiles inhabited these swampy lowlands, including crocodiles, alligators and various species of turtle; and in fresh water habitats, gar and pike were present (Hoganson and Murphy 2003, pp. 22-29).

Landforms in the region have been greatly influenced by glaciation; as glaciers retreated, meltwater shaped the rolling hills that are characteristic of the region, and carved the large river valleys. Glacial erratics near the study site are granite which originated in Canada. The site was covered by Early Wisconsinan glaciers (Bluemle 2000, p. 34) but not by younger glaciers. Direction of the Early Wisconsinan ice movement was northeast to southwest, toward the Missouri River; the river marks the approximate maximum southwestern extent of Early Wisconsinan glaciations in this part of the state. This is denoted as the Napoleon ice-marginal position, and is 40,000+ ybp (Bluemle 2000; adapted from Clayton et al. 1980).

Climatic Setting

The climate is dry, sub-humid continental, characterized by cold winters and warm summers. Approximately 80% of the yearly precipitation occurs from April through

October, with June and July being the only months each with greater than 50 mm (2 in); average annual precipitation is approximately 380 mm (15 in). Average daily maximum temperatures range from −7° C (20° F) in January to 30°C (86° F) in July; daily minimums range from −19° C (−2° F) in January to 15°C (59° F) in July.

North Dakota was glaciated during the Wisconsinan Age (ca 70,000 to 10,000 ybp) (Hoganson and Murphy 2003). It is generally accepted that ice retreated from North Dakota for the final time ca 12,000 ybp. At this time, the climate was cool and moist, supporting boreal forest species such as spruce and fir. During the Middle Holocene, North Dakota experienced a period of warming known as the Altithermal (or Hypsithermal) when average temperatures were up to 2° C warmer than today. During these times precipitation was markedly less than today resulting in periods of great erosional activity and thin surface horizons. This has been documented throughout the Great Plains in several studies (Honeycutt 1990a; Artz 1995; Ferring 1995; Mandel 1995; Mandel and Bettis 1995; and others).

The Late Holocene, after about 5000 ybp, is characterized by fluctuations in temperature and precipitation, where climatic patterns were similar to those of present day. There would have been additional erosion during drier periods, interspersed with episodes of surface stability and soil formation.

Cultural Setting

Rising approximately 20 m above the floodplain on a wide bend of the Missouri River, Double Ditch offers a commanding view for several kilometers up and down the river valley. The village was one of at least seven known traditional settlements of the

Mandan Indians in the region of the Heart River located on both sides of the Missouri River (Figure 2.1), from Huff Village south of Bismarck to the Knife River Indian Villages several miles to the north. From this location, smoke from fires in these villages would have been visible to the residents of Double Ditch. All were abandoned by the Mandans after attacks by the Sioux following the smallpox epidemic of AD 1781-1782 (Ahler 2003, p. 1).

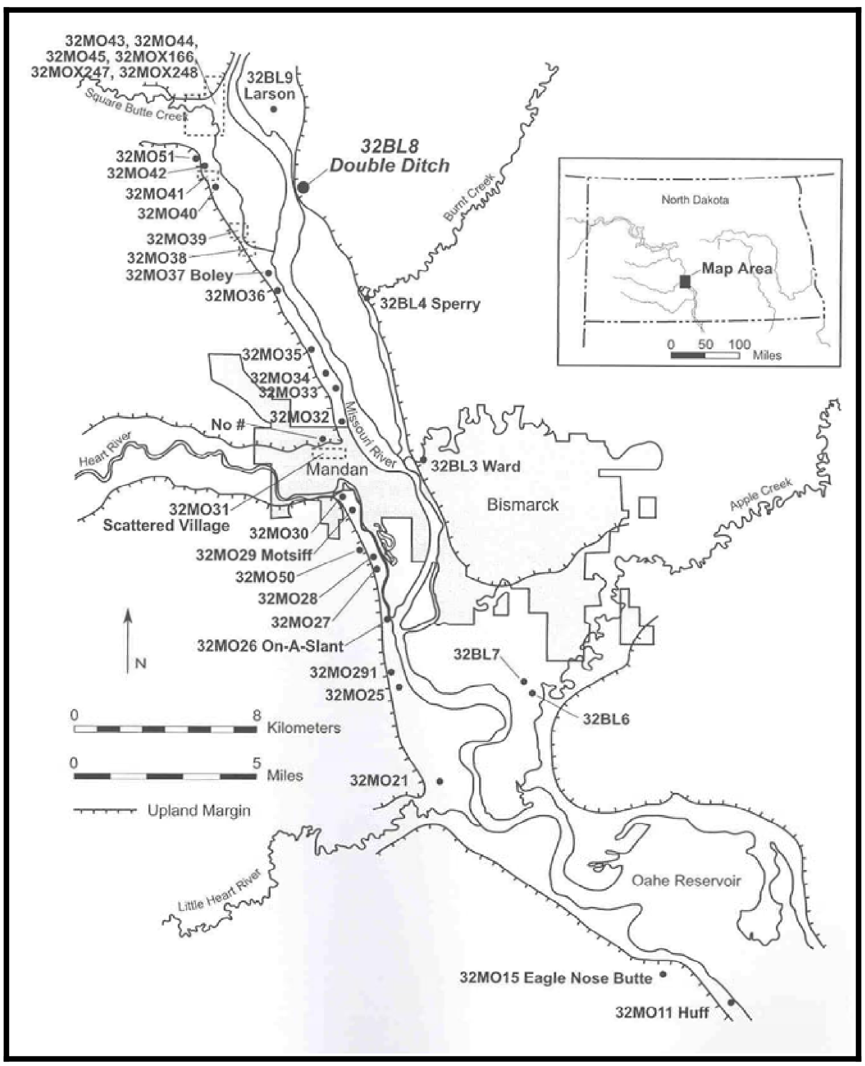


Figure 2.1 Mid-Missouri Valley Indian Villages in the Middle Missouri River valley (Ahler 2003, p. 2, courtesy PaleoCultural Research Group).

The remains of two, roughly circular and parallel fortification ditches surround numerous house depressions plus a series of various shaped mounds up to 3 m high scattered throughout the village make Double Ditch unique among Mandan villages in the area. Unknown until recently are the remains of two in filled, outer ditches that likely predate the two visible ditches. The site's impressive size of 9 ha makes it one of the largest of the Terminal Middle Missouri villages, with an estimated peak population of 1600 or more individuals; Ahler (2005) estimated the earliest and largest village might have contained 162 earthlodges within the perimeter of Ditch 4, the outermost ditch. As

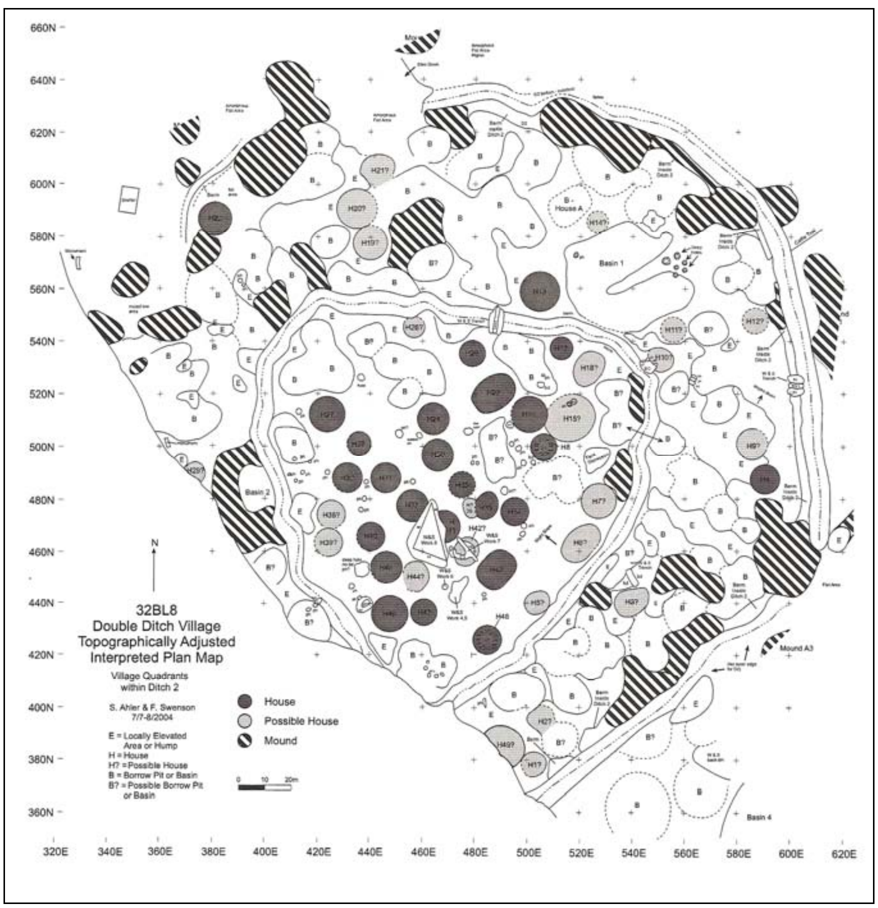


Figure 2.2 House locations and other features in the interior of Double Ditch Village. House sites are dark gray, possible sites are light gray, borrow areas are white and mounds are striped (courtesy Ahler 2005, p. 52).

the village contracted, the number of lodges decreased, from 162 to 126, then 62 and finally less than 40 lodges within Ditch 1 before the village was abandoned Figure 2.2). It is reasonable to assume 15 to 20 occupants in each earthlodge (Ahler 2005, p. 331).

History of the Mandans

Oral tradition, supported by linguistic evidence, suggests that the three major Siouan subgroups (Eastern, Central and Western) split from the proto-Siouans around 500 BC (Springer and Witkowski 1982); Mandan oral tradition places their origin in the lower Mississippi River valley, from whence they migrated through southern Minnesota, then eastern and central South Dakota (Bowers 1949 *cited in* Ahler 2003) While the Eastern and Central subgroups may have remained together until around 100 BC, the Western subgroup moved northwesterly and eventually settled in the Northern Plains, evolving into Mandans, Hidatsas and Crows (Henning 1998). For some time, the Mandan ancestors may have occupied villages along the Missouri River in South Dakota, and their oral traditions speak of at least two major migrations upstream (Fagan 2000, pp. 151-152).

Mandan roots lie in the Middle Missouri tradition (Lehmer 1971). According to Ahler (2003), by the AD 1300s, Middle Missouri tradition villages were found throughout the Missouri River valley in North and South Dakota. At this early date, villages were characterized by rectangular earth- or bark-covered dwellings with entrances facing the southwest and were smaller in size than later dwellings and unfortified. Around the mid-AD 1400s, Middle Missouri peoples left South Dakota entirely and moved north, possibly due to pressure from other tribes (perhaps ancestors of the Arikaras) moving into the Central Plains. Larger, fortified settlements were developed near the mouth of the Heart and Cannonball Rivers in North Dakota. Villages further upstream were still small and unfortified (Ahler 2003).

It seems that by circa AD 1500, most of the villages in North Dakota were “large, nucleated, fortified settlements” (Ahler 2003, p. 4) and earthlodges were circular in shape, rather than rectangular as seen at Huff (32MO11) (Fagan 2000; Winham and Calabrese 1998). The occupants of these villages were probably the direct ancestors of the Mandans and Hidatsas. Double Ditch Village was probably founded around this time, and remained continuously occupied for almost the next 300 years.

Although the remnants of earthlodges at Double Ditch Village are all circular, a few outlines are rectangular in shape with the long axis oriented in a northeast to southwest direction (Ahler and Swenson 2001; Kvamme 2002). Further investigation by geophysical methods revealed the hearth and pit features associated with a dwelling for two of the features (Kvamme 2002). One depression was determined to be a borrow area because it lacked such features (Ahler 2005). It was difficult to determine the shape of the original dwellings as nearly all surface features from the early years of the village have been obliterated (Ahler et al. 2004).

From AD 1600 to late AD 1700, the area around the mouth of the Heart River experienced several incursions of Hidatsas from the east, who settled as far north as the Knife River. As other tribes moved westward from the Great Lakes, conflicts became more likely over hunting territory which may have led to the adoption of fortification systems. With the introduction of several diverse cultures during this period, an important settlement such as Double Ditch Village could show a large variability in artifacts such as style of pottery; sources of stone used for tools and weapons; and possibly even trade goods (Ahler 2003).

European movement up the Missouri River also impacted tribes in North Dakota, not only in terms of trade but also the introduction of devastating diseases such as smallpox (Ahler et al. 2003). The earliest documented European contact with the Mandans was La Vérendrye in 1738 (G. Smith 1980), and by the middle 1820s American forts like Fort Clark were in use (Wood et al. 2011). Repeated episodes of disease along with frequent conflicts with nomadic tribes such as the Sioux reduced the population in villages such as Double Ditch (Johnson 1998). As a consequence, the village contracted in size, evidenced by a series of fortification ditches of different ages. Throughout the AD 1700s, the Mandans and other tribes suffered great losses in numbers, and after the last smallpox epidemic in 1781, the village was abandoned. By the late AD 1700s, the Mandans, Hidatsas and Arikaras all settled in the Knife River area at villages such as Big Hidatsa and Deapolis, and later around Fort Clark and Like-a-Fishhook at Fort Berthold. By 1886, they had all relocated to the Fort Berthold Reservation (Johnson 1998).

Description of Mandan Culture

As Plains Villagers, the Mandans were horticulturists and hunter-gatherers. Along with the Hidatsas and Arikaras, the Mandans based their economy on corn and other vegetables as well as on bison. In highly productive gardens on the river floodplain, the women grew a surfeit of produce which allowed the surplus to be used in trade for other goods (Peters 2000). At the center of a vast trade network, the Mandans traded goods from Mexico to Canada, and the Pacific Northwest to the eastern Plains (Wood and

Thiessen 1985). The women made this affluence possible through consummate horticulture.

The men hunted and went to war; women did nearly everything else. The women grew the crops; primarily corn, squash, beans, and sunflowers (Nickel 2005). They dried and preserved the harvest, which was stored in underground bell-shaped cache pits of several cubic feet in volume. While the men sometimes butchered game that was killed, this was most often the job of the women. Women made implements and tools from bone and horn, and robes and blankets from the hides. They manufactured baskets and pottery, painted robes with significant achievements of their husbands, and provided materials for sacred ceremonies (Peters 2000). Women also performed much of the heavy manual labor, digging ditches or dry moats that served as defensive fortifications. They erected the earthlodges, except the four heavy posts in the center of the lodge that were set by the men.

Earthlodges were 10 to 15 m (35 to 50 ft) in diameter. Large posts around the perimeter provided support for smaller rafters on top of which was laid willow branches, grass, and covered with earth. In addition to being living quarters for up to 20 people, dogs and horses also spent time inside the lodges. There was a fire pit in the center of the lodge with a smoke hole directly above, and bed compartments ringed the outer wall. There were underground storage pits for food or sacred items.

Mandan society was organized along matrilineal lines. Women owned much of the real property, including the lodges and the gardens. When a man married, he moved in with his wife's family; she was able to divorce him by putting his personal belongings outside the lodge. But his status in society was still determined by his mother's family (Peters 2000).

Society was organized into age-graded societies (Krause 1998) based on gender. When children reached the age of about twelve, they purchased into their first society, and became responsible for certain activities and duties. If they performed well, when they were old enough they passed to the next level. Religious ceremonies, conducted by the various societies, knit the village together; men and women each had their own ceremonies, but women provided the necessary accoutrements for the men's ceremonies as well as their own. Religious rights as well as property were inherited from one's mother (Peters 2000).

CHAPTER 3

Materials and Methods

During the course of two field seasons, 39 cores were obtained from four transects. Cores ranged in depth from about 1.8 m to 4.5 m; average depth of soil cores for the relatively undisturbed transect (T 1) is 3.22 m, and average depth of soil cores for the three transects located within the zone of anthropogenic activity (T 2, T 3 and T 4) is slightly less, at 3 m. Sampling strategy was designed to include the A and B horizon of the paleosol; where possible, the paleo-C horizon and parent material below the paleosol was obtained.

Transect Location and Field Sampling

Field sampling occurred during the summers of 2003 and 2004. Transects were run both within the village and in an adjacent area of similar but relatively undisturbed landscape. In 2003 three transects were sampled; the following summer samples were obtained in various cultural features (satellite locations), and in part were chosen based on results of previous soil and archaeological investigations (Figure 3.1).

Transect 1 was located on the northern perimeter of the study area to provide baseline data for geomorphic and pedologic soil features. This area of relatively undisturbed soil serves as a geomorphic control for loess deposition and depth to paleosol with distance from the source; it also serves as a control for anthropogenic activity with regard to its location outside the principle zone of borrow and mound activity.

Figure 3.1 Transect and pedon locations with 25 cm contour lines (after Kvamme 2004). Transect 1 is in relatively undisturbed soil on the northern perimeter of the site. Transect 2 begins outside of Ditch 4 in the northeast portion of the site and crosses the village in a southwest direction; locations were chosen by cultural feature (mound, ditch, borrow basin or house) in consultation with the archaeological investigators. Transect 3, in the northwest, is oriented approximately parallel to the edge of the terrace. Transect 4 locations are by cultural feature to provide additional information regarding anthropogenic activity.

The remaining transects (2, 3) as well as satellite locations in 2004 were all located by cultural features to provide information on degree of anthropogenic activity. A transect was run from the northeast perimeter to the village center (Transect 2) to obtain data for depth to paleosol relative to cultural features (anthropogenic activity) and includes both buried and visible ditches, house depressions, and borrow areas. A final transect (Transect 3) located approximately parallel to the Missouri River, provides additional information regarding anthropogenic activity near mound construction, and documents the original A-horizon at the time of village occupation. Satellite locations were determined to provide information by cultural feature.

Based on findings from the soil and archaeological investigations, soil cores were obtained the following field season from satellite locations throughout the village to provide data on depth to paleosol dependant on cultural feature (e.g., mounds, borrow areas, house depressions). These cores were located such that this information addressed variable depth to paleosol relative to cultural feature and offer insight into degree of earth-moving activity by the Mandan inhabitants. Based on information obtained from cores the previous field season, supplemental data was sought from locations in house depressions, near mounds, and across Ditch 3, a surface-invisible ditch. Locations were selected after consultation with the archaeology team to provide detail on patterns of earth moving relative to time and location. Transect investigation conducted by the archaeology team was limited to Oakfield probes; coring to depths of more than 1 m with a hydraulic probe in this study enhanced their understanding of soil/cultural feature relationships.

Soil cores were obtained using a Giddings® hydraulic probe, fitted with a 7 cm diameter probe; in the event of auger refusal, the probe was first rotated to the right, then to the left; if necessary, probe diameter was reduced to 5 cm. Causes of refusal included cementation due to carbonates and soil moisture, or presence of artifacts. Sampling depth was designed to encompass all or part of the paleosol to provide characterization data, so it was necessary to include the paleo-A and B horizons, and if possible, the C horizon. Cores were transferred to PVC half-shells for transport to the lab, wrapped in plastic wrap and taped, and labeled. In order to maintain the integrity of the Double Ditch State Historic Site, "dummy" cores obtained in similar soil outside the site environs were placed in core holes. Distance between core locations was measured; after sampling, the exact location to 0.001 m was obtained in reference to local grid coordinates. Surface elevation was measured with a transit; elevation of the paleo-A horizon was computed from measurements by subtracting measured depth to paleo-A from surface elevation.

Cores were evaluated in the field for total thickness, presence of artifacts, and conditions governing "refusal" and change of push tube diameter. Depth to and thickness of paleo-A horizon were measured in push tube and then again after transfer to PVC to provide data for depth corrections (discussed below). Field notes also included a brief description of carbonate features (depth, thickness and orientation), master horizon designations, and thickness and depth of master horizons. Location relative to surface cultural features and pre-existing survey grid was noted.

Soil Description and Laboratory Methods

Soil cores were described in detail according to standard NRCS procedure (Soil Survey Division Staff 1993). Depth, horizon designation, matrix and mottle color (dry and moist), texture, structure, consistence, roots, pores, effervescence (1 N HCl), horizon boundary, carbonate features, coarse fragments and cultural artifacts were described, as well as any other feature unique to the horizon. Soil horizons greater than 10 cm thick were divided into increments not to exceed 10 cm, and all samples were placed in plastic tubs and labeled with: Archaeology site number (32BL8), date, transect number, pedon number, horizon designation, depth increment, and number of sample if there was more than one per horizon. Selected samples were reserved whole to preserve such features as carbonate morphology, structure, or evidence of faunal turbation, among others; remaining samples were air-dried, ground by hand with mortar and pestle, and passed through a 2 mm sieve for physical and chemical analyses. Any artifacts encountered during this procedure were removed and bagged; bags were labeled with horizon designation, depth of horizon or depth at which the artifact was found, and type of artifact. Earthy material such as ash or backfill was treated as a soil horizon and described in as much detail as possible.

If a soil core was disrupted either by transfer from the push tube to PVC, or by transport between the field site and laboratory, it was necessary to make corrections to measured depths. Field measurements of total length of soil per push tube as well as undisturbed depths to major horizons were utilized to make these corrections during soil descriptions. Based on these measurements, “loss of volume” was determined and a more accurate thickness of a section of core could be obtained. For example, a horizon at a depth of 100 to 150 cm might have a 50% loss of volume from 120 to 140 cm depth (as measured in the PVC tube). The loss of volume is calculated as 20 cm × 0.50 to give an actual thickness of 10 cm; this 10 cm added to 20 cm (100 cm to 120 cm surface depth) plus 10 cm (140 cm to 150 cm surface depth) yields an actual thickness for the horizon of 30 cm, or 100 to 130 cm surface depth.

Three cores from Transect 1 (T1-1, T1-6 and T1-12) were sent to the Missouri Soil Characterization Laboratory (Columbia, Missouri) for particle size analysis by pipette method according to procedures detailed in the National Soil Survey Laboratory Methods Manual (Burt 2004). These pedons then served as the reference for other texture determinations ("by feel"). Standard pre-treatments to remove organic matter and carbonates were utilized; the soil was dispersed with sodium hexametaphosphate (Method 3A1a1a, Burt 2004). Particle size classes determined included clay, fine silt, coarse silt, very fine sand, fine sand, medium sand, coarse sand and very coarse sand. Clay was not useful in horizon boundary determinations during soil description because of low percentages; therefore estimates of percent very fine sand were given in pedon descriptions where possible.

Soil reaction was measured in 1:1 soil-to-water ratio and 1:2 soil-to-0.01 M $CaCl_2$ salt solutions (Methods 8C1a and 8C1e respectively, Burt 2004). Total organic carbon (TOC) was determined by dry combustion method 324H2a modified to 927 °C using a Leco C-144 carbon analyzer (Soil Characterization Laboratory). Carbonates were determined for some profiles by burning the organic carbon sample for 5 minutes total (Russ Dresbach, Lab Supervisor, Soil Characterization Laboratory, pers. comm.).

Generation of Pre-occupation Surface Topographic Model to Assess Relative Degree of Borrow and Fill

Germane to this study is the relationship among present-day surface elevation, paleo-surface elevation, and cultural feature. The Mandans relocated a staggering volume of soil contained in the visible mounds alone (Ahler 2003 estimated 6400 m^3). By using pedogenic soil features as stratigraphic references it should be possible to estimate the volume of surface soil borrowed and relocated. Pedogenic features include the paleosol A horizon, and the pre-occupation A horizon which is found preserved under mound fill in some locations.

The underlying premise is that by estimating the pre-occupation surface using key stratigraphic soil features as controls, it should be possible to determine relative volumes of earth borrowed and earth used as fill. Starting with an "undisturbed" pre-occupation surface, deviations in elevation from this surface will indicate borrow or fill (Figure 3.2).

Pre-occupation surface elevation was chosen as the baseline or primary value; present-day surface elevation was subtracted from pre-occupation surface elevation to mimic the

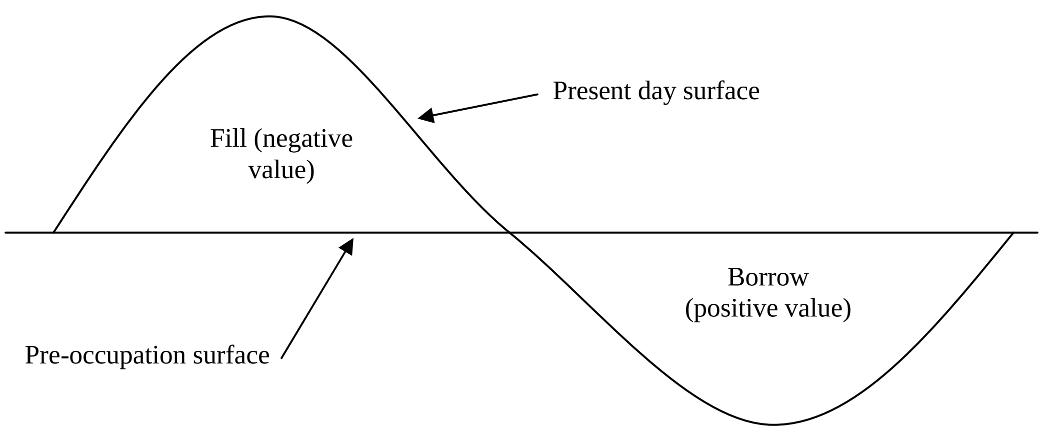


Figure 3.2 The relationship among pre-occupation surface, present-day surface and possible cultural features. If the cultural feature is a fill feature (e.g. a mound), the pre-occupation elevation is less than the present-day elevation, yielding a negative value for volume of earth used as fill. Borrow features result in positive values for pre-occupation elevation minus present-day elevation.

anthropogenic processes of borrow and fill. Because of this method, volume of fill is generated as a negative number and volume of borrow has a positive value. All values in tables are presented as an absolute value to avoid possible confusion.

Detailed Digital Elevation Model (DEM) data (Markussen et al. 2004; courtesy Ken Kvamme and associates at the Archeo-Imaging Laboratory, University of Arkansas-Fayetteville) formed the basis for the post-occupation present-day surface of the village (Figure 3.3). This model provides elevations for the present-day surface on a 0.5 m grid for the entire State Historic Site.

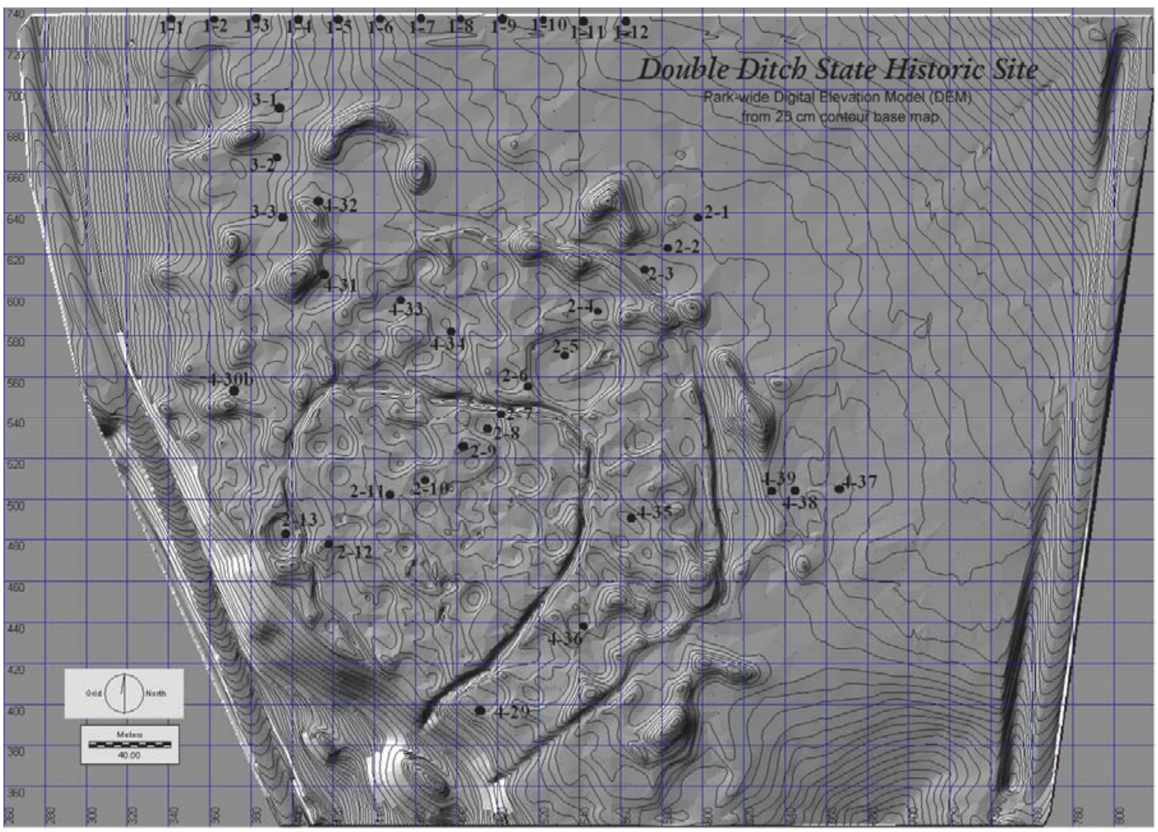


Figure 3.3 A Digital Elevation Model with a post-occupation topographic overlay (courtesy K. Kvamme and the Archeo-Imaging Laboratory, University of Arkansas) and transect and pedon locations. The grid system is that utilized by the archaeological investigation conducted by Fern Swenson of the State Historical Society of North Dakota and the PaleoCultural Research Group, led by Stanley Ahler.

Pre-occupation surface elevations were obtained utilizing geomorphic and pedogenic features, primarily the paleo-A horizon and the pre-occupation A horizon. The pre-occupation A horizon was observed to be preserved under mounds during the course of archaeological investigations, and was noted in detailed profile descriptions of some pedons in this study. However it is not certain that this pre-occupation A horizon was never eroded, and elevations may be compromised. It seems less likely that those A horizons found beneath mounds associated with Ditches 3 and 4 would be significantly eroded as construction of those features occurred early in the timeline of occupation.

Detailed profile descriptions also describe the paleo-A horizon and record the depth. By subtracting depth to surface of paleo-A horizon from the present-day surface elevation (obtained for each pedon using a total station), an elevation for the paleosol surface was obtained. Thickness of overlying loess could then be estimated by comparison with a pedon in the relatively undisturbed transect that is a similar distance from the source, and the elevation of the pre-occupation surface could be estimated. Depth to the surface of the paleo-A was chosen, rather than depth to the base of the paleo-A owing to the upper boundary being clearer and easier to determine. This requires the assumption that the surface of the paleosol was not eroded, or at least was eroded uniformly across the site, and that A horizon thickness is relatively uniform. In the future it may be beneficial to create a model based on the boundary between the paleo-A and paleo-B horizons and compare data with that generated by the model predicated on the surface of the paleo-A horizon.

For the construction of a model of the pre-occupation surface utilizing GIS, specific assumptions were made (Table 3.1). First, portions of the State Historic Site were assumed to be relatively undisturbed and to reflect natural, pre-occupation topography; specifically, these areas are the northeastern portion of the site, the southeastern portion of the site, and the northern perimeter, all of which appear surficially unaffected by borrowing activity (planar or otherwise). Second, the great majority of anthropogenic activity (borrow and fill) occurred within the area roughly defined by the surface-invisible, outermost fourth ditch. Third, knowledge of geomorphic processes and landscape formation (with special regard to eolian parent materials) could be used to guide placement of pre-occupation surface topographic lines.

Table 3.1 Summary of paleotopography models with associated assumptions and causes for revision.

Model	Key Assumptions	Causes for Revision
Initial	Lines of equal elevation could be connected from the southeast and south portions of the site to lines on the northern perimeter Portions of the site are relatively undisturbed.	Paleotopography did not reflect pedological data obtained from profile descriptions. Volume of fill >17,000 m^3 over entire site
Second	Improved elevation control through use of pedological features such as paleo-A horizon and pre-occupation A horizon	Basin 4 in the southwest corner yields zero value for volume of earth borrowed. Volume of fill >11,000 m^3 over entire site
Third	Landform associated with Basin 4 was inaccurate. Topographic lines needed to increase in elevation to provide depth for Basin 4	Tighter control of paleotopography within the zones of occupation interior to Ditch 4
Final	Strict application of elevations gained through pedological features plotted with reference to the survey grid on site.	

The northeast corner is a linear back slope with the present-day topography. Elevation lines were hand digitized and drawn across the village by connecting lines of equal elevation along the northern perimeter with those on east and south margins of the study area. As this process evolved, the pre-occupation land surface appeared to take the form of a broad nearly-level alluvial fan that sloped gently toward the edge of the terrace

(Figure 3.4). Serving as an initial model, this early attempt at generating the pre-occupation topography was integrated with the DEM to calculate volume differences. The area of interest was confined to the zones of most probable borrowing activity (based on modern-day surface appearance), that of the village within the perimeter of Ditch 4.

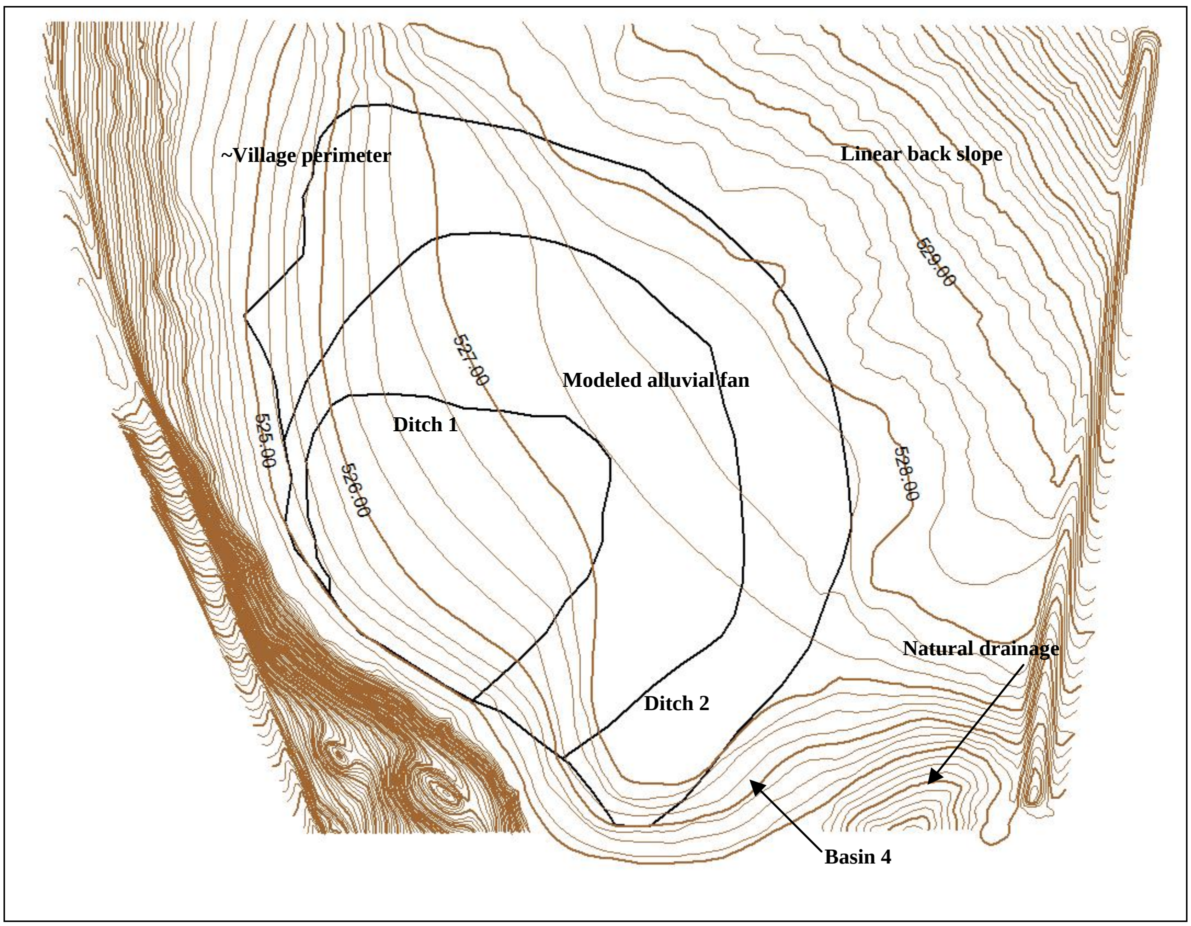


Figure 3.4 Initial attempt of pre-occupation surface topography at Double Ditch Village with 25 cm contour interval. The two inner black lines represent Ditches 1 and 2. The outer line demarks the area utilized in volume calculations for the initial models and is approximately the location of Ditch 4. The approximate location of Basin 4 is shown with an arrow.

The iterative process of pre-occupation surface reconstruction underwent revision as data on volumes of borrow and fill were generated from each version (Table 3.1). The first two versions generated large volumes of fill, on the order of 11,000 m^3 to greater than 17,000 m^3. These values are greatly in excess of the estimated 6400 m^3 of fill in the mounds (Ahler 2003) which was assumed to be an accurate approximation of volume of fill. There were also particular issues concerning Basin 4, a sizeable borrow area in the southwest corner of the site. These initial efforts revealed no earth removed from the basin, an obvious error. It seemed unlikely that a clearly surface-visible depression had been created by mounding earth around the area, and magnetic gradiometry and infra-red investigations (Kvamme et al. 2004) gave no indication of this type of fill activity. The initial contour lines in the vicinity of Basin 4 (Figure 3.4) were redrawn by extending the nose of the slope in the southwest direction, wrapping around Basin 4.

By following contour lines from the draw in the southeastern corner of the site (a possible natural drainage) around Basin 4 and connecting those contour lines to those of the river terrace on the western edge of the site, a model was created that provided a realistic scenario for volume of earth removed from the basin. This new model of paleo-topography followed and enhanced surface features present in the present-day landscape.

Effort was finally focused on revising that portion of the site within the approximate perimeter of Ditch 4. Elevation control data from archaeological reports (Ahler 2004, 2005) and detailed profile descriptions (Table 3.2) were plotted on the DEM, and topographic lines were redrawn.

Once a reasonable facsimile of the pre-occupation topography was generated, a method for estimating volumes of earth either borrowed or used as fill needed to be developed. A revised Area of Interest was defined which focuses on the areas of more intensive anthropogenic activity (illustrated in Figure 3.5). A portion of this area is outside the perimeter of the surface-invisible Ditch 4, and Ahler (2005, p. 308) notes

Table 3.2 Elevation control data used to generated pre-occupation surface elevations in the topographic model. Elevations were plotted by grid coordinates (location) to guide hand-digitized topographic contours.

Feature	Location	Elevation m	Source
Mound C2	515 NE 602-603	526.80	Ahler 2005, p. 66
	507 NE 623-624	526.80	
	507 NE 634-639	527.40	
	557 NE 640	526.35	Ahler 2004, p. 92
Mound V	557 NE 640	527.60	Ahler 2005, p. 141
	559 NE 640	527.60	
Mound D1	595 NE 595	527.60	Ahler 2004, p. 45
	585 NE 582	528.00	Ahler 2004, p. 46
	588-589 NE 581-583	527.50	Ahler 2004, p. 48
Mound E	638-639 NE 560-561	527.90	Ahler 2004, p. 52
Mound F	663-664 NE 458-459	526.25	Ahler 2004, p. 55
	663 NE 459-460	526.10	Ahler 2004, p. 56
Mound G	682 NE 421-423	526.35	Ahler 2004, p. 63
Mound H	678 NE 380	525.25	Ahler 2004, p. 67
Mound I1	643 NE 407	526.25	Ahler 2004, p. 71
Mound I2	607-608 NE 399	526.35	Ahler 2004, p. 77
Mound Y	627 NE 369	525.45	Ahler 2004, p. 95
T 2-6	555 NE 515	525.84	Profile description
T 2-9	524 NE 484	526.23	Profile description
T 2-11	501 NE 450	525.80	Profile description
T 2-12	570 NE 418	524.54	Profile description
T 2-13	484 NE 395	523.83	Profile description
4-37	506 NE 663	527.20	Profile description
4-38	506 NE 645	527.07	Profile description
4-39	506 NE 635	527.02	Profile description

that it may not be possible to distinguish between the effects of planar borrowing and historic cultivation. However, any possible cultivation is thought to be of limited extent, and confined to an area east of the village.

The topographic map generated with the DEM was used in concert with a rectified plan map showing mounds and borrow basins of Double Ditch Village (similar to Figure

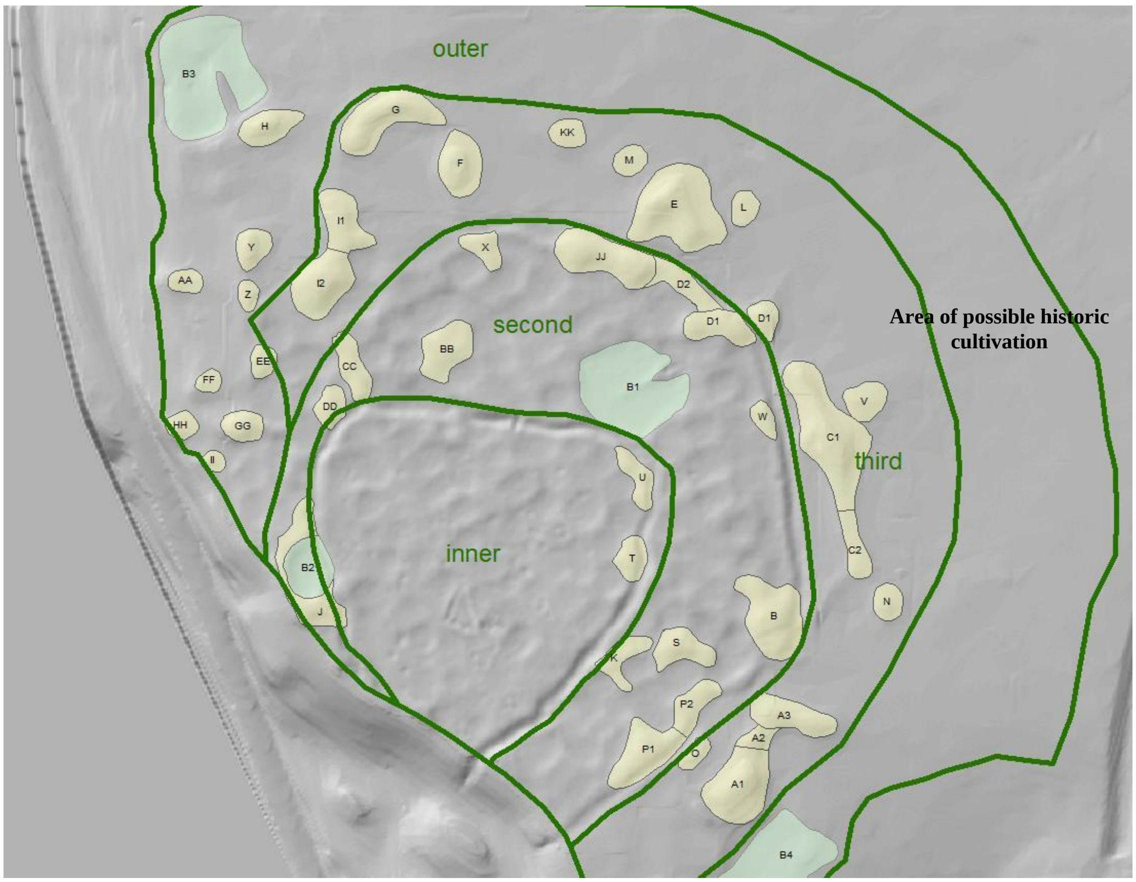


Figure 3.5 Area of Interest for determination of volume of borrow and fill. The Inner, Second, Third and Outer areas comprise the Area of Interest. Subdivisions are based on cultural features of the site such as mounds and surface-visible and surface-invisible ditches. Boundaries for Inner and Second areas follow Ditches 1 and 2, and are located to the exterior side of those features with the assumption that earth "borrowed" from Ditches 1 and 2 would approximately equal the backfill to the interior side of the ditch. Mounds (yellow) and borrow basins (green) are labeled. Some features visible on the gray hillshade underlay are features from the first archaeological investigation at Double Ditch Village by two Harvard undergraduate students, Will and Spinden (1906) (note the triangle below the label for the Inner area).

1.5, page 37 of this document). Lines were drawn by hand with ArcGIS software to delineate the perimeter of major borrow basins and the base of all recognized mounds. Area in m^2 could be derived for these features. Volume of soil for basins and mounds was calculated using software designed by Bryan Mayhan of CARES (Center for Agricultural, Resource and Environmental Systems, University of Missouri, Columbia), then applied to the model consisting of the detailed DEM and pre-occupation surface elevations created for this study. This software calculates pre-occupation surface elevation minus present-day surface elevation to provide values for depth of soil removed in cm. Data points in the DEM occur every 50 cm, providing a 2500 cm^2 area (pixel). Depth of borrow or height of fill was measured from that elevation at which grade equals zero, with grade defined as the pre-occupation surface elevation minus the present-day surface elevation. The area in cm^2 multiplied by depth (or height) in cm yields a value in cm^3 which was then converted to m^3.

The method used by Ahler (2003) to estimate volume of fill in the mounds[1] was to employ a formula combining elements of the volume of sphere and the volume of a cone. According to Ahler, this formula "approximates the median between the formulas for the volume of a segment of a sphere" and the volume of a cone (Ahler 2003, p. 13) and is:

$$\text{Volume} = (0.4165)\ (\text{area of the base})\ (\text{height})$$

This would appear to simplify the shape of a mound and may not account for any deviations from an idealized shape, especially regarding surface topography, which can be quite irregular. Basal area was determined by Ahler "based entirely on details visible in the 25 cm interval contour map" (Ahler 2003, p. 12), similar to the method employed

[1] It has not been determined if Ahler employed a similar method to estimate the volume of earth removed from the four borrow basins. Data on individual basins is scant, and this author could not discover if any tabulation exists.

in this study. The greatest difference in methodologies is the use of a median formula by Ahler and the use of detailed topography in GIS for this study.

Determinations of the amount of earth removed from the four discrete borrow basins involved measurements of diameter of a basin and depth measurements within the basin. Utilizing multiple data points from the DEM (a 50 cm grid) representing present-day elevations and pre-occupation surface elevations generated for this study, volume removed was calculated. In addition to the volume of soil removed from borrow basins, a previously undetermined amount of borrowing had occurred throughout the village in areas outside the four basins. Because of the shallow nature of this type of borrow and the fact that discrete areas cannot be determined, it has been difficult to quantify a volume. If certain quantities are known, however, it should be possible. By calculating the total volume of earth removed (all positive values generated when subtracting present-day surface elevation from pre-occupation elevation), and then subtracting the volume of earth removed from the four basins, the remainder should be the result of planar borrowing.

Determination of the volume of fill in the mounds follows a similar method as that for borrow basins. Lines were drawn around the base of mounds, utilizing the DEM topographic map with a rectified plan map showing cultural features and utilizing ArcGIS software. This provided a basal area for each mound, converted to m^2. By factoring in the values for height (the difference between pre-occupation elevation and present-day occupation, with a value for every 50 cm^2) for each mound, it was possible to determine the volume of fill (area multiplied by height).

In summary, volume results generated by early models of pre-occupation topography were utilized to assess the feasibility of the model. As mentioned above, Basin 4 provided some concerns early in the process. As the topographic model evolved, emphasis was placed on available control data. Descriptions and depth of pre-occupation A horizon as noted in archaeological excavations (as preserved beneath mound features), as well as pre-occupation A horizon and paleo-A horizon depths noted in detailed profile descriptions were plotted on the 25 cm contour interval topographic map as an overlay on the hillshade map and containing the grid system employed by State Historical Society of North Dakota and the archaeological investigation.

CHAPTER 4

Results and Discussion

The study area is on a loess terrace about 20 m above the Missouri River floodplain. Because of widespread and intensive anthropogenic activity while the village was occupied, the modern-day surface has very uneven topography, with local relief ranging from a few centimeters to a few meters. The surface soil is underlain by the Leonard Paleosol, a contiguous paleosol dating to approximately 8,000 to 10,000 ybp (Artz 1995) which serves as the stratigraphic reference.

Observations and Profile Descriptions of Transect 1

A baseline transect (Transect 1) was located in relatively undisturbed soil on the northern perimeter of the Double Ditch State Historic Site, roughly perpendicular to the Missouri River (refer to Figure 3.1, Chapter 3). Loess deposition overlying the paleosol thins with distance from the source (Figure 4.1, Table 4.1, Figure 4.2), although Transect 1 extends less than 400 m from the Missouri River. To determine if the loess thins with distance, this transect should be extended further east away from the river. Average thickness of loess overlying the paleosol in this transect is 2.21 m. It should be noted that the first two profiles (T 1-1 and T 1-2, closest to the Missouri River) show evidence of erosion of the modern surface probably owing to proximity to the edge of the terrace; this same portion of the paleo-surface is slightly upsloping and forms a bench as noted from elevations in this transect. Furthermore, it is possible that planar borrowing activity by

Table 4.1 Thickness of loess overlying the Leonard paleosol in the relatively undisturbed Transect 1, with elevation of modern-day surface and paleosol surface

Pedon	Distance (m) from Missouri River	Elevation (m) of the Surface Soil	Elevation (m) of Paleosol Surface	Depth (m) to the Paleosol Surface	Elevation (m) of the base of the paleo-A	Depth (m) to base of paleo-A
T 1-1	150.50	523.91	522.44	1.44	522.29	1.62
T 1-2	170.46	524.01	521.79	2.22	521.71	2.30
T 1-3	190.50	524.54	521.79	2.75	521.71	2.83
T 1-4	210.40	525.43	523.43	2.05	523.28	2.15
T 1-5	230.43	526.16	523.93	2.23	523.84	2.32
T 1-6	250.46	527.21	524.69	2.52	524.55	2.66
T 1-7	270.48	527.86	525.52	2.34	525.40	2.46
T 1-8	290.44	527.95	525.36	2.59	525.20	2.75
T 1-9	310.57	528.08	525.88	2.20	525.73	2.35
T 1-10	330.58	528.20	526.10	2.10	525.99	2.21
T 1-11	350.52	528.44	526.52	1.92	526.39	2.05
T 1-12	370.47	528.88	526.71	2.17	526.56	2.32

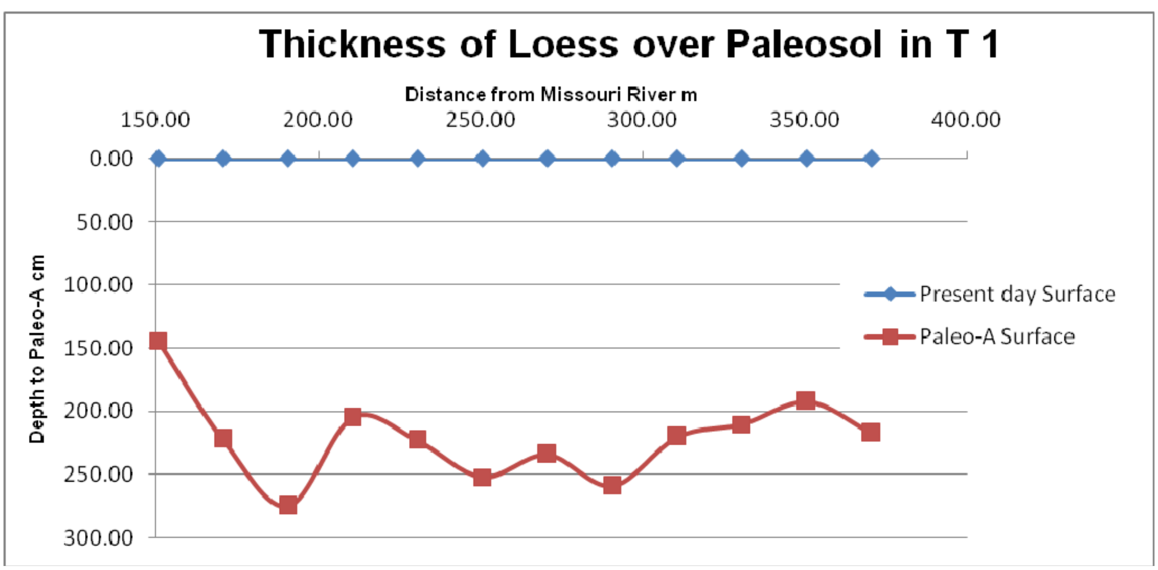


Figure 4.1 Thickness of loess overlying the paleosol surface in the relatively undisturbed transect. The present-day surface is assigned a value of zero to provide actual thickness of loess.

village inhabitants occurred in the vicinity of pedons 4 and 5 of Transect 1, affecting depth to paleosol (for a discussion of this see Ahler 2004, page 101). Topography of the paleosol surface is slightly more steep and irregular than that of the present surface; as expected with a loess mantle draping the older surface, the present-day surface is smoother; elevations of the paleosol in this transect are similar to the range across the entire site; the lowest elevation is approximately 522 m (in the southeast portion of the site), but some pedons in the northeast portion of the site (T 2-1, 2-2, 2-3, 2-4, 4-37, 4-38 and 4-39) give elevations up to 527.5 m for the paleo-surface; these profiles, with the exception of T 2-4, are all further east than T 1-12 and further from the source.

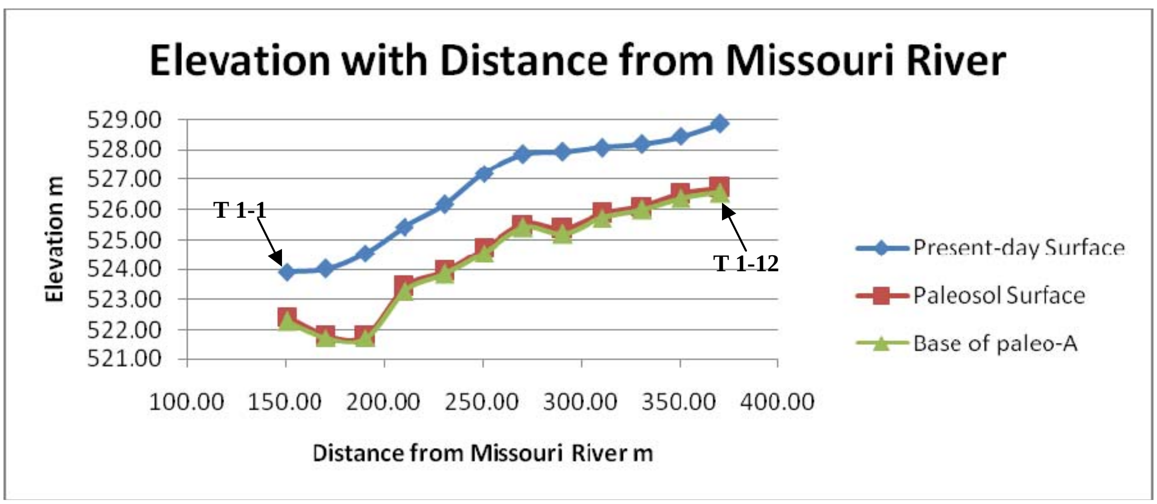


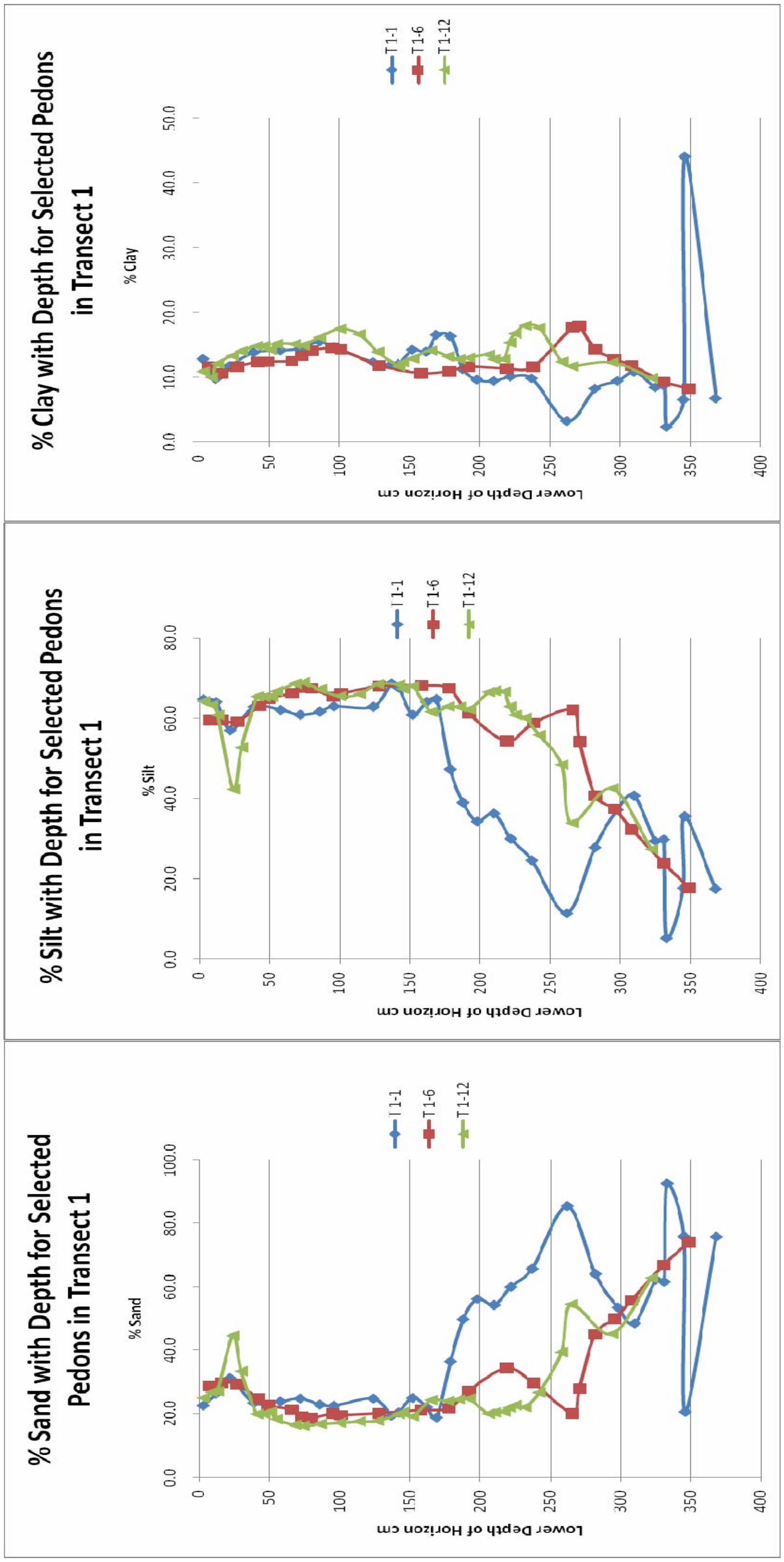
Figure 4.2 Elevation of present-day surface, paleosol surface and base of the paleo-A horizon with distance from the source of the loess. Thickness of loess over the paleosol is the difference between present-day surface and paleo-surface elevation. Pedon 1 in this transect is to the left (nearest the river) and pedon 12 is furthest from the source.

Detailed description of soil cores indicate parent material to be loess comprised of very fine sand and silt; textural fining with distance from the source was not observed, although distance from source is short at less than 400 m (Table 4.2 summarizes these data). Underlying the paleosol in many pedons at depths greater than 3.5 m was a parent material comprised of clean sands that exhibit stratification, subrounded morphology, and other characteristics of water-worked material (Figure 4.3). These cores contained strata

Table 4.2 Textural class of soil above the paleosol, the paleo-A horizon, the paleo-B horizon, and soil below the paleosol, with depth to paleosol and distance from the source, as described in Transect 1. Percentages refer to percent very fine sand[1]. Textural class abbreviations are standard (Soil Survey Manual, Soil Survey Division Staff 1993)

		Depth to	Textural Class			
Pedon	Distance (m)	Paleo-A (cm)	Above	Paleo-A	Paleo-B	Below
T 1-1	150.5	147	sil 18-25%	sil 20%	l 32-38%	vfsl, fsl, s, l, c
T 1-2	170.5	222	sil 18-25%	sil 22%	l 33-35%	vfsl, lvfs, sicl
T 1-3	190.5	275	sil 15-28%	sil 18%	l 38%	vfsl, fsl
T 1-4	210.4	205	sil 18-32%	sil 18%	l 32%	vfsl
T 1-5	230.4	223	sil 15-28%	sil 20-24%	l 22-35%	vfsl, fsl
T 1-6	250.5	252	sil 18-28%	sil 15-16%	l 21-33%	vfsl, fsl
T 1-7	270.5	234	sil 18-30%	sil 22%	l 32%	vfsl
T 1-8	290.4	259	sil 20-35%	sil 15-18%	l 30%	vfsl
T 1-9	310.6	220	sil 20-35%	sil 20-24%	l 36%	vfsl, lvfs
T 1-10	330.6	210	sil 18-32%	sil 33%	l 33%	fsl
T 1-11	350.5	192	sil 16-34%	sil 18%	l 25%	vfsl, lvfs
T 1-12	370.5	217	sil, l 15-40%	sil 19-20%	sil,l 25-37%	vfsl, l

[1] Clay percentages were so low as to be not useful in determining horizon boundaries. But as noted in Daniels and Hammer (1992) very fine sands may be transported by wind up to 450 m.



(c)

(b)

(a)

Figure 4.3 Depth distributions of sand (a), silt (b) and clay (c) for pedons 1, 6 and 12 of Transect 1 of water-worked fine to coarse sand, with or without gravel, which were present below the Leonard Paleosol. Textural change in the sand fraction was often abrupt and could include thin lenses or horizons of finer textured material. Two possible scenarios are that the paleo-landscape was networked with small water courses draining toward the Missouri River, or that the materials are glacial outwash; the presence of clay may be the result of slack water ponding (pedon T 1-1, although pedogenic clay films were present in pedon T 1-2). Data from the type location (the Riverdale Section) seem to indicate a clay bulge at the base of the Pick City Member, immediately above the A horizon of the Leonard Paleosol of the Aggie Brown Member (Figure 1.3, Chapter 1). In soil cores obtained throughout the study area, the paleo-A horizon was slightly cemented; if this were the case at the type location, water movement downward may have been impeded allowing clays to accumulate, but particle size distribution at the study site shows no significant increase in percent clay (Appendix C, Tables C.1, C.2 and C.3).

Because the climate of North Dakota is cool and dry, horizon differentiation in the surficial parent material is based primarily on calcium carbonate presence and morphology rather than any marked differences in color or texture. While carbonates have probably been introduced in eolian deposits, the carbonates do exhibit pedogenic characteristics, such as accumulations around pores, on ped faces, and surrounding pebbles. A mollic epipedon is present in some of the cores; however, the extensive anthropogenic activity on the site has altered this pedogenic aspect through soil relocation and increased rates of erosion.

Observations and Profile Descriptions of Other Transects and Satellite Pedons

Transect 1 serves as a baseline transect located in relatively undisturbed soil outside the village occupation zones. Transects 2 and 3 and satellite pedons (designated T 4) are located through the area of significant anthropogenic activity and are set in a variety of cultural features. Description of all cores at the study area indicates that color in the upper part of the soil is not greatly different until the upper submember of the Aggie Brown Member (the Leonard paleosol) is encountered. The A horizon of the Leonard paleosol is darker than any other portion of the Oahe Formation, commonly having a moist color of 10YR 2/1 or 2/2 (Table 4.3). This dark color and an increase in organic

Table 4.3 Percentage frequencies of Munsell color (moist) for B and C horizons above the Leonard paleosol, the paleo-A horizon, and the paleo-B horizon for all pedons. If multiple horizons within a master horizon have different colors, all colors were considered in the tabulation. Colors that occur with small frequency are omitted.

Horizon	Moist Color	Frequency (%)	Predominant		
			Hue	Value	Chroma
Upper B	2.5Y 3/2, 3/3	48.0	2.5Y	3, 4	2, 3
	2.5Y 4/2, 4/3	48.0			
Upper C	2.5Y 4/2, 4/3, 4/4	76.5	2.5Y	3, 4, 5	2, 3, 4
	2.5Y 3/2, 3/3	12.5			
	2.5Y 5/3, 5/4, 10YR 3/4	10.0			
Paleo-A	10YR 2/1, 2/2, 3/1, 3/2	64.2	10YR	2, 3	1, 2
	2.5Y 2.5/1, 3/1, 3/2, 3/3	19.3			
	7.5YR 2.5/1, 3/1	10.0			
	10YR 3/3, 3/4	6.4			
Paleo-B	2.5Y 4/4	62.5	2.5Y	3, 4	2, 3, 4
	2.5Y 3/3, 4/2, 4/3	17.5			
	2.5Y 4/6, 5/6	10.0			
	10YR 3/4, 4/3, 4/4, 4/6				

carbon support the theory that this is an A horizon formed in a cooler and moister environment than that of the present. The paleo-A is characterized by numerous insect or worm burrows which contribute to a substantial degree of soil mixing with horizons both above and below the A horizon.

Presence and type of artifact was an important part of soil profile description, and can provide clues concerning patterns of anthropogenic activity (Tables 4.4 and 4.5). For the purposes of this study, the term "artifact" is applied to objects introduced by human activity, including: charcoal, potsherds, fire-cracked rock (FCR), flint for tools (notably Knife River Flint and Tongue River Silicified Sediment, KRF and TRSS), lumps of ochre and clay, granite used for temper of pottery, and bone fragments of any size. Artifacts were often <5 mm in size. Areas that had experienced borrow activity, whether planar borrowing or concentrated borrowing, have only isolated artifacts or none at all[2]. A possible explanation for borrows that contain surficial artifacts may be age of the feature; if the borrow area had not been active it might have rapidly accumulated trash. Areas that experienced redeposition of earthy materials or trashy fill have a greater density of artifact content. Similarly, cores obtained in the near vicinity of mounds indicate the soil may have accumulated artifacts from slope wash off the mounds.

One curious anomaly is pedon T 2-6, located on the southwest rim of the largest concentrated borrow feature, Basin 1. It was anticipated that this profile would display characteristics of the surface soil at the time of occupation, in other words, the soil as it would have been prior to excavation of Basin 1 (T 2-5). But the pedon description shows

[2] One exception to this observation is Transect 2, pedon 8 which has common artifacts in the upper 60 cm. Originally thought to be an earthlodge depression, no hearth features were found in geophysical investigations. This led to the conclusion that this feature is a small borrow area (Ahler 2004).

Table 4.4 Type and density of artifact by cultural feature and depth in the Outer Residential Area[3]. Refer to detailed profiles descriptions for artifact type by pedon and horizon (Appendix A). Abbreviations: FCR (fire-cracked rock); KRF (Knife River Flint); TRSS (Tongue River Silicified Sediment); frags (fragments).

Cultural Feature	Pedon	Type of Artifact	Frequency[4]	Depth cm
Ditches				
Ditch 4 (fill)	T 3-1	bone frags	isolated	5-10
		bone, charcoal, rock, potsherd	few-common	17-120
Ditches 3 & 4	T 2-2	lithic spall, rim sherd, bone, burned bone	few	0-20
		rock frags, bone	few	225-230†
Ditch 3	T 2-3	bone frags, potsherd, charcoal	few	10-36
		bone frags	isolated	106-136†
Ditch 2 (inner rim)	T 2-7	FCR, bone, wood splinters, ash, pottery, lithics	common	0-170
Ditch 1 (outer south side)	T 4-29	FCR, KRF, bone, charcoal, potsherd, red ochre	common	0-190
Mounds				
Near Mound H	T 3-1, 2	bone frags, potsherd, granite, charcoal	isolated	5-170
Near Mound I1 (Pit Zone)	T 4-31	bone, granite, charcoal	common	0-150
(cache pit†)	T 4-32	potsherd, FCR, flint	common	200-280†
Near Mound I2	T 3-3	bone, frags, charcoal, flint, granite	few	10-40
		clay deposit, large stone (tool?), burned pottery, KRF, charcoal, bone frags	common	40-70
	T 4-31	bone frags, partial bone bead, lithics, possible trade artifact, potsherds	isolated	0-50
Near Mound GG	T 4-30b	bone frags, charcoal, granite, TRSS spall	few	20-50
Mounds K & S	T 4-36	bone frags, pebble		0-10
(vicinity)		bone frags, charcoal, granite frag		30-40
		charcoal	isolated	170-240†
Near Mound C2	T 4-39	charcoal, bone frags, wood frag, KRF,	few	5-52‡
(trench)	T 4-38	bone frags, small rodent tooth	few	5-75
		granite pebbles, yellow ochre	isolated	205†
	T 4-37	bone frags	isolated	210-230
Houses (House 21)	T 4-33	bone frags, charcoal, angular feldspar	isolated	0-50
Borrow Areas				
Inside Ditch 2	T 2-4	burned pottery, charcoal, wood frags	isolated	0-33
Basin 1	T 2-5	none		
Basin 1 (rim)	T 2-6	bone, bison bone, potsherds, lithics, charcoal, small mammal bone	common	0-50
		bone frags, seed	isolated	115-120‡
Borrow east of Mound T	T 4-35	bone, charcoal, KRF, subrounded granite	isolated	10-70

[3] For location of Outer and Inner (Core) Residential Areas, refer to Figure 1.2, page 3 of this volume.
[4] Frequency follows standard usage for mottles: few (< 2%), common (2 to < 20%); isolated (< 1%)
† Approximate surface of the Leonard paleosol. The cache pit in T 4-32 extends into the paleo-A.
‡ Directly above the pre-occupation surface soil.

Table 4.5 Type and density of artifact by cultural feature and depth in the Inner (Core) Residential Area. Refer to detailed profiles descriptions for artifact type by pedon and horizon (Appendix A). Abbreviations: FCR (fire-cracked rock); KRF (Knife River Flint); TRSS (Tongue River Silicified Sediment); frags (fragments).

Cultural Feature	Pedon	Type of Artifact	Frequency[5]	Depth cm
Houses				
Rim (house wall)	T 2-9	potsherd, bone frags, lithics, rock, FCR, charcoal, clay	common-many	0-75
Center	T 2-10	fine charcoal and bone frags,, bison bone, rodent bone, potsherds	common	5-50
(cache pit)		bone, ochre	isolated	120-203
High point between houses	T 2-11	bone frags, charcoal, rock, ash	many	0-60
		FCR, potsherd, shell frag, lithic spalls, rim sherd	many	85-150
Borrow Areas				
Center (small area)	T 2-8	bone frags, rocks frags, pottery	common	5-60
Basin 2	T 2-13	bone frags, charcoal, granite, KRF, potsherds	few	0-75
Local Elevation				
hump east of Basin 2	T 2-12	potsherd, TRSS spall, bone, rock, flint, clay, charcoal, arrow point	many	0-220

the profile to a depth of nearly 120 cm is comprised of several layers of fill containing a variety of artifacts. One additional factor affecting location and distribution of artifacts is faunal turbation; it was observed in some pedons that artifacts were associated with krotovinas and were probably relocated by the ubiquitous rodent activity (refer to Appendix A).

As part of the archaeological investigation, an east-west trench was dug from just under Mound C2 eastward about 50 m (Figure 1.7). The trench shows the A horizon of the original surface intact beneath the mound, which remains visible eastward for about 5 m, from 633E to about 638E. Sediment eroded from the eastern face of Mound C2 thins greatly with distance from the mound; light grayish brown lenses of silt have been are

[5] Frequency follows standard usage for mottles: few (< 2%), common (2 to < 20%); isolated (< 1%)

Table 4.6 Depth to paleosol relative to cultural feature for the relatively undisturbed transect (T 1) and transects and satellite pedons within the zones of occupation (T 2, T 3, and T 4).

Transect and Sample	Distance from Missouri River (m)	Surface Elevation (m)	Depth to Paleosol Surface (cm)	Site Feature
T1 – 1	150.499	523.905	144	North of Village near terrace edge, Block 364
T1 - 2	170.457	524.001	222	Block 365
T1 – 3	190.499	524.534	275	Block 318
T1 - 4	210.404	525.425	205	Possible large shallow borrow, Block 319
T1 - 5	230.429	526.159	223	Possible large shallow borrow, Block 320
T1 - 6	250.457	527.214	252	Block 314
T1 - 7	270.476	527.863	234	Block 315
T1 - 8	290.441	527.952	259	Block 316
T1 - 9	310.574	528.083	220	Block 317
T1 – 10	330.575	528.195	210	Block 317 (NW quadrant)
T1 - 11	350.515	528.435	192	NE of Block 321
T1 - 12	370.473	528.875	217	East end of undisturbed transect
T2 - 1	409.250	527.937	294	Outside Ditch 4, Block 215
T2 - 2	393.641	527.788	224	Between Ditches 3 & 4, Block 215
T2 - 3	383.545	527.598	151	Inside Ditch 3, Block 222
T2 - 4	360.371	527.313	112	Center of borrow area, Block 228
T2 - 5	342.332	526.285	56	Low area (center) of Basin 1
T2 - 6	325.162	527.002	196	Upper SW rim of Basin 1, Block 109
T2 - 7	311.548	526.564	176	Inside rim of Ditch 2, post and palisade, Block 109
T2 - 8	305.293	526.017	151	Center of borrow area, Block 110
T2 - 9	293.794	526.801	231	Wall of House 23 (possible), Block 110
T2 - 10	275.267	526.266	195	Center of House 24, Block 144
T2 - 11	259.810	526.672	232	High point between houses, north of Block 142
T2 - 12	228.429	525.812	235	Raised ridge inside (east of) Ditch 1, Block 140
T2 - 13	204.643	524.452	207	Center of Borrow Basin 2, Block 137
T3 - 1	202.810	525.322	330	East end of Trench F410 near Mound H, Block 301
T3 - 2	201.357	525.247	210	Low area between Ditches 3 & 4, Block 311
T3 - 3	202.365	525.471	185	Low area west of Mound I1
04-29	297.084	526.270	> 310	Near Mound P1
04-30b	182.650	524.629	185	North side of Mound GG
04-31	224.257	526.246	212	Near Mound I2
04-32	222.274	526.513	241	South of Block 122
04-33	264.614	525.641	213	House 21 south of Block 217
04-34	287.421	525.729	249	Borrow area Block 225
04-35	373.550	527.347	129	Borrow area between Ditch 1 & 2
04-36	350.643	526.993	131	Possible House 3
04-37	473.195	527.596	173	Near Mound C2 and Ditch 4 Block 355
04-38	455.138	527.598	244	East of Mound C2 Block 333
04-39	445.005	527.746	318	Edge of Mound C2 Block 332

present just beneath the surface; and the original A and B (and possibly C) horizons thoroughly mixed. The C horizon of the modern-day soil begins to appear about 10 m from the edge of the mound and has a very irregular boundary; this C horizon increases in elevation as it continues east, perhaps following the paleo-topography of the area. Through description and measurement of soil cores, it is possible to make a few general observations between cultural feature and depth to paleosol. By comparing thickness of loess overlying the paleosol in various cultural features with that in the undisturbed transect at similar distance from the source, patterns emerge (Table 4.6, previous page). Assuming an average depth to paleosol of 2.2 m (calculated from the relatively undisturbed Transect 1), it will be seen that in areas of concentrated borrow activity the paleo-surface is much closer to the present-day surface by 1 to 1.5 m meters (T 2-4, 2-5 and 4-35). Soil material overlying the paleosol in the largest borrow feature, Basin 1, is 56 cm. In Basin 2, there is 2 m of overlying material. Soil cores taken in house depressions indicate about 1.3 to 2 m of material above the paleosol. In the vicinity of mounds, depths to paleosol are usually 2 to 3 m. However, these are only general observations relative to cultural features, and do not take into account the topography of the paleo-surface.

Physical Properties of the Paleosol

The Leonard paleosol is a strikingly contrasting feature and is easily recognized by its concomitant physical properties. The paleo-A horizon is darker than that of the present-day surface, and is strongly contrasting in color from adjacent horizons above and below. An interesting feature is the numerous 4 mm diameter burrows, assumed to be made by earthworms, which redistribute and mix the soil among horizons. Soil core T 2-2 (Figure 4.4) illustrates the significant degree of mixing with adjacent horizons, which in some profiles accounted for up to 40% contrasting color. In Figure 4.4, the modern-day soil surface is to the right; the surface of the paleo-A horizon is at a depth of 224 cm. The C horizon immediately above the paleo-A is that of the modern-day soil (that of the time of

Figure 4.4 The Leonard paleosol illustrating faunal mixing of A-horizon material with the paleo-B horizon (left of photograph) and the C horizon of the modern-day soil (to the right). Soil core is from T 2-2 and shows approximately 180-260 cm sd; the paleo-A is at 224-242 cm. Knife for scale approximately 18 cm.

occupation of the village), referred to as the “sterile C horizon” in the archaeological reports for the project (Ahler 2003; Ahler 2004; Ahler 2005) because of the paucity of artifacts of any type in this horizon. Color of the C horizon is predominantly 2.5Y 4/3 or 4/4 or lighter when it is uncontaminated by faunal mixing (Table 4.3). The paleo-B horizon (to the left in Figure 4.4) usually has a color of 2.5Y 4/4 or lighter if it has not been affected by faunal activity. The profile description for this soil (T 2-2, Appendix A) indicates the paleo-A horizon has a Munsell color (moist) of 2.5Y 3/2 (2Ak1, 224-232 cm sd) or 2.5Y 2.5/1 (2Ak2, 232-242 cm sd). The C horizon adjacent to the paleo-A has a color of 2.5Y 3/2 at a depth of 178-224 cm and is as dark as the paleo-A; the paleo-B horizon is similarly affected with a color of 2.5Y 4/4.

Texture of the paleosol surface horizon is remarkably consistent as seen in the relatively undisturbed transect (Table 4.2). All profiles have a textural class of silt loam in the paleo-A horizon with the exception of T 4-38, which is a loam; percent very fine sand fraction for all pedons ranges from 10-33% with an average of 18.9%. However, the paleo-B horizon is somewhat more variable in both textural class (silt loam, loam or fine sandy loam) and in distribution of fine and very fine sand. Percent very fine sand has a wider range, from 10% up to 40%, and averages 29.2% very fine sand, about 10% more than the overlying paleo-A horizon. In addition to greater percent very fine sand, some profiles have 10-30% fine sand; others have 15-25% clay. Pedon T 4-30b possesses the coarsest texture in the paleosol, and may have been in a depositional portion of the paleo-landscape. It is near the edge of the terrace, and in other pedons in a similar location relative to the Missouri River (T 1-1, 1-2, 1-3 and T2-13) the paleo-surface is at a lower elevation than otherwise found on the site, ranging from 523.8 m to 524.5 m.

Calcium carbonates are present in all pedons. Carbonates may have been introduced into the parent material by aerial deposition, but they are a pedogenic feature of the soil. In soil profile descriptions, carbonate features were described as are mottles (Soil Survey Division Staff 1993) relative to size and abundance. Carbonates increase gradually with depth, ranging from less than two percent (few, by visual estimation) to perhaps as much as 20% or more (common to many). In finer-textured soil, thin coats may be present on horizontal and vertical ped faces; coats were variable in extent but generally did not exceed 10 mm in size. At some depth in nearly all pedons, carbonates formed "ring" shapes. This was most common in the paleosol and the C-horizon directly above the paleosol. Rings were very consistent in size (3 to 4 mm) and shape (circular) and seem to be a feature associated with earthworm burrows; in some horizons, carbonates are cemented around these burrows and formed a cast. Similarly, carbonates were found to line soil pores and abandoned root channels. Nodules are also a common presence in these soils, and were usually <2 mm in diameter. Carbonate threads (very fine or fine, with a dendritic branching habit) on ped faces are also a common manifestation in most horizons. As is characteristic for illuvial clay, carbonates were also observed bridging sand grains in coarser textures, especially in the paleo-C horizon and the water-worked parent material below the paleosol.

Chemical Analysis

Soil reaction in the relatively undisturbed transect follows a characteristic pattern for pH_w and pH_s with depth. The modern-day surface horizon has a range in pH_s of 6.5 to 7.2. The pH increases rapidly with depth (as carbonates increase and effervescence becomes stronger) until a maximum pH_s of 7.8 to 8.2 is obtained. This value is maintained until a contrasting parent material (present in some pedons) consisting of water-worked sands is encountered below the paleosol and pH decreases. In Figure 4.5 pH_s is slightly acidic (pH_s of 6.65) in the surface horizon but rapidly increases with depth to pH_s of 7.5 in the upper 30 cm of the profile. The pH_s remains less than 7.9 until the paleo-A horizon is encountered at about 150 cm, where it increases to 8.2. The pH_s

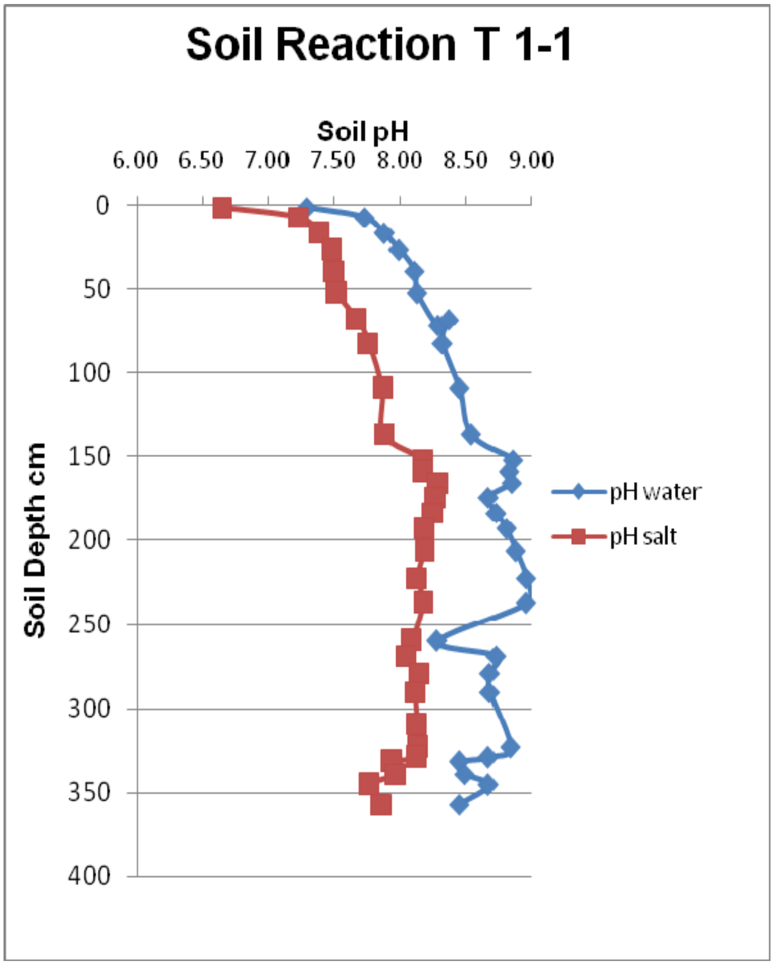


Figure 4.5 Depth distribution diagram of soil reaction with depth for Transect 1, pedon 1

remains greater than 8.0 until about 330 cm, where water-worked parent material is present and pH_s falls to less than 8.0.

Transect 2, pedon 5 (Figure 4.6), is located in the largest borrow area (Basin 1) and has the shallowest depth to paleosol (63 cm). Textures in the subsoil are very fine sandy loam at about 114 cm, but sand grains are still pitted and angular indicative of eolian parent material and pH_s remains slightly to moderately alkaline. Thin bands of clean very fine sand are found in the horizon immediately below (137-157 cm). At 182 cm and below, sand grains appear rounded and subrounded and textural banding is evident; soil reaction decreases to pH_s of 7.5 and remains less than pH_s 7.7 with increasing depth.

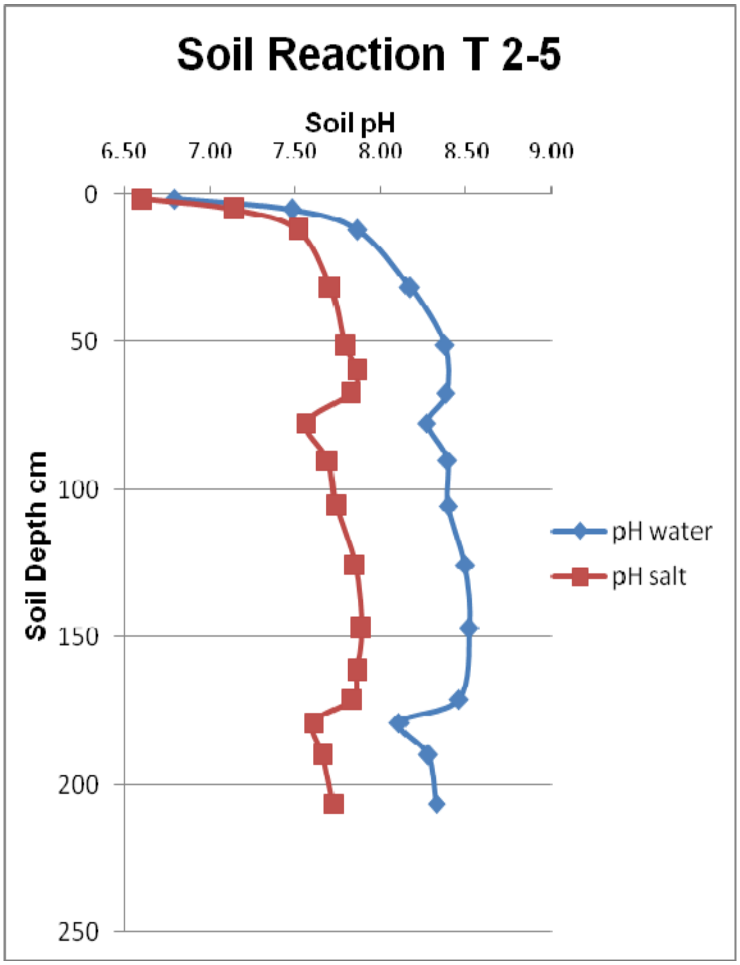
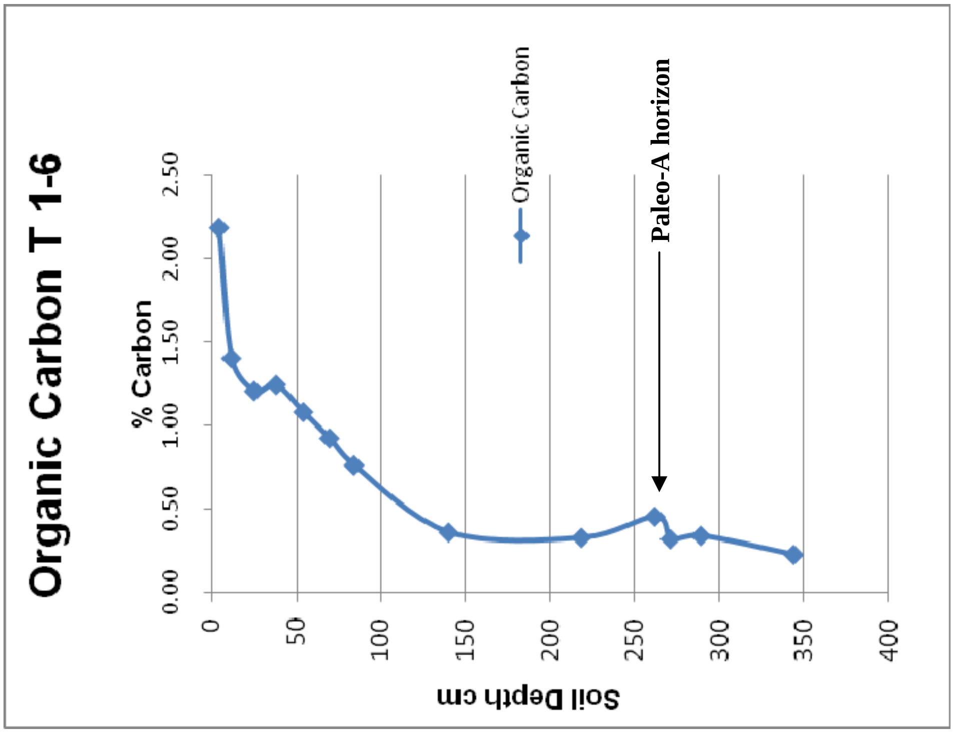


Figure 4.6 Depth distribution diagram of soil reaction with depth for Transect 2, pedon 5.

While these trends in soil reaction are relatively consistent in all pedons (see Appendix B and Appendix D), soil reaction was not useful for differentiating changes in parent material. It is probable that length of time for pedogenesis and continuing aerial deposition of carbonates has had greater effect on soil pH than varying episodes of loess deposition.

Organic carbon, however, does seem to be useful in detecting changes in parent material, especially regarding the A horizon of the paleosol. Figure 4.7 shows two pedons in the relatively undisturbed Transect 1 as representative examples, a pedogenic sequence is illustrated where organic carbon is great in the surface horizons and



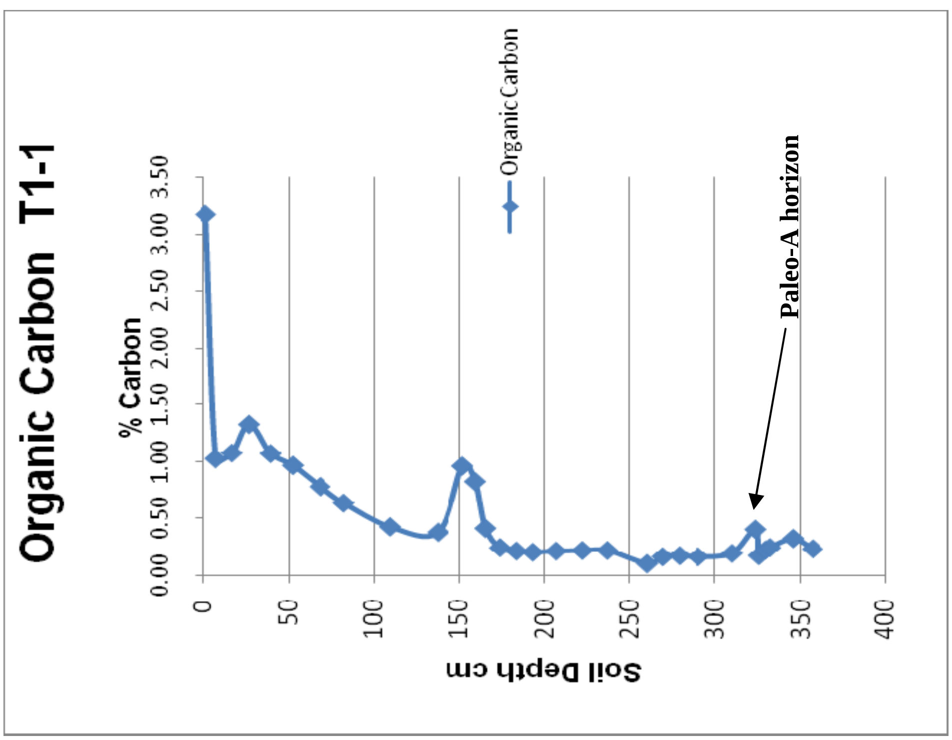


Figure 4.7 Depth distribution diagrams of organic carbon in two pedons in the relatively undisturbed transect (Transect 1, pedon T 1-1 and pedon T 1-6)

decreases with depth. The paleosol A horizon is shown as a bulge in organic carbon. Pedon T 1-1 occurs near the edge of the Missouri River terrace in the lower part of the backslope, and contains a greater percent organic carbon than does pedon T 1-6 in the surface horizon, as might be expected in a lower and slightly wetter portion of the landscape; the paleo-A horizon of pedon T 1-1 also reflects this trend, with nearly one percent organic carbon, while the paleo-A horizon of pedon T 1-6 contains about half that amount. In each pedon, the signature increase in organic carbon in the paleo-A horizon is consistent.

Organic carbon is even more useful from an archaeological perspective. Changes, often abrupt, in organic carbon content signal the presence of material excavated and redeposited by the Mandans in a different location in the village. Earthy fill commonly consists of randomly-alternating pedogenic surface horizons, and may alternate with trashy fill (ashes, household refuse rich in bone, and other organic debris). Pedons within the Outer Residential Area and the Residential Core clearly demonstrate this pattern (Figure 4.8). Pedon 4-32 is located in the "Pit Zone" on the northern side of the Outer Residential Area. Rich in numerous cache pits, the soil has been reworked as cache pits were excavated and filled repeatedly. The organic carbon content with depth is in an irregular distribution within the fill to a depth of 150 cm; C horizons are present from 150 cm to about 250 cm; the bulge in organic carbon from 250 to 275 cm corresponds to the paleo-A horizon.

Transect 2, pedon 11 (Figure 4.9) is located in the Residential Core and is thought to be an elevated area between closely-spaced earthlodges. Created by erosion from the lodges with additions of household trash, the soil to a depth of about 50 cm shows

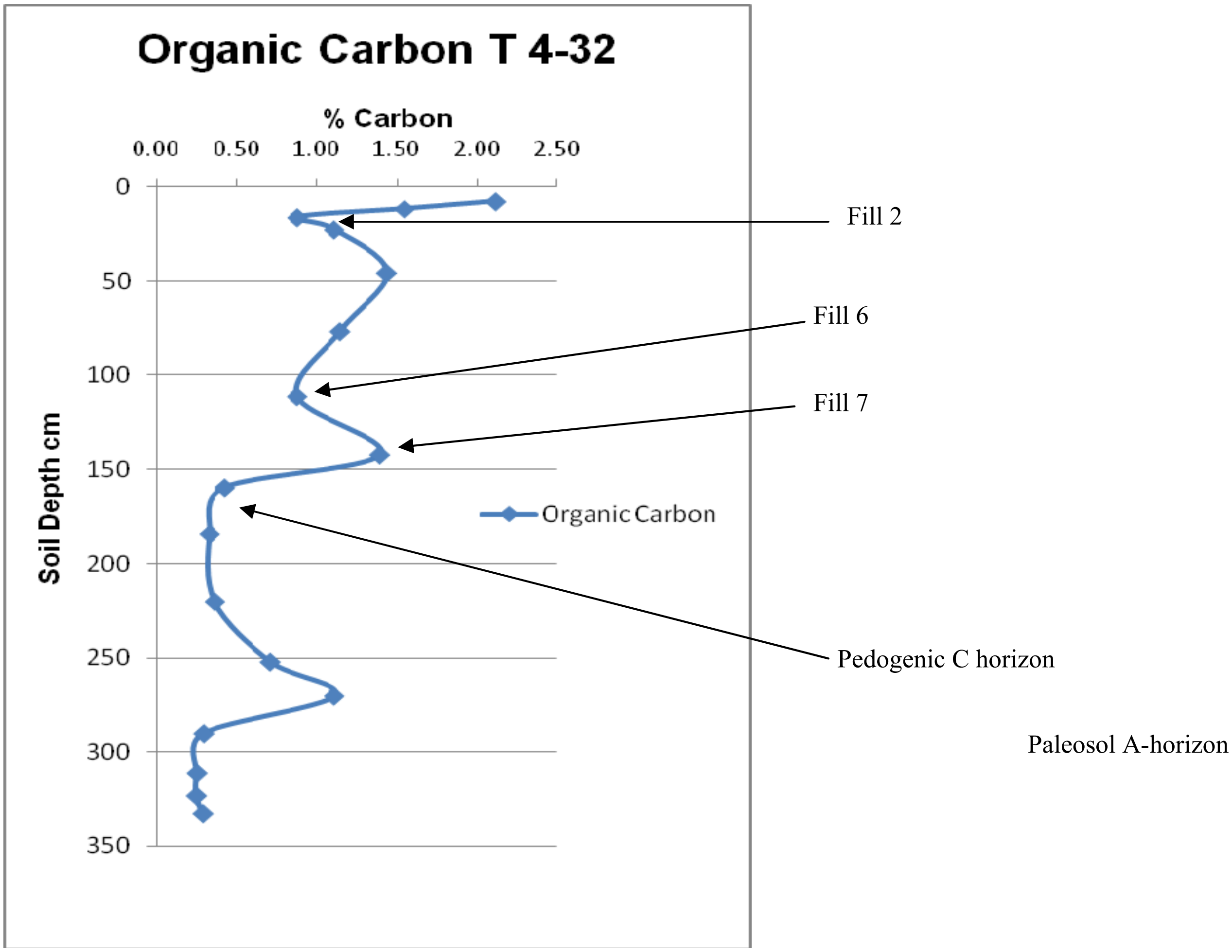


Figure 4.8 Depth distribution diagram of organic carbon for Transect 4, pedon 32

irregular depth distribution of organic carbon. It was not possible to determine the original (pre-occupation) ground surface with any degree of certainty in T 2-11, but it may occur around 90 cm and corresponds to the observed increase in organic carbon. Another A horizon is present from 116 to 121 cm depth and contained charcoal fragments, accounting for the sharp spike in organic carbon. The C horizon of the modern-day soil occurs from about 150 to 230 cm; the paleo-A horizon immediately below that C horizon increases two-fold in organic carbon from the C horizon (from 0.32 to 0.66 percent).

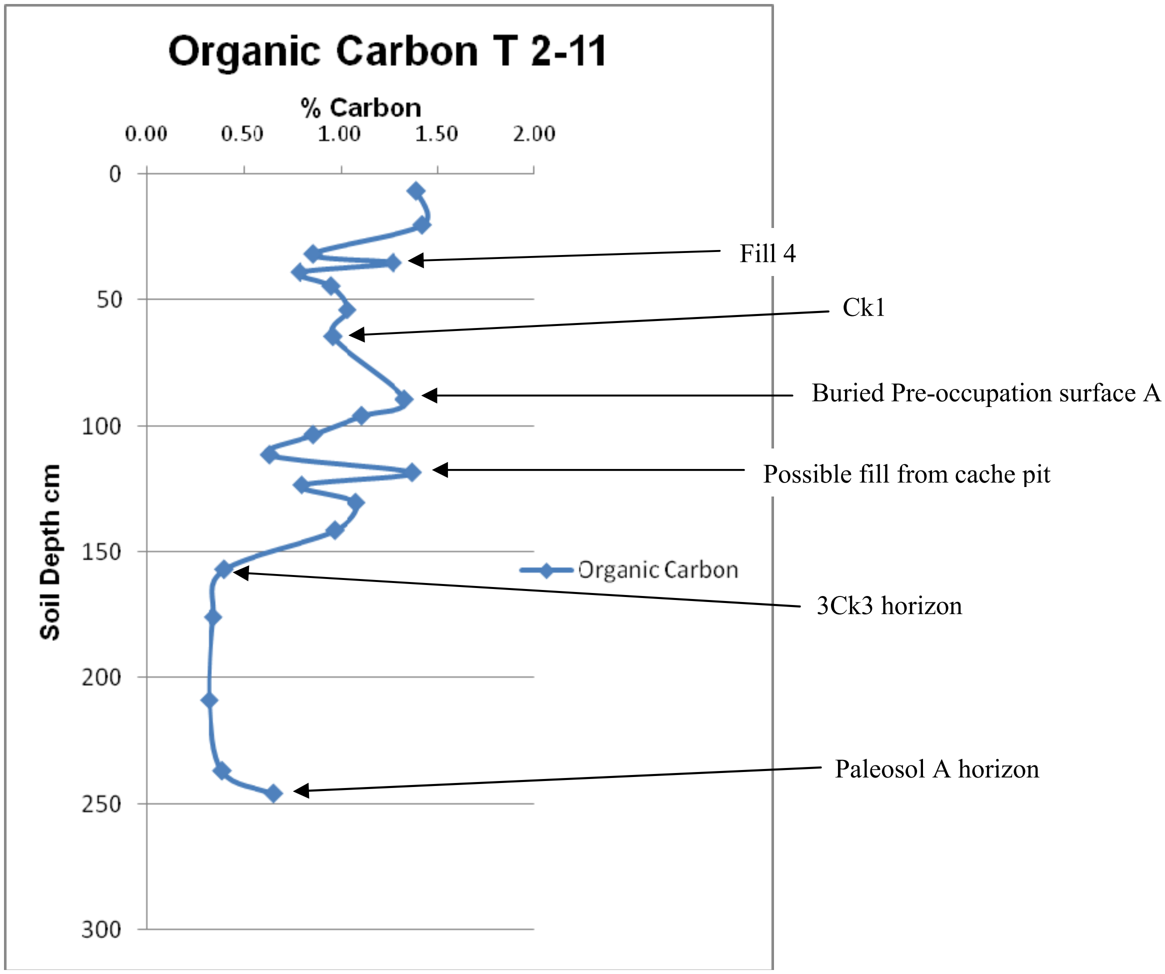


Figure 4.9 Depth distribution diagram of organic carbon for Transect 2, pedon 11

Two profiles associated with earthlodges provide examples of depth distribution fluctuations in organic carbon. Pedon T 2-9 (Figure 4.10) is the wall of House 23, and shows variable organic carbon in the material overlying the original surface A-horizon (57 to 63 cm depth). Pedon T 2-10 (Figure 4.11) is the approximate center of a house; the slight increase in organic carbon is associated with an ashy deposit in the floor of the house.

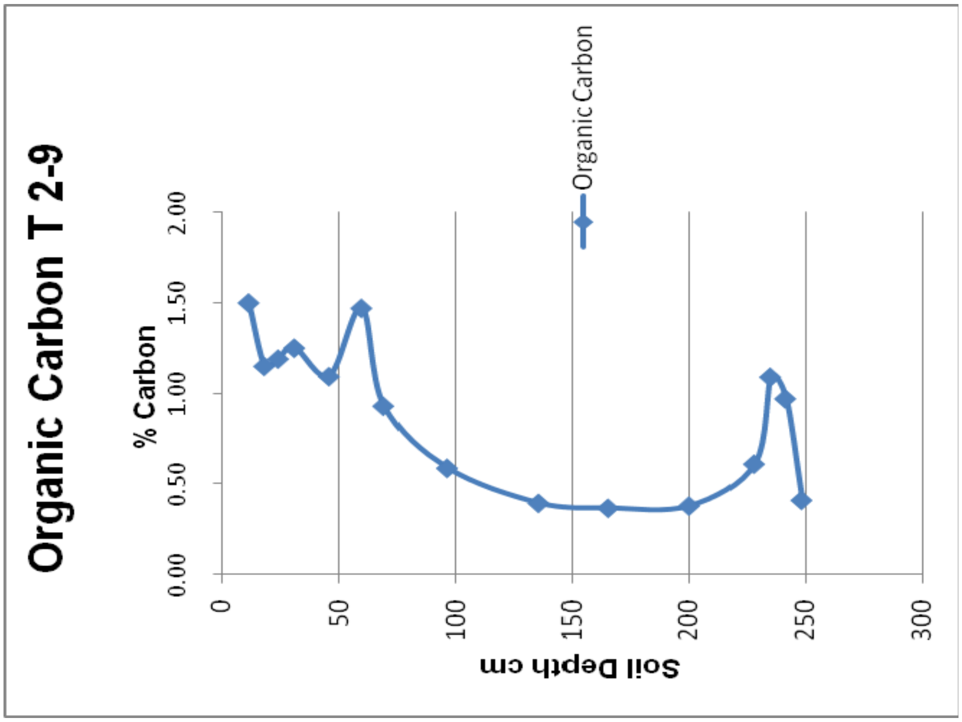


Figure 4.10 Depth distribution diagram of organic carbon for Transect 2, pedon 9

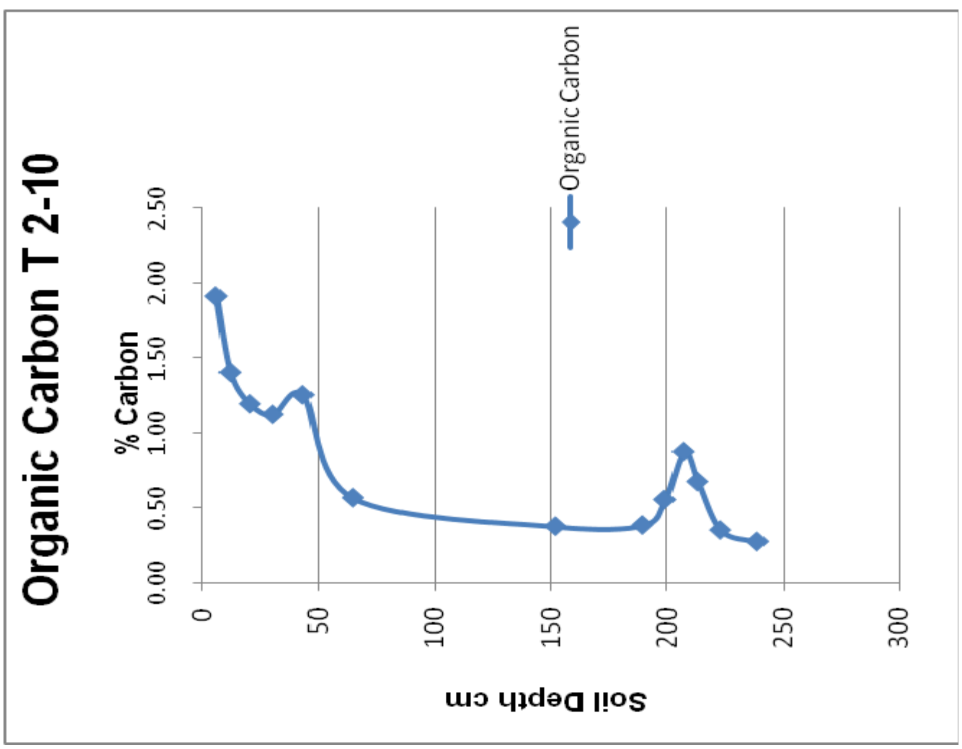


Figure 4.11 Depth distribution diagram of organic carbon for Transect 2, pedon 10

A further example of irregular distribution of organic carbon (Figure 4.12) occurs in Transect 3, pedon 2. Situated southeast of a midden mound in the Outer Residential Area, this pedon may have been influenced not only by slopewash from Mound H, but also by filling of the nearby Ditches 3 and 4. Surface horizons have characteristics indicative of the surface horizons in the relatively undisturbed transect (Transect 1)

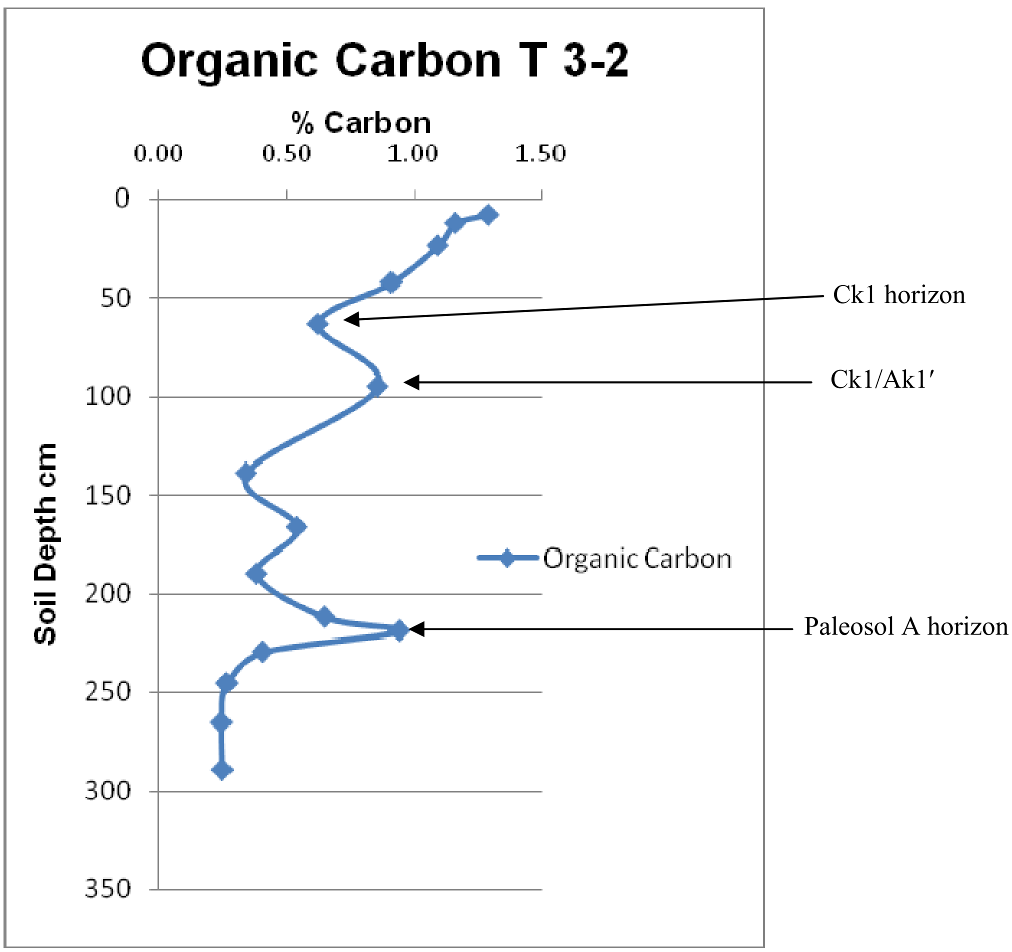


Figure 4.12 Depth distribution diagram of organic carbon for Transect 3, pedon 2

regarding color and structure. However, fill material was identified at a depth of 75 to 115 cm, based on discrete chunks of A and C horizon, a common feature of mixed and relocated fill material. It is probable that soil above 75 cm depth is also fill material, but perhaps has been in place for a great enough length of time to have undergone pedogenic processes. The spike in organic carbon at 115 cm is attributable to presence of charcoal and small bone fragments, a further indicator that this is indeed fill material.

Utilization of Geomorphic and Pedogenic Features to Assess Planar Borrowing: Results of Volume Determinations

After several iterations (Table 3.1, Chapter 3) a working model of pre-occupation topography was developed (Figure 4.13). Topography in the northeast portion of the site (exterior to the Third area) is relatively unaltered from that of the present-day topography (Figure 4.14), as is that of the Missouri River terrace to the southwest. Paleotopography was significantly different from present-day topography in the Inner and Second areas where anthropogenic activity was greatest, and near Basin 4 in the south. With this model of pre-occupation topography some interesting patterns emerge. Ditch 2 and several of the larger mounds associated with it (C1, C2, D1, D2 and JJ) align with a slope break in pre-occupation topography. The east and northeast portions of Ditch 2 are located where the surface becomes more flat. In the northern portions of the village, Mounds G, F, I1, I2 and CC are also positioned near slope breaks. Final results for volumes of borrow and fill generated by this study (Frey) differ somewhat from those values obtained by Ahler (2003, 2004, 2005) (Table 4.7). (See Appendix E for data generated from initial models for pre-occupation surface.) Differences in mound height between the two studies may be attributed to Ahler measuring height or depth from the present-day surface (which may or may not be a greater elevation than the pre-occupation surface); height or depth in this study was measured from grade (Figure 4.15, and as

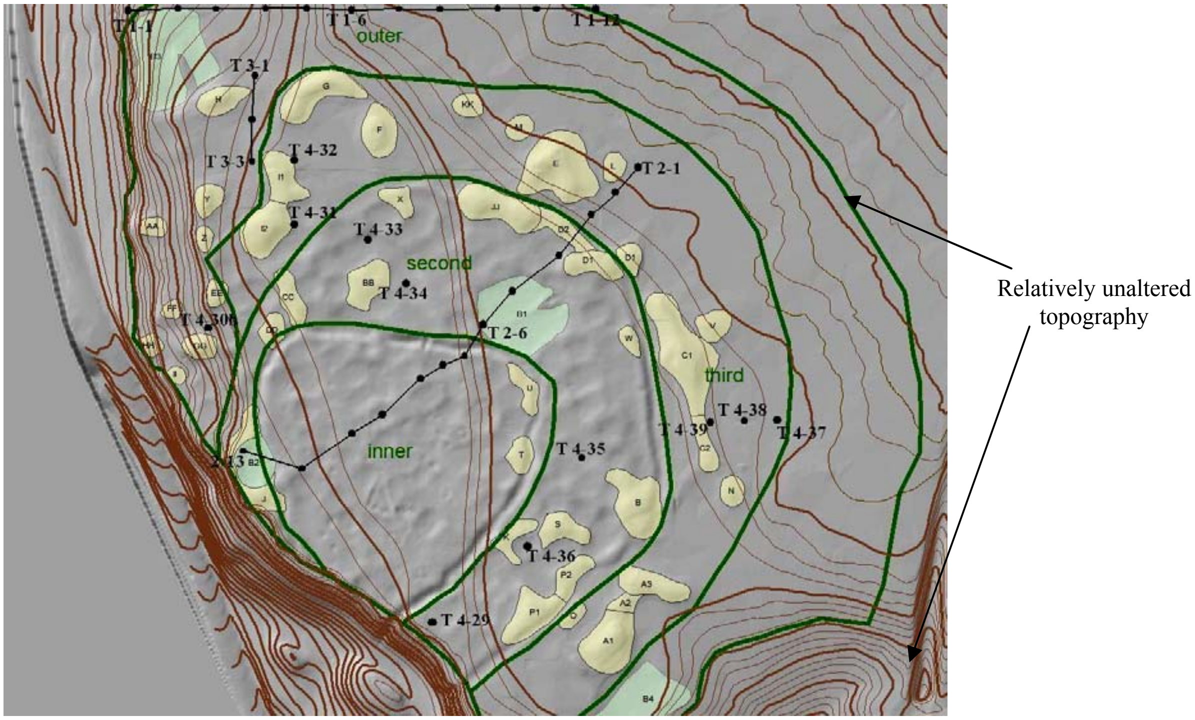


Figure 4.13 Model of the pre-occupation topography (25 cm contour interval) with hillshade underlay (courtesy ArcheoImaging Laboratory). Brown lines show proposed pre-occupation topography. The Missouri River terrace is the steep terrain to the southwest. Approximate locations of pedons are shown along with Borrow Basins and Mounds. Inner, Second, Third and Outer areas pertain to this study.

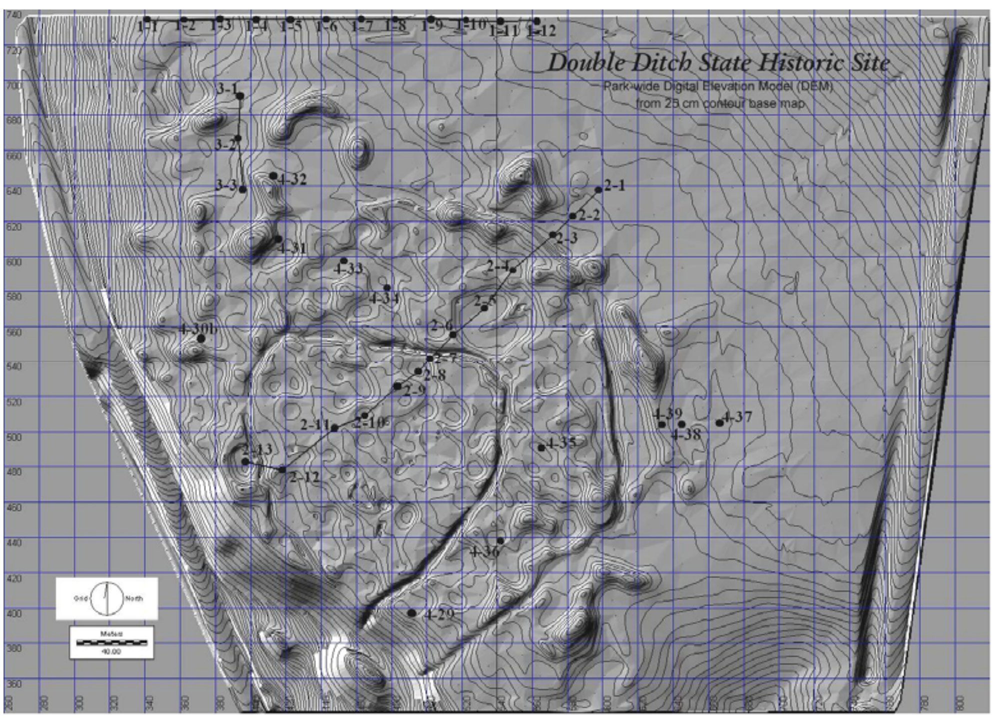


Figure 4.14 Present-day topography of Double Ditch Village, 25 cm contour interval with hillshade underlay (courtesy ArcheoImaging Laboratory).

explained in Chapter 3, Materials and Methods). Differences in volume of any given mound may arise from differences in height, or may perhaps relate to method of computation (Ahler's formula compared with GIS software and a 50 cm grid).

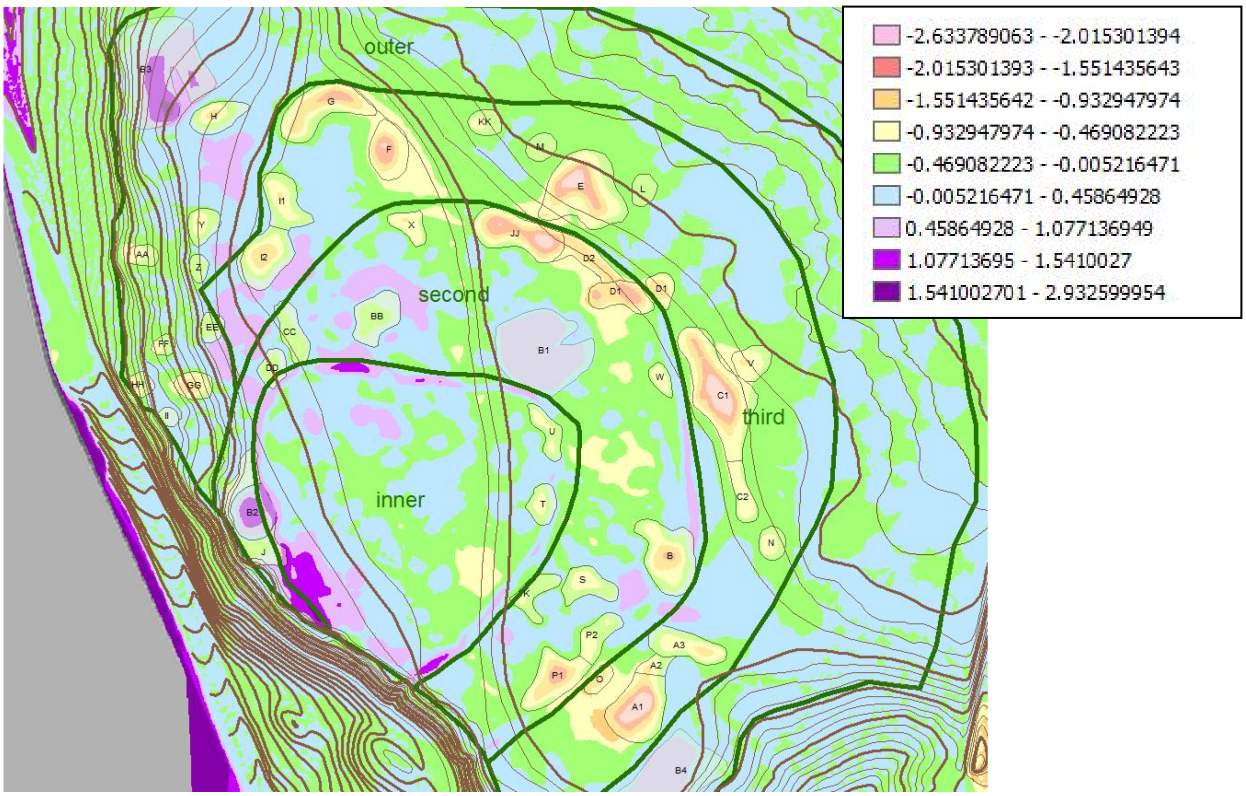


Figure 4.15 Illustration of above and below grade areas. Negative values are meters above grade and positive values are meters below grade, where grade is zero for pre-occupation surface elevation minus present-day surface elevation. Values of ± 5 cm are included in the ranges for light green and light blue.

Subtotaled volumes (by location) for Ahler range from 64% to 75% less than values in this study. Relative size of mounds has altered; although Mounds C1 and E in the periphery zone are still the greatest volumes of all mounds, their relative ranking is reversed. Mounds M and L no longer have the least volume (5.58 m^3 and 8.33 m^3 respectively) as seen with Ahler (2003); according to this study, mounds I1 (1.70 m^3) and EE (8.73 m^3) are the smallest.

Table 4.7 A comparison of values for volume of fill in mounds. Mounds are classified by location (core residential, outer residential and the zone between Ditches 2 and 4) and size class and ranked in order of increasing volume (after Ahler 2003). Data for basal area of each mound, height, and volume of fill are provided, as well as total volume of fill for location categories. Total volume for the site is Grand Total.

			Ahler 2003			Frey 2011		
Size Class	Mound	Location	Area m^2	Height m	Volume m^3	Area m^2	Height m	Volume m^3
small	U	core	201.87	0.596	50.11	218.50	0.75	81.19
small	T	core	169.01	0.765	53.85	153.25	0.70	55.80
TOTAL for Core Residential Mounds:					**103.96**			**136.99**
small	II	outer	87.53	0.338	12.32	14.75	0.23	1.70
small	K	outer	200.00	0.260	16.00	233.50	0.58	58.65
small	FF	outer	147.06	0.336	20.58	87.25	0.76	33.09
small	W	outer	116.43	0.496	24.05	120.75	0.74	61.06
small	HH	outer	104.25	0.695	30.18	102.25	1.22	56.10
small	X	outer	135.46	0.630	35.54	190.00	1.03	124.89
small	Z	outer	128.91	0.673	36.13	86.25	0.39	15.19
small	Q	outer	345.54	0.265	38.13	[no longer classified as a mound]		
small	DD	outer	187.17	0.526	41.01	95.00	0.41	17.42
small	P2	outer	254.12	0.410	43.39	248.00	0.78	106.75
small	EE	outer	213.43	0.607	53.96	69.25	0.25	8.73
medium	D2	outer	336.89	0.520	72.96	280.75	1.37	294.56
medium	BB	outer	356.29	0.560	83.10	173.25	0.38	32.37
medium	CC	outer	288.55	0.800	96.14	183.75	0.50	42.98
medium	S	outer	304.62	0.930	117.99	297.25	1.00	119.92
medium	GG	outer	254.50	1.142	121.05	196.00	1.40	154.65
medium	P1	outer	457.82	1.070	204.03	538.25	1.71	481.58
medium	J	outer	666.56	0.840	233.20	118.50	0.45	21.93
large	B	outer	589.38	1.410	346.12	599.25	1.56	407.99
large	I2	outer	507.71	1.710	361.60	389.25	1.39	259.35
large	JJ	outer	570.28	1.595	378.85	690.75	2.21	840.93
medium	D1	outer/periph.	528.92	0.977	215.23	508.00	1.84	593.06
TOTAL for Outer Residential Area Mounds:					**2581.56**			**3732.90**
small	M	periphery	118.55	0.113	5.58	156.00	0.31	37.18
small	L	periphery	133.26	0.150	8.33	148.50	0.36	33.94
small	AA	periphery	102.81	0.300	12.85	130.00	0.97	68.91
small	O	periphery	139.41	0.350	20.32	115.75	1.22	113.90
small	A2	periphery	101.81	0.570	24.17	112.00	1.13	68.14
small	KK	periphery	198.23	0.392	32.36	165.00	0.68	58.89
small	C2	periphery	292.45	0.290	35.23	244.00	0.78	142.76
small	N	periphery	169.99	0.550	38.94	169.50	0.88	82.11
small	V	periphery	212.90	0.556	49.30	251.00	1.07	158.71
medium	Y	periphery?	213.69	1.140	101.46	186.00	1.11	78.69
medium	F	periphery	300.71	1.250	156.56	431.75	2.10	487.05
medium	H	periphery	327.60	1.357	185.16	214.50	1.16	105.16
large	I1	periphery?	395.89	1.247	205.62	394.00	1.10	172.38
large	A3	periphery	484.92	1.68	339.31	394.00	1.19	224.42
large	G	periphery	693.43	1.45	418.78	693.00	1.81	627.33
large	A1	periphery	688.54	1.770	507.59	701.75	2.56	926.86
large	C1	periphery	967.83	1.806	728.00	1205.00	2.63	1413.97
large	E	periphery	919.84	2.170	831.36	1132.00	2.52	1116.99
TOTAL for Mounds located near Ditch 2 and outward:					**3700.92**			**5799.61**
GRAND TOTAL					**6386.44**			**9669.50**

Table 4.8 compares volume of earth removed from discrete borrow areas (Basins 1 through 4), and demonstrates differences in values calculated by Ahler (2003) and this study. Detail was not provided in Ahler (2003, 2004 or 2005) on area, depth or volume for individual borrow areas, but a total volume borrowed of 1400 m^3 was stated (Ahler 2003, p. 14 and elsewhere); Ahler (2003, p. 14) estimates this value to be approximately 22% of the volume of fill in all mounds. Values for this study are somewhat greater, possibly owing to the fact that some borrows may occur in areas already below the pre-occupation surface. This would yield a greater value for depth than what seems evident in the present-day landscape, as depths for this study are referenced to the pre-occupation surface elevation.

Table 4.8 A comparison of values for Ahler (2003) and this study (Frey) for volume of earth removed for each of the major borrow basins.

	Ahler			Frey (2011)		
Basin	Area m^2	Depth m	Volume m^3	Area m^2	Depth m	Volume m^3
1	78.54	1.5		1411.25	0.96	948.82
2	39.27	>1.5		444.50	1.40	389.67
3	no data			1598.75	1.60	1123.21
4	no data			993.25	0.89	525.52
TOTAL			1400			5649.10

Utilizing elevations of the pre-occupation topography, it is possible to generate values for volume of fill in mounds and borrow (both borrow basins and planar borrowing) by area of the village and by total area which includes a portion of the site outside the perimeter of Ditch 4 (Table 4.9, Figure 4.15). Volumes of fill and borrow (m^3) and area for mounds and basins (m^2) are given by location. The "No Change" field is volume and

Table 4.9 Volumes (m^3) of fill and borrow and area (m^2) of fill and borrow by location in the study area. The Inner area is that within the perimeter of Ditch 1. The Second area includes Basins 1 and 2. The Third area includes some of the larger mounds (e.g., C1, E and G). Basins 3 and 4 are within the Outer area, that portion of the study area between Ditch 2 and the Limit of Area of Interest as shown in Figure 4.16. The "No Change" fields are those volumes and areas where the present-day elevations are within ± 5 cm of the pre-occupation elevations.

Location	Volume of Fill m^3	Volume of Borrow m^3	Volume of No Change m^3	Fill Area m^2	Borrow Area m^2	No Change Area m^2
Inner	1500.29	3757.61	3.61	5698.00	9554.25	3046.50
Second	5580.47	4180.89	0.48	12,109.75	10,870.00	3819.75
Third	9006.92	1423.69	47.86	17,457.00	5759.00	9815.75
Outer	916.79	3471.63	81.86	3835.75	9155.50	32,750.25
TOTAL	17,004.47	12,833.82	181.33	39,100.50	35,338.75	49,432.25

area where the present-day elevation is within ± 5 cm of the pre-occupation elevation; elevation differences of this small magnitude might be attributable to activity other than anthropogenic. While perhaps significant in aerial extent, volumes of "No Change" are minimal, totaling less than 200 m^3 for greater than 100,000 m^2 of total area.

The Inner area denoted by the innermost white line on Figure 4.16 encompasses that part of the village within the perimeter of Ditch 1 (the Core Residential area) and is approximately 1.67 ha (Ahler 2005, p. 9). As might be expected, the Inner area has a greater volume of borrow than of fill. This area experienced the most intensive occupation over time. Ahler observed that the Core Residential area was originally thought to contain multiple house depressions, until geophysical analysis revealed a lack of hearth and other features commonly associated with earth lodge depressions (Ahler 2003, 2004 and 2005). He concludes the areas must have been small borrows. There are only two small mounds within this Core Residential area, T and U, with a total volume of

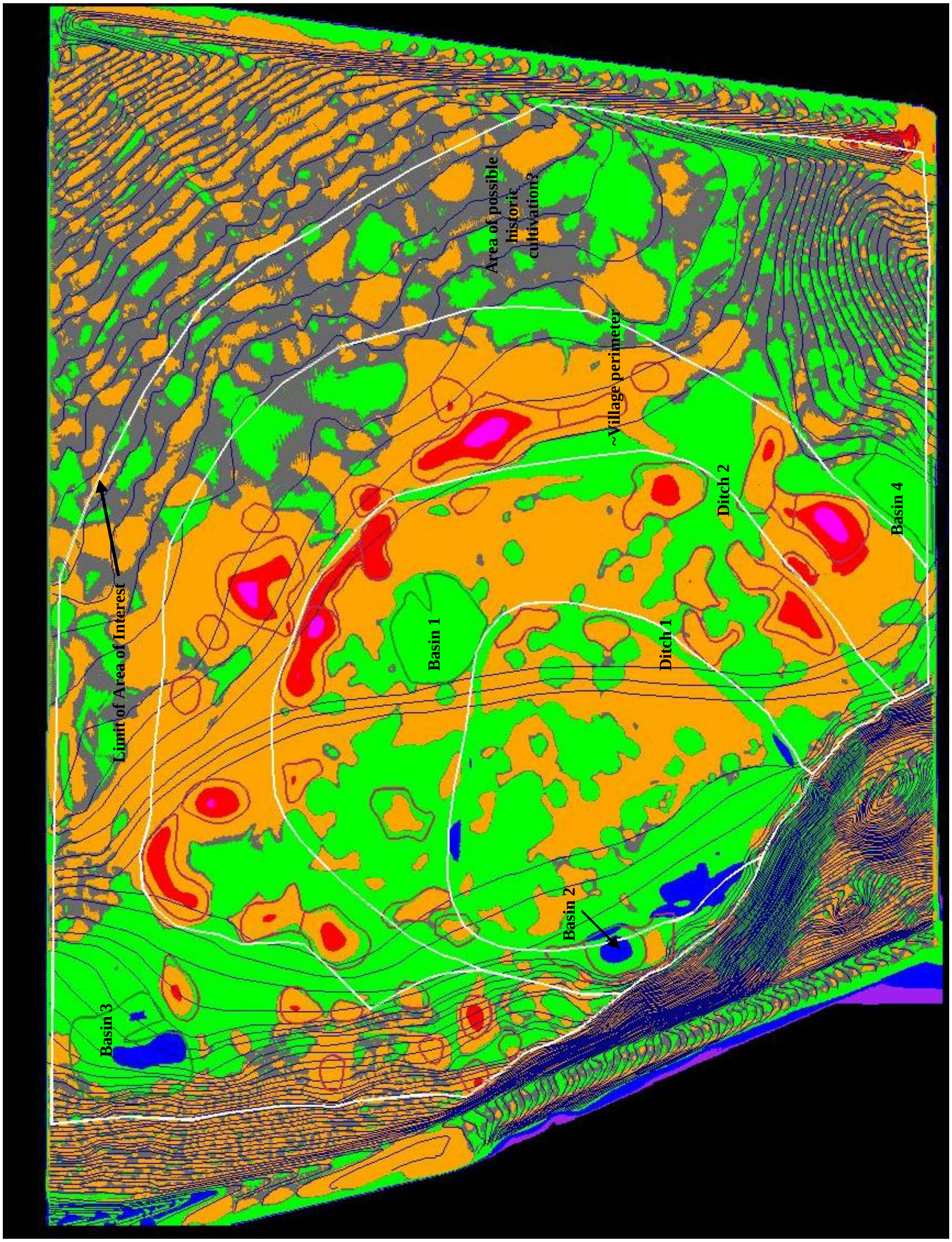


Figure 4.16 Double Ditch Village with some major features (north is to the left). Basins, Ditches 1 and 2, Area of Interest and Area of Possible Historic Cultivation are labeled. Colors indicate mound and borrow features. Code for Fill areas in meters above pre-occupation surface: Magenta > 2 m; Red 1-2 m; Orange 0-1 m; Gray 0 m. Borrow in meters below pre-occupation surface: Green 0-1 m; Blue 1-2 m; Purple > 2m.

approximately 137 m^3 (Figure 4.17). The remainder of the fill volume for this area is assumed to be material washed off the roofs of earthlodges, or what might be localized trash piles.

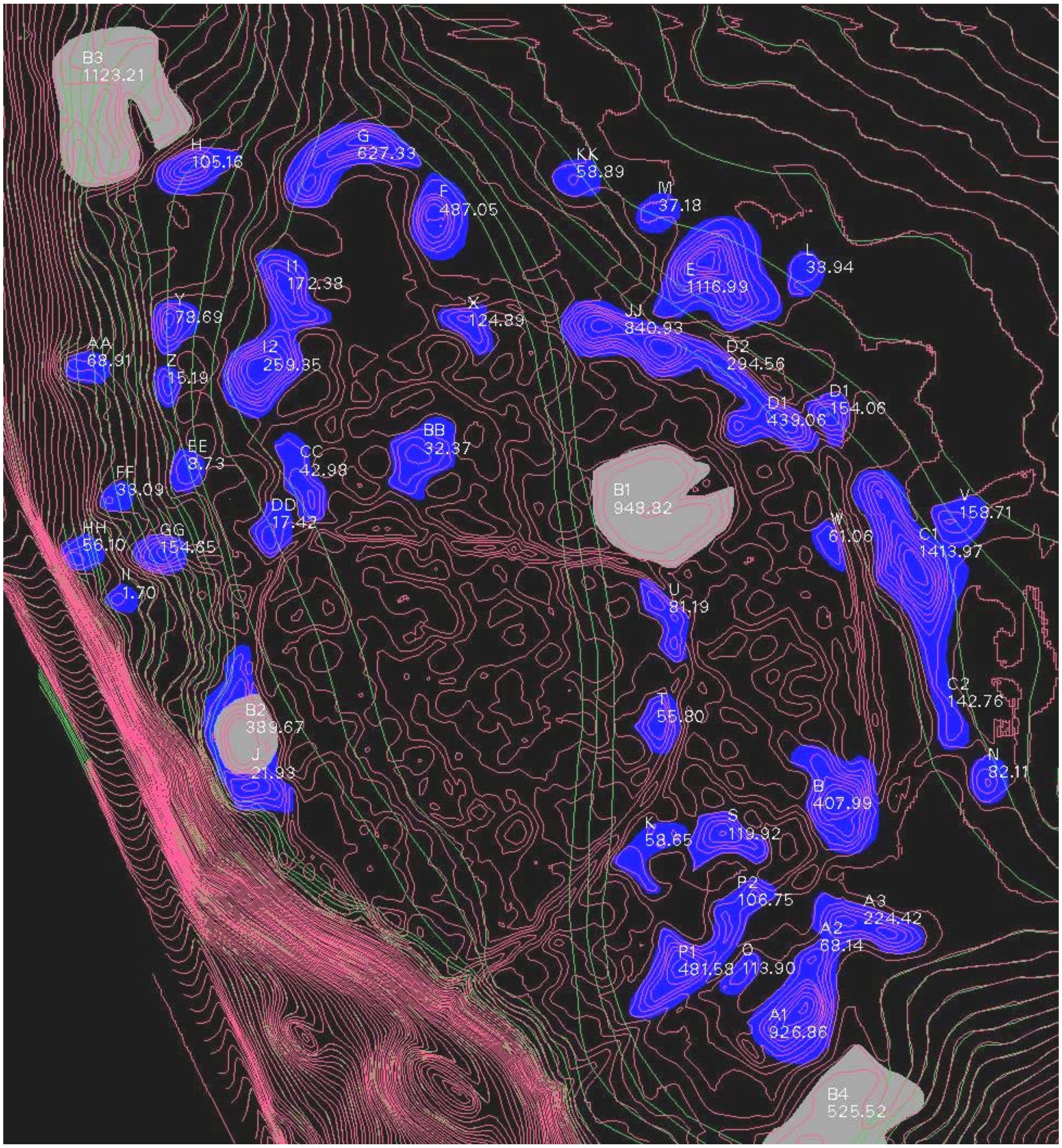


Figure 4.17 Volumes in m^3 for mounds and basins with pre-occupation (green) and present-day (red) topography, 25 cm contour interval. Mounds appear in blue and basins in gray. Note the positioning of Mounds X, F, G, I1, I2, CC and GG relative to the pre-occupation topography.

The Second area is that between Ditches 1 and 2 (the Outer Residential area), approximately 2.94 ha (Ahler 2005, p. 10). The Second area contains several of the larger mounds on the site. Mounds P1, P2, K, S and B in the southern end; W, part of D1, D2, JJ, and X to the northeast; and BB, CC, DD and J to the north and west contain more than 3000 m^3 of fill. Basins 1 and 2 contribute nearly 1350 m^3 of earth borrowed in this area. Lines demarking the First and Second areas were drawn exterior to ditches with the assumption that earth "borrowed" from Ditches 1 and 2 would approximately equal the backfill to the interior side of the ditch.

The Third area includes much of what Ahler (2005) terms the perimeter, or that portion of the site that is within the perimeter defined by the outer ring of mounds with an area of approximately 4.41 ha bringing the total area to 9 ha in the first three areas. The Third area contains some of the larger mounds, thought to be defensive components of Ditch 2, and perhaps constructed when Ditch 3 was filled in and abandoned (Ahler 2004, 2005). Mounds A1, A2, A3, C1, C2, E, G, F, I1 and I2 fall in this area, and contain nearly 5500 m^3 of fill. In calculations for this study, a few small mounds (for example H,Y, Z, AA and GG among others) in the west and northwest portions were not included as part of the Third area; its boundary approximates the location of the surface-invisible Ditch 4, which excludes certain mound and borrow features.

In an effort to include potential borrow activity outside the area defined by Ditch 4, this study created a fourth, Outer area which lies outside the perimeter of Ditch 4; included are Basins 3 and 4, and several small mounds in the west and northwest portions of the site. Basins 3 and 4 account for approximately 1650 m^3 of borrow; fill volume is primarily due to smaller mounds along the western side of the village near the river terrace: Mounds Y, Z, AA, EE, FF, GG, HH and II, as well as Mound H near Basin 3 are included, with slightly greater than 500 m^3 of fill material.

If the volume of borrow from Basins 1 through 4 (Table 4.8) is subtracted from the total volume of soil borrowed (Table 4.9) a value representing the volume of earth borrowed through planar borrowing should result (Table 4.10). This value is

Table 4.10 Relative values for volume of earth borrowed, volume of earth in fill, volume of earth for planar borrow, and planar borrow volume as a percentage of total borrowed and total fill.

Total volume m^3 soil borrowed	Total volume m^3 in fill	Volume m^3 from Basins 1 through 4	Volume m^3 from planar borrowing	Planar borrow % of Total	
				Borrowed	Fill
12,833.82	17,004.47	5649.10	7184.72	56%	42%

approximately 7200 m^3, or about 56% of total volume borrowed, and about 42% of the total volume for fill. This would seem to indicate that planar borrowing was a significant if not the primary source of fill material.

Total volumes of borrow and fill indicate slightly greater volumes of fill than of borrow (17, 004.47 m^3 and 12, 833.82 m^3 respectively). There is a deficit of about 4200 m^3 that represents the volume of fill unaccounted for by calculated volume of borrow within the area of interest.

Conclusions

The effects of the anthropogenic activity on the soils of Double Ditch are commonly evident, as seen when compared to soils in the relatively undisturbed transect. These soils exhibit increases in soil reaction from slightly acidic in the surface to slightly alkaline in the subsoil. Pedogenic carbonates are common and are probably attributable to parent material. Organic carbon is relatively high in the present-day surface horizon then decreases rapidly with depth. The Leonard paleosol A horizon has a characteristic increase in organic carbon that is equal to or exceeds the organic carbon content in the present-day surface; this increase aids in identification of the paleo-A horizon.

Processes of pedogenesis in the pre-occupation soil were disrupted and affected by anthropogenic activity generated by a great number of individuals occupying a small area for several centuries. Constant foot traffic would have denuded the site of vegetative cover, and erosion was probably the norm. In addition, soil was removed and reworked, then transported and redeposited out of pedogenic sequence.

Several pedons obtained in this study are located within the zone of anthropogenic activity. Many contain multiple layers of fill, either of earth, ash, or trash. The surface horizon of the present-day soil was absent through much of the village in the Inner Residential and Outer Residential areas; portions of the area outside of the outermost Ditch 4 also lacked this A horizon.

Patterns emerge when observing soils in concert with cultural features. Ditch fill and fill in several mounds contained soil that appeared to be mixtures of discrete A, B and/or C horizon material, with or without trash and artifacts. This fill frequently contained ash and charcoal from hearth fires and organic residue from food, which manifest as abrupt spikes in organic carbon as noted in some pedons. House features generally showed little evidence of organic carbon below living floors, about 50 cm surface depth, but house walls where earth material and associated debris eroded from earthlodges show irregular spikes in organic carbon. However, cache pits located within house features exhibit the same pattern in organic carbon as other fill features, with sometimes widely varying organic carbon content dependant on individual fill deposits. Borrow basins have low organic carbon content below the surface 15 cm; slightly greater levels of organic carbon in the surface may be owing to the resumption of surficial pedogenic processes in the aftermath of abandonment of either the feature or of the entire village.

Borrow activity by the Mandans was extensive, and falls into two categories: defined and discrete borrow basins and planar borrowing. The volume of earth removed from discrete borrow basins accounts for slightly less than half of the total volume of earth borrowed; the remainder must be attributable to planar borrow activity. To this date it has been difficult to assess the volume of soil removed by planar borrowing, as methods used to estimate volume removed from borrow basins are not easily applied to planar borrow activity.

A procedure was developed to assess the degree of planar borrowing activity. Through use of a DEM, elevations for the present-day surface were obtained. A model for paleo-topography was created using elevation data for known surfaces in concert with knowledge of landscape processes. By applying GIS software, it was possible to calculate the difference in elevation between the present-day surface and the paleosol surface. This not only allowed volume determinations for major borrow and mound features, but also for areas that experienced planar borrowing.

The interpretation of pedological and geomorphological characteristics of the soils present at Double Ditch in concert with detailed a DEM and GIS technology has provided an assessment of planar borrow activity. The method should be applicable to other archaeological investigations where similar behaviors may have occurred, or may aid in determination of presence or absence of planar borrow activity.

Broad applications exist between pedology and archaeology. Among these are the uses of paleosols as stratigraphic markers to predict stable surfaces where archaeological sites may be found, or as a tool in paleoclimatic reconstruction. Narrower applications, such as micromorphology and chemical analysis are also widely utilized by both pedologists and by archaeologists for site interpretation.

This study would indicate one further use: the application of a paleosol as a stratigraphic marker toward assessment of anthropogenic activity. It has been shown to be a key factor in assessing the degree of planar borrowing activity at Double Ditch, a unique behavior characteristic of this important site. It been shown that fill features such as mounds contain approximately the same volume of material as was borrowed. But it was also demonstrated that the degree of planar borrow activity, a unique behavior at this Mandan village, was approximately equal to the borrow activity from discrete borrow basins.

Further studies may address the issue of possibility of erosion of the paleosol A horizon prior to burial by the overlying Middle and Late Holocene loess, by utilizing elevation data based on the base of the paleosol a horizon rather than the surface of the paleo-A. While thickness of the paleo-A horizons did not vary to any great degree in the relatively undisturbed transect, the paleotopography was likely steeper in some areas of the site than in others and erosion may have occurred to an extent as to affect results of volumes of soil borrowed and used in fill.

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APPENDICES

APPENDIX A

DETAILED SOIL PROFILE DESCRIPTIONS

ABBREVIATIONS and NOTATION in PEDON DESCRIPTIONS

1. Procedure and abbreviations per Soil Survey Manual (Soil Survey Division Staff 1993).

2. **Horizon**: Horizon designation in bold typeface indicates the Leonard Paleosol A-horizon.

3. **Depth**: in centimeters.

4. **Matrix** and **Mottle** color: Munsell abbreviations are standard. A-horizon color on crushed (cr) sample.

5. **Texture**: texture is "by feel" for all pedons except T1-1, T1-6 and T1-12. These pedons served as the reference for texture by feel, especially regarding percentage very fine and fine sand. Abbreviations are standard.

6. **Structure**: difficult to ascertain coarse prismatic structure due to diameter of push tube. Abbreviations are standard.
   a. platy (pl) granular (gr) subangular blocky (sbk) angular blocky (abk) prismatic (pr)
   b. weak (w) moderate (m) strong (st)
   c. thin (tn) thick (th) fine (f) medium (m) coarse (c) very coarse (vc)

7. **Consistence**: abbreviations are standard.

8. **Roots**: abbreviations standard.
   a. few (1) common (2) many (3)
   b. very fine (vf) fine (f) medium (m) coarse (c)

9. **Pores**: abbreviations standard, as for roots.

10. **Effervescence**: abbreviations standard. Determined with 1 N HCl.

11. **Boundary**: abbreviations standard.

12. **Carbonates**: abbreviations follow usage for mottles.
    a. First letter: abundance. few (f) common (c) many (m)
    b. Second letter: size (mottle guidelines apply).

c. Lining pores ("l'ing") is only designated for abundance.
d. "Coats" refers to coatings on ped faces or soil material.
e. "Rings" refers to features that appear to be in-filled earthworm burrows that have carbonate accumulations surrounding them. They are typically 4 mm in diameter.

13. **Artifacts**: abbreviations as for roots, above.
    a. Fragments (frags)
    b. Knife River Flint (KRF)
    c. Tongue River Silicified Sediment (TRSS)
    d. Potsherd (potsh)

14. **Boundary**: abbreviations standard.

15. **Symbols**:
    a. **"*"** refers the reader to the **Notes** column for further information.
    b. **"↑"** refers to above horizon.
    c. **"↓"** refers to below horizon.
    d. "→" in **structure** is "parting to."

16**. Volume notations:** Where notes indicate broken soil in cores from transfer to PVC or during transport, volume corrections have been made in pedon descriptions. Refer to Material and Methods (Chapter 3) for procedure.

Double Ditch State Historic Site

Location N719.446 340.499E — Pedon # 32BL8 T1-1 SHEET 1 OF 2

Area Double Ditch: undisturbed transect, west end — Elevation 523.905 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence			Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
						Dry	Moist	Wet							
A1	0 - 3	10YR 6/2d 10YR 3/2m		sil 20% vfs	3 mgr	sh	fr	so po	3vf 3f	2vf 2f	NE			cs	hydrophobic
Bw1	3 - 12	2.5Y 6/3d 2.5Y 3/2m		sil 25% vfs	1 msbk	sh	fr	so po	2f 2vf	1m* 2vf	VSL			cs	* 1m pore is an insect burrow
Bw2	12 - 22	2.5Y 5/3d 2.5Y 3/2m		sil 27% vfs	2 msbk	sh	fr	so po	2f 2vf	2vf	SL		small (3-5 mm) snail shells; bone frags at 17-18 cm	cs	
Bk1	22 - 32	2.5Y 5/3d 2.5Y 3/3m		sil 23% vfs	2 msbk	sh	fr	so po	2vf	1vf	ST	ff coats		cs	
Bk2	32 - 47	2.5Y 5/3d 2.5Y 4/2m		sil 21% vfs	1 mabk	sh	fr	so po	2vf 1f	1vf 1f	ST	ff coats		cs	
Bk3	47 - 58	2.5Y 6/3d 2.5Y 4/3m		sil 21% vfs	1 mabk	sh	fr	so po	2vf	1vf 1f	ST	cm coats		cs	
Bk4	58 - 79	2.5Y 6/3d 2.5Y 4/3m		sil 21% vfs	1 mabk	sh	fr	so po	1vf	2vf	VE	cc coats	small deposit of organic material (seeds?) at 76-77 cm	cs	no evidence of krotovinas (re: artifacts)
BCk	79 - 86	2.5Y 6/3d 2.5Y 5/4m		sil 20% vfs	m	sh	fr	so po	1vf	2vf	VE	cm threads	isolated seeds as above, at 82 cm	gs	
Ck1	86 - 133	2.5Y 6/2d 2.5Y 5/3m		sil 22% vfs	m	sh	fr	so po	1vf	2vf	VE	fm coats		cs	
Ck2	133 - 142	2.5Y 6/2d 2.5Y 4/2m	fff 2.5Y 5/3d (3/2m)	sil 18% vfs	m	sh	fr	so po	1vf	1f	VE	fm coats, l'ing c pores		cs	
Ck3	142 - 147	2.5Y 5/3d 10YR 3/2m	cmf 2.5Y 5/2d (3/2m) in-filled worm channels	sil 20% vfs	m	sh	fr	so po	1vf	1vf 1f	VE	cf threads, few "rings"		gs	paleo-A horizon brought up into Ck3 by faunal activity
2Ak1	147 - 157	10YR 3/2d 10YR 2/2m		sil 20% vfs	1 fsbk	sh	fr	so po	1vf	1vf	ST	cf threads, few "rings"		cs	
2Ak2	157 - 162	10YR 3/3d 10YR 2/2m	ffd 10YR 6/6d (4/6m) from 2Ak1 ↑	sil 20% vfs	1 fsbk	so	fr	so po	1vf	1vf	ST	cf threads, few "rings"		cs	
2Ak/Bk	162 - 169	Ak: 10YR 3/3 10YR 2/2m	Bk: 2.5Y 5/4d 2.5Y 4/4m	sil 17% vfs	1 fsbk	so	fr	so po	1vf	2vf 1f	ST	ff coats in Bk material		cs	intermingled due to copious faunal mixing
2Bk5	169 - 179	2.5Y 5/4d 2.5Y 4/4m		l 32% vfs	1 fpr→ 1 fabk	sh	fr	so po	1vf	2vf 1f	ST	cm coats		cs	few worm channels lined filled with 10YR 4/2d material↓
2Bk6	179 - 188	2.5Y 5/4d 2.5Y 4/4m		l 38% vfs	1 mabk	sh	fr	so po	1vf	2vf 1f	ST	cm coats, l'ing c pores		gs	few worm channels lined filled with 10YR 4/2d material↑
2Ck4	188 - 198	2.5Y 5/4d 2.5Y 4/4m		vfsl 40% vfs	m	h	fr	so po	1vf	2vf 2f	ST	cf threads, few "rings," ff nodules		cs	
Other															

Figure A.1a Soil profile description, Transect 1, pedon 1 (sheet 1 of 2)

Double Ditch State Historic Site

Location: N719.446 340.499E — Pedon # 32BL8 T1-1 SHEET 2 OF 2

Area: Double Ditch: undisturbed transect, west end — Elevation 523.905 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence Dry	Consistence Moist	Consistence Wet	Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
2Ck5	198 - 215	2.5Y 5/4d 2.5Y 4/4m		vfsl 45% vfs	m	sh	fr	so po	1vf	1vf 1f	VE	ff nodules, cf threads, cf coats			few 2-4 mm channels lined with $CaCO_3$
2Ck6	215 - 230	2.5Y 6/4d 2.5Y 4/4m	ffp 7.5YR 5/8d (4/6m)	vfsl 40% vfs	m	sh	fr	so po	1vf *	3vf 1f	VE	cf nodules, mf coats, l'ing c pores, ff masses		cs	
2Ck7	230 - 244	2.5Y 6/4d 2.5Y 4/4m	see below[1]	vfsl 34% vfs	m	sh	fr	so po	1vf	2vf	VE	mf & m coats[1], l'ing m pores, cf nodules		cs	
3Bk7	244 - 258	2.5Y 5/4d 2.5Y 4/3m	cfp 10YR 5/6d (4/6m) ffp 10YR 6/8d (5/8m)	l 32% vfs	1 fsbk	sh	fr	so po		2vf	VE	ff nodules, cf cylindroids (2 mm)		as	this parent material appears alluvial in nature
4Ck8	258 - 262	2.5Y 6/3d 2.5Y 3/2m		lfs 54% vfs	sg	lo	lo	so po			VE	cf nodules		as	
4Ck9	262 - 273	2.5Y 6/3d 2.5Y 4/4m	ffp 10YR 6/6d (5/8m) ffp 7.5YR 4/6d,m	vfsl 42% vfs	1 fsbk	sh	vfr	so po		2vf	VE	mm coats, ff nodules		as	
4Ck10	273 - 276	2.5Y 5/2d 2.5Y 3/2m		lfs 52% fs	sg	lo	lo	so po			VE	cf nodules		as	
5Bk/Ck	276 - 282	see below[2]	ffp 10YR 5/8d (4/6m) ffp 10YR 7/6d (5/6m)	vfsl 38% vfs	1 fsbk	so	fr	so po		1vf	VE	cf nodules, cm hard masses (2-3mm)		cs	clay & co silt distribution changes
5Ck11	282 - 298	2.5Y 5/3d 2.5Y 4/3m	see below[3]	vfsl 37% vfs	1 fsbk *	so	fr	so po	1vf *	1vf	VE	cf nodules, cm hard masses		cs	* structure very weak, cemented by $CaCO_3$; traces of old root channels
5Ck12	298 - 322	2.5Y 6/3d 2.5Y 4/4m	cfp 10YR 6/1d,m mmp 7.5YR 5/8d,m	l 34% vfs	1 fsbk ($CaCO_3$)	so	fr	so po	1vf *	1vf	VE	mf coats, ff masses, cf nodules		as	*traces of old root channels; rounded and angular sand grains
6A2	322 - 325	2.5Y 5/3d 2.5Y 4/3m	cfp 10YR 6/8d (5/6m)	fsl *	2 mpl	so	fr	so po	1vf	1f	VE	cm coats, cf nodules		as	* 20% fs, 20% vfs, 17% med sand
6E	325 - 326	2.5Y 7/2d 2.5Y 5/1m		lfs *	sg	lo	lo	so po	1vf		SL	ff nodules		as	* 50% fs, 17% vfs
6Bw3	326 - 328	10YR 3/4d 10YR 3/3m	cmp 7.5YR 5/8d,m	fsl *	1 mpl	sh	fr	so po	1vf	1vf	NE			as	* 25% fs, 20% vfs
6Bk8	328 - 331	2.5Y 6/2d 2.5Y 4/2m	cmp 10YR 6/8 (5/6m) cfp 7.5YR 5/8d,m	vfsl *	1 mpl	sh	fr	so po	1vf	1vf	ST	cm masses, cf threads, cf nodules		as	* 30% vfs, 22% fs, 8% med sand
6C1	331 - 333	2.5Y 6/3d 2.5Y 4/2m		s *	sg	lo	lo	so po			NE	vf fine nodules		as	* 47% fs, 6% vfs, 35% med sand; angular sand grains
7Bw4	333 - 345	2.5Y 6/3d 2.5Y 5/3m	ffp 7.5YR 5/6d (4/6m) *	vfsl *	1 mpl	sh/lo	fr/lo	so po		2vf	NE/ST[4]	l'ing m pores w/ gray mottles		as	*30% fs, 44% vfs; cfp & cmp 10YR 6/8d (5/8m), fmp 10YR 4/2d (3/2m)
7Bw5	345 - 346	2.5Y 5/2d 2.5Y 3/1m	ffp 10YR 6/8d,m	c 44% c	1 fpl	sh	fr	so po		1f	VE	mf nodules		as	change in coarse silt distribution in this (7) parent material
7C2	346 - 368	2.5Y 6/3d 2.5Y 5/3m	see below[4]	vfsl *	1 mpl	sh	fr	so po		1f	NE/ST[4]	ff nodules		end	* 40% vfs, 30% fs

Other

[1]**2Ck7** - Mottles: ffp 7.5YR 5/8d (4/6m) near roots; cfp 10YR 6/8d (5/8m). Carbonates: carbonate coatings, some with vertical orientation (2×50 mm), and some in 10×10 mm patches. Mottles and carbonates associated?

[2]**5Bk/Ck** - Matrix color: (Bk) 2.5Y 6/4d (4/4m); (Ck) 2.5Y 7/3d (5/3m).

[3]**5Ck11** - Mottle color: cfp 10YR 6/8d (5/8m); cfp 10YR 6/1d (5/1m); cfp 5YR 4/6d (4/6m).

[4]**7C2** - Mottles: mmf 2.5Y 5/2m; cmp 10YR 5/6m; ccp 10YR 3/2d (2/1m) cemented; ffp 10YR 5/8m. Carbonates occur in pockets (as in **7Bw4** above).

Figure A.1b Soil profile description, Transect 1, pedon 1 (sheet 2 of 2).

Double Ditch State Historic Site

Location N719.509 360.457E — Pedon # 32BL8 T1-2 SHEET 1 OF 2

Area Double Ditch: undisturbed transect, west end — Elevation 524.005

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence			Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
						Dry	Moist	Wet							
A1	0 - 4	2.5Y 4/2d 2.5Y 3/2m		sil 20% vfs	2 vfsbk	sh	fr	so po	1f 3vf	2f 3vf	NE			cs	hydrophobic
A2	4 - 7	2.5Y 5/2d 2.5Y 3/2m		sil 25% vfs	2 fsbk	sh	fr	so po	2f 3vf	2f 3vf	NE			cs	
A3	7 - 13	2.5Y 5/3d 2.5Y 4/2m		sil 25% vfs	1 fsbk	sh	fr	so po	2f 2vf	1f 1vf	NE			cs	
Bw	13 - 26	2.5Y 5/3d 2.5Y 4/2m		sil 23% vfs	1 fpr	sh	fr	so po	2f 2vf	2f 1vf	SL			cs	texture feels gritty when dry: fine $CaCO_3$ nodules?
Bk1	26 - 36	2.5Y 5/3d 2.5Y 4/2m		sil 21% vfs	1 fpr	h	h	so po	1m 2f 2vf	1f 1vf	ST	ff nodules, ff coats	small (5mm) fleck of charcoal at 28 cm; small wood frag at 33 cm	cs	$CaCO_3$ morphology increases with depth
Bk2	36 - 53	2.5Y 5/3d 2.5Y 4/2m	fff 2.5Y 7/2d $CaCO_3$	sil 21% vfs	1 mpr	sh	fr	so po	1f 2vf	1f 1vf	ST	ff masses, cf nodules		cs	
Bk3	53 - 78	2.5Y 6/3d 2.5Y 4/2m	cmf 2.5Y 7/2d $CaCO_3$	sil 20% vfs	1 mpr→ 2 fsbk	sh	fr	so po	1f 2vf	1f 2vf	VE	cm masses, cf nodules, l'ing c pores		gs	$CaCO_3$ lining pores below 60 cm
Ck1	78 - 102	2.5Y 6/3d 2.5Y 5/3m	cff 2.5Y 5/2d (4/2m)	sil 20% vfs	m	sh	fr	so po	1vf	3vf	VE	cm masses, fm nodules, l'ing c pores		cs	
Ck2[1]	102 - 214	2.5Y 6/3d 2.5Y 4/2m		sil 20% vfs	m	sh/so	fr	so po	1vf	1vf *	VE	ff coats, ff masses, ff nodules		as	*195+ cm, 2 mm diam. straight verticle pores in-filled w/ looser soil
2Ak1	214 - 217	2.5Y 5/2d 2.5Y 3/2m	cfd 2.5Y 6/4d (5/4m) faunal mixing	sil 18%	m	so	fr	so po		2vf 1f	VE	ff coats, ff nodules		as	
2Ck3	217 - 222	2.5Y 6/3d 2.5Y 4/2m		sil 18% vfs	m	sh	fr	so po	1vf	1vf	VE	ff nodules, l'ing f pores		ai	
3Ak2	222 - 230	10YR 4/2d 10YR 3/2m		sil 22% vfs	1 fabk	sh	fr	so po		2vf	VE	see below[2]		ci	
3Bk4	230 - 250	2.5Y 5/4d 2.5Y 4/4m	ccf 2.5Y 6/4d (4/6m) ffp 7.5YR 5/8d (3/4m)	l 33% vfs	1 fsbk	sh	fr	so po	1vf	3vf	VE	mf threads, mf masses, cf coats		gs	faunal mixing with 3Ak2
3Bk5	250 - 270	2.5Y 6/4d 2.5Y 4/4m		l 35% vfs	1 fsbk	sh	fr	so po		1vf	VE	ff masses, cf nodules, ff threads, l'ing f pores		cs	nodules ~ .5 mm
3Ck4	270 - 300	2.5Y 6/3d 2.5Y 4/3m	fmd 2.5Y 6/1d (5/1m) ffp 7.5YR 5/8d (4/6m)	vfsl 40% vfs	m	sh	fr	so po		1vf	VE	cf nodules, cf threads, l'ing c pores, ff masses		gs	
3Ck5[3]	300 - 325	2.5Y 5/3d 2.5Y 4/2m	mff 2.5Y 6/4d (5/4m) cfp 7.5YR 5/8 (4/6m)	vfsl 46% vfs	m	sh	fr	so po		1vf	VE	cf nodules, cf threads, l'ing c pores, ff masses		cs	pink and black sand grains, quartz
3Ck6	325 - 341	2.5Y 5/4d 2.5Y 4/4m	see below[4]	vfsl 47% vfs	m	sh	fr	so po		1f 3vf	VE	cf nodules, cm masses		as	one pocket of clean sand at 328 cm

Other

[1]**Ck2** - Sample shattered from 102-119 cm, from transfer to pvc. Few pores (2mm) lined with 2.5Y 4/1d (2.5/1m) material, probably organic (smeared when wet). From 119-214, structure may be 1 mpr or massive; slightly hard with few pockets of soft consistence. [2]**3Ak2** - Carbonates: common fine masses and threads, obvious pattern of concentration around pores. Faunal mixing appears to come up from below; occurs 225-230 cm.

[3]**3Ck5** - Mottles: fmd 2.5Y 7/1d (6/1m) in addition to above. Few fine Mn concentrations. Texture: contains a few pockets (4 cm diameter) of loose clean sand 320-325 cm depth.

[4]**3Ck6** - Mottles: ccd 2.5Y 6/2d (10YR 6/1m), elongated; cmp 7.5YR 5/8d,m; cfp 5YR 5/8d (4/6m), a few of which contain 1mm black concretions in center of mottle; relict roots channels in-filled with 10YR 4/2d material.

Figure A.2a Soil profile description, Transect 1, pedon 2 (sheet 1 of 2)

Double Ditch State Historic Site

Location: N719.509 360.457E — Pedon #: 32BL8 T1-2 SHEET 2 OF 2

Area: Double Ditch: undisturbed transect, west end — Elevation: 524.005 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence			Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
						Dry	Moist	Wet							
4Ck7	341 - 350	2.5Y 4/4d 2.5Y 3/3m	see below[5]	lvfs 50% vfs	sg/m*	lo/sh	fr	so po		1vf	SL	ff nodules		as	* some cementation from $CaCO_3$
5Btk[6]	350 - 355	2.5Y 5/4d 2.5Y 4/3m	see below[6]	sicl[6] 15% vfs*	2 tkpl	h	fi	ss ps		1f 3vf	VE	mf nodules, cf threads[6]		as	*32% clay
5Ck8	355 - 360	2.5Y 6/4d 2.5Y 4/4m	cfp 10YR 7/8d (5/8m) see below[7]	vfsl 45% vfs	2 tnpl→ 2 vnpl	h*	fi	so po		1f 1vf	VE	mf nodules, cf threads[7]		end	

Other

[5] **4Ck7** - Mottles: cmd 2.5Y 6/2d (10YR 6/1m); ffp 7.5YR 6/8d (5/8m); ffp 5YR 6/8d (5/8m). Mottling similar to above horizon, influenced by 5Btk below. Texture: clean sand, sg to m, from 341-343; sampled separately.

[6] **5Btk** - Mottles: cfd 2.5Y 6/2d (5/1m); cfp 10YR 6/6d (5/6m); cfp 10YR 4/6d,m. Texture: clay films (2.5Y 5/4m) on horizontal ped faces. Carbonates: threads on horizontal ped faces.

[7] **5Ck8** - Mottles: one large mass/nodule, 3×2×1.5 cm, 7.5YR 4/6m with a few spots of 10YR 6/8m and one, 1mm spot of 2.5Y 7/1m in its center; firm consistence, SL eff. Carbonates: many 1-5 mm pitted eff. nodules of irregular shape.

Figure A.2b Soil profile description, Transect 1, pedon 2 (sheet 2 of 2)

Double Ditch State Historic Site

Location	N719.458 380.499E	Pedon #	32BL8 T1-3 SHEET 1 OF 2
Area	Double Ditch: undisturbed transect, near west end	Elevation	524.534 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence			Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
						Dry	Moist	Wet							
Oi	0 - 1								1m 3f 2vf	2f 2vf	NE			as	grasses and forbs
A1	1 - 3	2.5Y 4/2d 10YR 2/2m		sil 15% vfs	2 fsbk	sh	fr	so po	3vf 2f	3vf	NE			as	hydrophobic
A2	3 - 8	2.5Y 4/2d 2.5Y 3/2m		sil 18% vfs	2 fsbk	sh	fr	so po	2vf 1f	2vf 1f	NE			cs	possibly on edge of krotovina-- 3 fsbk structure and increased roots
Bw	8 - 33	2.5Y 5/3d 2.5Y 4/2m		sil 27% vfs	1 fpr→ 1 fsbk	so	vfr	so po	2vf 2f	2vf 1f	SL	ff masses (16-19 cm)*	bone frag at 19 cm*	cs	*krotovina from 19-33 cm, sampled separately
Bk1	33 - 63	2.5Y 5/2d 2.5Y 4/2m	fff 2.5Y 7/2d $CaCO_3$ coats	sil 25% vfs	1 fpr→ 2 mabk	sh	fr	so po	2vf 1f	2vf 1f	ST	ff coats, ff nodules		cs	
Bk2	63 - 77	2.5Y 5/3d 2.5Y 4/3m		sil 28% vfs	1 mpr→ 2 mabk	sh	fr	so po	2vf 1f	3vf 1f 1m	VE	ff coats, cf nodules, l'ing f pores		gs	
Bk3	77 - 118	2.5Y 6/2d 2.5Y 4/2m		sil 25% vfs	1 mpr→ 1 msbk	sh	fr	so po	2vf 1f 1m	3vf 2f 1m	VE	cf coats, cf nodules, l'ing f pores		gs	
Ck1	118 - 197	2.5Y 6/3d 2.5Y 4/3m		sil 20% vfs	m	sh	fr	so po	1vf 1f	3vf 1f 1m	ST	ff coats, cf nodules, l'ing f pores		cs	
Ck2	197 - 229	2.5Y 5/3d 2.5Y 4/3m		sil 28% vfs	m	h	fr	so po	1vf	3vf 1f	ST	ff coats, ff nodules		cs	
2Bk4	229 - 260	2.5Y 6/3d 2.5Y 4/3m	cfd 2.5Y 6/1d (5/1m) cfd 2.5Y 6/4d *	sil 25% vfs	2 mpr→ 3 cabk	vh *	fi	so po	1vf	3vf 1f	VE	mf nodules, cf masses, l'ing m pores *		as	*10YR 5/6m; cementation due to $CaCO_3$, ↓ with depth
2Ck3[1]	260 - 267	2.5Y 5/3d 2.5Y 4/3m	cfp 10YR 5/2d (3/2m) *	sil 23% vfs	m	vh	fi	so po	1vf	3vf 1f	VE	mf nodules, mf masses, l'ing m pores		as	*faunal mixing with 2Ck3 and 3Ak1
2Ck4[1]	267 - 275	2.5Y 5/2d 10YR 3/2m	see below[1]	sil 28% vfs	m	vh	fi	so po	1vf	3vf 1f	ST	cf masses, l'ing c pores		aw	darkening color from copius mixing by worms
3Ak1[1]	275 - 277	10YR 4/2d 10YR 2/1m	see below[1]	sil 18% vfs	1 fsbk	h	fr	so po	1vf 1f	2vf 2f	ST	cf masses, l'ing m pores		as	see below[1]
3Ak2[1]	277 - 283	10YR 4/1d 10YR 2/1m	see below[1]	sil 18% vfs	1 fsbk	h	fr	so po	1vf 1f	2vf 1f	ST	ff masses, l'ing c pores		cs	
3Bk4	283 - 298	2.5Y 6/2d 2.5Y 4/2m	ccf 2.5Y 6/3d (4/3m)	l 38% vfs	m	vh	fr	so po	1vf	1vf	ST	ff nodules, cf threads, ff coats, l'ing f pores		cs	$CaCO_3$ threads are concave, horizontal orientation
3Bk5	298 - 314	2.5Y 6/2d 2.5Y 4/2m		l 38% vfs	m	vh	fr	so po	1vf	1vf	ST	ff nodules, ff coats		cs	
3Ck5	314 - 334	2.5Y 6/3d 2.5Y 4/3m	see below[2]	vfsl 42% vfs	m	h	fr	so po		2vf	ST	ff nodules, ff masses		cs	

Other

[1]**2Ck3, 2Ck4, 3Ak1, 3Ak2** - Faunal turbation in all four horizons, extending in both directions. Some 2Ck3 material found in 3Ak1; some 3Bk5 material found in 3Ak1.

[2]**3Ck5** - Mottles: ffp 10YR 5/6d (4/6m); cff 2.5Y 6/4d (5/3m); cff 2.5Y 7/2d (6/1m).

Figure A.3a Soil profile description, Transect 1, pedon 3 (sheet 1 of 2)

Double Ditch State Historic Site

Location N719.458 380.499E — Pedon # 32BL8 T1-3 SHEET 2 OF 2

Area Double Ditch: undisturbed transect, near west end — Elevation 524.534 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence Dry	Consistence Moist	Consistence Wet	Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
3Ck6	334 - 356	2.5Y 6/3d 2.5Y 4/3m	see below[3]	vfsl 43% vfs	m	h	fr	so po		1m 1f 2vf	ST	see below[3]		cs	few Mn masses
4Ck7	356 - 366	2.5Y 5/3d 2.5Y 4/3m		fsl *	m	sh	vfr	so po		1vf	ST	cf nodules, 2f masses		end	* 32% fs, 31% vfs

Other: [3]**3Ck6** - Mottles: mottles total 60% of hoizon color; cmd 2.5Y 6/1d (5/1m); cmd 2.5Y 6/6d (5/6m); ffp 10YR 5/8d (4/6m); fcf 2.5Y 5/2d (4/2m) with 3f pores. Carbonate morphology clearly shown along f roots channels and associated with low chroma mottles

Figure A.3b Soil profile description, Transect 1, pedon 3 (sheet 2 of 2)

Double Ditch State Historic Site

Location: N719.496 400.404E — Pedon #: 32BL8 T1-4

Area: Double Ditch: undisturbed transect, west of center — Elevation: 525.425 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence Dry	Consistence Moist	Consistence Wet	Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
Oi	0 - 2								3vf 3f	3vf 3f				aw	very dense root mat, short and tall grasses
A1	2 - 5	2.5Y 4/2d 2.5Y 3/1m		sil 18% vfs	2 vfsbk	sh	fr	so po	3vf 2f	2vf 1f	NE			as	hydrophobic
A2	5 - 15	2.5Y 5/3d 2.5Y 3/2m		sil 22% vfs	1 fsbk	sh	fr	so po	2vf 1f	2vf 1f	NE			as	
Bk1	15 - 56	2.5Y 5/2d 2.5Y 3/2m	fmd 2.5Y 7/1d $CaCO_3$ coats	sil 20% vfs	2 fsbk	sh	fr	so po	2vf 1f	2vf 1f	SL	fm coats, ff nodules		cs	krotovina--see below[1]
Bk2	56 - 68	2.5Y 5/3d 2.5Y 4/2m	cmd 2.5Y 7/1d CaCO3 coats	sil 22% vfs	1 fpr→ 1 mabk	sh	fr	so po	1vf 1f	2vf 2f	ST	cm coats, cf nodules, l'ing f pores		gs	fine sand grains subrounded
Bk3	68 - 96	2.5Y 6/3d 2.5Y 4/3m	cmd 2.5Y 7/1d CaCO3 coats	sil 18% vfs	1 mpr→ 1 mabk	sh	fr	so po	1vf 1f	3vf 1f	VE	cm coats, cf nodules, l'ing m pores		cs	
Ck1	96 - 131	2.5Y 6/3d 2.5Y 4/3m		sil 25% vfs	m	sh	fr	so po	1vf	2vf 1f	ST	fm coats, cf nodules		cs	
Ck2[2]	131 - 205	2.5Y 6/3d 2.5Y 5/4m	cmd 2.5Y 5/2d (3/2m) 198-205 cm[2]	sil 32% vfs	m	sh	fr	so po	1vf	2vf 1f	ST	fm coats, ff nodules, l'ing f pores		cs	see below[2]
2A3	205 - 211	10YR 4/2d 10YR 3/2m	mmd 10YR 5/3(4/2m) faunal turbation	sil 18% vfs	1 fsbk	sh	fr	so po	1vf	2vf 1f	ST	ff nodules		cs	~ 5% fs (subrounded); mottling, mixing by worms with Ck2 above
2A4	211 - 215	10YR 4/2d 10YR 3/1m	cfd 10YR 5/4d (4/4m) faunal turbation	sil 21% vfs	1 fsbk	sh	fr	so po	1vf	2vf 1f	ST	ff nodules		cs	mixing by worms with 2Bk4 below
2Bk4	215 - 225	10YR 6/4d 10YR 4/3m	see below[3]	l 32% vfs	2 cpr	sh	fr	so po	1vf	3vf 1f	VE	2m coats, 1f nodules, l'ing f pores		as	mixing by worms with 2A4 above
2Ck3[4]	225 - 305	2.5Y 6/3d 2.5Y 5/2m	cfd 2.5Y 5/1d (4/1m) cmf 2.5Y 6/4d (5/4m)	vfsl[4] 40% vfs	m	so/sh[4]	vfr	so po	1vf	1vf 1f	SL/ST (bands)	2f coats, 2f nodules, l'ing c pores*		cs	*$CaCO_3$ holding pores intact; eff. varies w/ banding. Few Mn concr.
2Ck4	305 - 331	2.5Y 5/3d 2.5Y 4/3m		vfsl 42% vfs	m	sh	vfr	so po	1vf	1vf	ST	1f coats, 1f nodules		cs	fine sand is subrounded
3Ck5	331 - 343	2.5Y 6/3d 2.5Y 4/4m	cf & md 2.5Y 5/2d (4/2m)	vfsl 50% vfs	m	sh	fr	so po	1vf	3vf 2f*	ST	cf threads, ff nodules, l'ing f pores		end	*2f pores vertical in orientation (1fpr structure?)

Other

[1]**Bk1** - Krotovina: 24-36 cm (sampled separately); 2.5Y 4/2d (3/2m); sil, 20% vfs; so, fr, so, po; 3vf, 1f roots; 3vf, 2f pores; SL; ff $CaCO_3$ nodules.

[2]**Ck2** - Texture: two small pockets of soil and organic matter (partially decomposed, still fibrous) at 141 cm and 149 cm; 10YR 4/2d (3/1m). Mottling: (198-205 cm) vertical pockets of darker soil from below.

[3]**2Bk4** - Mottles: cmd 10YR 4/1d (2/1m), often vertical, probable worm channels (4 mm diameter); mmp 2.5Y 7/2d (6/2m) $CaCO_3$ coats.

[4]**2Ck3** - Texture: frequent bands of clay loam and fine sand within a matrix of vfsl. From 297-305 cm have slightly hard dry consistence. Mottles: 2.5Y 5/1d are thin horizontal bands assoc with clay loam.

[5]**3Ck5** - Structure: definite vertical orientation of cracks. Mottles: appear to be in-filled worm channels, from a now nonexistant A-horizon. Not from paleo-A; no similar feature between 221-331 cm.

Figure A.4 Soil profile description, Transect 1, pedon 4

Double Ditch State Historic Site

Location: N719.548 420.429E — Pedon # 32BL8 T1-5 SHEET 1 OF 2

Area: Double Ditch: undisturbed transect, west of center — Elevation 526.159 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence Dry	Consistence Moist	Consistence Wet	Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
A	0 - 6	2.5Y 4/2d 2.5Y 3/2m		sil 24% vfs	1 fsbk	sh	fr	so po	3f 2vf	1f 3vf	NE			cs	very fine roots in a mat on the surface; hydrophobic
Bw1	6 - 12	2.5Y 4/3d 2.5Y 3/2m		sil 28% vfs	1 msbk	sh	fr	so po	2f 2vf	2f 2vf	NE			cs	
Bw2	12 - 18	2.5Y 5/2d 2.5Y 3/2m		sil 28% vfs	1 mabk	sh	fr	so po	2f 3vf	1f 2vf	SL			as	
Bk1	18 - 27	2.5Y 5/2d 2.5Y 3/2m		sil 25% vfs	1 cabk	sh	fr	so po	2f 2vf	1f 3vf	SL	ff coats		as	
Bk2	27 - 38	2.5Y 5/2d 2.5Y 4/2m	cmf 2.5Y 6/2d ($CaCO_3$)	sil 22% vfs	1 fpr	sh	fr	so po	2f 3vf	2f 2vf	ST	cm coats, l'ing c pores		cs	moist color slightly more red, but not 10YR
Bk3	38 - 49	2.5Y 5/2d 2.5Y 4/2m	cmf 2.5Y 6/2d (CaCO3)	sil 20% vfs	1 mabk	sh	fr	so po	1f 2vf	3vf 1f	ST	cm coats, l'ing f pores		cs	a few insect burrows present (5 mm diameter)
Bk4	49 - 76	2.5Y 6/3d 2.5Y 5/3m	cmf 2.5Y 6/2d (CaCO3)	sil 17% vfs	1 mabk	sh	fr	so po	1f 2vf	2vf 1f	ST	cf coats, l'ing f pores		gs*	
Bk5	76 - 89	2.5Y 6/3d 2.5Y 5/3m	cfd 2.5Y 5/2d (4/1m)	sil 17% vfs	1 fabk	sh	fr	so po	1f 1vf	3vf 1f	VE	cf coats, l'ing f pores		cs	
BCk	89 - 107	2.5Y 6/3d 2.5Y 4/3m		sil 20% vfs	1 msbk	h	fr	so po	1f 1vf	2f 1vf	VE	ff coats, cf nodules, l'ing c pores		cs	*soil from 93-102 cm shattered from transfer; depths corrected
CBk	107 - 123	2.5Y 6/3d 2.5Y 4/3m		sil 22% vfs	m	sh	fr	so po	1vf	1f 1vf	ST	cf coats, l'ing f pores, cf nodules		cs	
Ck1	123 - 162	2.5Y 6/3d[1] 2.5Y 4/3m	see below[1]	sil 25% vfs	m	sh	fr	so po	1vf	2vf 1f	ST	fm nodules, 2f & 1m coats, l'ing c pores		gs	<5% f or m sand, quartz, subrounded
Ck2	162 - 177	2.5Y 5/2d 2.5Y 3/2m	ccd 10YR 4/1d (3/2m)	sil 25% vfs	m	sh	fr	so po	1vf	2vf 2f	ST	fm nodules,ff coats		cs	change in color due to underlying A-horizon?
2Ak1	177 - 184	2.5Y 5/2d 2.5Y 3/2m	ccd 10YR 4/1d (3/2m)	sil 15% vfs	1 fsbk	sh	fr	ss po	1vf	1vf 2f	ST	fm nodules, 2f coats	small piece of charcoal (bagged)	cs	slight increase in fs content from Ck horizons
2Bk6	184 - 223	2.5Y 5/2d 2.5Y 3/2m	see other *	sil 28% vfs	1 msbk	sh	fr	so po	1vf	1m 2f 2vf	ST	fm nodules, 1f coats	charcoal (<1 mm) at 202 cm; piece of wood; snail shell	gs	* cfd 10YR 4/1d (3/2m), ccd 10YR 4/1d (3/2m), ffp 10YR 6/4d (5/6m)
3Ak2	223 - 228	2.5Y 4/1d 2.5Y 3/1m	see below[2]	sil 24% vfs	1 mabk	h	fr	so po		2vf 1f	ST	cf coats, cf threads, l'ing c pores		cw	
3Ak3	228 - 232	2.5Y 5/2d 10YR 3/3m	cfd 2.5Y 4/1d (3/1m)	sil 20% vfs	1 fabk	h	fr	ss po		2vf	ST	mf threads, l'ing c pores, ff nodules		cs	mixing by worms with above horizon
3Bk7	232 - 256	2.5Y 5/4d 2.5Y 4/4m	see below[3]	l 22% vfs	1 fabk	sh	fr	ss po		1f 2vf	ST	mf coats, mf threads, l'ing c pores, ff masses		gs	

Other

[1] **Ck1** - Matrix color: soil becomes slightly grayer/darker with depth (129-142 cm); not measurable with Munsell; due to carbonates? Mottles: at ~157 cm (increasing at 165-172 cm), fmp 10YR 3/2d (2/1m); fcd 2.5Y 5/2d (3/2m).

[2] **3Ak2** - Mottles: cfp 10YR 6/6d (4/6m), ffp 10YR 4/3d (3/3m); mixing by worms with horizons above and below. Weakest expression of the paleo-A, paler and thinner--diluted by mixing, especially with 2Bk6.

[3] **3Bk7** - Mottles: cfd 2.5Y 4/1d (3/1m), in-filled worm channels; cfd 2.5Y 5/1d (4/1m); cmp 10YR 4/2d (2.5Y 4/2m).

Figure A.5a Soil profile description, Transect 1, pedon 5 (sheet 1 of 2)

Double Ditch State Historic Site

Location N719.548 420.429E — Pedon # 32BL8 T1-5 SHEET 2 OF 2

Area Double Ditch: undisturbed transect, west of center — Elevation 526.159 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence			Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
						Dry	Moist	Wet							
3Bk8	256 - 263	2.5Y 5/4d 2.5Y 4/3m	ffp 2.5Y 6/8d (5/8m)	l 35% vfs	1 fpr→ 1 fsbk	sh	fr	so po		1vf	ST	cf threads, mf nodules		gs	
3Ck3	263 - 286	2.5Y 5/3d 2.5Y 4/3m		vfsl 40% vfs	m	sh	fr	so po		1vf	VE	cf coats, cf threads, cf nodules		cs	
3Ck4	286 - 307	2.5Y 6/3d 2.5Y 4/3m	see below[5]	vfsl 37% vfs	m	sh	fr	so po		1vf	VE	cf coats, cf nodules, l'ing f pores		cs	
4Ck5	307 - 321	2.5Y 5/3d 2.5Y 4/3m	see below[6]	fsl *	m	so	vfr	so po		1f	VE	cm threads, cf nodules, l'ing c pores		end	* 30% fs, 30% vfs; pores preserved by $CaCO_3$s

Other

[5]**3Ck4** - Mottles: cfp 10YR 6/6d (5/6m); ffp 7.5YR 4/6d (3/4m).

[6]**4Ck5** - Mottles: in upper 3 cm, cmd 5Y 7/1d (6/1m) surrounded by very thin band of 10YR 6/8d (5/8m); ffp 2.5N (d,m). In lower 10 cm, ccd 10YR 3/2d (2/2m), ffp 10YR 3/6d,m; ffd 10YR 3/2d (2/2m) tubular, as if pores filled with A-horizon material. Texture: characterized by several bands of grayer, very clean, very fine sands.

Figure A.5b Soil profile description, Transect 1, pedon 5 (sheet 2 of 2)

Double Ditch State Historic Site

Location: N719.527 440.457E — Pedon #: 32BL8 T1-6

Area: Double Ditch: undisturbed transect, center — Elevation: 527.214 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence Dry	Consistence Moist	Consistence Wet	Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
Oe	0 - 1.5								3f 3vf	3f	NE			aw	short and tall grasses and roots
A1	1.5 - 7	2.5Y 5/2d 2.5Y 3/2m		sil 23% vfs	1 msbk	sh	fr	so po	3vf 2f	2f	VSL		slightly decomposed wood fragments into A2 and Bk1	as	wood frags 7.5YR 5/6d, unrubbed, 1.5×5 cm, vertical orientation
A2	7 - 16[1]	2.5Y 5/2d 2.5Y 3/2m		sil 25% vfs	1 msbk	sh	fr	so po	3vf 3f	3f	NE		wood frags extend into this horizon from above	aw	
Bk1	16 - 34	2.5Y 5/2d 2.5Y 3/2m		sil 25% vfs	1 fpr→ 2 fsbk	sh	fr	so po	3vf 2f	2f	SL	ff nodules		cs	
Bk2	34 - 42	2.5Y 5/2d 2.5Y 3/2m		sil 21% vfs	2 mpr	sh	fr	so po	3vf 2f	2f	ST	ff nodules, ff threads		cs	
Bk3	42 - 66	2.5Y 5/2d 2.5Y 4/2m	cmf 2.5Y 7/2d $CaCO_3$ coats	sil 20% vfs	2 mpr	sh	fr	so po	2vf 1f	2vf	ST	cm coats (ped faces), cm nodules, f masses*		cs	* masses below 60 cm, 4 mm diameter
Bk4	66 - 73	2.5Y 5/3d 2.5Y 4/3m		sil 18% vfs	2 mpr	sh	fr	so po	2vf	2vf	VE	mm masses, cf nodules, l'ing f pores		cs	$CaCO_3$ masses are soft
Bk5	73 - 95	2.5Y 6/3d 2.5Y 4/3m		sil 18% vfs	1 cpr	sh	fr	so po	2vf	2vf	VE	mm nodules, mm masses, mf threads *		as	* $CaCO_3$ concentrated around most pores; nodules 0.5-1.5 mm
Ck1	95 - 185	2.5Y 6/3d 2.5Y 4/3m		sil 20% vfs	m	h	fr	so po	1vf 1f*	2vf 1f	VE	cf nodules, ff masses around pores		gs	* very few very fine roots below 150 cm
Ck2	185 - 252	2.5Y 6/3d 2.5Y 4/2m[2]	fmf 2.5Y 5/2d (3/2m) 214+ cm (worms ↓)	sil 28% vfs	m	sh	fr	so po	1vf	2vf 1f	VE	cf masses, l'ing f vertical pores	shell fragments[2]	cs	faunal turbation with 2Ak1
2Ak1	252 - 258	10YR 4/2d 10YR 3/1m	fmf 10YR 6/3d (4/2m) mixing by worms ↑	sil 15% vfs	m	h	fr	so po		1vf	VE	cm threads, cf nodules, l'ing c pores		cs	common vf Mn concretions; horizon has a brittle quality
2Ak2	258 - 266	10YR 4/4d 10YR 3/3m	mff 10YR 4/2d (3/2m) mixing by worms ↑	sil 16% vfs	m	sh	fr	so po	1vf	1vf	VE	mm threads, mf nodules, l'ing f pores		cs	mixing by worms extends from ~214-278 cm
2Bk6	266 - 276	10YR 4/6d 10YR 3/3m	cfd 10YR 3/3d, m mixing by worms ↑	sil 21% vfs	1 mpr ?	sh	fr	so po	1vf	2vf 1f	VE	mm threads, mf nodules, l'ing f pores		cs	ffp 5YR 4/6d (3/4m) at lower boundary (266 cm)
2Bk7	276 - 302	2.5Y 5/4d 2.5Y 4/3m	see below[3]	l 33% vfs	1 mpr ?	sh	fr	so po		2vf	VE	cm threads, cf nodules, l'ing c pores *		gs	* fm soft $CaCO_3$ masses
2Ck3	302 - 314	2.5Y 6/2d 2.5Y 4/2m	ffp 7.5YR 5/8d (4/6m)	vfsl * 37% vfs	m	sh	fr	so po		2vf 1f	VE	ff nodules, ff threads, l'ing c pores, cf masses		cs	* 16% fs. $CaCO_3$ primarily on vertical ped faces
3Ck4	314 - 321	2.5Y 5/3d 2.5Y 4/2m	ffp 7.5YR 5/8d (4/6m)	vfsl * 30% vfs	m	sh	fr	so po		3vf 1f	VE	ff nodules, ff threads, l'ing f pores, ff masses		cs	* 20% fs; some thin banding, clean fs, vfs at 311 cm (rounded)
3Ck5	321 - 367	2.5Y 6/3d 2.5Y 4/4m	see below[4]	fsl[4]	m	so	vfr	so po		1vf 1f	VE	mf nodules, cf masses, l'ing f pores		end	

Other

[1] **A2, Bk1** - lower boundary of A2 from 13.5-18 cm; it appears that the A2 horizon has been driven into the Bk1 with the wood fragments (wooden stake?).

[2] **Ck2** - Matrix color: slightly grayer than Ck1. Below 196 cm is darker than 185-196 cm; not describable by Munsell. Relict root channels below 207 cm. Shell fragments at 248-252 cm. Worm activity blurred lower boundary.

[3] **2Bk7** - Mottles: cfp 10YR 4/6d, m, elongated; ffp 7.5YR 5/6d, m (with 16× hand lens); ffp 10YR 6/1d (5/1m).

[4] **3Ck5** - Mottles: cff 2.5Y 6/4d (6/6m); cfd 10YR 5/6d (5/8m); fff 2.5Y 6/1d (5/1m). Texture: varies from 20% fs with 27% vfs to 32% fs with 31% vfs. Majority of sand grains appear water-worked (rounded).

Figure A.6 Soil profile description, Transect 1, pedon 6

Double Ditch State Historic Site

Location: N719.538 460.476E — Pedon #: 32BL8 T1-7

Area: Double Ditch: undisturbed transect, east of center — Elevation: 527.863 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence Dry	Consistence Moist	Consistence Wet	Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
A	0 - 3	2.5Y 4/2d 2.5Y 3/1m		sil 20% vfs	2 tkpl→ 2 fsbk	sh	fr	so po	2m 3f 3vf	2f 3vf	NE			aw	hydrophobic
Bw1	3 - 7	2.5Y 5/2d 2.5Y 3/2m		sil 25% vfs	1 tkpl→ 2 fsbk	sh	fr	so po	1m 3f 3vf	2vf	NE			as	
Bk1	7 - 15	2.5Y 5/3d 2.5Y 3/3m		sil 25% vfs	1 fsbk	sh	fr	so po	2f 2vf	1f 2vf	VSL	c rings (pores?), ff nodules		cs	
Bk2	15 - 33	2.5Y 4/2d 2.5Y 3/2m		sil 23% vfs	1 mpr	sh	fr	so po	1m 1f 2vf	1m 1f 2vf	SL	f rings, cf nodules, l'ing f pores	bone frags, rock frags (w/ $CaCO_3$ coats), charred seed	cs	
Bk3	33 - 46	2.5Y 4/3d 2.5Y 3/2m		sil 20% vfs	2 fpr	sh	fr	so po	2f 2vf	1m 1f 2vf	ST	cm coats, cf nodules, l'ing f pores		cs	
Bk4	46 - 56	2.5Y 5/2d 2.5Y 3/2m		sil 18% vfs	2 fpr	sh	fr	so po	1f 2vf	1m 1f 3vf	ST	ff masses, cf nodules, l'ing f pores		aw *	truncated by underlying krotovina
krotov.	56 - 62	2.5Y 4/2d 2.5Y 3/2m		sil 18% vfs	3 fsbk	sh	fr	so po	1f 2vf	1f 3vf	ST			aw	abrupt boundary with Ck1
Ck1	62 - 73	2.5Y 5/3d 2.5Y 4/3m	cff 2.5Y 5/3d (4/3m) *	sil 17% vfs	m	sh	fr	so po	2vf	1f 3vf	ST	cf nodules, l'ing c pores,* ff masses		cs	* in-filled roots channels ringed by $CaCO_3$
Ck2	73 - 168	2.5Y 6/3d 2.5Y 4/3m	cff 2.5Y 5/3d (4/3m) ($CaCO_3$ as above)	sil 20% vfs	m	sh	fr	so po	1vf	1m 1f 3vf	VE	cm masses, cf nodules, l'ing c pores	bird bone (?) frag (thin and hollow)	gs	somewhat cemented by $CaCO_3$
Ck3	168 - 202	2.5Y 5/3d 2.5Y 3/3m		sil 25% vfs	m	sh	fr	so po	1vf	1f 3vf	VE	see below[1]		gs	
Ck4	202 - 228	2.5Y 5/3d 2.5Y 3/3m	cfd 2.5Y 4/1d (3/2m) *	sil 30% vfs *	m	sh	fr	so po	1vf	1f 2vf	VE	cf nodules, c'ing f pores, com rings	shell	cs	* mottles = in-filled worm channels; increased fs from Ck3
Ck/Ak	228 - 234	Ck: 2.5Y 5/3d 2.5Y 3/3m	Ak: 2.5Y 4/2d 2.5Y 3/2m	l 15% fs 15% vfs	2 msbk	sh	fr	so po	1vf	2vf	ST	ff nodules	small shell fragments	gs *	* copius mixing by worms with 2Ak below
2Ak	234 - 246	2.5Y 4/2d 10YR 2/2m		sil 22 % vfs	2 fsbk	sh	fr	so po	1vf	2vf	VE	ff nodules, ff coats		cs	mixing by worms with horizons above and below
2Bk5	246 - 252	2.5Y 5/4d 2.5Y 3/3m	cfd 2.5Y 4/1d (3/1m) mixing by worms	l 32% vfs	m	h	fi	so po		1vf	VE	cf threads, l'ing c pores		cs	
2Ck5	252 - 266	2.5Y 5/4d 2.5Y 4/3m	ffp 2.5YR 4/8d, m ffd 2.5Y 2.5/1d, m	vfsl 35% vfs	m	eh	vfi	so po			ST	mf threads, few rings		end	

Other: [1]**Ck3** - Carbonates: mf nodules, ff threads, few "rings" ($CaCO_3$'s surrounding in-filled pores), mf soft masses, lining common pores.

Figure A.7 Soil profile description, Transect 1, pedon 7

Double Ditch State Historic Site

Location: N719.496 480.441E — Pedon #: 32BL8 T1-8 — SHEET 1 OF 2

Area: Double Ditch: undisturbed transect, east of center — Elevation: 527.952 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence Dry	Consistence Moist	Consistence Wet	Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
A1	0 - 3	2.5Y 3/2d 10YR 2/1m		sil 25% vfs	2 fsbk	so	vfr	so po	3f 2vf	2vf	NE		few vf bone frags (bison)	as	hydrophobic
Bw1	3 - 8	2.5Y 5/3d 2.5Y 3/3m		sil 27% vfs	3 mpl	sh	fr	so po	1f 2vf	1vf	VSL			cs	
Bw2	8 - 16	2.5Y 4/2d 2.5Y 3/2m		sil 28% vfs	1 mpr	sh	fr	so po	1f 2vf	2vf	SL			as	
Bw3	16 - 24	2.5Y 4/2d 2.5Y 3/2m		sil 28% vfs	2 mpr	sh	fr	so po	1f 2vf	1f 2vf	ST	ff nodules, ff masses (soft)		as	
2A2	24 - 27	2.5Y 4/2d 2.5Y 3/2m		sil 20% vfs	1 msbk	sh	fr	so po	1f 2vf	2f 2vf	ST	cf nodules, cf masses (soft)	bone frag ($CaCO_3$ chunk?)	as	
2Bw4	27 - 33	2.5Y 5/3d 2.5Y 3/3m		sil 20% vfs	1 mpr	sh	fr	so po	1f 2vf	1f 2vf	VE	c soft masses (2-4 mm)	bone frags; 1 insect egg sack (5 mm long)	as	krotovina with 2A2 material ~ ⅓ of horizon, below upper boundary
2Bk1	33 - 49	2.5Y 4/2d 2.5Y 3/2m		sil 22% vfs	1 mpr→ 1 msbk	sh	fr	so po	2vf	1m 2vf	ST	see below[1]		cs	
2Bk2	49 - 67	2.5Y 5/3d 2.5Y 4/4m		sil 26% vfs	2 fsbk	sh	fr	so po	2vf	2f 3vf	VE	cf nodules, c rings, l'ing c pores, c masses		cs	hard $CaCO_3$ masses
3Ak1	67 - 72	2.5Y 4/3d 2.5Y 3/3m		sil 5% fs 25% vfs	1 fsbk	sh	fr	so po	1m 1vf	1f 1vf	ST	cm nodules, cm coats, l'ing f pores		as	
3Bk3	72 - 100	2.5Y 6/2d 2.5Y 4/3m*		sil 28% vfs	1 mpr→ 1 mabk	sh	fr	so po	1c 2vf	1m 2f 2vf	ST	cf nodules, c coats, f rings, l'ing f pores		gs	* lightens slightly with depth (incr. $CaCO_3$?)
3Ck1	100 - 139	2.5Y 6/3d 2.5Y 4/3m		sil 32% vfs	1 mpr	sh	fr	so po	1f 1vf	1f 1vf	VE	ff nodules, f thin coats		cs	
4Bk4	139 - 152	2.5Y 5/2d 2.5Y 4/3m	mmf 2.5Y 6/3 (5/4m) mixing by worms*	sil 35% vfs	1 msbk	sh	fr	so po	1vf	2vf	ST	ff nodules, around f pores		cs	ffd 2.5Y 4/2d (3/1m) from non-existent A-horizon?
4Ck2	152 - 173	2.5Y 6/3d 2.5Y 4/3m		sil 30% vfs	m	sh	fr	so po	1vf	1f 2vf	ST	ff nodules, around f pores, l'ing f pores		cs	greater dolomite in "4" parent material? Slower fizz.
4Ck3	173 - 199	2.5Y 5/2d 2.5Y 4/2m	cff 2.5Y 6/3d (5/4m)	sil 32% vfs	m	sh	fr	so po	1vf	1m* 1f 2vf	ST	ff nodules, l'ing c pores		cs	* medium pores (~3 mm) appear to be earthworm channels, no in-fill
4Ck4	199 - 213	2.5Y 5/2d 2.5Y 4/3m	see below[2]	sil 30% vfs	m	sh	fr	so po	1vf	2vf	ST	ff nodules, c threads, l'ing f pores		cs	
4Ck5	213 - 239	2.5Y 5/2d[3] 2.5Y 4/3m	cfd 2.5Y 6/4d (5/4m) ffd 2.5Y 4/1d (3/1m)	sil 28% vfs	m	sh	fr	so po	1vf	2vf	ST	ff nodules, c threads, l'ing f pores		gs	soil fractured in thin vertical sheets (from coring?)
4Ck6	239 - 246	2.5Y 5/2d3 2.5Y 4/3m		sil 28% vfs	m	sh	fr	so po	1vf	2vf	ST	cf nodules, c threads, l'ing c pores		gs	

Other

[1] **2Bk1** - Carbonates: $CaCO_3$ on vertical ped faces, common to many medium, thin masses (or coatings); cf nodules, lining c pores, few "rings" (surrounding in-filled pores or insect burrows, ~ 4 mm diameter).

[2] **4Ck4** - Mottles: cfd 2.5Y 6/4d (5/4m); ffd 2.5Y 4/1d (3/1m), pores in-filled with A-horizon material (mixing by earthworms). Wormcasts present.

[3] **4Ck5, 4Ck6** - Color: each horizon is slightly darker than the horizon above it, but is not measuable by Munsell. Some mottles appear to be worm activity, possibly contributing to darker matrix color.

Figure A.8a Soil profile description, Transect 1, pedon 8 (sheet 1 of 2)

Double Ditch State Historic Site

Location N719.496 480.441E — Pedon # 32BL8 T1-8 SHEET 2 OF 2

Area Double Ditch: undisturbed transect, east of center — Elevation 527.952 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence			Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
						Dry	Moist	Wet							
4Ck7	246 - 259	2.5Y 4/2d 2.5Y 3/2m	cfd 2.5Y 6/4d (4/4m) worm mixing lower 6 cm	sil 30% vfs	m	sh	fr	so po	1vf	2vf	VE	cf nodules, c threads, l'ing c pores		as	
5Ak2	259 - 269	10YR 3/1d 10YR 2/1m	see below[4]	sil 15% vfs	1 fsbk	sh	fr	so po	1vf	2vf	VE	ff nodules, c threads, f rings		gs *	* mixing by worms
5Ak3	269 - 275	10YR 5/3d 10YR 3/2m	cfd 10YR 4/1d (3/1m) mixing by worms	sil 18% vfs	2 mpl *	sh	fr	so po		1vf	ST	ff nodules, c threads		as	* 5Bk5 below is very dense
5Bk5	275 - 288	2.5Y 6/3d 2.5Y 4/4m		l 30% vfs	2 mpl *	h	fr	so po	1vf	1vf	VE (rapid)	ff nodules, f thin masses, l'ing f pores		cs	* still appears platy, but orientation is not horizontal.
6Ck8	288 - 298	2.5Y 5/8d 2.5Y 4/4m	see below[5]	vfsl *	m	eh	vfi	so po		2vf	VE (rapid)	mf nodules, m threads, l'ing c pores		end	* 15% fs, 35% vfs

Other

[4]**5Ak2** - Mottles: consist of ~40% of horizon; copius mixing by earthworms; mfp 2.5Y 5/4d (4/3m); ffp 2.5Y 6/4d (5/4m).

[5]**6Ck8** - Mottles: ccd 2.5Y 5/4d (4/3m); ffp 2.5Y 4/2d (3/2m) mixing by earthworms (from a now-nonexistant A-horizon?).

Figure A.8b Soil profile description, Transect 1, pedon 8 (sheet 2 of 2)

Double Ditch State Historic Site

Location	N 719.518 500.574E	Pedon #	32BL8 T1-9
Area	Double Ditch: undisturbed transect, east of center	Elevation	528.083 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence Dry	Consistence Moist	Consistence Wet	Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
A1	0 - 4	10YR 4/2d 10YR 3/2m		sil 20% vfs	2 fsbk	sh	fr	so po	1m 2f 3vf	1f 3vf	NE			as	hydrophobic
A2	4 - 8	2.5Y 4/2d 2.5Y 3/2m		sil 25% vfs	1 msbk	sh	fr	so po	1co 1m 1f 2vf	1co 1f 2vf	NE			as	two 5×8 mm pores with many vf roots
Bw1	8 - 13	2.5Y 5/3d 2.5Y 3/3m		sil 25% vfs	1 msbk	sh	fr	so po	1co 1f 2vf	1co 1f 2vf	NE			as	
Bw2	13 - 19	2.5Y 4/2d 2.5Y 3/2m		sil 28% vfs	1 msbk	sh	fr	so po	1co 1f 2vf	1co 1f 2vf	SL	ff nodules, f rings		cs	
Bk1	19 - 35	2.5Y 4/2d 2.5Y 3/2m		sil 25% vfs	1 fsbk	sh	fr	so po	1f 2vf	1f 2vf	ST	cm nodules, cf coats		cs	
Bk2	35 - 51	2.5Y 4/2d 2.5Y 3/2m		sil 28% vfs	1 mpr	sh	fr	so po	1m 1f 1vf	1m 1f 1vf	ST	ff ndoules, fm coats, l'ing f pores		cs	
Bk3	51 - 71	2.5Y 5/2d 2.5Y 3/2m		sil 28% vfs	1 mpr	sh	fr	so po	1f 1vf	1m 1f 2vf	ST	ff nodules, ff masses, cf threads	few bone frags	cs	62 cm, oval insect cavity w/ soft in-fill; 6 mm channel leads to it
Bk4	71 - 81	2.5Y 5/3d 2.5Y 4/4m	cff 2.5Y 5/2d (4/2m)	sil 30% vfs	2 mpr	sh	fr	so po	2vf	1m 1f 2vf	VE	ff nodules, cf threads, l'ing f pores		cs	similar feature to above, at 73 cm
Ck1	81 - 102	2.5Y 6/3d 2.5Y 4/3m	fmf 2.5Y 5/2d (4/2m)	sil 28% vfs	2 mpr	h	fr	so po	1vf	1m 2vf	VE	cf nodules, l'ing c pores, cf threads*		gs	*threads on vertical ped faces; void at 99 cm, lined with $CaCO_3$
Ck2	102 - 178	2.5Y 6/3d 2.5Y 4/3m		sil 32% vfs	m	h	fr	so po	1vf	1vf 1f	VE	cf nodules, l'ing c pores		gs	
Ck3[1]	178 - 216	2.5Y 5/2d 2.5Y 4/2m		sil 35% vfs	m	h	fr	so po		1vf	VE	ff nodules, ff threads		cs	
CkAk	216 - 220	2.5Y 5/3d 2.5Y 3/3m	cmf 2.5Y 5/2d (4/3m) cfd 2.5Y 4/1d (3/1m)	sil 30% vfs	m	sh	fr	so po		1vf	VE	ff nodules, cf rings, l'ing f pores		cs	darker "mottles" A horizon
2Ak1	220 - 230	2.5Y 4/1d 2.5Y 3/1m	cmd 2.5Y 5/4d (4/4m) mixing by worms	sil 20% vfs	1 msbk	sh	fr	so po		2vf	VE	cf nodules, cf threads, l'ing f pores		cs	
2Ak2	230 - 235	2.5Y 5/3d 2.5Y 3/2m		sil 24% vfs	1 msbk	sh	fr	so po		1f 2vf	VE	cf nodules, cf threads, l'ing c pores		cs	
2Bk5	235 - 247	2.5Y 6/4d 2.5Y 4/4m	ffd 2.5Y 4/1d (3/1m) worm channels	l 36% vfs	1 fsbk	sh	fr	so po		1vf	VE	mf nodules, cf threads, l'ing c pores		cs	
2Ck4	247 - 268	2.5Y 5/4d 2.5Y 4/4m		vfsl *	m	sh	vfr	so po		1vf	VE	ff nodules, ff threads		gs	* 15% fs, 40% vfs; vertical fracturing but is not structure
2Ck5	268 - 301	2.5Y 5/4d 2.5Y 4/4m		vfsl *	m	so	vfr	so po		1vf	ST	cf nodules, ff threads, l'ing f pores*		cs	* pores are associated with $CaCO_3$s
2Ck6	301 - 331	2.5Y 5/4d 2.5Y 4/4m	see below[2]	vfsl 45% vfs	m	sh[2]	fr	so po		2vf	ST	cf nodules, ff threads, l'ing f pores, cm coats		as	
2Ck7	331 - 337	2.5Y 6/3d 2.5Y 4/3m	ffd 10YR 3/3d (2/2m)	lvfs 50% vfs	sg	so	vfr	so po			ST	ff nodules, coating com sand grains		end	

Other:

[1]**Ck3** - Matrix color: slight grayinig/darkening of color from 206-216 cm; new horizon? Possibly fewer carbonates or more organic matter brought up from **2Ak1** below.

[2]**2Ck6** - Mottles: cfd 2.5Y 6/1d (5/1m); fff 2.5Y 6/4d (5/4m); ffp 10YR 3/3d (2/2m). Consistence: soil is more dense than above 2Ck5 horizon.

Figure A.9 Soil profile description, Transect 1, pedon 9

Double Ditch State Historic Site

Location: N719.466 520.575E — Pedon #: 32BL8 T1-10

Area: Double Ditch: undisturbed transect, near east end — Elevation: 528.195 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence Dry	Consistence Moist	Consistence Wet	Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
A1	0 - 4	10YR 4/2d 10YR 2/1m		sil 18% vfs	3 fsbk	sh	vfr	so po	3vf 1f	2vf 1f	NE			cs	hydrophobic
Bw1	4 - 12	2.5Y 5/2d 2.5Y 3/2m		sil 24% vfs	2 tkpl→ 1 msbk	sh	fr	so po	2vf 2f	2vf 1f	NE			cs	hydrophobic
Bw2	12 - 17	2.5Y 4/2d 2.5Y 3/2m	fff 2.5Y 6/4d (5/3m)	sil 25% vfs	2 tkpl→ 2 cabk	sh	fr	so po	2vf 1f	1vf 1f	NE			as	
2A2	17 - 21	2.5Y 4/2d 2.5Y 3/1m	ffd 2.5Y 7/4d (6/4m) $CaCO_3$?	sil 30% vfs	1 fsbk	sh	fr	so po	2vf	1vf 1f	VSL	ff coats?		as	
2A3	21 - 37	2.5Y 4/2d 2.5Y 3/2m		sil 28% vfs	m ?	so	fr	so po	2vf 1f	1vf 1f	SL	ff coats, ff nodules (incr with depth)		cs	
2Bk1[1]	37 - 49	2.5Y 4/2d 2.5Y 3/2m		sil 30% vfs	1 fsbk[1]	sh	fr	so po	2vf	2vf	ST	cc coats, ff nodules, l'ing f pores, f rings		cs	
3Ak1	49 - 72	2.5Y 4/2d 2.5Y 3/2m		sil 22% vfs	2 fsbk	so	vfr	so po	2vf	2vf 1f	ST	cm coats, cf nodules	bone fragment at 55 cm	cs	slightly hydrophobic
3Bk2	72 - 81	2.5Y 6/3d 2.5Y 4/3m		sil 30% vfs	1 mpr	sh	fr	so po	2vf	3vf 1f	ST	ff nodules, mf threads, mf coats, l'ing c pores		gs	cored through a krotovina with A-horizon material; sampled separately
3Bk3	81 - 94	2.5Y 6/3d 2.5Y 4/3m		sil 28% vfs	1 mpr	sh	fr	so po	1vf	3vf 2f	ST *	ff nodules, mf threads, mf coats, l'ing m pores		gs	* rapid effervescence but not "thick foam"
3Ck1	94 - 125	2.5Y 6/3d 2.5Y 4/3m		sil 30% vfs	1 mpr	sh	fr	so po	1vf	2vf 1f	ST	ff coats, ff nodules, l'ing f pores		gs	
3Ck2	125 - 153	2.5Y 6/2d 2.5Y 4/3m		sil 32% vfs	m	sh	fr	so po	1vf	2vf	ST	cm coats, ff nodules, l'ing c pores		gs	
3Ck3	153 - 208	2.5Y 5/3d 2.5Y 4/2m		sil 27% vfs	m	sh	fr	so po	1vf 1f	2vf 1f	ST	see below[2]		cs	
3Ck/Ak	208 - 210	Ck: 2.5Y 6/4d 2.5Y 5/4m	Ak: 2.5Y 5/2d 2.5Y 3/2m	sil 24% vfs	m	sh	fr	so po		3vf	ST	ff masses, l'ing f pores		cs	strong evidence of mixing by earthworms
4Ak2	210 - 221	10YR 4/1d 10YR 3/2m	see below[3]	sil 33% vfs	1 fsbk	sh	fr	so po	1vf	2vf 1f	VE	ff masses, ff nodules, l'ing c pores		ci	
4Bk4	221 - 242	2.5Y 6/4d 2.5Y 4/4m	10% 4Ak2: 10YR 4/1d (3/2m)	l 33% vfs	1 mpr	sh	fr	so po	1vf	2vf	VE	cf nodules, cf threads, cf masses, l'ing c pores		cs	1 rounded pebble (15×10×4mm) coated with $CaCO_3$
4Ck4	242 - 257	2.5Y 5/3d 2.5Y 4/3m		fsl *	m	sh	fr	so po		1vf	VE	ff masses, ff nodules		end	* 20% fs, 25% vfs

Other

[1]**2Bk1** - Structure: Horizon appears to be developing in fill (or transported, slope wash?) material. Given a Bk designation due to illuvial carbonates.

[2]**3Ck3** - Carbonates: common medium coats, few fine nodules (one nodules 2mm diameter), lining common vertical pores; below 174 cm, find common carbonate ring features (old worm channels?).

[3]**4Ak2** - Color: 20% 3Ck2 horizon (2.5Y 6/4d, 5/4m) and 10% 4Bk4 horizon (2.5Y 6/4d, 4/4m) due to strongly defined mixing by earthworms.

Figure A.10 Soil profile description, Transect 1, pedon 10

Double Ditch State Historic Site

Location: N719.559 540.515E — Pedon # 32BL8 T1-11 SHEET 1 OF 2

Area: Double Ditch: undisturbed transect, near east end — Elevation 528.436 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence Dry	Consistence Moist	Consistence Wet	Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
A1	0 - 3	10YR 4/1d 10YR 2/1m		sil 20% vfs	3 fsbk	sh	fr	so po	2f 3vf	2f 3vf	NE			as	hydrophobic, overlain by 2 cm of grass stems and root mat
Bw1	3 - 9	2.5Y 5/3d 2.5Y 3/2m		sil 24% vfs	1 msbk and 1 fsbk	sh	fr	so po	2f 2vf	2f 3vf	NE		few small (<2mm) fragments of bone	cs	
Bw2	9 - 18	2.5Y 4/2d 2.5Y 3/2m	cff 2.5Y 5/3d (4/4m) on → and ↑ ped faces	sil 25% vfs	2 fsbk	sh	fr	so po	2f 2vf	2f 3vf	NE		bone as above, angular chert frag at 11 cm	as	2A? Doesn't look like an A, but abrupt boundary
2A2	18 - 26	2.5Y 4/2d 2.5Y 3/2m		sil 34% vfs	2 fsbk	sh	fr	so po	2f 2vf	2f 2vf	SL	fm nodules (soft, 2 mm)	pottery chip, bone frags	as	see below[1]
2A3	26 - 38	2.5Y 5/2d 2.5Y 3/2m		sil 30% vfs	2 fsbk	so/sh*	fr	so po	1f 2vf	3f 2vf	ST	cf nodules	few bone frags (<2mm), insect egg case (<2mm)	as	*individual aggregates sh, but horizon is very fragile
2Ak1	38 - 44	2.5Y 4/2d 2.5Y 3/2m		sil 32% vfs	2 fsbk	so/sh*	fr	so po	2f 3vf	2f 3vf	ST	cf nodules, cf coats	one, 2mm frag of quartz or mica	cs	*as above horizon; color variations from 3 42 cm are subtle
2Bk1	44 - 52	2.5Y 5/2d 2.5Y 3/2m		sil 24% vfs	1 fpr→ 1 fsbk	sh	fr	so po	2vf 1f	2f 3vf	ST	cf threads, few rings, l'ing f pores		cs	
3Ak2	52 - 58	2.5Y 5/2d 2.5Y 3/2m	cmd 2.5Y 6/4d (4/4m) worm activity	sil 22% vfs	1 mpr→ 1 mabk	sh	fr	so po	1f 2vf	1f 2vf	ST	cm coats, ff nodules, l'ing f pores		ci	worm activity throughout; lower boundary shows increased amount
3Bk2	58 - 91	2.5Y 6/3d 2.5Y 4/2m	cmf 2.5Y 6/4d (4/3m)	sil 24% vfs	1 mpr	sh	fr	so po	2vf	2vf 1f	ST	mm coats, cf nodules, c rings, l'ing f pores		gs	
3Ck1	91 - 105	2.5Y 6/3d* 2.5Y 5/3m		sil 16% vfs	m	h	fr	so po	1vf	2vf 1f	VE	mf nodules, cf coats		gs	*dry color lighter than above horizon
3Ck2	105 - 117	2.5Y 6/3d 2.5Y 4/3m		sil 18% vfs	m	sh	fr	so po	1vf	2vf 1f	VE	cf nodules, ff coats		gs	
3Ck3	117 - 148	2.5Y 6/3d 2.5Y 4/3m		sil 18% vfs	m	sh	fr	so po	1vf	2vf 1f	VE	cf nodules, ff coats, ff masses, l'ing f pores		gs	
3Ck4	148 - 172	2.5Y 5/3d 2.5Y 4/3m		sil 20% vfs	m	sh	fr	so po	1vf	2vf 1f	VE	cf nodules*, ff masses, ff coats, l'ing f pores		cs	*also ff nodules of $CaSO_4$
3Ck5	172 - 186	2.5Y 6/3d 2.5Y 4/3m	cff 2.5Y 5/2d (3/2m) fff 2.5Y 6/4d (5/4m)	sil 20% vfs	m	sh	vfr	so po	1vf	2vf 1f	VE	cf nodules, cf masses, f rings, l'ing f pores	thin (snail?) shell fragment	as	faunal activity has brought up small amount of 4Ak3 material
3CkAk[2]	186 - 192	2.5Y 5/3d 2.5Y 3/3m		sil 20% vfs	1 fsbk	sh	vfr	so po	1vf	2vf	VE	cf & m nodules, f rings, l'ing f pores		as	
4Ak3	192 - 205	2.5Y 4/2d 2.5Y 2.5/1m*	cfd 2.5Y 5/4d (4/4m) mixing by worms*	sil 18% vfs	2 msbk	sh	fr	so po	1vf	2vf	ST	cf nodules, fm nodules, l'ing f pores		ai	*discrete chunks of 4Bk3 occur within structural peds of A horizon
4Bk3	205 - 230	2.5Y 6/4d 2.5Y 5/6m	mfd 2.5Y 4/2d (3/2m) mixing by worms*[3]	l 25% vfs	1 mpr	h	fi	so po		3vf	ST	see below[3]		cs	*copius mixing in upper 7 cm, with lesser amounts throughout

Other

[1]**2A2** - Horizon boundary: lower boundary rests on a diagonal, 2-cm thick layer of 3 fsbk (or 3 mgr) soil. Seen in other cores; photo taken.

[2]**3CkAk** - Color: result of faunal turbation, but very uniform, with exception of a very few discrete in-filled worm burrows (7.5YR 3/1m). Based on $CaCO_3$ morph., hue, and general appearance, is more like 3Ck than 4Ak; boundary abrupt.

[3]**4Bk3** - Carbonates: lining many pores, many fine threads on primarily vertical ped faces following root channels. Mottles: Also cmf 2.5Y 6/2d(5/1m) in lower 10 cm of horizon.

Figure A.11a Soil profile description, Transect 1, pedon 11 (sheet 1 of 2)

Double Ditch State Historic Site

Location N719.559 540.515E — Pedon # 32BL8 T1-11 SHEET 2 OF 2

Area Double Ditch: undisturbed transect, near east end — Elevation 528.435 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence Dry	Consistence Moist	Consistence Wet	Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
4Ck6	230 - 240	2.5Y 6/3d 2.5Y 4/3m		vfsl 38% vfs	1 fsbk	so	vfr	so po		2vf	ST	cf nodules, f threads, fm masses		cs	
5Ck7	240 - 257	2.5Y 5/3d 2.5Y 4/4m		vfsl* 45% vfs	m	so	vfr	so po		2vf	VE	cf nodules, f threads, f masses*		gs	*few lenses of cleaner sand; $CaCO_3$ occur 288-292 cm
5Ck8	257 - 277	2.5Y 5/4d 2.5Y 4/4m	see below[1]	vfsl*	m	h	vfi	so po		3vf 1f	ST	cf nodules, cf threads, l'ing f pores		as	* 15% fs, 38% vfs
6Ck9	277 - 285	2.5Y 5/3d 2.5Y 5/4m	see below[2]	lvfs*	sg	lo	lo	so po	1vf live root	2vf	ST	cf nodules, ff masses, ff threads		as	* 22% fs, 28% vfs
6C	285 - 288	2.5Y 5/3d 2.5Y 4/3m	cmd 2.5Y 6/1d (5/1m) cff 2.5Y 7/4d (6/4m)	lvfs*	sg	lo	lo	so po			ST	cf nodules, ff masses		end	* 27% fs, 50% vfs

Other

[1]**5Ck8** - Mottles: mfd 2.5Y 5/2d (4/2m), cfp 10YR 2/2d (2/1m), cfp 10YR 5/8d (4/6m), cfd 2.5Y 6/1d (5/1m).

[2]**6Ck9** - Mottles: mfd 2.5Y 6/1d (5/1m); mff 2.5Y 5/2d (4/2m); ffp 10YR 4/6d (3/6m); fmf 2.5Y 7/4d (6/4m); ffp 10YR 2/2d (2/1m).

Figure A.11b Soil profile description, Transect 1, pedon 11 (sheet 2 of 2)

Double Ditch State Historic Site

Location	N719.383 560.473E	Pedon #	32BL8 T1-12 SHEET 1OF 2
Area	Double Ditch: undisturbed transect, east end	Elevation	528.875 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence			Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
						Dry	Moist	Wet							
A1	0 - 3	2.5Y 4/2d 10YR 3/2m		sil 21% vfs	3 vfsbk	sh	vfr	so po	3vf 2f 1m	2vf 1f 1m	NE			as	hydrophobic
Bw1	3 - 13	2.5Y 5/3d 2.5Y 3/3m		sil 25% vfs	3 fsbk	sh	fr	so po	2vf 2f 1m	1vf 2f	NE			cs	
2A2	13 - 18	2.5Y 4/2d 2.5Y 3/1m		l 40% vfs	2 fsbk	sh	fr	so po	2vf 2f	2vf 1f 1m	NE			as	
2A3	18 - 24	2.5Y 4/2d 2.5Y 3/2m		l 40% vfs	1 fpr→ 2 fsbk*	sh	fr	so po	2vf 2f	2vf 1f	VSL			cs	*sbk, but elongated vertically
2A4	24 - 36	2.5Y 4/2d 2.5Y 3/2m		sil 30% vfs	1 fpr→ 1 mabk	sh	fr	so po	2vf 1f	2vf 1f	SL		few fine bone frags	cs	structure appears m→ 1 mabk
2Bk1	36 - 46	2.5Y 5/2d 2.5Y 3/2m	ccf 2.5Y 7/2d $CaCO_3$ coatings	sil 17% vfs	1 fpr→ 1 fsbk	sh	fr	so po	2vf	3vf 1f	ST	cc coats, cm nodules		as	few in-filled channels (large root or earthworms?)
3Ak1	46 - 51	2.5Y 4/2d 2.5Y 3/2m		sil 18% vfs	1 fsbk	sh	fr	so po	2vf	2vf 1f 1m	ST	cf nodules, fm coats		cs	
3Bk2	51 - 60	2.5Y 5/2d 2.5Y 3/2m		sil 16% vfs	1 mpr→ 1 fabk	h	fr	so po	2vf	2vf 1f	VE	cf nodules, fm coats, ff threads, ff rings*		cs	* also, l'ing f pores
3BkCk	60 - 68	2.5Y 5/3d 2.5Y 3/3m		sil 15% vfs	1 mpr→ 1 mabk	h	fr	so po	2vf 1f	3vf 1f	VE	mm coats, mf nodules, mf threads*		cs	* also, l'ing c pores
3Ck1	68 - 79	2.5Y 5/3d 2.5Y 4/3m	cff 2.5Y 5/2d (4/2m) earthworms[1]	sil 15% vfs	1 mpr	vh	fr	so po	2vf	2vf 2f 1m	VE	see below[1]		cs	vertical fracturing (from coring?)
3Ck2	79 - 142	2.5Y 6/3d 2.5Y 5/3m	fff 2.5Y 5/2d (4/2m) earthworms	sil 16% vfs*	1 mpr	vh	fr	so po	1vf	2vf 1f	VE	cf coats, cf nodules, l'ing c pores		ai	*vfs increases from 15% (79-121 cm) to 18% (121-142 cm)
4Ak2	142 - 145	2.5Y 5/2d 2.5Y 4/2m	2.5Y 6/3d (4/3m) mixing by worms	sil 20% vfs	1 cabk (m?)	h	fr	so po		1vf	VE	cf coats, cf nodules, l'ing c pores		cs	
4Bk3	145 - 185	2.5Y 6/3d 2.5Y 4/3m	mmf 2.5Y 6/2 (4/2m) mixing by worms?	sil 22% vfs	1 fsbk *	h	fr	so po		2vf	VE	ff coats, cf nodules, l'ing c pores		cs	*prismatic tendencies 177-185 cm
4Bk4	185 - 210	2.5Y 5/3d 2.5Y 4/3m	cff 2.5Y 5/2d (4/2m) tubular	sil 19% vfs	m	sh	fr	so po	1vf	2vf	VE	cf coats, cf nodules, l'ing f pores		cs	
4C	210 - 217	2.5Y 5/4d 2.5Y 4/3m	see below[2]	sil 18% vfs	1 fsbk	sh	fr	so po		2vf 1f	SL	ff nodules		ci	
5A5	217 - 221	10YR 4/2d 10YR 3/2m	cfp 2.5Y 5/4d (4/3m) mixing by worms	sil 19% vfs	2 fsbk	sh	fr	so po		3vf 1f	ST	cf nodules		cs	horizon is fractured and mixed--at least 2 A-horizons, inseperable
5Ak3	221 - 225	7.5YR 4/1d 7.5YR 3/1m	mcp 2.5Y 5/3d (4/3m) mixing by worms	sil 19% vfs	2 fsbk	sh	fr	so po		1m 2vf	VE	cf nodules, ff threads, f rings		cs	

Other

[1]**3Ck1** - Mottles and carbonates: The "ring" features appear to be $CaCO_3$ accumulations surrounding earthworm channels. Carbonates occur on ped faces and interiors; cf nodules, f threads (distinct and faint), com rings, lining com pores.

[2]**4C** - Mottles: cfd 2.5Y 5/2d (3/2m) mixing by worms at upper boundary; mfd 2.5Y 4/2d (3/2m) mixing by worms below 213 cm.

Figure A.12a Soil profile description, Transect 1, pedon 12 (sheet 1 of 2)

Double Ditch State Historic Site

Location: N719.383 560.473E — Pedon #: 32BL8 T1-12 SHEET 2 OF 2

Area: Double Ditch: undisturbed transect, east end — Elevation: 528.875 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence			Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
						Dry	Moist	Wet							
5Ak4	225 - 232	2.5Y 4/2d 2.5Y 3/2m	cfd 2.5Y 6/4d (4/3m) mixing by worms↓	sil 20% vfs	1 fsbk	sh	fr	so po	see below[3]	2vf	VE	ff nodules, cf threads, cf coats		cs	
5Bk5	232 - 242	2.5Y 6/4d 2.5Y 4/4m	cfd 2.5Y 4/2d (3/2m) mixing* by worms↑	sil 25% vfs	2 fpr	sh	fr	so po		2vf 1f	VE	cf nodules, mf threads, ff coats		cs	*worm activity common in upper 6-8 cm
5Bk6	242 - 258	2.5Y 5/4d 2.5Y 4/4m		l 37% vfs	1 fpr	sh	fr	so po		1vf	ST	cf nodules, ff threads		cs	
6Ck3	258 - 286	2.5Y 5/3d 2.5Y 3/3m	cff 2.5Y 5/3d (5/4m) dendritic	vfsl 34% vfs	m	sh	fr	so po		1vf	VE	cf nodules, cf threads, cf coats, l'ing f pores		end	
Other	[3]**5Ak4** - Roots: what appear to be relict root channels are closely spaced and fine, and oriented vertically.														

Figure A.12b Soil profile description, Transect 1, pedon 12 (sheet 2 of 2)

Double Ditch State Historic Site

Location: N639.905 599.250E — Pedon #: 32BL8 T2-1 SHEET 1 OF 2

Area: Double Ditch Village: Outside of Ditch 4, NE area — Elevation: 527.937 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence Dry	Consistence Moist	Consistence Wet	Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
Oi	0 - 3													as	grass stems and leaves
Oe	3 - 4								3vf 3f	3vf 3f				as	root mass, fine and very fine roots
A1	4 - 9	10YR 3/2d 10YR 2/2m		sil 28% vfs	1 mgr	so	vfr	so po	3vf 1f	3vf	NE		?	as	
A2	9 - 16	10YR 4/2d 10YR 3/2m		sil 28% vfs	2 vf&f sbk	so	vfr	so po	2vf	2f	NE		?	cs	
Bw	16 - 36	10YR 4/2d 10YR 2/2m		sil 26% vfs	2 fsbk	so	vfr	so po	1vf 2f	2f	NE		?	cs	few vf $CaSO_4$ filaments
2Bk1	36 - 43	10YR 4/2d 10YR 2/2m	fmp 2.5Y 6/6d (5/4m) $CaCO_3$	sil 18% vfs	1 msbk	so	fr	so po	2vf 2f	3vf	SL	fm coats, ff nodules	?	cs	
2Bk2	43 - 58.5	10YR 3/2d 10YR 2/2m	ffp 2.5Y 6/6d (5/4m)	sil 18% vfs	1 msbk	sh	fr	so po	2vf 1f	2vf	SL	ff coats, ff nodules	?	cs	
2Bk3	58.5 - 71	2.5Y 4/2d 2.5Y 3/2m		sil 16% vfs	1 mabk	sh	fr	so po	2vf 1f	2vf	SL	ff nodules, ff coats	?	cs	few grains angular sand in B horizon; biotite observed with hand lens
2Bk4	71 - 84	2.5Y 4/2d 2.5Y 3/2m	cmf 2.5Y 4/1d (3/2m) fcp 2.5Y 7/2d (5/2m)	sil 15% vfs	1 mabk	sh	fr	so po	1vf 1f	3vf	ST	cf coats, ff nodules		cw	
2Bk5	84 - 94.5	2.5Y 5/3d 2.5Y 4/2m		sil 15% vfs	1 mpr	sh	fr	so po	1vf 1f	3vf 1f	ST	mm coats, mf nodules, l'ing c pores		as	2.5Y 4/2d lining root channels (silt coats?)
2Bk6	94.5 - 114	2.5Y 6/3d 2.5Y 4/2m	fmf 2.5Y 5/3d (4/2m)	sil 16% vfs	1mpr→ 2fabk	sh	fi	so po	1vf 1f	3vf 1f	VE	mm coats, mf nodules, l'ing c pores		as	
2Btk1	114 - 139	2.5Y 6/3d 2.5Y 5/2m	fmf 2.5Y 5/3d (4/2m)	sil 20% vfs	2mpr	h	fi	so po	1vf 1f	3vf 1f	VE	mm coats, mf nodules, l'ing c pores		cs	thin clay films on 5-10% on vertical ped faces
2BCk1	139 - 149	2.5Y 6/4d 2.5Y 5/3m		sil 15% vfs	1mabk	sh	fi	so po	1vf 1f	2vf	ST	ff coats, ff nodules		cs	
2BCk2	149 - 158	2.5Y 6/4d 2.5Y 5/3m		sil 19% vfs	1fabk	sh	fi	so po	1vf	1vf	ST	ff coats, ff nodules		cs	
2Ck1	158 - 179	2.5Y 6/3d 2.5Y 5/4m		sil 21% vfs	m	sh	fr	so po	1vf	2vf 1vf	ST	few faint coats		cs	
2Ck2	179 - 186	2.5Y 7/3d 2.5Y 5/3m		sil 23% vfs	m	sh	fr	so po	1vf	2vf	ST	isolated threads <5mm		as	
3Bk7[1]	186 - 205	2.5Y 6/2d 2.5Y 4/2m	2.5Y 4/2 (d & m) lining root channels	sil 20% vfs	1 fsbk	sh	fr	so po	1vf	2vf	ST	few isolated threads <5 mm		as	abandoned roots channels 1-2mm diameter

Other

[1]**3B horizons** - evidence 3vf & f, 2m root channels, all lined with 2.5Y 4/2 (d & m) material, possibly clay.

Figure A.13a Soil profile description, Transect 2, pedon 1 (sheet 1 of 2)

Double Ditch State Historic Site

Location: N 639.905 599.250E — Pedon #: 32BL8 T2-1 SHEET 2 OF 2
Area: Double Ditch Village: Outside of Ditch 4, NE area — Elevation: 527.937 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence Dry	Consistence Moist	Consistence Wet	Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
3Btk2	205 - 221	2.5Y 5/4d 2.5Y 4/2m	cff 2.5Y 4/2 (d & m)*	sil 20% vfs	2 mpr	sh	fr	so po	1vf	2vf	VE	few isolated threads		cs	*patches and lining root channels; all abandoned root ch. filled
3Bk8	221 - 231	2.5Y 5/3d 2.5Y 4/2m	fff 2.5Y 4/2 (d & m)**	sil 25% vfs	1 msbk	sh	fr	so po	1vf	2vf	ST	ff nodules		cs	**a few abandoned root channels filled
3Ck3	231 - 252	2.5Y 6/3d 10YR 3/2m		sil 19% vfs	1 fsbk	s	fr	so po		1vf	ST	ff coats		as	
4Ak1	251 - 254	10YR 4/2d 10YR 3/2m		sil 20% vfs	1 fsbk	s	fr	so po			ST	ff nodules		as	
4Bk9	254 - 268	2.5Y 5/3d 10YR 3/2m	fmd 2.5Y 6/4m	sil 18% vfs	1 mabk	sh	fr	so po			ST	ff coats		as	
4Ak'	268 - 272	2.5Y 4/2d 2.5Y 3/2m		sil 10% vfs	2 tkpl	sh	fi	so po			ST	ff nodules		cs	
4Bk'	272 - 282	2.5Y 6/2d 2.5Y 3/2m	ffd 2.5Y 5/4m	sil 10% vfs	1 fsbk	sh	fi	so po		2vf	ST	fm nodules, ff coats		as	
4Ak"	282 - 286	2.5Y 4/2d 2.5Y 3/2m	mff 2.5Y 5/3m	sil <5% vfs	1 fsbk	sh	fi	so po		1f 2vf	VE	ff nodules, ff coats		cs	larger pores filled with 2.5Y 3/2m material (from 4Bk1'?)
4Bk"	286 - 294	2.5Y 5/2d 2.5Y 4/2m	mff 10YR 4/2m*	sil <5% vfs	1 fabk	sh	fi	so po		1f 1vf	VE	l'ing c pores, ff nodules, ff coats		as	*a pocket of 7.5YR 2.5/1m, irregular shape, 4 × 1 × 2 cm
5Ak2	294 - 297	10YR 3/2d 10YR 3/1m	cfd 10YR 6/2d (4/2m)	sil <2% vfs	1 fabk	sh	fr	so po		1f 2vf	ST	cf threads, cf nodules		as	highly organic
5Ak3	297 - 309	10YR 3/1d 10YR 2/1m	cmf 10YR 4/2d (3/2m)	sil <2% vfs	1 fabk	sh	fi	so po		2vf	ST	cf nodules, cf threads, cf "rings"		cw	highly organic
5Bk10	309 - 321	2.5Y 6/6d 2.5Y 4/4m	cfd 2.5Y 7/6m mmd 10YR 2/2m*	sil 5% vfs	1 mpr	sh	fr	so po		2vf	SL	cm threads, ff nodules		cs	*many 2-3mm diam. channels filled with 5Ak3 material (worms)
5Ck4	321 - 356	2.5Y 5/4d 2.5Y 4/4m	see below[2]	sil 10% vfs	m	sh	fr	so po		1f 2vf	ST	cf threads, l'ing c pores	cluster of gastropod shells, 340-342 cm sd	cs	
5Ck5	356 - 380	2.5Y 5/4d 10YR 5/6m	see below[3]	sil 10% vfs	m	sh	fr	so po		2f 2vf	ST	cf threads, cf soft masses		end	

Other:
[2]**5Ck4** - Mottles: cmf 2.5Y 4/4d (4/4m); fcp 10YR 4/4d (3/6m); cfd 2.5Y 6/6d (6/6m); ffp 7.5YR 6/8d (5/8m).
[3]**5Ck5** - Mottles: cfd 10YR 4/6d (4/4m); cfd 10YR 6/1d (5/1m); ffd 10YR 7/6d (6/6m); cmd (10YR 7/8d (6/8m).

Figure A.13b Soil profile description, Transect 2, pedon 1 (sheet 2 of 2)

Double Ditch State Historic Site

Location	N624.404 583.641E	Pedon #	32BL8 T2-2
Area	Double Ditch Village: NE between Ditches 3 and 4	Elevation	527.788 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence			Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
						Dry	Moist	Wet							
Oi/Oe	0 - 2								3vf 3f	3vf	NE			aw	
A1	2 - 6	2.5Y 4/2d 10YR 3/1m		sil <5% vfs	2 msbk	sh	fr	so po	2vf 2f	3vf	NE		lithic spall on ground surface	as	hydrophobic
A2	6 - 16.5	2.5Y 5/2d 2.5Y 3/2m		sil 15% vfs	2 msbk	sh	fr	so po	1m 3vf 1f	2vf 1f	SL	vff masses below 12 cm	rim sherd at 9 cm; bone chip at 11.5 cm	cs	
Bk1	16.5 - 35	2.5Y 4/2d 2.5Y 3/1m		sil 10% vfs	1 mpr→ 2 fsbk	sh	fr	so po	1m 2vf 1f	2vf 2f	ST	ff masses	bone and burned bone chips at 20 cm	cs	
Bk2	35 - 45	2.5Y 5/2d 2.5Y 3/2m	fff 2.5Y 6/3d (5/3m) $CaCO_3$	sil 10% vfs	2 mpr→ 2 msbk	h	fr	so po	1f 2vf	3vf 2f 1m	ST	ff masses, l'ing c pores		gs	$CaCO_3$ on horizontal and vertical ped faces
Bk3	45 - 53	2.5Y 5/2d 2.5Y 3/2m	cff 2.5Y 7/1d (6/2m) $CaCO_3$	sil 20% vfs	1 cpr? (2 msbk)	h	fr	so po	1f 2vf 1m	3vf 2f 2m	ST	cf masses, l'ing c pores		gs	increase in carbonates
Bk4	53 - 74	2.5Y 5/3d 2.5Y 4/3m	cff 2.5Y 7/1d (6/2m) CaCO3	sil 30% vfs	1 cpr? (2 msbk)	h	fr	so po	1f 2vf 1m	3vf 2f 1m	ST	cm masses,, l'ing c pores		cs	see below[1]
Ck1	74 - 146	2.5Y 6/3d 2.5Y 4/3m		sil 38% vfs	m	vh	fr	so po	2vf 1f	3vf 1f 1m	ST	ff nodules, cf&m masses, l'ing f pores		gs	see below[2]
Ck2	146 - 178	2.5Y 6/2d 2.5Y 4/2m		vfsl 60% vfs	m	h	fr	so po	1vf	3vf 1f	ST	cf nodules, cf masses, l'ing f pores		gs	
Ck3	178 - 224	2.5Y 5/2d 2.5Y 3/2m		vfsl 60% vfs	m	sh	fr	so po	1vf	3vf 1f	VE	ff masses, cf nodules		cs	copius mixing in lower 6 cm
2Ak1	224 - 232	2.5Y 4/2d 2.5Y 3/2m		sil 10% vfs	1 fsbk	sh	fr	so po	1vf	2vf 1f	VE	ff masses, l'ing f pores	9 mm fragment of bone? rock?	cs	
2Ak2	232 - 242	2.5Y 4/1d 2.5Y 2.5/1m	cfd 2.5Y 5/4d (4/2m)*	sil 12% vfs	2 fsbk	sh	fr	so po	1vf	2vf 1f	VE	ff nodules		gs	*mottle color material brougt up by faunal activity from 2Bk5
2Bk5	242 - 250	2.5Y 5/3d 2.5Y 4/4m	faunal mixing from 2Ak1 and 2Ak2	sil 15% vfs	1 fsbk	vh	fi	so po	1vf	2vf	VE	cf threads, cm masses, cf nodules	shell (gastropod?) fragments	as	
2Ck4[3]	250 - 258	2.5Y 6/3d 2.5Y 5/3m	ffp 10YR 5/8d (4/6m) ffp 5YR 4/6d (3/4m)	sil 10% vfs*	m	eh	vfi	so po			ST	fm masses, mf nodules		aw	*sand is gritty (angular?)
2Ck5	258 - 263	2.5Y 5/3d 2.5Y 4/4m		sil 15% vfs	m	eh	vfi	so po			ST	fm masses, mf nodules	small intact gastropod shell at 259 cm	aw	see sketch on hand-written sheets
3Ak3	263 - 264	2.5Y 5/2d 2.5Y 4/2m	mff 2.5Y 4/1d (3/1m)	sil <5% vfs	m	eh	fi	so po		1vf	ST	ff nodules		aw	
4Ck6	264 - 271	2.5Y 5/3d 2.5Y 4/4m	see below[4]	sil 15% vfs*	m	sh	fr	so po		3vf 2f	VE	mf masses, threads & nodules, l'ing f pores		end	*sand grains gritty, but some fine sand grains rounded

Other

[1]**Bk4** - Roots and pores are primarily oriented vetically, but at approximately 60 cm depth, the orientation in medium pores changes to ~30° from horizontal. Did not observe an obstruction. Large, unlined cavity (8 × 14 × 17 mm) at 71 cm.

[2]**Ck1** - Large cavity at 90 cm (20 × 20 × 15 mm) with 3 medium-size pores exiting below; several smallerr cavities (as in Bk4 or smaller) to a depth of 110 cm. Several medium pores 74-104 cm are 4mm in diameter.

[3]**2Ck4** - This horizon is very compacted; field notes indicate difficulty coring. Possible very strongly cemented with $CaCO_3$. No pores or roots, no sign of faunal activity (abrupt upper boundary). But in lower 8-14 cm there is a band of 2.5Y 5/2 (d) material speckled with 2.5Y 4/1, possibly from 2Ak2 horizon. Common to many earthworm channels from overlying horizons end abruptly at 250 cm.

[4]**4Ck6** - Mottles: cfp 5Y 7/1d (5/1m); cmp 5Y 7/1d (5/1m); cfp 10YR 4/6 (d & m); cmd 2.5Y 5/6d (4/4m); ffd 2.5Y 2.5/1 (d & m).

Figure A.14 Soil profile description, Transect 2, pedon 2

Double Ditch State Historic Site

Location: N613.819 573.545E — Pedon #: 32BL8 T2-3

Area: Double Ditch Village: NE, inside Ditch 3 — Elevation: 527.598 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence Dry	Consistence Moist	Consistence Wet	Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
A1	0 - 2	10YR 4/2d 10YR 2/2m		sil 5% vfs	2 msbk	sh	fr	so po	3vf 2f 1m	3vf 2f	NE			as	hydrophobic
A2	2 - 9.5	2.5Y 5/2d 2.5Y 3/2m		sil 10% vfs	2 m&f sbk	sh	fr	so po	2vf 1f	2vf 1f	VSL	very few f coats		as	
A3	9.5 - 15	2.5Y 5/2d 2.5Y 3/2m		sil 5% vfs	2 m&f sbk	sh	fr	so po	2vf 1f	1vf 1f	NE		few vf bone frags (½ × 2mm or less)	as	
Bw	15 - 23.5	2.5Y 5/2d 2.5Y 3/2m		sil 5% vfs	1 mpr→ 2 fsbk	sh	fr	so po	2vf 2f	2vf 1f	ST	ff coats	few vf bone frags (as above), potsherd	cs	
Bk1	23.5 - 36	2.5Y 5/2d 2.5Y 3/2m		sil 10% vfs	1 mpr→ 2 f&m sbk	sh	fr	so po	2vf 1f 1m	2vf 1f 1c	ST	cf coats, l'ing f pores, cf nodules	few vf bone frags (as above), few vf charcoal frags	gs*	*lower boundary mixed by earthworm activity
Ck1	36 - 56	2.5Y 6/2d 2.5Y 4/2m		sil 10% vfs	m	sh	fr	so po	2vf 1f	3vf 2f	ST	cm coats, l'ing c pores, cf nodules		cs	filled earthworm channels common 36-42 cm, but extend to 65 cm
Ck2	56 - 106	2.5Y 6/3d 2.5Y 4/3m	fff 2.5Y 5/2d (3/3m) fff 2.5Y 5/2d (3/1m)*	sil 15% vfs	m	sh	fr	so po	1vf 1f	3vf 2f 1m	ST	cm coats, l'ing c pores, cf nodules		cs	*2.5Y 5/2d (3/1m) are located within the other mottles
Ck3	106 - 136	2.5Y 6/2d 2.5Y 4/2m	cff 2.5Y 6/2d (5/6m)	sil 15% vfs*	m	sh	fr	so po	2vf	2vf 1f 1m	ST	f m&f masses, l'ing c pores, cf nodules	ff bones frags (~3mm)	gs*	*<2% coarse sand or fine gravel
Ck4	136 - 151	2.5Y 5/3d 2.5Y 3/3m	see below[1]	sil 10% vfs*	m	sh	fr	so po	1vf	2vf 1f	ST	f m&f masses, l'ing f pores, f "rings"*		cs	*"rings" are $CaCO_3$-lined earthworm channels; f gravel 7mm @ 151 cm
2A/Bk	151 - 153	Bk: 2.5Y 5/3d 2.5Y 4/3m	A*: 10YR 3/1d 10YR 2/1m	sil 20% vfs	1 fsbk	sh	fr	so po	1vf 1f	2vf 1f	ST	cf masses in Bk and around A material		cs	*A material ~20%; possible remnant of eroded paleo-A horizon
2Bk2	153 - 165	2.5Y 5/3d 2.5Y 4/3m	ffp 10YR 3/1d (2/1m)	sil 20% vfs	1 fsbk	sh	fr	so po	1vf 1f	2vf 1f	ST	ff masses, ff coats, ff nodules		cs	isolated worm channels extend through this horizon
2Bk3	165 - 195	2.5Y 5/4d 2.5Y 4/4m	ffd 10YR 4/3d (3/2m) earthworms?	sil 20% vfs	1 fsbk	sh	fr	so po	1vf 1f	2vf 1f	ST	cf coats, cf nodules		gs	4 mm rock frag at 169 cm, larger at 176 cm
3Ck5[2]	195 - 232	2.5Y 6/2d 2.5Y 4/2m	fmf 2.5Y 5/2d (4/1m)	vfsl 60% vfs	1 fsbk/sg	so	vfr	so po	1vf	2vf 1f&m	VE	c f&m masses, l'ing f pores, cf nodules*		gs	*increasing % nodules below 225 cm
3Ck6[2]	232 - 244	2.5Y 6/2d 2.5Y 4/2m		vfsl 65% vfs	1 fsbk/sg	so/lo	vfr	so po	1vf	2vf	ST	fm masses, mf nodules		gs	
3Ck7	244 - 262*	2.5Y 6/3d 2.5Y 4/2m		lvfs 80% vfs	sg	lo	vfr	so po	1vf	1vf	SL	ff nodules		cs	*used 2" push tube below 253 cm (soil cemented)
3Ck8	262 - 272	2.5Y 6/2d 2.5Y 4/3m	ffp 5YR 4/6d (4/6m)	lvfs* 80% vfs	sg	lo	vfr	so po	1vf	1vf 1f	ST (slow)	fm nodules, fm masses		as	*<5% gravel; few 4mm earthworm channels (10YR 4/2d (2/1m)
4Ak	272 - 275	2.5Y 4/3d 2.5Y 3/3m		gr lvfs* 75% vfs	1 fsbk	sh	fr	so po		1vf	ST (slow)	c nodules (5mm)		end	*35% small and large gravel

Other:

[1]**Ck4** - Lower boundary is mixed by earthworm activity; material from underlying, nonexistent A-horizon has been brought up. [see notes on hand written sheet]

[2]**3Ck6** - well-defined, in-filled earthworm channels (2.5Y 4/2d, 3/2m) begin at 240 cm. Soil structure is nearly single grain; <5% coarse sand from 238 cm.

Figure A.15 Soil profile description, Transect 2, pedon 3

Double Ditch State Historic Site

Location	N593.095 550.371E	Pedon #	32BL8 T2-4
Area	Double Ditch Village: Inside Ditch 2, center of borrow area	Elevation	527.313 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence			Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
						Dry	Moist	Wet							
Oi	0 - 2								3vf 2f	3vf 2f	NE			as	thick root mat with some mineral soil; grasses
A1	2 - 6	10YR 4/2d 10YR 2/1m		sil 10% vfs	2 fsbk	sh	fr	so po	2vf 2f	2vf 1f	NE		few small burned fragments of pottery (≤2mm)	as	hydrophobic
A2	6 - 15	2.5Y 5/1d 2.5Y 3/2m		sil 10% vfs	1 msbk→ 2 fsbk	sh	fr	so po	2vf 1f	2vf 1f	NE		few fine charcoal fragments (≤2mm); bone frags	cs	possible thin (5 mm) ash layer at 10 cm
Bk1	15 - 33	2.5Y 5/2d 2.5Y 3/3m		sil 15% vfs	1 msbk	sh	fr	so po	2vf 1f	2vf 1f	SL	ff masses, fm nodules	bone frags (<1 mm), wood frags, potsherd	gs	7 mm diameter krotovina
Bk2	33 - 50	2.5Y 5/2d 2.5Y 3/3m	cff 2.5Y 7/3d (6/4m) carbonates	sil 18% vfs	1 mpr→ 1 fsbk	sh	fr	so po	2vf 1f	1vf 1f	ST	cf coats, ff nodules, l'ing f pores		cs	
Bk3	50 - 71	2.5Y 6/3d 2.5Y 4/3m		sil 22% vfs	2 mpr→ 2 mabk	sh	fr	so po	2vf 2f	3vf 2f	ST	cf nodules, fm coats		gs	
Bk4	71 - 109	2.5Y 6/3d 2.5Y 4/2m	see below[1]	sil 25% vfs	2 mpr→ 2 msbk	sh	fr	so po	2vf 1f	2vf 1f	ST	cm coats, cf nodules, l'ing f pores		cs	in-filled earthworm channel below 104 cm
Ck1	109 - 112	2.5Y 4/2d 2.5Y 3/2m		sil 25% vfs	2 msbk	sh	fr	so po	1vf 1f	1vf	VE	ff masses, fm nodules		cs	wormcasts common; color from 2A horizon?
2Ak	112 - 116	2.5Y 4/2d 2.5Y 2.5/1m	mmd 2.5Y 6/3 (4/4m) *	sil 10% vfs	m	h	fi	so po	1vf	2vf 1f	VE	mf nodules		as	*some mixing from 114-116 cm
2Bk5	116 - 121	2.5Y 5/3d 2.5Y 4/4m	cfd 2.5Y 4/2 (2.5/1m)	sil 15% vfs	m	h	fi	so po	1vf	1vf	ST	cf nodules	shell (gastropod)	as	mixing with 2Ak by earthworms
2Ck2	121 - 133	2.5Y 6/4d 2.5Y 5/6m		sil 20% vfs	m	h	fi	so po	1vf	1vf	VE	3 f&m coats, 2f threads, mf nodules		cs	large krotovina (2.5Y 4/3d, 3/3m) at 121-133 cm; earthworm activity
2Ck3	133 - 147	2.5Y 5/4d 2.5Y 4/4m		sil 38% vfs	m	vh	vfi	so po	1vf	2vf 1f	ST	ff coats, ff nodules		cs	
3Ck4	147 - 181	2.5Y 5/3d 2.5Y 4/3m	ffd 10YR 4/2d (3/2m)	sil 20% vfs	m	sh	fr	so po	1vf	2vf 2f	ST	ff coats, cf nodules (<2mm)		end	decayed medium roots, increase in % pores: new parent material?

Other	[1]**Bk4** - Color becomes grayer (2.5Y 5/2d, 3/3m) below 104 cm due to mixing from earthworms. Soil (106-121 cm,corrected) is broken in pvc, making faunal turbation difficult to confirm. In all characteristics except color, lower part is consistent with upper part of horizon.

Figure A.16 Soil profile description, Transect 2, pedon 4

Double Ditch State Historic Site

Location: N571.243 532.332E — Pedon #: 32BL8 T2-5

Area: Double Ditch Village: low spot of Basin 1 — Elevation: 526.159 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence Dry	Consistence Moist	Consistence Wet	Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
A	0 - 3	2.5Y 4/2d 2.5Y 2.5/1m		sil 22% vfs	2 msbk	sh	fr	so po	3vf 2f	2vf 1f	NE			cs	hydrophobic; few Mn concretions
Bw1	3 - 7	2.5Y 5/3d 2.5Y 3/2m		sil 25% vfs	1 fsbk	sh	fr	so po	2vf 1f	2vf 1f	NE			as	hydrophobic
Bw2	7 - 17	2.5Y 5/3d 2.5Y 3/2m		sil 27% vfs	1 fpr ?	sh	fr	so po	2vf 1f	2vf 1f	NE			cs	
Bw3	17 - 46	2.5Y 5/3d 2.5Y 3/2m		sil 25% vfs	1 fsbk	sh	fr	so po	2vf 1f	2vf	SL			cs	
Bk1	46 - 56	2.5Y 6/2d 2.5Y 4/2m	fff 2.5Y 7/2d (6/2m) CaCO3	sil 30% vfs	1 fsbk	sh	fr	so po	1vf 1f	2vf 1f	ST	ff masses		cs	
2Ak	56 - 63	10YR 3/2d 7.5YR 2.5/1m	cmp 2.5Y 6/2d (4/2m) cmp 2.5Y 5/4d (3/2m)	sil 5% fs 20% vfs	1 fpr→ 1 fsbk	sh	fr	so po	2vf 1f	2vf 1f	ST	cf threads, l'ing c pores		cs	earthworm mixing with Bk1 and 2Bk2 horizons
2Bk2	63 - 72	2.5Y 5/4d 10YR 3/2m	cmf 2.5Y 6/3d (4/3m) earthworm activity	sil 30% vfs	1 fpr	sh	fr	so po	3vf 2f	2vf 2f	ST	mf coats, cf threads, ff nodules		cs	mixing from above, not much from lower (2Bk3) horizon
2Bk3	72 - 83	2.5Y 5/4d 10YR 4/3m		sil 32% vfs	1 fpr	sh	fr	so po	2vf 2f	2vf 2f	VE	mf coats, cf threads, ff nodules		cs	fm vertical root channels filled with 10YR 4/1 (3/1m) organic material
2Bk4	83 - 97	2.5Y 5/3d 2.5Y 4/4m		l 10% fs 38% vfs	1 mpr ?	sh	fr	so po	1vf 2f	2vf 2f 1m	VE	ff nodules, cf threads, l'ing c pores, cf coats		gs	
2Bk5	97 - 114	2.5Y 5/3d 2.5Y 4/3m	cff 2.5Y 6/3d (5/3m)	l 6% fs 38% vfs	m	sh	fr	so po	1vf 2f	2vf 2f	VE	cf nodules, cf threads, cf coats, l'ing c pores		cs	
2Ck1	114 - 137	2.5Y 5/3d 2.5Y 4/3m		vfsl*	m	so	fr	so po	1vf 1f	2vf	VE	cf nodules, ff threads, cf coats		cs	*15% fs, 45% vfs; windblown sand; slightly lower chroma
3Ck2	137 - 157	2.5Y 6/3d 2.5Y 4/4m		vfsl*	m	sh	fr	so po	1vf 1f	2vf 1f	VE	cf nodules, cf coats		as	*25% fs, 32% vfs; thin banding (<5mm) of clean vfs
3Ck3	157 - 166	2.5Y 6/3d 2.5Y 4/4m	see below[1]	vfsl*	m	sh	vfr	so po	1vf 1f	2f 2vf	ST	ff nodules, cf coats, l'ing f pores		cs	*20% fs, 35% vfs
3Ck4	166 - 176	2.5Y 6/3d 2.5Y 4/3m	see below[2]	vfsl*	m	sh	vfr	so po	1vf 1f	1f 2vf	SL	ff nodules, ff coats		cs	*25% fs, 40% vfs
4C1	176 - 182	2.5Y 6/3d 2.5Y 4/3m		vfsl*	m	so	vfr	so po	1vf 1f	1f 1vf	NE	vf masses at base of horizon		cs	*35% vfs, 15% fs
4C2	182 - 198	2.5Y 6/2d 2.5Y 4/3m	fff 10YR 6/6d	vfsl*	m	sh	vfr	so po	1vf	1vf	SL	f masses cvf nodules		as	*35% vfs, 15% fs vfs round/subround (16x)
5C3	198 - 215	2.5Y 6/3d 2.5Y 4/3m	see below[3]	vfsl*	m	so	vfr	so po	1vf	1f	NE	vfvf nodules in upper 3 cm		as	*35% vfs, 20% fs; see below[3]
5C4	215 - 222	2.5Y 6/3d 2.5Y 4/3m	see below[4]	lvfs	m	so	vfr	so po	1vf	1vf	ST	c masses, nodules and l'ing pores			*40% vfs, 15% fs; see below[4]

Other

[1]**3Ck3** - Mottles: very few fine faint 10YR 5/6d (4/4m) visible only with a 16× hand lens. Long, vertical channels 4mm diameter (earthworms?)

[2]**3Ck4** - Mottles: visible under 16× hand lens, very few fine prominent 7.5YR 4/6d (4/4m); very few fine distinct 10YR 6/6d (4/6m).

[3]**5C3** - Mottles: few fine distinct 5Y 7/1d (6/1m); few fine faint 10YR 6/6m oriented horizontally. Thin bands of clean fine sand present throughout.

[4]**5C4** - Mottles: few fine distinct 5Y7/1d (6/1m); very few fine prominent 7.5YR 3/2 (d/m); very few fine faint 10YR 6/6m. Structure: very thin cracks (jointing?). Texture: round/subround sand.

Figure A.17a Soil profile description, Transect 2, pedon 5

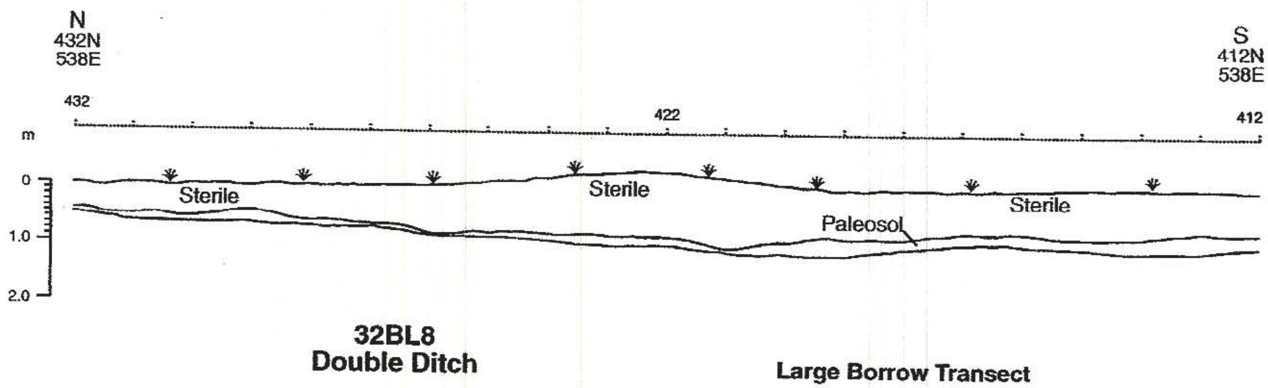


Figure A.17b Subsurface profile in the center of Basin 1 in the Outer Residential Area showing the “sterile C-horizon” as a central ridge with varying depth to the paleosol (with permission of the PaleoCultural Research Group, Ahler 2003)

Double Ditch State Historic Site

Location: N555.385 515.162E — Pedon # 32BL8 T2-6 — SHEET 1 OF 2

Area: Double Ditch Village: upper SW rim of Basin 1 — Elevation 527.002 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence Dry	Consistence Moist	Consistence Wet	Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
Oi	0 - 2								3vf 3f	3vf 3f				as	thick rootmass of grasses
A1	2 - 4	2.5Y 4/2d 2.5Y 3/2m		sil 10% vfs	2 f&m sbk	sh	fr	so po	3vf 2f	2vf 2f	NE			as	hydrophobic
fill 1	4 - 10	2.5Y 5/3d 2.5Y 3/3m		sil 10% vfs	1mabk	sh	fr	so po	2vf 3f	3vf 2f	NE		few fine bone frags (<3mm)	cs	probable fill material
fill 2	10 - 19.5	2.5Y 4/2d 2.5Y 3/2m		sil 20% vfs	2 fsbk	sh	fr	so po	2vf 2f 1m	3vf 2f	SL	ff coats, ff nodules	several bison bone frags[1], potsherds, ff charcoal	ci	probable fill material
fill 3	19.5 - 23.5	2.5Y 4/2d 2.5Y 3/2m		sil 10% vfs	3 msbk	sh	fr	so po	2vf 2f 1m	2vf 3f	ST	cm nodules	bone, charcoal, lithics, potsherds (trash)	as	formed in trash fill
fill 4	23.5 - 32	2.5Y 5/2d 2.5Y 4/2m		sil 20% vfs	3 mabk	h	fi	so po	2vf 2f 1m	2vf 2f	VE	cm nodules, mf threads*	ff bone frags, potsherds, 1 frag charcoal <1 mm	cs	*threads on horiz. & vertical ped faces; faint traces of layering (fill)
fill 5	32 - 39	2.5Y 6/3d 2.5Y 4/3m		sil 22% vfs	3 mpr (m?)	h	fi	so po	2vf 2f 1m	3vf 1f	ST	cm nodules, mf threads, l'ing f pores	f bone frags, f potsherds	aw	
fill 6	39 - 49	2.5Y 6/2d 2.5Y 4/2m	see below[2]	sil 22% vfs	1 msbk	sh	fr	so po	2vf 1f 1m	3vf 2f 1m	VE	cm nodules, ff threads, f "rings"	bone frags, incl. small mammal; lithics, charcoal	as	high % organic carbon from charcoal
fill 7	49 - 102	2.5Y 6/3d 2.5Y 4/3m	see below[2]	sil 10% vfs	m	sh	fr	so po	2vf 1f	3vf 1f	ST	ff masses, ff threads, cf&m nodules		gs	
fill 8	102 - 116.5	2.5Y 6/2d 2.5Y 4/2m	see comment*	sil 18% vfs	2 msbk	sh	fr	so po	3vf 2f	3vf 2f 1m	ST	2f&m nodules, l'ing f pores		cs	*few incl. 10YR 3/1d (2/1m), 2mm diameter, tubular
2Ak1*	116.5 - 123	2.5Y 5/2d 2.5Y 4/2m		sil 25% vfs	3 fsbk	sh	fr	so po	2vf 3f 1m	2vf 2f	ST	cf coats, l'ing c pores, 2f&m nodules	f bone frags, 1 seed	ci	*original ground surface?
2Ak2	123 - 128.5	2.5Y 5/3d 2.5Y 4/3m		sil 25% vfs	1 csbk→ 3 fsbk	sh	fr	so po	2vf 2f	2vf 2f	ST	cf nodules, ff coats, l'ing f pores		cs	structure, roots indicate pedogenic A horizon
2Bk1	128.5 - 158	2.5Y 5/3d 2.5Y 4/2m		sil 25% vfs	1 mpr→ 2 mabk	sh	fr	so po	2vf	2vf 1f 1m	ST	ff coats and masses*		gs	*also presence of $CaSO_4$ coating vf roots and lining vertical pores.
2Bk2	158 - 166	2.5Y 5/2d 2.5Y 3/3m		sil 20% vfs	1 cabk? m?	sh	fr	so po	2vf	3vf 1f	ST	ff coats*		as	*strong expression of $CaSO_4$ as f nodules and filing vertical pores
2Ck1	166 - 173	2.5Y 6/3d 2.5Y 4/4m	mff 2.5Y 7/2d (6/2m) $CaCO_3$ coatings	sil 18% vfs	m	sh	fr	so po	2vf	2vf 1f	VE	mf coats, l'ing c pores*		gs	*ff nodules $CaSO_4$
2Ck2	173 - 191	2.5Y 5/2d 2.5Y 3/3m	fmp 10YR 6/6 (5/6m)	sil 15% vfs	m	sh	fr	so po	1vf	3vf 1f	ST	ff masses, ff nodules*		cs	*ff nodules $CaSO_4$
2Ck3	191 - 196	2.5Y 5/2d 2.5Y 3/2m	cmf 2.5Y 4/1d (3/1m) earthworm channels	sil 18% vfs	m	sh	fr	so po	1vf	3vf	ST	ff nodules $CaSO_4$		cs	

Other

[1]**fill 2 -** Bison scapula resting on upper boundary of fill 3 horizon. [2]**fill 6, 7 and 8 -** From 37-102 cm, soil shows circular mottles, randomly oriented, approximately 3 mm diameter. Color difficult to quantify: possibly 2.5Y 5/3d (4/3m). Surrounded by a ring of $CaCO_3$. Worm channel or large pore?

Figure 1.18a Soil profile description, Transect 2, pedon 6 (sheet 1 of 2)

Double Ditch State Historic Site

Location: N555.385 515.162E — Pedon # 32BL8 T2-6 SHEET 2 OF 2

Area: Double Ditch Village: upper SW rim of Basin 1 — Elevation 527.002 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence Dry	Consistence Moist	Consistence Wet	Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
3Ak3	196 - 202	10YR 4/1d 10YR 3/2m	mmd 10YR 6/3(4/3m) earthworms*	sil 15% vfs	1 msbk	sh	fr	so po	1vf	2vf 1f	ST	ff masses, mf nodules **		cs	*earthworm mixing: fmf 10YR 3/1d (2/1m) **also ff nodules $CaSO_4$
3Ak4	202 - 212	2.5Y 3/2d 2.5Y 2.5/1m	mmf 2.5Y 5/3 (3/3m) cmd 10YR 4/4 (3/4m)	sil 15% vfs	2 msbk	sh	fr	so po	1vf	2vf	ST	cm masses, mf nodules, l'ing f pores		cs	mottles from faunal mixing
3Ak5	212 - 222	2.5Y 5/3d 2.5Y 4/4m	mmd 2.5Y 3/2d (3/1m) earthworms	sil 15% vfs	1 fpr	sh	fr	so po	1vf	2vf	ST	cf&m coats, ff threads of $CaSO_4$		cs*	*earthworm mixing from 3Ak4
3Ak/Bk[4]	222 - 228	Ak: 2.5Y 5/3d 2.5Y 4/4m	Bk: 10YR 6/8d 10YR 4/6m	sil 18% vfs	1 mpr→ 2 msbk	sh	fr	so po	1vf*	2vf 1f	ST (Ak) VE (Bk)	ff coats, cf&m threads of $CaSO_4$		cs	see note below for color patterns[4]
3Bk3	228 - 254	2.5Y 5/4d 10YR 4/4m		sil 20% vfs	m	sh	fr	so po	1vf	2vf 1f	VE	ff&m coats, ff threads, ff nodules,& l'ing m pores		as	earthworm mixing (5%) to 247 cm
slough	254 - 259	2.5Y 5/3d 2.5Y 4/2m		sil 25% vfs	m	sh	fr	so po	1vf	2vf 1f	ST	cf coats, ff nodules		as	slough from coring
3Ck4	259 - 278	2.5Y 5/4d 2.5Y 4/4m		sil 30% vfs	m	vh	fr	so po	1vf	2vf	ST	cf threads, mf nodules, l'ing c pores		cs	dense material
4C	278 - 281	2.5Y 6/3d 2.5Y 3/3m		fs 90% fs & vfs	m/sg	lo	vfr	so po	1vf	1vf	SL			end	

Other:

[3]**3Ak3, 3Ak4, 3Ak5** - Volume impacted by transfer from push tube, ~50% (depths corrected).

[4]**3Ak/Bk** - Color: 3Ak4 and 3Ak5 material present through in-filling of earthworms channels. Horizon also contains 3Bk3 material brought in from below. Colors of these are as in each individual horizon; 45% 3Ak5, 45% 3Bk3, 10% 3Ak4.

Figure A.18b Soil profile description, Transect 2, pedon 6 (sheet 2 of 2)

Double Ditch State Historic Site

Location: N542.008 501.548E — Pedon #: 32BL8 T2-7

Area: Double Ditch Village: inner rim of Ditch 2 (post and pallisade) — Elevation: 526.564 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence Dry	Consistence Moist	Consistence Wet	Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
A1	0 - 5	2.5Y 5/2d 2.5Y 3/2m		sil 25% vfs	2 fsbk	sh	fr	so po	2vf 1f	2vf 1f	NE		heat-treated granite, bone frags	as	hydrophobic
A2	5 - 8	2.5Y 5/2d 2.5Y 3/2m	cmf 2.5Y 6/3d carbonates	sil 10% vfs	2 msbk	sh	fr	so po	2vf 1f	2vf 1f	SL	cm coats	bone frags, wood splinters, charcoal frags; one unidentified	as	
fill 1	8 - 20[1]	2.5Y 5/2d 2.5Y 3/3m	ffd 2.5Y 4/1d (3/1m)	sil 15% vfs	3 cabk	sh	fr	so po	2vf 2f	3vf 1f	ST	mm masses, cf nodules	bone frags, potsherds, charcoal frags	aw	
fill 2	20 - 38[1]	2.5Y 5/2d 2.5Y 3/2m		sil 10% vfs	3 msbk	so	vfr	so po	3vf 2f	2vf 2f	ST	mm coats	bone frags, potsherds	aw	lower boundary ranges in depth from 36-41 cm
fill 3[2]	38 - 105	2.5Y 6/3d 2.5Y 4/3m		sil 10% vfs	1 mpr→ 2 msbk	sh	fr	so po	3vf 1f	3vf 1f 1m	ST	see below[2]		aw	increase in vfs at ~55 cm?
fill 4	105 - 110	2.5Y 6/2d 2.5Y 4/2m		sil 5%fs 10% vfs	3 f&msbk	sh	fr	so po	3vf matted	2vf 1m	SL	cm nodules	bone frags, charcoal frags, pottery frags 1-2 mm	aw	root mat seperates horizon from fill 5 below
fill 5	110 - 166	2.5Y 5/2d 2.5Y 3/2m		sil 10% vfs	3 fsbk	sh	fr	so po	2vf	3vf 1f	ST	ff nodules on roots 110-117 cm	bone frags, charcoal frags, wood?, lithic chips	cs	ash, bone charcoal and potsherds comprise trashy fill
fill 6	166 - 168	2.5Y 6/2d 10YR 3/2m		sil 25% vfs	m	so	vfr	so po	1vf	3vf	ST	cf nodules	ash, bone frags	as	fill--thin layer, but different from above
2Ck1	168 - 176	2.5Y 6/2d 2.5Y 4/4m	mmd 10YR4/2 (2/2m) *	sil 25% vfs	m	sh	fr	so po	1vf	1vf	VE	ff masses, l'ing f pores		cs	*faunal mixing; 2" diameter cores to end; sterile C on top of paleo-A
3Ak1	176 - 182	10YR 3/2d 10YR 2/1m	mmd 2.5Y 5/3 (4/4m) *	sil 20% vfs	m	sh	fr	so po	1vf	2vf	ST	ff nodules, l'ing f pores		cs (5 cm)	faunal mixing with 2Ck1 and 3Ak2
3Ak2	182 - 190	10YR 4/3d 10YR 3/3m	fmf 10YR 5/4d (3/3m) *	sil 10% vfs	m	sh	fr	so po	1vf	2vf	VE	cm masses, l'ing f pores		ai	mixing with 3Bk1 throughout (30%)
3Bk1	190 - 216	2.5Y 5/4d 2.5Y 4/4m		sil 10% vfs	m	sh	fr	so po	1vf	2vf	ST	cm masses, ff threads, cf nodules		cs	few thin bands of clean fs; slight mixing with 3Ak2
3Ck2	216 - 224	2.5Y 6/3d 2.5Y 4/3m		sil 25% vfs	m	h	fr	so po		2vf 1f	VE	cf&m masses, cf threads, l'ing c pores		cs	most of the remaing pedon is fractured
4Ck3	224 - 250	2.5Y 6/3d 2.5Y 4/3m	see below[3]	vfsl 70% vfs	m	lo	vfr	so po		1vf	VE	cf&m nodules, cm masses, ling f pores		as	lenses of clean sand
4Ck4[4]	250 - 280	2.5Y 6/3d 2.5Y 4/3m	cfd 2.5Y 7/1d (6/1m) cfd 2.5Y 6/6d (5/6m)	vfsl 70% vfs	m	lo	vfr	so po		2vf assoc with $CaCO_3$	VE↓ with depth	cm nodules, cm masses, l'ing f pores		gs	bedding evident
4Ck5	280 - 298	2.5Y6/3d 2.5Y 4/3m	cfd 2.5Y 7/1d (6/1m) cfd 2.5Y 6/6d (5/6m)	lvfs 80% vfs	m	lo	vfr	so po			NE	fm nodules and coats		end	

Other

[1]**fill 1, fill 2** - Horizon boundary between these two horizons ranges from 16 cm to 26 cm. Possible post hole from palisade fence? The majority of the fill 1 is above the 20 cm depth.

[2]**fill 3** - Soil fractured parallel to fill 4 horizon, as if packed at the time of deposit. Carbonates coating 3 pebbles with accumulations on the underside; cm coats and masses, mf nodules, lining f pores.

[3]**4Ck3** - Mottles: ffd 2.5Y 7/1d (6/1m) surrounded by ffd 2.5Y 6/6d (5/6m); ffp 10YR 2/2d (2/2m). Carbonates: pores appear to be the nucleus for medium nodules (hard masses).

[4]**4Ck4** - There was 17 cm of surface slough from coring, overlying this horizon; that soil was hydrophobic; 2.5Y 5/2d (3/2m); so, fr, so, po; ST effervescent; contained a few granite fragments.

Figure A.19 Soil profile description, Transect 2, pedon 7

Double Ditch State Historic Site

Location N535.564 495.293E — Pedon # 32BL8 T2-8

Area Double Ditch Village: Inner Residential Area, center of borrow area — Elevation 526.017 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence Dry	Consistence Moist	Consistence Wet	Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
Oi/Oe	0 - 2								3vf 2f					ai	dense root mat
A	2 - 6.5	2.5Y 4/1d 2.5Y 3/1m		sil 10% vfs	2 tkpl	sh	fr	so po	2vf 2f	1f	NE		?	as	extremely hydrophobic
Bw1	6.5 - 13	2.5Y 5/3d 2.5Y 3/2m	in upper 1 cm: cmf 2.5Y 4/2d (3/1m)	sil 12% vfs	m	h	fr	so po	1vf	1vf 1f	NE		small rotten bone frags; no ash	cs	mixing by worms in upper 1 cm
Bw2	13 - 22	2.5Y 5/2d 2.5Y 3/2m		sil 10% vfs	m	h	fr	so po	2vf	2vf 1f	SL	ff thin coats	bone frags, rock frags <2mm	cs	some worm activity
Bk1	22 - 34	2.5Y 5/2d 2.5Y 3/2m		sil 18% vfs	m	sh	fr	so po	1vf	2vf 1f	ST	cf coats, cf nodules	bone frags, rock frags	ai	mixing by worms or other insects; 5mm diameter, extend into Bk2
Bk2	34 - 62	2.5Y 6/2d 2.5Y 4/2m		sil 20% vfs	1 msbk	sh	fr	so po	1vf	3vf 2f 1m	ST	cm coats, mf nodules	very fine bone frags and pottery frags; larger bone at 42 cm	gs	
Bk3	62 - 91	2.5Y 6/3d 2.5Y 4/3m	fmf 2.5Y 5/2d (3/2m) *	sil 20% vfs	1 msbk	sh	fr	so po	1vf	3vf 2f	ST	cm coats, mf nodules, l'ing f pores		gs	*mottles appear as isolated bits of A-horizon, 78 cm depth
Bk4	91 - 114	2.5Y 5/3d 2.5Y 4/3m		sil 25% vfs	1 fpr ?	sh	fr	so po	1vf	3vf 1f 1m	VE	cm coats, mf nodules, l'ing c pores		cs	
Ck1	114 - 151	2.5Y 6/2d 2.5Y 4/2m		sil 30% vfs	m	sh	fr	so po	1vf	2vf 1f	VE	cf coats, mf nodules, l'ing f pores		cs	muscovite in the sand fraction
2Ak1	151 - 159	10YR 4/2d 10YR 3/2m	mmd 2.5Y 6/2 (4/2m) faunal mixing	sil 18% vfs	m	h	fr	so po	1vf	3vf 1f	VE	cf coats, mf nodules, l'ing c pores	small rounded pebble	cs	Ck1 material in-fills common earthworm channels
2Ak2	159 - 166	10YR 3/1d 10YR 2/1m	cfp 2.5Y 5/3d (4/3m) faunal mixing	sil 20% vfs	1 fsbk	h	fr	so po	1vf	3vf 1f 1m	VE	cf coats, mf nodules, l'ing f pores, f "rings"		cs	carbonate nodules felt like sand when texturing
2Ak/Bk	166 - 170	A: 10YR 3/1d 10YR 2/1m	B: 2.5Y 5/4d 2.5Y 4/4m	sil 20% vfs	1 fsbk	h	fr	so po	1vf	3vf 1f	ST	cf coats, cf nodules, l'ing c pores		cs	Ak/Bk due to copius mixing by earthworms
2Bk5	170 - 189	2.5Y 5/4d 2.5Y 4/4m		sil 27% vfs	1 msbk	h	fr	so po		2vf 1f	ST	cf coats, mf nodules*, l'ing f pores		cs	*nodules of $CaCO_3$ and $CaSO_4$; incr. hornblende in sand fraction
3Ck2	189 - 194	2.5Y 5/3d 2.5Y 4/3m	mmd 2.5Y 6/4d (10YR 4/3m)	fsl 35% fs 30% vfs	m	so	vfr	so po	1vf	1f 1m	VE	ff nodules		cs	increased hornblende in the sand fraction
3Ck3	194 - 203	2.5Y 5/4d 2.5Y 4/4m	see below[1]	vfsl 60% vfs	m	sh	vfr	so po	1vf	2vf 1m	VE	cm masses, cf nodules, l'ing f pores	snail (gastropod?) shell, associated with medium pore	gs	Mn concretion at 214 cm contact (10YR 3/2d, 2/2m)
3Ck4	203 - 284	2.5Y 5/4d 2.5Y 4/4m	see below[2]	vfsl[2] 50% vfs	m[2]	sh	vfr	so po	1vf	2vf 1m	VE	mf nodules, cf threads, cm coats, l'ing c pores		end	few Mn coatings & concentrations

Other

[1]**3Ck3** - Mottles: ffp 10YR 6/8d (5/8m); mfd 2.5Y 6/1d (5/1m). Texture: horizon contains a few bands (<2.5cm) of 2.5Y5/2 (d&m) fine sand, increasing with depth.

[2]**3Ck4** - Mottles: cfd 2.5Y 6/6d (5/4m); cfp 7.5YR 4/6d (3/4m). Texture: horizon has <10% fine sand (while 3Ck3 contained somewhat more fine sand). Structure: massive with some vertical fracturing. Carbonates: 226-233 cm has a greater concentration of carbonates than the rest of the horizon; assume it is an isolated pocket. This area has structure of 2 fsbk, 2 fabk and 2 mabk.

Figure A.20 Soil profile description, Transect 2, pedon 8

Double Ditch State Historic Site

Location: N524.377 483.794E — Pedon # 32BL8 T2-9

Area: Double Ditch Village: Inner Residential area, possible house wall — Elevation 526.801 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence Dry	Consistence Moist	Consistence Wet	Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
A1	0 - 2	10YR 5/2d 10YR 3/2m		sil 15% vfs	1 msbk & 2 fsbk	sh	vfr	so po	2m 2f 3vf	2f 2vf	ST		potsherds, bone frags, one lithic frag	as	unusual for surface horizons to be strongly effervescent
A2	2 - 7.5	10YR 5/2d 10YR 3/2m		sil 10% vfs	2 fsbk	sh	vfr	so po	1m 2f 2vf	2f 2vf	ST		insect eggs in an oval void ~1 × 1 × 2 cm	as	
2A3	7.5 - 15	2.5Y 5/2d 2.5Y 3/2m		sil 22% vfs	2 fsbk	sh	fr	so po	1m 2f 3vf	1m 1f 3vf	VSL		potsherd, bone frags, stone	as	dense root mat at 7.5 cm
2A4	15 - 21	2.5Y 5/2d 2.5Y 3/2m		sil 15% vfs	3 fsbk	sh	vfr	so po	1m 1f 3vf	1m 3vf	ST		bone frags, charcoal	as	highly aggregated
2Bw1	21 - 27	2.5Y 5/3d 2.5Y 3/2m		sil 20% vfs	2 fsbk	so	vfr	so po	2f 3vf	2f 2vf	ST	ff coats, cf nodules	potsherd, bone frags, charcoal	cs	
3A5[1]	27 - 35	2.5Y 5/2d 2.5Y 3/2m		sil 10% vfs	3 fsbk	so	vfr	so po	2f 3vf	1m 1f 2vf	ST	fm soft masses	potsherds, bone frags, charcoal, granite	cs	highly aggregated[1]
3Bk1	35 - 57	2.5Y 5/2d 2.5Y 3/2m		sil 10% vfs	2 msbk	so	fr	so po	1f 3vf	1f 3vf	ST	mf coats, mf threads, l'ing c pores		cs	few insect eggs as in A2, in a small void at 37 cm
4A6[2]	57 - 63	2.5Y 5/2d 2.5Y 3/2m		sil 18% vfs	2 fsbk	sh	fr	so po	1f 2vf	2f 3vf	ST	cf nodules, ff coats	potsherds, bone frags, heat-treated granite, charcoal, clay[2]	as[2]	hydrophobic[2]--original ground surface?
4Bw2	63 - 76	2.5Y 5/3d 2.5Y 4/3m		sil 22% vfs	2 fpr	sh	fr	so po	1f 2vf	1f 2vf	ST	l'ing c pores, cf coats, f "rings"	few bone frags, few fine charcoal frags	cs	Possible house floor? No platy structure.
4Ck1[3]	76 - 117	2.5Y 6/3d 2.5Y 4/3m		sil 30% vfs	m	sh	fr	so po	2vf	1f 2vf	VE	masses, nodules, threads, few "rings"[3]		gs	core broken with ~50% loss of volume below 85 cm (corrected)
4Ck2	117 - 155	2.5Y 6/3d 2.5Y 4/3m		sil 30% vfs	m	so	vfr	so po	2vf	1f 1vf	ST	cf masses, cf coats, l'ing f pores		gs	
4Ck3	155 - 176	2.5Y 6/2d 2.5Y 4/2m		l 50% vfs	m	sh	vfr	so po	2vf	2vf	VE	cf threads, cf nodules, l'ing c pores, f "rings"		gs	new pm? But gs upper boundary
4Ck4	176 - 225	2.5Y 6/2d 2.5Y 4/2m		sil 35% vfs	m	so	vfr	so po	1vf	2vf	VE	ff coats, l'ing c pores, f "rings"; *		cs	*common $CaSO_4$ nodules <1mm, and lining c pores, incr with depth
4Ck5	225 - 231	2.5Y 5/2d 2.5Y 3/2m	mff 2.5Y 4/1d (3/1m) faunal mixing	sil 10?% vfs	m	sh	vfr	so po	?	2vf	ST	mf nodules, cf coats		cs	
5A7	231 - 239	2.5Y 4/2d 2.5Y 3/2m	mmd2.5Y3/1(2.5/1m) ffd 2.5Y 5/3 (4/3m)*	sil 20% vfs	2 msbk ?	sh	fr	so po	?	1vf 1f	ST	cf nodules, ff coats; ff $CaSO_4$ nodules	charcoal frags (burned twigs?)	cs	*mottling from faunal mixing, above and below
5A8	239 - 244	2.5Y 4/2d 2.5Y 3/2m	cmd 10YR 5/4 (4/6m) faunal mixing	sil 15% vfs	2 msbk ?	sh	fr	so po	?	2vf 1f	ST	cf nodules, ff coats; ff CaSO4 nodules		cs	
5Bk2	244 - 253	2.5Y 6/4d 2.5Y 5/6m	cfd 2.5Y 4/2d (3/1m) faunal mixing	sil 25% vfs	m	sh	fr	so po	1vf	3vf 1f	ST	cf masses, cf nodules, l'ing c pores		end	broken in pvc, ~50% volume reduction (corrected)

Other

[1]**3A5** - Lower boundary ranges from 33-36.5 cm deep acros the core; smooth, gradual slant.

[2]**4A6** - This horizon is hydrophobic, as are many A-horizons of present day soil. Working theory is that the first 3 sequences are sloughed house walls of earthlodges. Clay (silty clay?) 2.5Y 4/1d (3/1m), 5mm. Lower boundary looks artificially abrupt. [3]**4Ck1** - Color gradually lightens with depth, especially below 100 cm, as carbonates increase. At 88-91 cm, only very few pores are lined; by 96 cm, common pores. At 112+ cm, many pores are lined. Color changes not measurable by Munsell.

Figure A.21 Soil profile description, Transect 2, pedon 9

Double Ditch State Historic Site

Location: N509.835 465.267E — Pedon #: 32BL8 T2-10

Area: Double Ditch Village: Inner Residential, approx. center of earthlodge — Elevation: 526.266 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence Dry	Consistence Moist	Consistence Wet	Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
A1	0 - 4	2.5Y 4/2d 2.5Y 3/2m		sil 15% vfs	1 mpl→ 2 fsbk	sh	fr	so po	1f 2vf	1f 2vf	NE			as	hydrophobic; very weak platy structure
A2	4 - 7	2.5Y 4/3d 2.5Y 3/2m		sil 15% vfs	2 fsbk	sh	fr	so po	1f 2vf	1f 1vf	NE		traces of fine charcoal; fine bone frags	as	
Bw1	7 - 16	2.5Y 5/3d 2.5Y 3/3m		sil 20% vfs	2 mabk	sh	fr	so po	1f 2vf	1f 2vf	NE		few very fine bone frags (not bagged)	cs	on edge of krotovina?
Bk1	16 - 24	2.5Y 5/3d 2.5Y 3/2m		sil 18% vfs	1 mabk	h	fr	so po	2vf	1f 2vf	ST	cf nodules, cf coats, l'ing f pores	fine bone frags	cs	
fill 1	24 - 36	2.5Y 6/3d 2.5Y 4/3m		sil 18% vfs	m	sh	fr	so po	2vf	2vf	VE	ff nodules, fc soft masses	bison bone, rodent bone, charcoal, KRF spalls, potsherds	ai	
ash 1	36 - 50	2.5Y 6/1d 2.5Y 5/2m			m	so	vfr	so po	2vf		VE		bone frags, charcoal, fine trash	ai	
Ck1	50 - 79	2.5Y 6/3d 2.5Y 4/3m		sil 30% vfs	m	sh	fr	so po	1f 1vf	1m 2f 3vf	VE	mf nodules, cf coats, l'ing c pores		ai	
pit fill 2	79 - 120	2.5Y 5/3d 2.5Y 4/3m		sil 20% vfs	2 msbk ?	sh	fr	so po	1vf	1vf	VE	?	see below[1]	as	not sampled due to bone content; see sketch on description sheet
Ck2	120 - 184	2.5Y 5/3d 2.5Y 4/3m		l? sil? *	m	sh	fr	so po	1vf	1vf	VE	cm masses, cf threads, cf nodules, f "rings"**	insect burrow 5 mm diameter	cs	*30% vfs, 10% fs; **also l'ing c pores
Ck3	184 - 195	2.5Y 5/3d 2.5Y 4/3m	fmd 10YR 3/2d (2/1m) faunal mixing	l 10% fs 35% vfs	m	so	vfr	so po	1vf	2vf 1f	ST	fm coats, cf nodules, l'ing f pores	bone frag, ochre	cs	discreet worm channels in-filled with 2Ak material
2Ak1	195 - 203	2.5Y 4/1d 2.5Y 3/2m	cmp 2.5Y 6/6d (5/4m) faunal mixing	sil 20% vfs	m	so	vfr	so po	1vf	2vf	VE	ff nodules, c "rings," l'ing f pores	decomposed bone?	cs	
2Ak2	203 - 211	2.5Y 4/2d 2.5Y 2.5/1m	cmd 2.5Y 5/4d (4/3m) faunal mixing	sil 15% vfs	m	sh	fr	so po	1vf	2vf	ST	cf nodules, ff threads, l'ing f pores		cs	
2Ak3	211 - 215	2.5Y 4/2d 2.5Y 3/2m	cmd 2.5Y 5/4d (4/4m) faunal mixing	sil 20% vfs	m	sh	fr	so po	1vf	2vf	ST	cf nodules, ff threads, l'ing f pores		ci	
2Bk2	215 - 231	2.5Y 5/4d 2.5Y 4/4m	fmp 10YR 4/2d (3/2m) faunal mixing	l 30% vfs	m	sh	fi	so po		2vf 1f	ST	cf nodules, cf threads, l'ing c pores		cs	mixing by earthworms and larger insects with above A-horizons
2Ck4	231 - 247	2.5Y 6/3d 2.5Y 4/3m		fsl 30% fs 30% vfs	m	sh	fr	so po		1vf	VE	cf threads, cf nodules		end	horizon placed in bag in field--very broken & crushed

Other

[1]**pit fill 2** - Cache pit fill with high concentration of porous bone, especially from 96-120 cm. Texture is sil with small amount of angular sand. Soil appears to be finer textured, or compacted, or both, and fills some voids between bone.

All or part of this horizon was not analyzed.

Figure A.22a Soil profile description, Transect 2, pedon 10

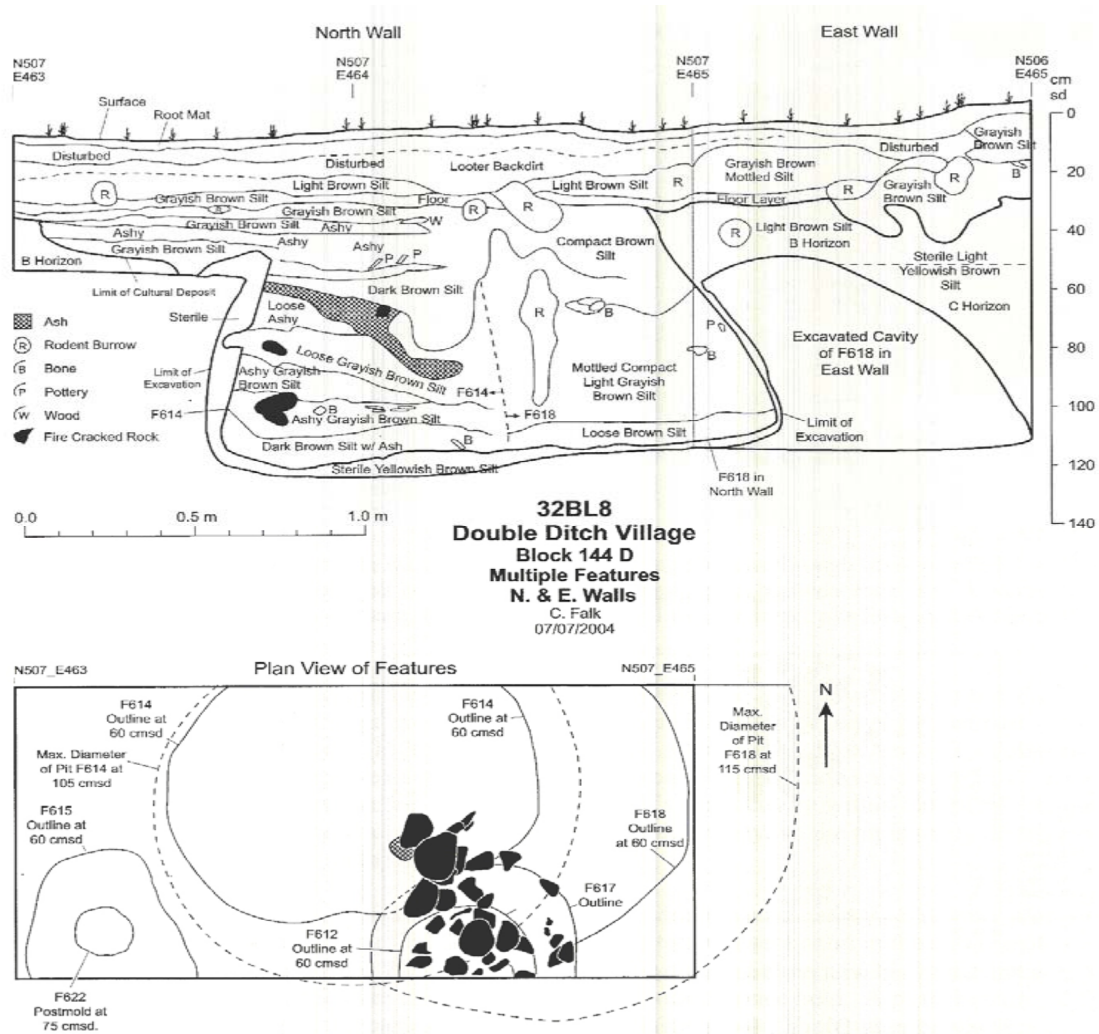


Figure A.22b North and east profiles and plan drawing near pedon 10 in Transect 2 illustrating a cache (storage) pit with layers of earthy fill. Note the "sterile C-horizon" on the right (with permission of the PaleoCultural Research Group, Ahler 2005)

Double Ditch State Historic Site

Location: N501.157 449.810E[1] — Pedon # 32BL8 T2-11 SHEET 1 OF 2

Area: Double Ditch Village: Inner Residential, high point between lodges — Elevation 526.672 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence Dry	Consistence Moist	Consistence Wet	Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
A1	0 - 3	2.5Y 4/2d 10YR 2/2m		sil 18% vfs	1 mpl→ 2 fsbk	sh	fr	so po	3f 3vf	1f 2vf	NE		?	as	hydrophobic
fill 1	3 - 10.5	2.5Y 5/3d 2.5Y 3/3m	mfd 2.5Y 4/2d 10YR 2/2m	sil 20% vfs	1 mpl→ 2 msbk	sh	fr	so po	2f 3vf	2f 2vf	NE		very few bone frags <2mm	as	evidence of copius worm activity with above horizon
fill 2	10.5 - 30	2.5Y 5/3d 2.5Y 3/3m		sil 20% vfs	1 fsbk	sh	fr	so po	1f 3vf	2f 2vf	SL		ashy pockets; common fine bone frags, charcoal, heat-treated granite	as	assumed slough from earthlodges
fill 3	30 - 33.5	2.5Y 6/4d 2.5Y 4/4m	fff 2.5Y 4/3d (3/3m)*	sil 22% vfs	1 fsbk	sh	fr	so po	3vf	1f 2vf	ST	cf threads (in fill?)	bone frags, rock, charcoal	as	*earthworm activity? Roots? Found in fill 5.
fill 4	33.5 - 37	2.5Y 5/2d 10YR 3/2m		sil 18% vfs	1 tkpl→ 1 fsbk	sh	fr	so po	3vf	1f 2vf	ST	see below[2]	bone frags, rock, charcoal, potsherd	as	slightly hydrophobic
fill 5	37 - 41	2.5Y 5/4d 2.5Y 4/4m	mmf 2.5Y 5/3 (4/2m) cff 2.5Y 4/3d (3/3m)*	sil 20% vfs	2 tkpl	sh	fr	so po	3vf	2vf	ST	mf threads, ff nodules (matrix only)	potsherd ("gold flecks"), bone frags, charcoal	cs	linear mottles; continuation from fill 3?
fill 6*	41 - 48	2.5Y 4/3d 2.5Y 3/3m		sil 18% vfs	2 f&msbk	sh	fr	so po	3vf	2vf	ST	cf threads, ff nodules	very few bone frags <2mm	ci	*old krotovina (color, structure)
Bk1	48 - 60	2.5Y 5/3d 2.5Y 3/3m		sil 18% vfs	2 f&msbk	sh	fr	so po	2vf	3vf	ST	cf threads, ff nodules, l'ing f pores	very few bone frags <2mm	cs	some rounded coarse sand; sand not evenly distributed (pedogenic?)
Ck1	60 - 69	2.5Y 6/2d 2.5Y 4/3m		sil 20% vfs	1 fsbk ?	sh	fr	so po	2vf	2vf	VE	cf nodules, mf threads, l'ing c pores, f "rings"		cs	
Ck2	69 - 87	2.5Y 6/3d 2.5Y 4/3m		sil 22% vfs	m	sh	fr	so po	2vf	2f	ST	cf threads, cf nodules, l'ing f pores		ai	
Akb1[3]	87 - 92	2.5Y 4/3d 2.5Y 3/3m	small amount of mixing with Ck2	sil 20% vfs	1 fsbk	so	vfr	so po	3vf	1f 2vf	ST (slow)	cf nodules, fm nodules, l'ing f pores	charcoal, few small bone frags	cs	some $CaCO_3$ features may be $CaSO_4$ (and below)
Akb2	92 - 100	2.5Y 5/2d 2.5Y 4/3m	cmd 2.5Y 6/4d (5/4m) mixing by worms	sil 20% vfs	1 fsbk	so	vfr	so po	2vf	2vf	ST	cf & m nodules, l'ing f pores	bone frags (rodent and bison), few charcoal	cs	soil fractured in pvc; original surface?
Bkb	100 - 107	2.5Y 5/3d 2.5Y 4/3m	mmd 2.5Y 6/4 (5/4m) cmd 2.5Y 7/2d (5/3m)	sil 25% vfs	1 msbk	sh	fr	so po	2vf	2vf	ST	cf & m nodules, cf threads	charcoal, potsherds, bone frags, lithic chips, shell frag	ci	few "gold flecks" as in potsherd, above (fill 5)
Akb/Bkb/Ckb	107 - 116	see below[4]		sil 35% vfs	1 fsbk	sh	fr	so po	1vf	2vf	ST	see below[4]	charcoal frags	as	
2A2	116 - 121	2.5Y 4/2d 2.5Y 3/2m		sil 28% vfs	2 fsbk	so	vfr	so po	2vf	2vf	ST (slow)	ff nodules	see below[5]	cs	roots are continuous through next few horizons
2Ak/Ck	121 - 126	2Ak: 2.5Y4/2 2.5Y 4/2m	2Ck: 2.5Y 6/3d (4/3m)	sil 22% vfs	2 fsbk	sh	fr	so po	2vf	2vf	VE	cf & fm nodules, cf threads	bone frags, charcoal, granite	cs	
3 Ak2	126 - 135[6]	2.5Y 4/1d 2.5Y 3/1m		sil 25%vfs	2 fsbk	so/h*	fr	so po	2vf	2vf	SL	cf & m nodules, ff threads	bone frags, rock, charcoal, hematitie?; rim sherd shared with 3Ak/Ck below	aw	dry consitence variable--hard lumps may be clay or silty clay texture

Other

[1]**location:** Auger refusal at surface, rotate south and refusal at 15 inches. Relocate to final coordinates. Littered with rodent burrows with bone and pottery in back spoil.

[2]**fill 4** - Carbonates: carbonate threads and vf roots are concentrated on top of a horizontal potsherd at 34 cm.

[3]**Akb1** - Confirmed through field notes and core description that this is not slough from coring. Believe is original surface around time of initial occupation (of this portion of village?). Many of the m nodules are $CaSO_4$

[4]**Akb/Bkb/Ckb** - Color: 60% 2.5Y 5/2d (4/3m) (Bbk); 20% 2.5Y 4/2d (3/2m) (Abk); 20% 2.5Y 6/4d (5/4m) (Cbk). Carbonates/sulfates: Akb has mm nodules; Bkb and Ckb have cf nodules, ff threads; Ckb lining few very fine pores.

[5]**2A2** - Artifacts: high density; abalone shell fragment, "large bone" frags, rodent or bird bone, small talon, potsherds, granite with many "gold" flecks, rusted metal, TRSS spall, charcoal.

[6]**3Ak2** - Horizon boundary ranges from 129 - 137 cm across the core.

Figure A.23a Soil profile description, Transect 2, pedon 11 (sheet 1 of 2)

Double Ditch State Historic Site

Location N501.157 449.810E Pedon # 32BL8 T2-11 SHEET 2 OF 2

Area Double Ditch Village: Inner Residential, high point between lodges Elevation 526.672 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence			Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
						Dry	Moist	Wet							
3Ak/ Ck[1]	135 - 148	3Ak: 2.5Y5/2 2.5Y 4/3m	3Ck: 2.5Y 6/3 (5/4m) ffd 2.5Y 4/2 (3/2m)*	sil 20% vfs	1 fsbk	h/so*	fr	so po	2vf	1f 1vf	ST/VE	cm threads, c f&m nodules	rim sherd with above horizon	as	* mottles from mixing by worms; A hard consistence, C soft
3Ck3	148 - 166	2.5Y 6/3d 2.5Y 4/3m		sil 30% vfs	m	sh	fr	so po	1vf	2vf 1f	ST	c f&m nodules, l'ing c pores, on few roots	sterile C horizon	cs	pedogenic C horizon; some organic debris (wood?) in upper 6 cm
3Ck4	166 - 186	2.5Y 5/3d 2.5Y 4/3m		sil 30% vfs	m	sh	fr	so po	1vf	3vf 1f	ST	long threads ($CaSO_4$) and cm nodules		cs	
3Ck5	186 - 232	2.5Y 6/2d 2.5Y 4/3m	fff 2.5Y 5/2d (4/2m) earthworm mixing ↓	sil 25% vfs	m	sh	fr	so po	1vf	2vf	ST	c $CaSO_4$ upper 7 cm; cf nodules $CaCO_3$		cs	some faunal mixing with next horizon
4Ak3	232 - 242	2.5Y 5/2d 2.5Y 3/3m	cff 2.5Y 6/2d (4/3m) earthworm mixing ↑	sil 19% fs 20% vfs	m	sh	fr	so po		1vf	ST	ff nodules, ff masses		cs	paleo-A very weak
4Ak4	242 - 250	2.5Y 4/3d 10YR 2/2m	cmp 2.5Y 6/4d (5/4m)	sil 15% fs 18% vfs	m	h	fi	so po		1vf	ST	ff nodules, l'ing c pores	very fine charcoal (bagged)	end	paleo-A horizon

Other: [1]**3Ak2** - Horizon seems artificially mixed; may not be pedogenic. Compare with T3-2.

Figure A.23b Soil profile description, Transect 2, pedon 11 (sheet 2 of 2)

Double Ditch State Historic Site

Location: N479.924 418.429E — Pedon #: 32BL8 T2-12 SHEET 1 OF 2

Area: Double Ditch Village: Residential Core, raised ridge near Inner Ditch — Elevation: 525.812 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence Dry	Consistence Moist	Consistence Wet	Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
A1	0 - 4.5	2.5Y 4/3d 10YR 2/2m		sil 18% vfs	2 msbk	sh	fr	so po	2f 3vf	2f 2vf	NE		thin potsherds, TRSS spall, bone frags	aw	hydrophobic, a lot of fine woody debris
Bw1	4.5 - 9	2.5Y 5/3d 2.5Y 3/3m		sil 22% vfs	2 tk & m pl	sh	fr	so po	1f 2vf	2vf	ST	ff nodules	porous bone frags, potsherds, rock, charcoal	cs	some ash and burned soil--fill?
Bw2	9 - 21	2.5Y 5/2d 2.5Y 3/3m		sil 20% vfs	1 fsbk	so	vfr	so po	1f 2vf	2f 2vf	ST	ff nodules	bone, potsherds, rock, charcoal, abalone frag, corn (?) kernel	cw	some ash--fill?
Bw3	21 - 28	2.5Y 6/4d 2.5Y 4/4m		sil 22% vfs	1 msbk	so	vfr	so po	1f 2vf	1f 2vf	ST		arrow point, bone, rock, potsherds	cw	thin partial layer of 10YR 3/1d silt, very hard; fill?
fill 1	28 - 34.5	2.5Y 6/2d		ash	m	so	vfr	so po	1f 3vf		VE		potsherds, bone frags, small amount of charcoal	cs	
fill 2	34.5 - 39	2.5Y 6/2, 6/3d ash		ash & wood frag	m	so	vfr	so po	1f 2vf		VE		charcoal, bone frags	cs	woody, organic debris (7.5YR 2.5/2d)
fill 3	39 - 46	see below[1]	*	ash, vfs, fs, organic	m	so	vfr	so po	2vf	1f 1vf	fs/vfs: VE org.: NE		charcoal, bone frags, potsherds	cs	*fs, vfs: 35% 2.5Y 4/2d (3/2m); 35% 2.5Y 4/3d (10YR 2/2m)
fill 4	46 - 60	2.5Y 5/3d 10YR 3/3m		vfsl/ash	sg	so	vfr	so po	2vf		VE		charcoal, bone frags, flint spalls, potsherd	as	
2Bk1	60 - 69*	2.5Y 5/4d 2.5Y 4/4m		sil 22% vfs	1 fpr→ 2 fsbk	sh	fr	so po	2vf	1f 2vf	ST	cf nodules, cf coats, l'ing f pores, f "rings"	bone frags	ai	*lower boundary irregular (69 - 74 cm)
2 Ck1	69 - 112	2.5Y 6/3d 2.5Y 4/3m		sil 25% vfs	m	sh	fr	so po	2vf	2vf 1f 1c	VE	mf coats, l'ing c pores	few charcoal frags at 83-90 cm	gs	few threads (needles) $CaSO_4$
2Ck2	112 - 127	2.5Y 6/3d 2.5Y 4/4m	fff 2.5Y 5/2d (4/2m) insect channels?	sil 28% vfs	m	so	fr	so po	1vf	2vf 1f	VE	cf nodules, l'ing c pores		ai	few threads $CaSO_4$; some mixing (chunks) with 3A2
3A2	127 - 144	2.5Y 5/3d 10YR 3/2m		sil 20% vfs	1 fsbk	so	vfr	so po	1vf		ST	patchy, mixing with 3Ck3 horizon	large bone frag, charcoal, potsherds	ai	slightly hydrophobic
3Ck3	144 - 175	2.5Y 6/3d 2.5Y 4/3m	fff 10YR 5/3d (3/3m) below 165 cm*	sil 28% vfs	m	so	vfr	so po	1vf	1vf	VE	cf nodules, ff coats, l'ing f pores	upper 5 cm contain chunks of 3A2 with bone & charcoal frags (1-2mm)	cs	few threads $CaSO_4$
3Ck3/ 4Ak1	175 - 181	Ck3: 2.5Y 6/3 2.5Y 4/3m	Ak1: 10YR 4/2d 10YR 3/3m	sil 22% vfs	1 fsbk	sh	fr	so po	1vf	1vf	ST	ff nodules, l'ing f pores	large chunk of charcoal	cs	1 cm long tubes of $CaSO_4$
4Ak1	181 - 194	2.5Y 4/1d 2.5Y 3/2m	mfd 2.5Y 5/3d (4/3m) mixing by worms?	sil 28% vfs	1 msbk	sh	fr	so po	1vf	1f 2vf ($CaSO_4$)	ST	fm masses, cf nodules, $CaSO_4$ l'ing fine pores	KRF arrowhead frag, bone frags, rimsherd, vf charcoal	cs	
4Ak2	194 - 206	2.5Y 5/3d 2.5Y 3/2m	ffp 7.5YR 4/6d (3/4m)	sil 22% vfs	1 fsbk	sh	fr	so po	1vf	2vf	ST	ff nodules, ff coats	charcoal, fine bone, white clay lump, potsherd	cs	$CaSO_4$ in upper 7 cm
4Ck4	206 - 226	2.5Y 5/3d 2.5Y 3/3m	fmp 7.5YR 6/3d (4/4m)	sil 18% vfs	m	sh	fr	so po			VE	ff nodules, ff coats	large bone frag at 218 cm	cs	

Other: [1]**fill 3** - 40% organic (10YR 3/2d, w/ 1-2mm spots of 10YR 2/1); hydrophobic; 60% mineral & organic: 2.5Y 4/3d vertical band is vfs and fs (with hand lens) and organic (hydrophobic). Pocket of vfs & organic appears ashy (2.5Y 4/2d).

Figure A.24a Soil profile description, Transect 2, pedon 12 (sheet 1 of 2)

Double Ditch State Historic Site

Location: N479.924 418.429E | Pedon # 32BL8 T2-12 SHEET 2 OF 2

Area: Double Ditch Village: Residential Core, raised ridge near Inner Ditch | Elevation 525.812 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence Dry	Consistence Moist	Consistence Wet	Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
4Ck5	226 - 235	2.5Y 5/3d 2.5Y 4/4m		sil 32% vfs	m	vh	vfi	so po		1vf	VE	cf nodules, ff coats, few "rings"		cs	
5Ak3	235 - 246	10YR 4/1d 10YR 2/1m	cmp 10YR 6/3 (4/2m) see *	sil 22% vfs	1 fsbk	sh	fr	so po		2vf	ST	com "rings", cf nodules, l'ing c pores	few vf charcoal frags	cs	*mmd 2.5Y 4/2d (10YR 3/2m); all mottles from faunal mixing
5Ak4	246 - 254	10YR 5/2d 10YR 3/2m	mmd 10YR 4/2(2/2m) mff 10YR 5/4 (3/4m)	sil 20% vfs	1 fsbk	sh	fr	so po		3vf 1f	ST	cf nodules, l'ing c pores	few vf charcoal frags	cs	ffp 10YR 6/6d (4/6m) mixing with 5Bk below
5Bk2	254 - 286	10YR 5/6d 10YR 3/4m	ffd 2.5Y 4/2d (3/2m) cmf 10YR 4/3 (3/2m)	l 32% vfs	1 fsbk	sh	fr	so po		2vf 1f	ST	mf nodules, cf coats, l'ing c pores		gs	copious mixing by worms
5Ck6	286 - 294	2.5Y 5/3d 2.5Y 3/3m		vfsl *	m	sh	fr	so po		2vf	ST	cf nodules, l'ing f pores		end	*30% vfs, 12% fs

Other

Figure A.24b Soil profile description, Transect 2, pedon 12 (sheet 2 of 2)

Double Ditch State Historic Site

Location	N484.414 394.643E	Pedon #	32BL8 T2-13
Area	Double Ditch Village: Residential Core, center of Basin 2	Elevation	524.452 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence Dry	Consistence Moist	Consistence Wet	Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
A1	0 - 3	2.5Y 4/2d 10YR 2/2m		sil 18% vfs	3 fsbk	sh/h	fr	so po	2f 2vf	1m 2f 2vf	NE		bone frags, few charcoal	aw	hydrophobic
A2	3 - 7	10YR 4/2d 10YR 2/2m		sil 18% vfs	2 tkpl→ 2 fsbk	sh	fr	so po	1f 1vf	1f 2vf	NE		bone frags	as	slightly hydrophobic
Bw1	7 - 11	2.5Y 5/3d 2.5Y 3/3m		sil 20% vfs	1 mpl→ 1 fsbk	sh	fr	so po	2vf	1m 1f 1vf	SL	ff nodules, ff coats	bone frags, 1 piece of charcoal	as	
2Bw2	11 - 20	2.5Y 5/2d 2.5Y 3/2m	fff 2.5Y 5/4d (4/4m) fff 2.5Y 4/1d (3/1m)	sil 22% vfs	2 fpr	sh	fr	so po	2vf	1m 1f 2vf	NE	ff nodules, cm coats, fm hard masses	bone frags, granite	cs	few to common in-filled worm channels (2.5Y 4/1d)
2Bw3	20 - 28	2.5Y 5/3d 2.5Y 3/3m		sil 22% vfs	1 mpr	sh	fr	so po	1f 2vf	1m 1f 2vf	SL	ff nodules, ff coats	very fine bone frags, 2 rounded pebbles	cs	insect (worm) channels = 1m pores
2Bk1	28 - 46	2.5Y 5/3d 2.5Y 3/3m		sil 5% fs 25% vfs	1 mpr	sh	fi	so po	1f 2vf	1m 2f 3vf	ST	cf nodules, cm coats, l'ing f pores	KRF frag, bone frags, charcoal, potsherds	cs	1m pores probably worm channels, some contain worm casts
2Bk2	46 - 62	2.5Y 5/3d 2.5Y 3/3m	fcf 2.5Y 4/2d (3/2m) (A horizon?)	sil 28% vfs	1 mpr?	sh	fr	so po	1f 2vf	2m 2f 2vf	ST	cf nodules, l'ing f pores, cf & m coats	bone frags, potsherds	cs	
3Ak1	62 - 77	2.5Y 4/2d 2.5Y 3/3m	cmd 2.5Y 7/3d (5/3m)	sil 10% fs 20% vfs	1 mpr	sh	fr	so po	2vf	1m 1f 2vf	ST	cf nodules, cf masses & coats	bone frags (not bagged)	cs	sands feel angular
3Bk3	77 - 115	2.5Y 6/4d 2.5Y 4/4m	mff 2.5Y 7/4d (5/4m) $CaSO_4$ coats?	sil 27% vfs	1 cpr?	sh	fr	so po	2vf	1m 2f 3vf	ST	cf nodules, l'ing c pores, ff threads		gs	common mixing by worms in upper 7 cm
3Ck1	115 - 200	2.5Y 5/3d 2.5Y 4/4m	see below[1]	sil 10% fs 30% vfs	m	sh	fr	so po	1vf	1m 3vf	VE	cf nodules, l'ing c pores, cf threads	sterile C horizon	ai	ff $CaSO_4$ nodules
4Ak/ 3Ck	200 - 207	see below[2]	see below[2]	sil 15% vfs	3 fsbk/m	sh	fr	so po	1vf	1f 2vf	ST	cf nodules, l'ing c pores, cf threads		as	angular sand grains?
4Ak2	207 - 209	10YR 4/2d 10YR 2/2m	cfp 2.5Y 5/4d (3/4m) (4Bk4)	sil 20% vfs	2 fsbk	sh	fr	so po	1vf	2vf	ST	ff nodules, l'ing c pores, cf threads		cs *	* mixing by worms into upper 4 cm of 4Bk4
4Bk4	209 - 225	10YR 5/6d 10YR 3/4m	ffd 10YR 5/2d (4/3m) lower 10 cm	l 40% vfs	3 fsbk/m *	sh	fr	so po	1vf	2vf	ST	cf nodules, l'ing c pores, ff coats		cs	* 3 fsbk in upper 4 cm, well aggragated; then massive
4Bk5	225 - 239	2.5Y 5/4d 2.5Y 4/4m	cff 2.5Y 5/3d (4/3m)	l 32% vfs *	m	sh	fr	so po	1vf	1vf	ST	ff noules, ff coats		cs	* increase in fs
4Ck2	239 - 253	2.5Y 5/3d 2.5Y 4/4m	cff 2.5Y 5/2d (4/2m) ffp 10YR 2/2d,m	fsl 35% fs 10% vfs	m	h	fi	so po	1vf	2vf	ST (slow)	mf nodules, mf coats, l'ing c pores		cs	very few rounded sand grains in lower half of horizon
5Ck3	253 - 267	2.5Y 5/4d 2.5Y 4/4m	cfp 10YR 4/6d (3/6m) cfp 10YR 5/1d (4/1m)	fsl 40% fs 15% vfs	m	sh	fr	so po	1vf	2vf	ST (slow)	ff nodules, mf threads, l'ing m pores	few fs-sized charcoal	gs	see below[3]
5Ck4	267 - 295	2.5Y 5/3d 2.5Y 4/3m	ffp 10YR 4/6d (3/6m) ffp 10YR 5/1d (4/1m)	lvfs *	m	so	vfr	so po	1vf	1vf	ST	ff nodules, ff threads, ff masses		end	* 20% fs, 40% vfs

Other

[1]**3Ck1** - Mottles: A few faint in-filled worm channels, sometimes surrounded by $CaCO_3$. Also a few channels filled with soil loose enough to fall out. A very few are filled with 10YR 4/2d (2/1m).

[2]**4Ak/3Ck** - Matrix: (Ak) 2.5Y 4/1d (10YR 2/2m); (Ck) 2.5Y 6/4d (2.5Y 4/4m); 30% A/70% C in upper 3 cm, then 70% A/30% C. Mottles: evidence of faunal turbation, but also mixing of larger chunks of soil. Irregular upper boundary.

[3]**5Ck3** - Texture: sands appear to have some stratification, very thin (1-2 mm) infrequent banding (every 4-5 cm? irregular), slight textural variations. Also variable amounts of rounded and angular grains: fine sands rounded, vf sands rounded in parts of the horizon, angular in other parts. Did not attempt to split out, but may be different deposits.

Figure A.25 Soil profile description, Transect 2, pedon 13

Double Ditch State Historic Site

Location: N691.345 392.810E — Pedon # 32BL8 T3-1 SHEET 1 OF 2

Area: Double Ditch Village: east of Trench F410 near Mound H — Elevation 525.322 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence Dry	Consistence Moist	Consistence Wet	Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
A1	0 - 3.5	2.5Y 4/2d (cr) 10YR 2/1m		sil 5% vfs	3 f&msbk	sh	fr	so po	2f 3vf	1m 2f 2vf	NE		?	as	slightly hydrophobic vfm grass tillers
A2	3.5 - 6	10YR 4/2d 10YR 2/1m		sil 5% vfs	2 mpl	sh	fr	so po	1f 2vf	1f 1vf	NE		?	as	
A3	6 - 9	2.5Y 4/2d 2.5Y 3/2m		sil 2% vfs	2 fsbk	sh	fr	so po	2vf	2vf	NE		very few vf bone frags	as	
Bw1	9 - 17	2.5Y 5/3d 2.5Y 3/3m	fmf 2.5Y 6/3d (4/3m)	sil 10% vfs	1 fpr? 1 fabk?	sh	fr	so po	2vf	1f 2vf	NE			cs	
2Bw2[1]	17 - 26	2.5Y 4/2d 2.5Y 3/2m	fmd & cfd 2.5Y 5/4d (3/3m)	sil 10% vfs	1 fabk?	sh/h	fr	so po	2vf	1f 2vf	VS	f "rings"	common vf & f bone frags, charcoal, rock, KRF	cs	few in-filled earthworm burrows
2Bk1	26 - 53	2.5Y 4/2d 2.5Y 3/2m		sil 10%vfs	1 fpr→ 1 mabk?	sh	fr	so po	2vf	1m 2f 2vf	SL	c "rings," ff nodules, ff threads, ff masses	bones frags, several small beetles	cs	vertical tendencies to the structure, but irregular; massive?
2Bk2[2]	53 - 113	2.5Y 4/2d 2.5Y 3/2m		sil 15% vfs	1 fsbk	sh	fr	so po	2vf	1m 2vf	SL	ff coats, f "rings," fm & c nodules[2]	potsherd at 59 cm, leg bone frag at 110 cm; vf, f bone frags	cs	
2 Ak/Ck	113 - 121	Ak: 2.5Y 4/2d 2.5Y 3/2m	Ck (20%): 2.5Y 6/4d 2.5Y 4/4m	sil 15% vfs	Ak: 1 fsbk Ck: m	sh	vfr	so po	1vf	Ak: 2vf Ck: 1vf	SL	fm nodules, ff coats	1 small bone frag, 1 rock	cs	mixing of Ak/Ck material prior to redeposition by Mandan
2Ck/Ak	121 - 170	Ck: 2.5Y 6/4d 2.5Y 4/4m	Ak (15%): 2.5Y 4/2d 2.5Y 3/2m	sil 15% vfs	Ck: m Ak: 1 fsbk	h*	fr	so po	1vf	2f 3vf	ST	cf nodules, cf threads, l'ing c pores, ff coats	?	cs	*vh below 157 cm; Ak may be introduced by worms and rodents
3Ck1[3]	170 - 239	2.5Y 6/3d 2.5Y 4/3m	fcf 2.5Y 4/2d (3/2m)[3]	sil 20% vfs	m	h	fr	so po	1vf	1f 3vf	ST	l'ing m pores, cf coats, cf nodules		cs	1st horizon that is not fill (Ditch 4?) (but see note, 3Ck3)
3Ck2	239 - 280	2.5Y 5/3d 2.5Y 3/3m		sil 5%fs 25% vfs	m	sh	fr	so po	1vf	1f 2vf	ST	l'ing c pores, ff coats, cf nodules*		cs	*vf,f $CaSO_4$ nodules
3Ck3	280 - 296	2.5Y 5/3d 2.5Y 4/4m		sil 15% vfs	m	sh	fr	so po	1vf	1vf	ST	cf threads, ff coats, f "rings"		as	*some A horizon at 294 - 296 cm (see note, 3Ck1)
4Ck4	296 - 330	2.5Y 5/3d 2.5Y 3/3m	cmf 2.5Y 7/8d (5/8m) faunal activity[4]	sil 5% vfs	m	vh	fi	so po	1vf	1vf 1f	VE	f "rings," l'ing c pores, ff threads°		ai	
5Ak1	330 - 343	2.5Y 4/2d 10YR 3/2,		sil 15% vfs	m	sh	fr	so po	1vf	1f 3vf	ST	cf nodules, ff threads, l'ing m pores	very few f charcoal frags	ci	upper boundary abrupt but irregular due to copius earthworm mixing
5Ak2	343 - 349	2.5Y 4/2d 10YR 2/2m	ffd 2.5Y 5/4d 10YR 2/2m	sil 10% fs 15% vfs	m	sh	fr	so po	1vf	1f 2vf	VE	cf nodules, ff threads, l'ing c pores		cs	
5Ak3	349 - 359	2.5Y 3/2d 10YR 2/1m	mfd 10YR 4/6d(3/4m) *	sil 10% vfs	m	sh	fr	so po	1vf	1f 2vf	VE	cf nodules, l'ing c pores		ci	*faunal turbation occurs in downward direction, more than upward
5Ak/Bk	359 - 369	10YR 4/3d 10YR 3/4m	see below [5]	sil 15% vfs	m	sh	fr	so po	1vf	2f 2vf	ST	cf nodules, ff threads, l'ing c pores		ci	some mixing at lower boundary

Other

[1]**2Bw2** - This looks like it is A horizon material (color) but has no other attributes of an A-horizon in terms of structure, roots. Is this a former surface relocated and deposited by Mandan? [2]**2Bk2** - This horizon is too consistent! $CaCO_3$ rings decrease with depth (drop out at 70 cm) and nodules (≤ 1 cm) and coatings become the predominant carbonate form. Horizon is broken from transfer below 100 cm (50% loss of volume). [3]**3Ck1** - A few mostly vertical, 3 mm diamter channels; relict root channels? Some portions contain a light reddish brown, papery material in them. Extremely minor amounts of A-horizon present (225 - 232 cm). [4]**4Ck4** - Faunal activity gives fff 2.5Y 4/2d (3/3m) and ffp 2.5Y 3/2d (2.5/1m). This horizon is very dense. $CaCO_3$ threads follow a convex pattern. [5]**5Ak/Bk** - Transition horizon due to faunal turbation. Mottles: mmf 10YR 4/2d (3/2m), ffd 10YR 3/2d (2/1m).

Figure A.26a Soil profile description, Transect 3, pedon 1 (sheet 1 of 2)

Double Ditch State Historic Site

Location N691.345 392.810E — Pedon # 32BL8 T3-1 SHEET 2 OF 2

Area Double Ditch Village: east of Trench F410 near Mound H — Elevation 525.322 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence			Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
						Dry	Moist	Wet							
5Bk3	369 - 395	2.5Y 5/4d 2.5Y 4/4m	ffp 2.5Y 3/2d(2.5/1m) earthworms	l 20%c 30% vfs	m*	sh	fr	ss po	1vf	1f 3vf	ST	cf nodules, ff threads, l'ing m pores		cs	*structure has 1 fpr tendencies 389 - 395 cm
6Ck5	395 - 442	2.5Y 5/4d 2.5Y 4/4m	see below[6]	fine banding[6]	m/sg	so	vfr	so po	1vf	1vf	ST	cf nodules, cf threads, fm masses (soft/hard)		end	rounded sand grains

Other

[6]**6Ck5** - Sample broken in pvc with ~50% loss of volume. Texture: variable, Primarily dominated by sandy textures, but bands of finer-textured material occur. Difficult to judge thickness of bands because smaple is broken, but probably < 1 cm thick. Mottles: mff 10YR 5/3d (4/3m); ffp 10YR 3/2d (2/1m); cmd 2.5Y 6/1d (5/1m); mfd 10YR 5/8d (4/6m); ffp 5YR 5/8d (4/6m).

Figure A.26b Soil profile description, Transect 3, pedon 1 (sheet 2 of 2)

Double Ditch State Historic Site

Location: N664.160 391.357E — Pedon #: 32BL8 T3-2

Area: Double Ditch Village: SE of Mound H between Ditches 3 and 4 — Elevation: 525.247 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence Dry	Consistence Moist	Consistence Wet	Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
A1	0 - 2	2.5Y 3/2d 10YR 2/2m		sil 15% vfs	2 f&msbk*	sh	fr	so po	2f 3vf	2f 1vf	NE		?	as	*structure appears smashed; roots horizont. at 2 cm sd; hydrophobic
A2	2 - 6	2.5Y 4/2d 10YR 3/2m		sil 15% vfs	2 fsbk	sh	fr	so po	1f 1vf	1f 1vf	NE		?	as	
Bw1	6 - 10	2.5Y 4/2d 2.5Y 3/3m		sil 15% vfs	1 fsbk	sh	fr	so po	2vf	2vf	VS		?	as	
Bw2	10 - 14.5	2.5Y 4/3d 2.5Y 3/3m		sil 25% vfs	2 fsbk	sh	fr	so po	2vf	1f 2vf			?	cs	
Bk1	14.5 - 33	2.5Y 5/2d 2.5Y 3/2m		sil 25% vfs	1 fpr & 2 fsbk	sh	fr	so po	2vf	1f 2vf	SL	ff nodules, ff masses, f thin coats	bone frags, flint, potsherd, charcoal (very few of all)	aw	
Bk2	33 - 52	2.5Y 5/3d 2.5Y 4/3m		sil 30% vfs	1 mpr & 1 fsbk	sh	fr	so po	2vf	1f 2vf	ST	l'ing f pores, mf coats, fm masses, cf nodules	bone frags, few granite pieces	cs	
Ck1	52 - 75	2.5Y 6/3d 2.5Y 4/3m	fcf 2.5Y 6/2d (4/2m)*	sil 30% vfs	1 mpr	h	fr	so po	1m 2vf	2m 1f 2vf	ST	m f&m coats, mf nodules, l'ing m pores		ai	* earthworm activity: ffd 2.5Y 4/2d (3/2m)
Ck1/ Ak1[1]	75 - 115	Ck: 2.5Y 6/3d 2.5Y 4/3m	Ak: 2.5Y 4/2d 2.5Y 3/2m	sil[1]	Ck: 1 mpr Ak: 2 fsbk	sh	fr	so po	1f 2vf	2f 3vf	ST	Ck:c nodules,c threads, & l'ing c pores	potsherd, bone frags, charcoal	cs	fill material[1]
Ck1'	115 - 163	2.5Y 6/3d 2.5Y 4/3m		sil 30% vfs	m	sh	fr	so po	2vf	2m 1f 2vf	ST	cf nodules, l'ing c pores, c f&m coats		cs	broken and 50% volume loss from 115 - 142 cm.
Ck1'/ Ak1'	163 - 170	Ck: 2.5Y6/3d 2.5Y 4/3m	Ak1': 2.5Y 4/2d 2.5Y 3/2m	sil 20% vfs	1 fsbk ?	sh	fr	so po	1vf	1f 2vf	ST	ff nodules, l'ing f pores	bone frag at 170 cm	cs	fill material
Ck2	170 - 210	2.5Y 5/3d 2.5Y 4/3m	fff 2.5Y 5/2d (4/2m) earthworm activity*	l 40% vfs	m	sh	fr	so po	1vf	1m 1f 3vf	ST	cf nodules, ff coats, l'ing c pores, f "rings"	snail (?) shell at 209 cm	cs	*208 - 210 cm many in-filled earthworm burrows
2Ak2	210 - 214	2.5Y 4/2d 10YR 3/2m	*	sil 10% fs 10% vfs	m	sh	fr	so po	1vf	3vf	ST	ff nodules, l'ing c pores		cs	*mottles: mfd 2.5Y 6/4d (5/4m); cfd 2.5Y 4/1d 10YR 3/1m
2Ak3	214 - 224	10YR 3/2d 7.5YR 2/1m	see below[2]	sil 5% fs 10% vfs	m	sh	fr	so po	1vf	1m 1f 2vf	ST	cf nodules, l'ing c pores		cs (~5 cm)	
2Bk3	224 - 235	2.5Y 5/6d 2.5Y 4/6m	cff 2.5Y 6/2d (5/2m)*	l 35% vfs	1 msbk ?	sh	fr	ss po	1vf	1f 2vf	VE	cf nodules, cf threads, l'ing c pores		cs	* in-filled earthworm burrows: mmp 2.5Y 4/2d, 10YR 3/2m
2Bk4	235 - 256	2.5Y 5/6d 2.5Y 4/4m	cmd 2.5Y 6/4d (4/4m) cfd 2.5Y 6/2d (5/1m)	sil 5% fs 35% vfs	m	so	vfr	so po	1vf	2vf	ST	cf nodules, ff threads		gs	core broken from 235 - 242 cm with some loss of volume.
2Ck3	256 - 283	2.5Y 5/4d 2.5Y 4/4m		vfsl*	m	so	vfr	so po	1vf	2vf	ST	cf nodules, cm masses, l'ing c pores, ff threads		cs	*10% fs, 55% vfs; Core broken from 256 - 271 cm.
3Ck4[3]	283 - 296	2.5Y 5/3d 2.5Y 4/3m	cmf 2.5Y 6/1d (5/1m) ffd 2.5Y 5/6d (4/6m)	lfs[3]	m	so	vfr	so po		1vf	ST	cf nodules, cf masses		end	core smashed but intact from 271 - 295 cm.

Other:

[1]**Ck1/Ak1** - Appears to be earthworm activity carrying A material into C, but generally have very abrupt boundaries between the two materials. Do not appear to be krotovinas. Textures: Ck: sil (20% vfs, 5% fs); Ak: sil (15% vfs, 5% fs).

[2]**2Ak3** - Copius mixing by earthworms: from 2Ak2 - mmd 2.5Y 5/3d (4/3m); from 2Bk3 - mmd 2.5Y 5/6d (4/4m). [3]**3Ck4** - Texture: loamy fine sand (40% fs, 20% vfs) banded with lenses of clean fine sand, angular grains.

Figure A.27 Soil profile description, Transect 3, pedon 2

Double Ditch State Historic Site

Location: N639.944 392.365E — Pedon #: 32BL8 T3-3

Area: Double Ditch Village: low spot west of Mound I2 — Elevation: 525.471 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence Dry	Consistence Moist	Consistence Wet	Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
A1	0 - 2.5	2.5Y 4/2d 10YR 3/2m		sil 10% vfs	2 f&msbk	sh	fr	so po	2f 3vf	1f 2vf	NE		?	as	hydrophobic
A2	2.5 - 6	2.5Y 5/2d 2.5Y 3/2m		sil 10% vfs	3 vkpl	sh	fr	so po	2vf	1c* 1vf	NE		?	as	*insect burrow
fill 1	6 - 13	2.5Y 5/3d 2.5Y 3/3m		sil 20% vfs	m? 1 fsbk?	sh	fr	so po	2vf	2vf	NE		?	cs	
fill 2	13 - 18	2.5Y 5/2d 2.5Y 3/2m		sil 20% vfs	m? 1 fsbk?	sh	fr	so po	2vf	1m* 2vf	VS		bone frags, flint spall, granite frags, ff charcoal	as	*1m pore earthworm burrow
fill 3	18 - 29	2.5Y 5/3d 2.5Y 3/3m		sil 20% vfs	m	sh	fr	so po	2vf	1f 2vf	SL		bone frags, granite, charcoal, KRF spall	as	earthy fill from here to surface
fill 4	29 - 38	2.5Y 5/2d 2.5Y 5/3m		sil 10% vfs	m	sh	fr	so po	2vf	1f 2vf	ST	fm masses	bone frags	as	ashy fill
fill 5	38 - 52	2.5Y 4/3d 2.5Y 3/3m		sil 5% fs 10% vfs	m	so	vfr	so po	2vf	2f 3vf	ST	fm masses	clay deposit, large stone (tool?), burned potsherds, KRF spall, charcoal	cs	
fill 6	52 - 64	2.5Y 4/2d 2.5Y 3/2m	mfd 2.5Y 7/2d (6/2m) ffp 7.5YR 4/6d (3/4m)	sil 10% vfs	m	sh	fr	so po	1vf	1f 2vf	ST	cm masses, mf masses	few charcoal, few bone frags (not bagged)	cs	subtle color difference with fill 5
fill 7	64 - 70	2.5Y 4/2d 2.5Y 3/2m	cfd 2.5Y 7/2d (6/2m)	sil 20% vfs	m	sh	fr	so po	2vf	2f 2vf	ST	cf masses, fm masses	bone frags, very few charcoal frags	as	
Ck1[1]	70 - 108	2.5Y 6/4d 2.5Y 4/4m	ffd 2.5Y 5/2d (4/2m) earthworm activity	sil 30% vfs	m	h	fi	so po	1vf	2vf	ST	cf nodules, fm masses, l'ing c pores		gs	
Ck2	108 - 185	2.5Y 5/3d 2.5Y 4/3m*	fmf 2.5Y 5/2d (4/2m) faunal turbation**	sil 10% fs 35% vfs	m	sh	fr	so po	1vf	1f 2vf	ST	cf nodules, cf masses, l'ing c pores, f "rings"		ci	*color gradually becomes darker to 150 cm; **from 176 - 185 cm
2Ak1	185 - 190	10YR 5/2d 10YR 3/2m	cfd 2.5Y 6/4d (4/4m) ffd 2.5Y 4/1d (3/1m)*	sil 15% vfs	1 fsbk	sh	fr	so po	1vf	2vf	ST	cf nodules, f "rings", l'ing f pores,		cs	*mottles: mixing by earthworms
2Ak2	190 - 200	7.5YR 4/1d 7.5YR 2.5/1m	ffp 2.5Y 6/4d (4/4m) ffp 2.5Y 5/2d (4/2m)	sil 20% vfs	m	sh	fr	so po	1vf	2vf	ST	cf nodules, l'ing f pores, fm masses		cs	
2Ak/Bk	200 - 206	10YR 5/2d 10YR 3/3m	cmd 10YR 6/6 (4/6m) worm mixing	sil 25% vfs	m	h	fi	so po	1vf	1f 2vf	VE	mf threads, l'ing c pores, cf nodules		cs	
2Bk1	206 - 227	2.5Y 5/4d 2.5Y 4/4m	cfd 10YR 5/1d (4/1m) earthworms	l*	m	h	fi	so po	1vf	1f 3vf	VE	mf threads, l'ing m pores, cc coats		gs	*18% c, 35% vfs
2Bk2	227 - 235	2.5Y 5/4d 2.5Y 4/4m		l*	m	sh	fr	so po	1vf	2vf	VE	cf threads, l'ing f pores		gs	*18% c, 40% vfs
2Ck3	235 - 258	2.5Y 5/4d 2.5Y 4/4m	see below[2]	fsl*	m	sh	fr	so po	1vf	1f 2vf	VE	ff threads, l'ing f pores		end	*35% fs, 15% vfs

Other

[1]**Ck1** - All material above this horizon is fill; pedogenesis has occurred from 0 - 6 cm. From 90 - 121 cm (into Ck2) the material is broken from push tube transfer, with ~40% loss of volume. Missing a chunk of sample from 70 - 77 cm.

[2]**2Ck3** - Mottles: mmf 2.5Y 6/6d (5/4m); mfd 10B 8/0d (7/0m); ffp 7.5YR 3/1d (2.5/1m).

Field Notes - auger refusal at 60 cm; rotated auger to the left. Difficult coring from 60 - 120 cm, then easy.

Figure A.28 Soil profile description, Transect 3, pedon 3

Double Ditch State Historic Site

Location: N397.171 487.084E — Pedon #: 32BL8 04-29

Area: Double Ditch Village: Outer Residential Area Mound Q — Elevation: 526.270 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence Dry	Consistence Moist	Consistence Wet	Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
A	0 - 3	2.5Y 4/2d 10YR 2/2m		sil 10% vfs	3 vkpl	sh	fr	so po	2f 1vf	1vf	SL		sandstone fragment, KRF spall	as	hydrophobic
fill 1	3 - 8.5	2.5Y 5/4d 2.5Y 3/3m		sil 20% vfs	m	sh	fr	so po	2vf	1m* 2vf	ST	fm coats	charcoal frags, bone frags, potsherd, rocks	cs	* 1m pore from insect activity ashy fill
fill 2	8.5 - 14	2.5Y 5/3d 2.5Y 3/3m		sil 20% vfs	m	sh	fr	so po	1f 1vf	1f 1vf	ST	f f&m coats, fm nodules	potsherds, charcoal, bone frags, pebble	cs	ashy fill
fill 3	14 - 37	10YR 6/2d 10YR 3/3m		sil 25% vfs	1 fsbk	so	vfr	so po	2f 2vf	1m 1f 2vf	VE	f m&f masses	potsherds, bone frags, charcoal, rock, KRF spall	cs	soil fill wood frags from 35 - 37 cm
fill 4*	37 - 51	10YR 5/3d 10YR 3/2m		sil 15% vfs	2 fsbk	so	vfr	so po	1f 3vf	1f 3vf	VE	f m&f masses (ash?)	potsherds, bone frags, rock, TRSS spall, charcoal, red ochre, shell	cs	*hydrophobic, some organic debris: former A horizon?
fill 5[1]	51 - 74	2.5Y 5/2d 10YR 3/2m		sil 15% vfs	2 fsbk	so	vfr	so po	2m 3vf	1f 3vf	VE	?	red ochre, bone frags, potsherds, charcoal	cs	
fill 6[2]	74 - 90	Ck: 2.5Y 7/3d 2.5Y 3/3m	Ak: 2.5Y 5/3d 2.5Y 3/3m	sil 30% vfs	m	sh	fr	so po	1vf	1vf (Ck)	VE	cf nodules	fine charcoal, bone frags, large piece of pink granite	as	
fill 7[3]	90 - 100	2.5Y 5/2d 2.5Y 3/3m*		sil 15% vfs	m	eh	vfi	so po			ST	?	charcoal, bone frags, KRF	as	*with thin bands of 2.5Y 7/3d (5/3m) soil, $CaCO_3$, and ash
fill 8	100 - 124	2.5Y 4/3d 10YR 3/2m	ash/soil includes: 2.5Y 6/4d (4/4m)	sil 5% vfs	m	sh	fr	so po		1vf	VE	mf soft masses (ash)	bone, f & c frags charcoal, ash, potsherds, bean seed	as	ash and soil fill
fill 9	124 - 133	2.5Y 6/3d 2.5Y 5/4m		sil 10% vfs	m	sh	fr	so po	1vf		ST	?	very few artifacts--bone, charcoal	as	contains organic/A horizon (1-4cm) (slanted), 2.5Y 5/3d (3/2m) (cr)
fill 10	133 - 176	2.5Y 6/2d 2.5Y 4/4m		sil 15% vfs	m	sh	fr	so po		1vf (2f, 3vf)	ST	fm soft masses	wood frags, bone frags, TRSS	ai	very few artifacts
fill 11[4]	176 - 188	2.5Y 6/3d 2.5Y 4/3m		fsl 30% fs 30% vfs	m	h	fr	so po		(2vf)	ST	fm soft masses	vf charcoal	as	irregular upper boundary
Ck1	188 - 196	2.5Y 5/4d 2.5Y 4/4m		vfsl*	m	vh	fr	so po		?	ST	fm coats, ff threads, cf nodules		as	Leonard paleosol C-horizon? *35%vfs, 25% fs
2Ck2[5]	196 - 213	2.5Y 5/4d 2.5Y 4/3m		vfsl*	m	so	vfr	so po	1vf	1f 1vf	ST	cf nodules, cf threads, ff masses, l'ing c pores		cs	*25% fs, 35% vfs
2Ck3[a]	213 - 233	2.5Y 5/3d 2.5Y 4/4m		vfsl*	m	so/sh	vfr	so po	1vf	2vf	ST	cf nodules, l'ing m pores		cs	*10% fs, 50% vfs; $CaCO_3$ impregnated soil sh to h
3Ck4[6]	233 - 310	2.5Y 5/4d 2.5Y 4/4m	see below	lfs/lvfs (banding)	m/sg	so	vfr	so po		2vf	ST	cf nodules, l'ing c pores, ff threads*		end	*amts. fs and vfs vary: 40/40% to 20/60% **ff coats, cf masses

Other

[1]**fill 5** - Contains chunks of horizon below. Chunks of Ck/Ak material are well-mixed with fill 5 material, as if mixed prior to deposition as part of Mound Q. Live root masses integrate the two materials. [2]**fill 6** - composed of same material as fill 5, except the Ck/Ak banded material (which is thinly banded, but in big chunks) predominates. It is "nested" in the "A horizon" soil from fill 5 above. (This fill 5 soil is soft, loose fsbk structure.)

[3]**fill 7** - Very compacted; layers approximately 1 mm thick. [4]**fill 11** - thin (< 1.5 cm) banding of 10YR 4/3d (3/3m) and 2.5Y 6/2d (4/4m) in matrix. [5]**2Ck2** - Water-worked sand (round and subrounded) commonly found below the Leonard paleosol. All **2Ck** horizons have round/subround sand grains with a small amount (10%?) angular grains. [6]**3Ck4** - Texture: At 257 - 258 cm occurs a 1 cm thick band of finer-textured silty soil with a few (earthworm?) channels which are in-filled with clean fine to meduim sand grains (10YR 3/3d, 3/2m). High degree of $CaCO_3$ expression in finer-textured bands throughout the horizon, as well as just above them (H_2O movement)--a few bands are fine-textured and thicker (0.5 - 1.5 cm). Most are <0.5 cm and are variable in fs/vfs ratio. Mottles: cfp 7.5YR 4/4d (3/3m); ffp 10YR 3/1d (2/1m); below 281 cmsd, fmf 10YR 7/1d (6/1m), fmd 10YR 7/6d (5/6m), cfd 10YR 5/8d (4/6m); few soft Fe concr.

Figure A.29 Soil profile description, Transect 4, pedon 29

Double Ditch State Historic Site

Location: N553.172 372.650E — Pedon #: 32BL8 04-30 alt.

Area: Double Ditch Village: Outer Residential, north side of Mound GG — Elevation: 524.629 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence			Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
						Dry	Moist	Wet							
A1	0 - 3	2.5Y 4/2d(cr) 10YR 3/2m		sil 20% vfs	3 tkpl	sh	fr	so po	2m 2vf	1vf	NE		?	aw	hydrophobic
A2	3 - 5.5	2.5Y 4/3d 2.5Y 3/2m		sil 20% vfs	3 tkpl	sh	fr	so po	1m 1vf	1vf	NE		?	as	the following horizon sequence appears to be pedogenic
Bw1	5.5 - 10	2.5Y 4/2d 2.5Y 3/2m	cff 2.5Y 6/4d (4/4m) horizon below?	sil 20% vfs	m? 1mpr?	sh	fr	so po	2vf	2vf	VSL			cs	
Bw2	10 - 20	2.5Y 5/3d 2.5Y 3/2m		sil 15% vfs	2 mpr[1]	sh	fr	so po	2vf	2vf	SL			as	
2A3	20 - 23	2.5Y 4/2d 2.5Y 3/2m		sil 20% vfs	1 fsbk	sh	vfr	so po	2vf	1f 2vf	VSL			as	
2Bw3	23 - 35	2.5Y 5/3d 2.5Y 4/3m		sil 20% vfs	1 fsbk	sh	fr	so po	2vf	1m 2vf	ST	ff nodules	few bone frags, 1 piece of charcoal	cs	
2Bk1	35 - 50	2.5Y 5/2d 2.5Y 4/3m	fff 2.5Y 4/2d (3/1m) faunal turbation?	sil 20% vfs	1 msbk	sh	fr	so po	1f 2vf	1f 2vf	ST	cf nodules, fm masses; mm mases 45-50 cm	granite pocket, few bone frags, TRSS spall	ai	
2Ck1	50 - 92	2.5Y 6/4d 2.5Y 5/4m		sil 30% vfs	m? 1mpr?	h	fr	so po	1f 2vf	1f 3vf	ST	cf nodules, cm coats, l'ing c pores		gs	lower boundary shows very subtle color change
2Ck2*	92 - 135	2.5Y 6/3d 2.5Y 5/3m		sil 5% fs 30% vfs	m	sh	fr	so po	1vf	1f 2vf	ST	cf nodules, cf coats, l'ing f pores		cs	*sample broken in chunks; approximately 50% volume loss
2Ck3	135 - 170	2.5Y 5/3d 2.5Y 4/4m	fff 10YR 4/2d (3/2m) worm burrows	sil 40% vfs	m	h	fr	so po	1vf	2m 1f 2vf	ST	cf nodules, l'ing c pores, ff threads		cs	thin (1 cm) band of 10YR 4/2d (3/2m) at 141 cm
2Ck4	170 - 185	2.5Y 4/2d 2.5Y 3/3m	cmp 10YR 3/3d(2/1m) earthworm activity[2]	sil 40% vfs	m	sh	fr	so po	1vf	1f 2vf	VE	cf nodules, cf coats, l'ing f pores, few rings		cs	
3Ak	185 - 203	10YR 4/2d 10YR 2/2m[3]		sil 40% vfs	m	sh	fr	so po	1vf	1f 3vf	VE	cf nodules, l'ing c pores		gs (mixing)	3Ak and 3Bk2 are broken from transfer to pvc
3Bk2	203 - 224	2.5Y 5/4d 2.5Y 4/4m	fff 10YR 5/6d (4/6m) ffd 10YR 4/1d(3/1m)*	fsl**	m	sh	vfr	so po	1vf	1f 3vf 1m	ST	cf nodules,l'ing c pores, fm masses		gs	*faunal mixing (earthworms) **15% c, 30% fs, 25% vfs
3Ck5	224 - 259	2.5Y 5/3d 2.5Y 4/3m	fff 2.5Y 5/2d (4/2m) *	fsl** 60% fs	m	sh	vfr	so po	1vf		ST	cf nodules, cf threads, fm masses		end	*ffp 7.5YR 4/6d (3/4m) **angular sand grains

Other

[1]**Bw2** - Unusual to have prismatic structure this close to the surface--already noted that the sequence appears to be pedogenic (vs. anthropogenic). Is this a site of soil erosion or soil removal? [2]**2Ck4** - Faunal turbation occurs with diameters of 2 - 8 mm, both smaller and larger than is usual. At the base of the horizon is a cluster of worm burrows occupying approximately ⅓ of the core volume. [3]**3Ak** - A-horizon contains large chunks of lighter soil (2.5Y 5/3d, 4/3m), which is similar in color to the underlying Bk horizon, but NOT similar in texture. It is obvious there has been faunal mixing by stringers of color leading down from this mass of "non-A." Mixing with 3Bk2 occurs in the lower 6 cm (197 - 203 cm).

Figure A.30 Soil profile description, Transect 4, pedon 30 alternate

Double Ditch State Historic Site

Location: N612.863 414.257E — Pedon #: 32BL8 04-31

Area: Double Ditch Village: Outer Residential Area Mound I2 — Elevation: 526.246 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence Dry	Consistence Moist	Consistence Wet	Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
Oi/Oe	0 - 2													as	small forbs and grasses, thick root mat
A1	2 - 5	10YR 3/2d 10YR 2/2m		sil 5% vfs	3 vkpl	h	fr	so po	1f 1vf	1f 1vf	NE		bone frags	as	<2mm bone and charcoal, high om, hydrphobic
A2	5 - 10.5	10YR 4/2d 10YR 3/2m		sil 10% vfs	3 tkpl	h	fr	so po	1f 1vf	1f 1vf	VSL		bone frags, unident*	cs	hydrophobic, *trade artifact?
fill 1	10.5 - 36	2.5Y 5/2d 2.5Y 3/2m	cff 2.5Y5/3d (3/2m)	sil 15% vfs	m	h	fr	so po	1m 1f 1vf	1f 3vf	ST	mf coats, ff nodules, l'ing f pores	bone frags, 1/2 bone bead*, potsherds, rock, seed, few charcoal	as	*trade artifact?
fill 2[1]	36 - 55	2.5Y 5/3d 2.5Y 4/3m		sil 15% vfs	1 fsbk	so	vfr	so po	1f 3vf	2f 3vf	ST	mm coats, cf threads, l'ing c pores	bone frags, TRSS lithic, KRF, potsherds	as	broken small spearpoint, some charcoal
2Ck1[2]	55 - 141	2.5Y 6/4d 2.5Y 4/4m		sil 25% vfs	m	sh	fr	so po	2vf	2f 3vf	ST	mf coats, cf nodules, l'ing c pores		gs	original C horizon? Broken from 75 - 114 cm (end of pvc 1)
2Ck2	141 - 178	2.5Y 5/3d 2.5Y 4/3m		sil 30% vfs	m	sh	fr	so po	1vf	1f 2vf	VE	cf nod'ls, l'ing c pores, cf threads, cf coats		gs	
2Ck3	178 - 189	2.5Y 5/4d 2.5Y 4/4m		sil 30% vfs	m	sh	vfr	so po	1vf	1f 3vf	ST	cf nodules, l'ing m pores, c "rings"		cs	fm CaSO4 threads; broken from 183 - 190 cm
2Ck4	189 - 207	2.5Y 5/3d 2.5Y 4/3m	cff 2.5Y5/2d (4/2m)*	sil 5%fs 25% vfs	m	sh	fr	so po	1vf	2vf	ST	c "rings," ff coats, cf nodules		cs	*bioturbation, cm $CaSO_4$ tubes 4 - 8mm long; broken 190 - 215 cm
2Ck5	207 - 212	2.5Y 5/2d 2.5Y 3/2m	cff 2.5Y 5/3d (4/3m)*	sil 10%vs 25% vfs	m	sh	fr	so po	1vf	2vf	ST	cf "rings," cf nodules, l'ing f pores		cs	*bioturbation, cm $CaSO_4$ tubes 4 - 8mm long
3Ak1[3]	212 - 219	10YR 3/2d 7.5YR 2.5/1m	cfp 2.5Y 6/4 (4/4m) cfp 2.5Y 6/2 (4/3m)	sil 15% fs 15% vfs	1 fsbk	sh	fr	so po	1vf	1f 2vf	ST	cf "rings," cf nodules, l'ing f pores		cs	com. $CaSO_4$ threads 4 - 8mm; pvc 2 ends at 232 cm
3Ak2	219 - 224	10YR 4/2d 10YR 2/2m	cfd 10YR 5/6d (4/6m) cfp 7.5YR 2.5/1m	sil 15% fs 15% vfs	1 fsbk	sh	fr	so po	1vf	3vf	ST	cvf coats,l'ing c pores, ff threads, cf nodules		cs	mottles from bioturbation; ff $CaSO_4$ threads < 4mm
3Bk	224 - 243	2.5Y 5/4d 2.5Y 4/4m	mfp10YR 4/2d (2/2m)	sil 15% fs 20% vfs	m	h	fr	so po	1vf	3vf	ST	cf nodules, ff threads, l'ing c pores		gs	mottles from bioturbation upper 8 cm; horizon broken 252 - 285 cm
3Ck6	243 - 264	2.5Y 5/6d 2.5Y 4/4m		fsl 30% fs 30% vfs	m	sh	fr	so po	1vf	1vf	VE	cf nodules, cf threads, l'ing f pores		as ?	moist color 2.5Y 4/6? Not a chip
4Ck7	264 - 269	2.5Y 5/3d 2.5Y 4/3m		lfs 50% fs 30% vfs	m/sg	so	vfr	so po		2vf	VE	ff nodules, ff coats, l'ing f pores		end	check morph of sand grains

Other

[1] **fill 2** - krotovina 34 - 42 cm and 50 - 53 cm; soft dry consistence; 3 fsbk.

[2]**2Ck1** - a minor amount of faunal turbation in the upper 2 - 3 cm, mixing with **fill 2** above

In all horizons that are "broken" from transfer out of the push tube, volume loss is approximately 50%; all depths are corrected.

[3]**3Ak** horizons - Leonard paleosol

Figure A.31 Soil profile description, Transect 4, pedon 31

Double Ditch State Historic Site

Location	N645.163 412.274E	Pedon #	32BL8 04-32 SHEET 1 OF 2
Area	Double Ditch Village: "Pit Zone" Mound I1	Elevation	526.513 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence Dry	Consistence Moist	Consistence Wet	Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
Oi/Oe	0 - 2								2f 3vf	3cf				as	grass and small forbs, stems and roots
A1	2 - 5	2.5Y 4/3d 10YR 2/2m		sil 15% vfs	3 vkpl	sh	fr	so po	2vf	1vf	NE		bone frags, rock	as	hydrophobic
A2	5 - 10	2.5Y 4/2d 10YR 3/2m		sil 15% vfs	2 tkpl	h	fi	so po	1vf	2vf	NE		bone frags, vf charcoal, potsherds, KRF spall	as	surface soil to A2 undergone pedogenesis
fill 1	10 - 13	10YR 4/3d 10YR 3/1m		sil 10% vfs	m	h	fi	so po	1vf	1f 2vf	ST		bone frags, charcoal, potsherds, rock	as	
fill 2	13 - 19	2.5Y 5/3d 2.5Y 4/4m		sil 40% vfs	m	sh	fr	so po	2vf	1f 2vf	VSL		bone at 11 cm, potsherd	cs	very clean horizon (few artifacts)
fill 3	19 - 26	2.5Y 5/3d 2.5Y 3/3m		sil 30% vfs	m	sh	fr	so po	2vf	2vf	SL		bone frags, potsherd, few charcoal	cs	
fill 4	26 - 65	2.5Y 4/3d 2.5Y 3/3m		sil 25% vfs	m	sh	fr	so po	2vf	1f 2vf	ST		bone frags, fine charcoal, rock, flint, large chunk of granite, ash	cs	granite at 38 - 43 cm, bison scapula 46 - 49 cm, potsherd and rimsherd
fill 5	65 - 88	2.5Y 5/3d 2.5Y 3/2m		sil 20% vfs	m/1 fsbk	sh/so	vfr	so po	2vf	3vf	ST	cm soft masses (ash?)	ash, bone frags, charcoal, potsherd; granite coarse frag	as	horizon broken 72 - 87 cm (vol loss 30 - 40% corrected)
fill 6	88 - 134	2.5Y 6/3d 2.5Y 4/3m*	2.5Y 5/2d (3/2m)*	sil 15% vfs	m/1 fsbk	sh/so	vfr	so po	2vf	2m 1f 3vf	VE	cf soft nodules, l'ing f pores, fm coats	1 insect egg; rock, bone, wood; charcoal at 114 cm	as	mottling from mixing prior to dep; faunal turb; $CaSO_4$ thr. 11 -127 cm
fill 7	134 - 150	2.5Y 4/2d 2.5Y 3/2m		sil 20% vfs	m→1 fsbk	sh	vfr	so po	1vf	1m 2f 2vf	ST	fm threads $CaSO_4$	large bone frags, charcoal, granite, rimsherd	as	similar to LP A horizon; is mixed A-horizon and ash; charcoal common
2Ck1	150 - 169	2.5Y 6/4d 2.5Y 4/4m		sil 35% vfs	m	sh	fr	so po	1vf	1m 3vf	ST	l'ing m pores, cf nodules, cf coats		cs	compacted 148 - 153 cm; broken 165 - 170 cm
2Ck2[1]	169 - 199	2.5Y 6/3d 2.5Y 4/3m	cff 2.5Y 7/4d (5/4m) circular?	sil 10%fs 30% vfs	m	sh	vfr	so po	1vf	1m 1f 3vf	ST	l'ing m pores, cf threads, cf nodules*		gs	*f "rings," ff coats
2Ck3	199 - 241	2.5Y 5/3d 2.5Y4/3m	mff 2.5Y 5/2d (4/2m); mfd 256-269cm	sil 5%fs 30%vfs	m	sh	vfr	so po	1vf	3vf	VE	l'ing c pores, fm soft masses, mf threads*	1 bone frag (from below? With transfer to pvc?)	as, br/mixed	*cf nodules, c "rings" broken with 40% vol loss
3Ak1[2]	241 - 263	10YR 4/1d 10YR 2/1m	*	sil 15%fs 15%vfs	m	sh	fr	so po	?	1f 2vf	VE	l'ing c pores, cf nod, mf threads, cvf coats	bone frags, fired granite. Old cache pit? Slough from coring?	cs, br/mixed	*c(f,m)d 10YR 4/3d (3/2m), 10YR 5/4d (3/4m) faunal mixed
3Ak2	263 - 277	10YR 4/3d 10YR 3/3m	cfd 10YR 4/1d (2/1m) faunal mixing	sil 10% fs 20% vfs	m	sh	fr	so po	1vf	1vf	ST	filling c pores, cf nodules	bone frags, granite, vf,f charcoal	as	
3Bk1	277 - 303	2.5Y 5/6d 2.5Y 4/4m	mff 2.5Y 5/3d (4/3m) *	l 30% c 30% vfs	m	sh	fr	ss po	1vf	1m 3vf	ST	l'ing m pores, cf threads, cf nodules		cs	* cfp 10YR 3/2d (4/3m) faunal activity; cff 2.5Y 7/2d (6/2m)
3Bk2	303 - 319	2.5Y 5/6d 2.5Y 4/4m	cff 2.5Y 5/3d (4/3m) cmd 2.5Y 6/1d (5/1m*	l 25% vfs 18% c**	m	sh	fr	ss po		1f 3vf	ST	l'ing c pores, cf nodules, cf threads		cs	*ffd 10YR 5/8d (4/6m) **>10% fs *** l'ing c worm channels

Other:

[1] **2Ck2** - few 3 - 5mm lumps of silt (2.5Y4/1d, 3/1m); fill? Broken to 190 cm. Evidence of faunal (worm?) activity.

[2] **3Ak1** - broken from transfer to pvc. Leonard paleosol (depth corrections made). Is this an old cache pit that undercuts the paleo-A? Or is this surface slough from coring?

Figure A.32a Soil profile description, Transect 4, pedon 32 (sheet 1 of 2)

Double Ditch State Historic Site

Location: N645.163 412.27E | Pedon #: 32BL8 04-32 SHEET 2 OF 2

Area: Double Ditch Village: "Pit Zone" Mound I1 | Elevation: 526.513 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence			Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
						Dry	Moist	Wet							
3Ck4	319 - 327	2.5Y 6/3d 2.5Y 5/3m	see below[3]	fsl 30%fs 25% vfs	m	sh	fr	so po		2vf	ST	l'ing c pores, cf nodules, mf threads		cs?	end of pvc3 at 349cm; rest of core in ziplock bags
3Ck5	327 - 338	2.5Y 5/2d 2.5Y 4/2m	see below[4]	vfsl*	m	sh	vfr	so po		2vf	ST	l'ing c pores, cf nodules, mf threads**		end	*40% vfs, 20% fs **fm soft masses

Other	
	[3]**3Ck4** - Mottles: cmd 10YR 6/6d (5/6m); ffp threads 10YR 5/6d (4/6m); cfp 10YR 3/1d (2/1m); cfd 2.5Y 6/1d (5/1m).
	[4]**3Ck5** - Mottles: mff 2.5Y 5/1d (4/1m); mfd 10YR 5/6d (4/6m); mmd 10YR 6/1d (5/1m); cfp 7.5YR 3/1d (2.5/1m). A few in-filled faunal burrows occur. Sample all in one tub.

Figure A.32b Soil profile description, Transect 4, pedon 32 (sheet 2 of 2)

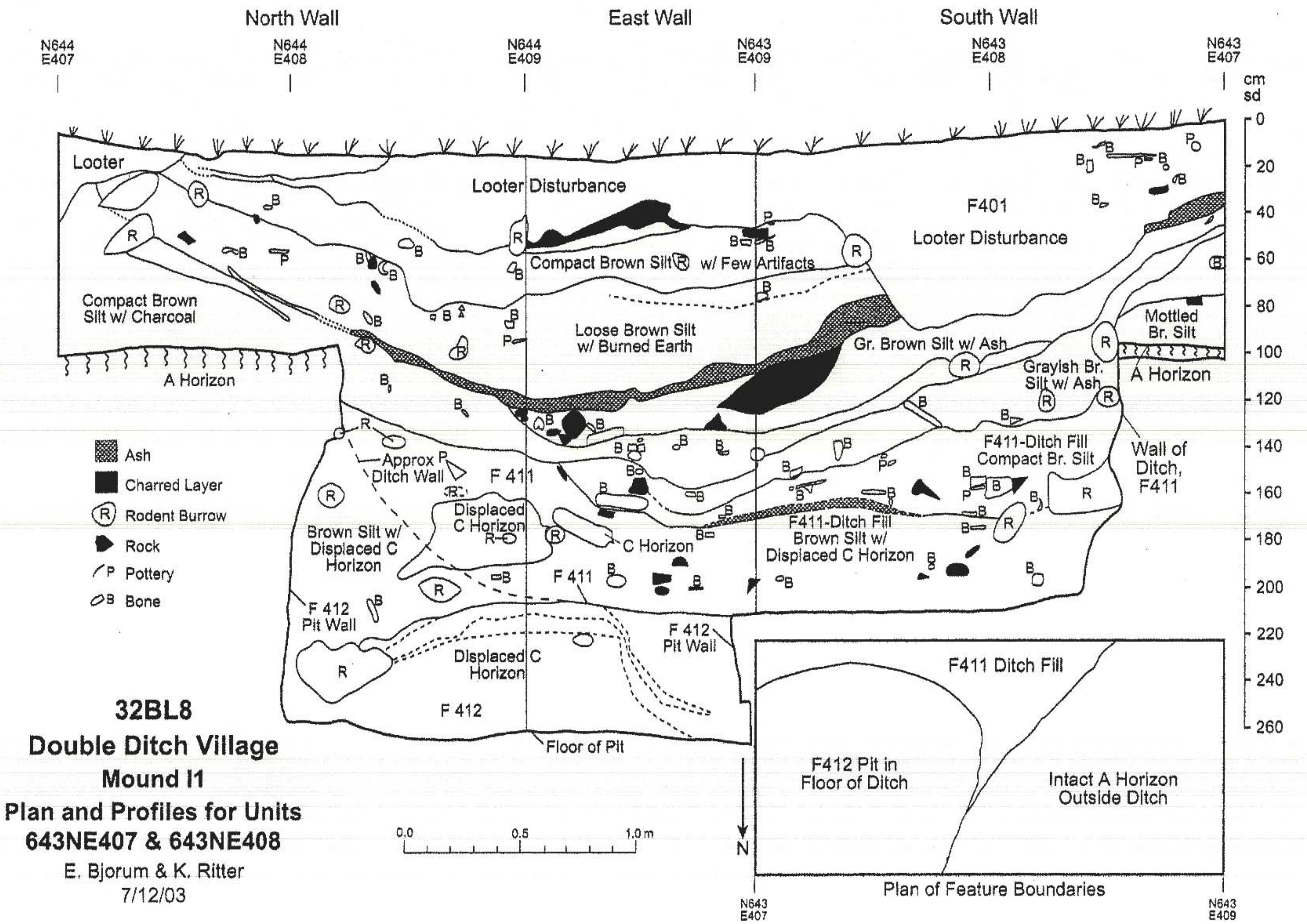


Figure A.32c Final profile drawings for the Mound I1 test with a drawing showing the cut for Ditch 3 and the outline of a large storage pit that predated the ditch (with permission of the PaleoCultural Research Group, Ahler 2004)

Double Ditch State Historic Site

Location: N598.536 454.614E | Pedon #: 32BL8 04-33

Area: Double Ditch Village: Outer Res. Area n. of Mound B (House 21) | Elevation: 525.641 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence Dry	Consistence Moist	Consistence Wet	Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
Oi/Oe	0 - 2								1m 1f 3vf	2m 2f 3vf			?	as	grasses
A1	2 - 5	2.5Y 4/2d 2.5Y 3/1m		sil 20% vfs	2 vkpl	sh	fr	so po	1m 2vf	2vf	NE		few fine bone frags	as	very hydrophobic
A2	5 - 10	2.5Y 5/4d 2.5Y 3/2m		sil 20% vfs	m	h	fr	so po	1m 1vf	2vf	NE		?	as	slightly hydrophobic
fill 1	10 - 17	2.5Y 4/3d 2.5Y 3/3m		sil 25% vfs	m	h	fr	ss po	2vf	1f 2vf	VSL	cvf coats	few very fine bone frags and charcoal	as	
fill 2	17 - 32	2.5Y 4/3d 2.5Y 3/2m		sil 30%vfs	1 vkpl → 1 fsbk	sh	fr	so po	2vf	1f 2vf	VSL	cf coats, fm soft masses	bone frags, angular feldspar	as	f roots oriented horiz, vf roots hor & vert; some earthworm (?) activity
fill 3	32 - 47	A: 2.5Y 4/3d 2.5Y 3/2m	C: 2.5Y 5/4d 2.5Y 4/4m	sil 25% vfs	m?	sh	fr	so po	2vf	1f 2vf	ST	ff nodules, cf coats, ff masses	bone frags (2)	as	mixed A (85%) and C horizons; C in chunks 3 - 5 cm diameter
2Ck1	47 - 82	2.5Y 6/3d 2.5Y 5/4m	mff 2.5Y 6/2d (5/2m) faunal activity?*	sil 25% vfs	m?	h	fr	so po	1vf	1f 3vf	VST	cf coats, cf nodules, l'ing f pores		cs	*66 - 80 cm: fmf 2.5Y 5/2d (4/2m)
2Ck2	82 - 117	2.5Y 6/3d 2.5Y 4/4m	cmp 2.5Y 4/2d (3/2m) worms 80 - 86 cm[1]	sil 25% vfs	m	sh	fr	so po	1f 1vf	1m 2f 2vf	VE	ff threads, cf nodules, l'ing f pores		gs	
2Ck3	117 - 145	2.5Y 5/3d 2.5Y 4/3m	fmf 2.5Y 7/3d (5/3m)	sil 30% vfs	m	h	fi	so po	1vf	2vf 1m 1f	VE	cf threads, cf nodules, l'ing f pores		gs	
2Ck4	145 - 195	2.5Y 5/3d 2.5Y 4/3m	mmf 2.5Y 5/2d(4/2m) worm activity	sil 25% vfs	m	h	fr	so po	1vf	2vf 1m 2f	VST	ff threads, cf nodules, l'ing c pores, f "rings"		cs	
2Ck5	195 - 213[2]	2.5Y 5/2d 10YR 3/2m	cmf 2.5Y 4/2d (3/1m) worm activity	sil 10% fs 20% vfs	m	h	fr	so po	?	2vf 1f	ST	cf threads, cf nodules l'ing c pores		cs (4cm)	increase in % fs; 1 subround pebble at 224 cm
3Ak1	213 - 219	2.5Y 4/1d 10YR 2/2m		sil 20% vfs	m	sh	fr	so po	1vf	2vf 1f	ST	cf threads, cf nodules, cm rings, l'ing f pores		cs?	
3Ak2	219 - 236	2.5Y 3/1d 10YR 2/1m		sil 10% fs 15% vfs	1 fsbk	sh	fr	so po	?	2vf 1f	ST	ff threads, cf nodules, l'ing f pores		cs (4cm)	lower boundary blurred from copius faunal mixing
3Bk[3]	236 - 263	2.5Y 5/4d 2.5Y 4/4m		1 *	1 mabk (m?)	sh	fi	s po	1vf	3vf	ST↓	mf threads, cf nodules, l'ing f pores		end	*18% c, 10% fs, 20% vfs; decrease clay 294 - 300 cm?

Other

[1] **2Ck2** -"clustered" earthworm (?) activity 80 - 86 cm

[2] All horizons somewhat broken from transfer to pvc. Approximately 50% loss of volume for the following depths: 224 - 255cm, 272 - 290 cm (depths corrected).

[3] **3Bk** - earthworm activity in upper 7 cm of this horizon; horizon is broken from 272 - 300 cm with approximately 50% volume loss (depths corrected).

Figure A.33 Soil profile description, Transect 4, pedon 33

Double Ditch State Historic Site

Location: N582.371 477.421E — Pedon # 32BL8 04-34

Area: Double Ditch Village: Outer Res. Area borrow area east of Mound BB — Elevation 525.729 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence Dry	Consistence Moist	Consistence Wet	Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
A1	0 - 5.5	2.5Y 3/2d, cr 10YR 2/1m		sil 15% vfs	1 tkpl	sh	fr	so po	2f 1vf	1f	NE		?	as	hydrophobic; highly organic
A2	5.5 - 17	2.5Y 4/3d 2.5Y 3/2m	mff 2.5Y 3/2d (3/1m) faunal turbation*	sil 15% vfs	1 msbk	sh	fr	so po	1vf	2vf	VSL		?	as	*faint evidence of common earthworm activity
Bw1	17 - 27	2.5Y 5/3d 2.5Y 3/3m	fff 2.5Y 4/3d (3/3m) worms 17 - 22 cm	sil 18% vfs	1 mpr??	sh	fr	so po	2vf	2vf	SL		very few very fine bone frags	cs	
Bw2	27 - 41	2.5Y 5/3d 2.5Y 4/3m		sil 20% vfs	1 mpr?	sh	fr	so po	2vf	1f 2vf	ST	vf, f coats, ff nodules, incr with depth		cs	not enough carbonate features for "Bk"
Ck1**	41 - 53	2.5Y 5/4d 2.5Y 4/4m		sil 25% vfs	1mpr	sh	fr	so po	1vf	1f 3vf	ST	cf coats, fm masses, cf nodules, l'ing c pores		cs	**horizon fractured with small loss of volume (depths corrected)
Ck2	53 - 81	2.5Y 6/3d 2.5Y 4/3m	cff 2.5Y 6/2d (4/2m) worms?	sil 30% vfs	2 mpr	sh	fr	so po	2vf	1m 1f 3vf	ST	mf threads, l'ing c pores, cf nodules		cs	
Ck3[1]	81 - 155	2.5Y 6/3d 2.5Y 4/3m		sil 35% vfs	m	sh	fr	so po	1vf	1f 2vf 1m	ST	cf coats, c nodules, l'ing c pores		gs	
Ck4[2]	155 - 210	2.5Y 5/2d 2.5Y 3/3m	fff 2.5Y 5/3d (4/4m) fmf 2.5Y 6/4d (5/3m)	sil 35% vfs	m	sh	fr	so po	1vf	1f 2vf	ST	ff coats & threads, cf nodules, l'ing c pores		cs	
Ck5	210 - 249	2.5Y 5/2d 2.5Y 3/2m		sil 38% vfs	m	sh	fr	so po	1vf	2vf	SL/ST	ff coats, cf nodules, l'ing c pores		as	
2Ak	249 - 264	10YR 4/1d 10YR 2/1m		sil 5% fs 30% vfs	m	sh	fr	so po	1vf	1f 2vf	VST	mf threads, l'ing f pores, cf nodules		cs	faunal mixing with Ck5 and 2Bk
2Bk	264 - 272	2.5Y 5/6d 2.5Y 4/4m		l 30% fs & vfs	m	h	fi	so po		1vf	VE	cf threads, mf nodules		end	not a good color match

Other

[1]**Ck3** - horizon broken from 88 - 102 cm with 30 - 40% volume loss (depths corrected). A 3 cm thick (128 - 131 cm) layer of slough (not sampled) was subtracted out.

[2]**Ck4** - some mottles look like very old worm channels. More distinct worm channels appear approximately 184 cm (2.5Y 4/2d, but 3/3m). All worm features in this horizon hold their shape when soil is broken around them.

Figure A.34 Soil profile description, Transect 4, pedon 34

Double Ditch State Historic Site

Location: N491.550 563.550E | Pedon #: 32BL8 04-35

Area: Double Ditch Village: Outer Residential (borrow east of Mound T) | Elevation: 527.347 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence			Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
						Dry	Moist	Wet							
Oi/Oe	0 - 3								2f 3vf					as	grass stems and thick mat of f & vf roots
A*	3 - 8	2.5Y 4/2d 10YR 2/2m		sil 20% vfs	1 mpl	sh	fr	so po	1f 1vf	2f 2vf	NE		?	cs	very hydrophobic. *Color implies horizon formed in B horizon
Bw1	8 - 16	2.5Y 5/2d 2.5Y 3/3m	ffd 2.5Y 4/2d (3/2m) faunal mix w/ A	sil 5% fs 20% vfs	1 f&m sbk	sh	fr	so po	1f 2vf	2f 2vf	VSL		1 - 2 mm bone frags, <1mm charcoal	cs	1 - 2cm thick ash/charcoal layers, some faunal mixing
Bw2	16 - 28	2.5Y 4/3d 2.5Y 3/3m		sil 25% vfs	2 msbk	sh	fr	so po	1f 2vf	1f 3vf	SL	fm soft masses, ff nodules	?	ai**	**fill here to surface?
Bk1	28 - 36	2.5Y 6/3d 2.5Y 4/3m	fff 2.5Y 5/2d (4/2m) faunal mixing	sil 25% vfs	2 fpr	sh	fr	so po	1f 2vf	2f 3vf 1m	ST	cf coats, cf nodules	KRF spall, <1mm charcoal	cs	
Ck1[1]	36 - 71	2.5Y 6/4d 2.5Y 4/4m		sil 30% vfs	m? 1 fpr?	h	fr	so po	2f 2vf	1m 2f 2vf	VE	mf nodules, cf coats, l'ing f pores	1 subround frag granite	gs	
Ck2	71 - 125	2.5Y 5/3d 2.5Y 4/3m		sil 25% vfs	m	h	fr	so po	1vf	1f 3vf	VE	mf nodules, ff threads, ff coats*		cs	* l'ing c pores, f "rings;" krotovinas-worm activity?
2Ak/Ck	125 - 129	Ak: 2.5Y 4/2d 2.5Y 3/2m	Ck: 2.5Y 5/4d 2.5Y 4/4m	sil 20% vfs	m	h	fr	so po	1vf	1f 2vf	VE	cf nodules, ff threads, l'ing c pores		cs	copius faunal mixing; 70% Ak, 30% Ck
2Ak	129 - 136	10YR 3/2d 10YR 2/1m	cfd 2.5Y 5/4d (4/4m) faunal mixing*	sil 15% fs 10% vfs	m	h	fr	so po	1vf	1f 2vf	ST	cf nodules, cf "rings," l'ing c pores		cs	*131 - 133 cm mixing with 2Bk2 material brought up
2Bk2[2]	136 - 175	10YR 5/6d 10YR 4/6m	cfd 10YR 5/2d (3/2m) earthworm mixing*	l **	m	h	fi	so po	1vf	1f 1m 2vf	ST	mf nodules, l'ing c pores, c "rings"		cs	* other faunal mixing: ccd 10YR 4/3d (3/3m); **22% c, 20% vfs
2Ck3[3]	175 - 202	2.5Y 5/3d 2.5Y 4/4m	ffp 7.5YR 4/6d(3/4m)	fsl 30% fs 30% vfs	m	sh/lo	vfr	so po	1vf	1f 2vf	ST	cm coats, fm soft masses, cf nodules		cs	angular and subangular sand grains
3Ck4	202 - 227	2.5Y 5/3d 2.5Y 3/3m	fff 2.5Y 6/4d (5/4m) elongated channels	vfsl*	m/sg	so/lo*	vfr	so po	1vf	2vf	SL/ST	cm soft masses, cf nodules, l'ing f pores	mottled shell fragment	gs?	*20% fs, 40% vfs; round and subrnd. grains; pockets of clean sand
3Ck5	227 - 247	2.5Y 5/3d 2.5Y 4/3m	see below[4]	lfs*	m/sg	so/lo	vfr	so po	?	2vf	SL/ST	cm soft masses, ff nodules, l'ing f pores		end	*40% fs, 30% vfs

Other

[1]**Ck1** - Insect krotovinas (3 - 4) between 43 - 47 cmsd infilled with A-horizon (or organic) material. Cavities are approximately 6 ×15 mm, ovoid. Some thin channels run out from these. Larger (15 × 30 mm) interconnected features at 57 cmsd also infilled with organic-rich (A?) material (2.5Y 4/2d, 3/2m, slightly hydrophobic). [2]**2Bk2** - vertical roots, but horizontal f & m pores (earthworms?)

[3]**2Ck3** - a few in-filled worm channels through masses of $CaCO_3$ (2.5Y 5/2d, 4/4m).

[4]**3Ck5** - Mottles: ffp 7.5YR 3/4d (3/4m); fff 2.5Y 6/4d (5/4m); cff 2.5y 5/2d (4/3m) circular (3mm diameter). All of this horizon in 1 ziplock bag--half in one sample tub, half in another.

Figure A.35 Soil profile description, Transect 4, pedon 35

Double Ditch State Historic Site

Location N440.380 540.634E — Pedon # 32BL8 04-36

Area Double Ditch Village: Outer Residential between Mounds K and S — Elevation 526.993 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence Dry	Consistence Moist	Consistence Wet	Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
Oi/Oe	0 - 2.5								3f 3vf	3vf				as	duff layer: roots and grass stems
A	2.5 - 6	2.5Y 3/2d (cr) 10YR 2/1m (cr)		sil 22% vfs	2 tkpl	sh	fr	so po	2m* 1f 1vf	1f	NE		few fine bone frags (not bagged)	as	*2m roots oriented horizontal in upper 1 cm. Hydrophobic.
Bw1	6 - 12	2.5Y 6/3d 2.5Y 4/3m	cff 2.5Y 5/2d (3/2m) root/worm channels	sil 24% vfs	1 coabk	sh	fr	so po	1m* 2vf	1f 1vf	VSL	v few <5mm masses	bone frag	cs	*horizontal orientation
Bw2	12 - 16	2.5Y 5/2d 2.5Y 3/2m	mff 2.5Y 6/3d (4/3m)	sil 22% vfs	2 coabk	h	fi	so po	2vf	2f 2vf	SL	l'ing f pores	bone frag, pebble (3 mm)	cs	small insect cavities
Bw3	16 - 27	2.5Y 5/3d 2.5Y 3/3m		sil <5% fs 20% vfs	1 mpr	sh	fr	so po	2vf	1f 3vf	SL	ff threads, l'ing f pores		cs	small insect cavities
Bk1	27 - 43	2.5Y 5/3d 2.5Y 3/3m		sil 24% vfs	m?	sh	fr	so po	2vf	1f 2vf	ST	ff threads, f soft masses, l'ing f pores	bone frags, few charcoal, granite frag	cs (5 cm)	
Ck1	43 - 76	2.5Y 6/3d 2.5Y 4/3m		sil 26% vfs	m?	sh	fr	so po	2vf	2f 3vf	ST	cf coats, l'ing f pores		cs	
Ck2	76 - 123	2.5Y 5/3d 2.5Y 4/3m		sil 28% vfs	m?	h	fr	so po	2vf	3vf 1f 1m	ST	cf coats, cf nodules, l'ing c pores, "rings"		cs	
Ck3	123 - 131	2.5Y 6/4d 2.5Y 4/4m	mfd 10YR5/2d (3/2m) *	sil 5% fs 25% vfs	m?	h	fr	so po	1vf	1f 1vf	ST	ff nodules, l'ing f pores		ci	*mmp 10YR 4/1d (7.5YR 2.5/1m); 50% (128-133 cm) faunal mixing
2Ak	131 - 135	10YR 4/1d 7.5YR 3/1m	cfp 2.5Y 5/3d 10YR 3/3m*	sil 20% vfs	m	sh	fr	so po	1vf	1m 1f 2vf	VE	ff nodules, l'ing f pores, f "rings"		ci*	*faunal turbation, mixing with Ck3 and 2Bk2
2Bk2	135 - 161	2.5Y 5/4d 2.5Y 4/4m	ffp 2.5Y 4/2d 10YR 3/2m*	l 22% c 30% vfs	m	sh	fr	ss sp	1vf	1m 2f 2vf	VE	cf nodules, l'ing m pores, cf threads		cs	*sl mixing to 151 cm; 2 mm burrows come up from 2Ck4 (dead end)
2Ck4	161 - 169	2.5Y 5/3d 2.5Y 4/3m	cff 2.5Y 4/3d, m in-filled worm burrows	vfsl 50% vfs	m	sh	fr	so po	1vf	1m 3vf	ST	cf masses & coats, ff nodules		cs	mix of round, subround & angular vfs and fs
3Ck5	169 - 228	2.5Y 5/3d 2.5Y 4/4m	ffd 2.5Y 4/1d (3/1m) at 197-209 cm	vfsl[1] *	m	sh/so	fr	so po	1vf	2f 3vf	ST	ff nodules, l'ing f pores, cf coats[1]	few small pieces of charcoal	cs	* 20% fs, 50% vfs
3C1	228 - 238	2.5Y 5/3d 2.5Y 4/3m		lfs 60% fs 20% vfs	m/sg	so/lo	vfr	so po	vfvf	vfvf	ST	vf coats give some shape to peds	charcoal flecks	as	
3C2	238 - 268	2.5Y 6/3d 2.5Y 4/3m	ffp 7.5YR 4/6d (3/4m)	vfsl*	m	so/lo	vfr	so po	vfvf	vfvf	NE/SL	ff coats, ff nodules; CO_3 bridge sand grains		end	*15% fs, 60% vfs with thin bands of clean fs; round/subround granis

Other

[1]**3Ck5** - significantly thick bands of cleaner sand at 177 - 182 cm and 212 - 219 cm. These are sampled seperately. Very fine and fine sands appear subangular rather than subround. Isolated areas in finer texture have medium to large (5 cm) areas of $CaCO_3$ concentrations: masses, coatings and lining many vf pores. Evidence of in-filled insect (earthworm) channels into areas of carbonates (191 - 193 cm). Round and subround sand at approximately 230 cm. From 219 cm to end, soil is broken and/or loose with approximately 50% loss of volume (depths corrected).

Figure A.36 Soil profile description, Transect 4, pedon 36

Double Ditch State Historic Site

Location: N506.639 663.195E — Pedon # 32BL8 04-37

Area: Double Ditch Village: Trench SE of Mound C2 (east end) — Elevation 527.596 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence			Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
						Dry	Moist	Wet							
A1	0 - 7	2.5Y 4/2d 2.5Y 3/2m		sil 18% vfs	2 tkpl*	sh	fr	so po	1m 2f 2vf	1f 1vf	NE		?	as	hydrophobic; *tkpl structure oriented at ~45° angle
A2	7 - 12	2.5Y 4/2d 10YR 3/1m		sil 5% fs 15% vfs	1 tkpl	sh	fr	so po	1f 2vf	1f 1vf	NE		?	cs	1 3×4 mm quartz pebble
A3	12 - 26	2.5Y 4/2d 2.5Y 3/2m		sil 2% fs 18% vfs	1 fpr?*	sh	fr	so po	1m 1f 2vf	1f 2vf	SL	ff masses, vff coats	?	cs	*2 fsbk around vf roots
A4	26 - 32	2.5Y 4/2d 2.5Y 3/1m		sil 18% vfs	1 fpr ?	sh	fr	so po	1f 2vf	1f 2vf	SL	cf masses, cf nodules	bone frag	aw	a few relict coarse root channels with some organic remains
Bk/Ak	32 - 40	Bk: 2.5Y 5/3d 2.5Y 3/3m	Ak: 2.5Y 5/3d 2.5Y 3/1m (30%)	sil 22% vfs	m	sh	fr	so po	1f 2vf	1f 2vf	ST	cf masses, cf coats, cf nodules	?	cs	horizon is 30% Ak material, 70% Bk material
Ak1	40 - 48	2.5Y 4/2d 2.5Y 3/2m		sil 25% vfs	1 mpr	sh	fr	so po	1f 2vf	1f 3vf	ST	ff masses, cf coats, ff nodules		cs	possible fill from here to surface
Bk1	48 - 66	2.5Y 5/2d 2.5Y 3/3m		sil 28% vfs	m	sh	fr	so po	1m 2f 2vf	2f 1vf	ST	cf coats, ff nodules		as	
Ck1	66 - 81	2.5Y 5/3d 2.5Y 4/3m	ffd 2.5Y 4/1d (3/2m) (in-filled pores)	sil 33% vfs	m	sh	fr	so po	2f 3vf	1f 1vf	VE	mm coats, cf nodules, l'ing c pores		cs	1 subrounded pebble (3×5 mm) at 80 cm
Ck2	81 - 142	2.5Y 6/3d 2.5Y 4/3m	fmf 2.5Y 6/2d (4/2m) below 95 cm	sil 35% vfs	m	h	fr	so po	2vf	1m 1f 3vf	VE	mm coats, ff nodules, l'ing c pores, ff threads		gs (~12 cm)	1 in-filled, vertical burrow 4 mm diameter, at 140+ cm
Ck3	142 - 173	2.5Y 5/3d 2.5Y 4/4m	ffd 2.5Y 4/2d (3/2m)[1]	sil 35% vfs	m	sh	fr	so po	1vf	3vf	ST	ff coats, ff nodules, l'ing f pores, ff threads		cs	
2Ak2	173 - 181	10YR 4/2d 10YR 3/2m[2]	mcd 10YR 3/2d(2/1m) in-filled worm burrows	sil 25% vfs	m	sh	fr	so po	1f 1vf	1f 2vf	ST	l'ing f pores, ff threads, ff nodules		cs	Ck3 material (173 - 176 cm) is 2.5Y 5/2d, 4/4m
2Bk2	181 - 198	10YR 5/4d 10YR 4/6m	mcd 10YR 4/2d(2/2m) faunal mixing*	l 22% c 30% vfs	m	sh	fr	ss po	1vf	1m 1f 2vf	VE	l'ing c pores, c "rings," ff nodules, cf threads		cs	* 181 - 188 cm
2Ck4	198 - 209	2.5Y 5/3d 2.5Y 4/4m		vfsl*	m	so	vfr	so po	1vf	2vf	ST	ff threads, l'ing f pores, ff nodules[3]		cs	*angular sand grains; 30% fs, 30% vfs
3Ck5	209 - 228	2.5Y 5/3d 2.5Y 4/3m	ffp 10YR 4/6d (3/6m) fmd 10YR 5/2d(4/3m)	fsl*	m	sh	vfr	so po	1vf	1vf	ST	ff nodules, ff masses, cf threads, pebbles	bone frag?	end	*40% fs, 25% vfs very dense from 220 - 228 cm

Other

[1]**Ck3** - earthworm burrows in-filled with 2Ak2 material, extend upward 4 cm from the base of this horizon (i.e., 169 - 173 cm), 10YR 4/2d, 3/2m. Also note presence of "ring" $CaCO_3$ features; assume these are lining former burrows in the soil--diameter is always about 4 mm and is approximately the same as earthworm burrows. [2]**2Ak2** - At 173-176 cm, 60% 2Ak2 and 40% Ck3 material; 176-181 cm is 50% 2Ak2 and 50% in-filled earthworm burrows (10YR 3/2d, 2/1m).

[3]**2Ck4** - Presence of several rounded pebbles with $CaCO_3$ caotings on pebbles and in voids.

Figure A.37 Soil profile description, Transect 4, pedon 37

Double Ditch State Historic Site

Location: N506.827 645.138E — Pedon #: 32BL8 04-38 — SHEET 1 OF 2

Area: Double Ditch Village: Trench, SE of Mound C2 (middle) — Elevation: 527.598 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence Dry	Consistence Moist	Consistence Wet	Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
A1	0 - 3	10YR 4/2d 10YR 2/1m		sil 15% vfs	m	so	vfr	so po	2f 1vf	1f 1vf	NE		?	as	hydrophobic; horizontal roots
A2	3 - 6.5	10YR 4/2d 10YR 2/1m		sil 10% vfs	3 vkpl	so	vfr	so po	1m 1f 1vf	1f 1vf	NE		?	as	hydrophobic; horizontal roots
A3	6.5 - 9	2.5Y 4/2d 2.5Y 3/1m		sil 15% vfs	3 tkpl	sh	vfr	so po	2vf	1f 1vf	NE		few bone frags	as	
A4	9 - 13	2.5Y 4/2d 2.5Y 3/1m		sil 12% vfs	2 vkpl	sh	fr	so po	2vf	1vf	NE			cs (2.5 cm)	A3 & A4 slightly grayer than A1 & A2
A5	13 - 21	2.5Y 4/3d 2.5Y 3/2m		sil 18% vfs	1 tkpl & 2 fsbk*	sh	fr	so po	2vf	1vf	NE		ff bone frags	as	*2 fsbk around a root cluster
A6	21 - 27	2.5Y 4/2d 2.5Y 3/2m		sil 20% vfs	2 fpr	sh	fr	so po	3vf	2vf	NE		ff bone frags	cs	
A7[1]	27 - 52	2.5Y 4/2d 10YR 2/2m		sil 22% vfs	1 mpr→ 3 mabk	h	fr	so po	1f 3vf	2m 2f 2vf	VS	f thin coats	ff bone frags	cs	from here to surface may be slope wash off Mound C2
A8	52 - 74	2.5Y 4/2d 10YR 2/2m		sil 25% vfs	1 mpr	sh	fr	so po	2vf	2m 2f 2vf	SL	cf coats, fm masses, ff nodules, l'ing f pores	small tooth	cs	in-filled channels 5 mm in diameter
Bk1	74 - 85	2.5Y 4/2d 2.5Y 3/2m		sil 15% vfs	1 mpr	sh	fr	so po	2vf	2m 1f 2vf	ST	cf coats, cf nodules, l'ing c pores,fc masses		cs	common in-filled channels, 4 mm diam, vertical (worm casts)
Bk2	85 - 100	2.5Y 4/2d 2.5Y 3/2m		sil 15% vfs	m	sh	fr	so po	2vf	1m 2f 2vf	ST	cm masses, cf nodules, l'ing f pores, cm coats		cs	common in-filled channels, 4 mm diam, vertical (worm casts)
Bk3	100 - 128	2.5Y 5/2d 2.5Y 3/3m		sil 20% vfs	m	h	fr	so po	1vf	1m 1f 2vf	ST (fast)	cf nodules, mm coats, l'ing c pores		gs	
Ck1	128 - 142	2.5Y 5/3d 2.5Y 4/4m		sil 5% fs 25% vfs	m	h	fr	so po	1vf	1f 2vf	ST (fast)	cf nodules, cm coats, l'ing c pores		gs	soil in large chunks (135-145 cm) (depths corrected)
Ck2	142 - 181	2.5Y 6/3d 2.5Y 4/4m		sil 35% vfs	m	sh	fr	so po	1vf	2f 3vf	ST	cf nodules, cf coats, l'ing c pores		as	soil broken with 40% volumes loss, 140-180 cm (depths corrected)
Ck3	181 - 239	2.5Y 5/3d 2.5Y 4/3m		sil 15% fs 30% vfs	m	h	fr	so po	1vf	1f 3vf	ST	ff nodules, cf threads, cf coats, l'ing c pores	granite pebbles[2]	cs	
Ck/2Ak	239 - 244	Ck: 2.5Y 5/3d 2.5Y 3/3m	2Ak: 2.5Y 4/1d 10YR 2/2m	sil 15% fs 15% vfs	m	h	fr	so po	1vf	2f 3vf	ST	cf nodules, ff threads, l'ing m pores		ai	2Ak material brought up by earthworm activity
2Ak1	244 - 263	10YR 4/1d 10YR 2/2m	fmd 10YR 5/4d(3/4m)	l 25% fs 15% vfs	m	h	fr	so po	1vf	2f 3vf	ST	mf threads, cf nodules, l'ing c pores		ci	copius faunal mixing with 2Ak2 horizon
2Ak2	263 - 271	10YR 4/3d 10YR 3/4m	mmd 10YR 4/1(2/2m) faunal mixing	sil 15% fs 15% vfs	m	sh	fr	so po	1vf	1f 2vf	ST	cf coats, cf nodules l'ing f pores		cs	copius faunal mixing with 2Ak1; ffd 10YR 7/4 (5/4m) $CaCO_3$

Other

[1]**A7** - Sampled separately 34-39 cm; 3 msbk structure, 3 vf roots, bone fragments; krotovina? Two large insect burrows (5 - 8 mm) lead into (but not through?) this area (2m pores). [2]**Ck3** - Artifacts: pebbles with associated $CaCO_3$ accumulations (coats and masses); few pieces of yellow ochre. No artifacts present below 205 cm; below this depth, see faint evidence of in-filled vertical pores (earthworms?)--more a difference in density than color or structure.

Figure A.38a Soil profile description, Transect 4, pedon 38 (sheet 1 of 2)

Double Ditch State Historic Site

Location N506.827 645.138E — Pedon # 32BL8 04-38 SHEET 2 OF 2

Area Double Ditch Village: Trench, Mound C2 to Ditch 4 (middle) — Elevation 527.598 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence			Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
						Dry	Moist	Wet							
2Bk4	271 - 277	2.5Y 6/4d 2.5Y 4/4m	cmp 10YR 4/2 (2/2m) faunal mixing	l*	m	sh	fr	so po	1vf	2f 3vf	VE	ff coats, cf nodules, l'ing f pores**		cs	*15% fs, 25% vfs, 20% c; **ff $CaSO_4$ threads
2Bk5	277 - 297	2.5Y 5/4d 2.5Y 4/4m	fff 2.5Y 6/1d (5/1m) >293 cm	l as above	m	sh	fr	so po	?	2f 2vf	ST	ff coats, cf nodules, l'ing f pores**		cs	ff in-filled vertical channels, 4 mm diameter
2Ck4	297 - 318	2.5Y 5/4d 2.5Y 4/4m	see below[3]	fsl 30% fs 30% vfs	m	sh	vfr	so po	?	1f 2vf	VE	see below[3]		end	Angular fs throughout

Other

[3]**2Ck4** - Mottles: cmp N 8/ d (6/ m); mcd 10YR 7/1d (6/1m); cfd 10YR 5/8d (3/6m); ffp 10YR 2/1d & m. Carbonates: common masses and threads, lining few pores. Many of the N 8/ mottles contain carbonate threads.

Figure A.38b Soil profile description, Transect 4, pedon 38 (sheet 2 of 2)

Double Ditch State Historic Site

Location: N506.841 635.005E — Pedon # 32BL8 04-39

Area: Double Ditch Village: Trench, SE of Mound C2 (west end) — Elevation 527.746 m

Horizon	Depth cm	Matrix Color	Mottle Color	Texture	Structure	Consistence Dry	Consistence Moist	Consistence Wet	Roots	Pores	Efferves	Carbonates	Artifacts	Boundary	Comments
A1	0 - 2	10YR 3/2d 10YR 2/1m		sil 18% vfs	2 tkpl	sh	fr	so po	1f 3vf*	1vf	NE			as	*roots oriented horizontal; extremely hydrophobic
A2	2 - 5	2.5Y 3/2d 2.5Y 2/2m		sil 20% vfs	1 tkpl	sh	fr	so po	1f 1vf**	1vf	NE			as	**roots horizontal; hydrophobic
fill 1	5 - 14	2.5Y 4/2d 2.5Y 3/2m	cmf 2.5Y 5/3d (4/3m)	sil 22% vfs	m	sh	fr	so po	2f 1vf	2vf	NE		vf charcoal frags, bone frags; 1 fine wood frag	as	
fill 2	14 - 41	2.5Y 4/2d 10YR 3/2m		sil 22% vfs	m	sh	fr	so po	1vf	2vf	SL		charcoal frags, bone frags, KRF spalls, fine potsherds	cs	vf bone frags felt as sand in texturing?
fill 3[1]	41 - 72	2.5Y 4/2d 10YR 3/2m		sil 18% vfs	1 mpr	sh/so	fr	so po	2vf	1f 2vf	ST	ff & fm nodules, cf nodules	KRF spall at 52 cm	cs	fewer artifacts than above
2Ak1	72 - 98	2.5Y 3/2d 10YR 2/2m		sil 15% vfs	1 msbk	sh	fr	so po	1f 2vf	1f 1vf	VSL	cf threads, l'ing c pores, c f&m nodules		cs	pre-occupation ground surface
2Ak2	98 - 113	2.5Y 4/2d 2.5Y 3/2m		sil 20% vfs	1 msbk	sh	fr	so po	3vf	1f 2vf	SL	mf threads, cf nodules, l'ing c pores		cs	
2Bw1	113 - 136	2.5Y 4/2d 2.5Y 3/2m		sil 22% vfs	1 fsbk	sh	fr	so po	2vf	1f 2vf	SL	ff threads, l'ing f pores, fm soft masses		as	
2Bk1	136 - 143	2.5Y 5/3d 2.5Y 4/3m	cmf 2.5Y 4/2d (3/2m)	sil 25% vfs	1 fsbk	sh	fr	so po	2vf	1f 3vf	ST	mm threads, f "rings," l'ing c pores		cs	few in-filled 4 mm channels, vertical and 45°, lined with $CaCO_3$
2Ck1	143 - 266	2.5Y 6/3d 2.5Y 4/4m		sil 30% vfs	m	eh	fi	so po	2vf	1f 3vf	ST	cf threads, l'ing c pores, f hard masses*		gs	*hard masses up to 1 cm diameter
2Ck2	266 - 300	2.5Y 5/3d 2.5Y 4/3m		sil 33% vfs	m	eh	fi	so po	1vf	1f 2vf 1m*	ST	mm threads*, cf nodules, l'ing c pores		gs	*5mm diam channel w/ decomposed om; threads are horizontal
2Ck3	300 - 318	2.5Y 5/2d 2.5Y 3/3m		sil 35% vfs	m	h	fi	so po	1vf	2vf	ST (rapid)	ff threads, cf nodules, l'ing c pores		ci	mixing with 3Ak3 below
3Ak3	318 - 322	2.5Y 4/2d 2.5Y 3/2m		sil 28% vfs	m	sh	fr	so po	1vf	3vf	VE	mf threads, cf nodules, l'ing c pores		ci	mixing with 3Ak4 below
3Ak4	322 - 330	2.5Y 3/2d 10YR 2/1m	fmd 2.5Y 5/4d (4/4m) mixing with 3Bk2↓	sil 26% vfs	m	sh	fr	so po	1vf	3vf	VE	mf threads, cf nodules, l'ing m pores		cs	
3Bk2	330 - 339	2.5Y 4/2d 2.5Y 3/2m	mmd 2.5Y 5/4d (4/4m)	l 22% c 25% vfs	m	sh	fr	ss po	1vf	2vf	SL*	cf nodules, [mf threads, l'ing c pores]*		cs	*$CaCO_3$ in clusters (ST); elsewhere, SL effervescence
3Bk3	339 - 352	2.5Y 5/4d 2.5Y 3/3m	mmd 2.5Y 4/2 (3/2m) faunal mixing*	l 25% c 25% vfs	m	sh	fr	ss po	1vf	2vf	SL*	cf nodules, [cm threads, l'ing c pores]*		cs	*CaCO3 in clusters (ST); elsewhere, SL effervescence
3Bk4	352 - 380	2.5Y 5/4d 2.5Y 4/4m	see below[2]	l 25% c 30% vfs	m	sh	fr	so po	1vf	3vf	ST	cf threads, ff coats, cf nodules		cs	
3C1	380 - 392	2.5Y 6/4d 2.5Y 5/4m	mmd 2.5Y 5/2(3/2m)* ccd 2.5Y 7/1 (6/1m)	vfsl 60% vfs	m	sh	vfr	so po	1vf	2vf	NE	ff threads		aw	* faunal mixing
4C2	392 - 402	2.5Y 5/3d 2.5Y 4/3m	cfp 7.5YR 4/6 (3/4m) cfp 10YR 5/6d (4/6m)	vgr c *	m	h	fi	s p	2vf	?	SL			end	* 45% clay, 30% sand (50% of sand is medium, rounded)

Other

[1]**fill 3** - Is this slopewash from Mound C2, with carbonates and 1 mpr structure?

[2]**3Bk4** - Mottles: cmp 10YR 7/1d (5/1m) increase in size and number with depth; cfp 10YR 5/6d (4/6m); ffp 7.5YR 5/6d (4/6m).

Figure A.39 Soil profile description, Transect 4, pedon 39

APPENDIX B

Table B.1 Soil reaction and organic carbon, Transect 1, pedon 1. In this and subsequent tables, the 120 second reading is an estimate of carbonates; the 5 minute reading is carbonates.

Horizon	Upper Depth cm	Lower Depth cm	Soil pH water	Average pH water	Soil pH salt	Average pH salt	% organic C	120 seconds	Average % organic C	Average 120 seconds
A1	0	3	7.29		6.65	6.65	3.16	3.34	3.16	3.34
Bw1	3	12	7.73	7.20	7.23	7.23	1.02	1.52	1.02	1.52
Bw2	12	22	7.88	7.73	7.39	7.39	1.07	1.61	1.07	1.61
Bk1	22		7.95	7.88	7.44		1.37	1.83		
Bk1		32	7.99		7.51	7.48	1.27	1.66	1.32	1.75
Bk2	32		8.06	7.97	7.52		1.10	1.43		
Bk2		47	8.11		7.48	7.50	1.03	1.46	1.07	1.45
Bk3	47	58	8.13	8.09	7.52	7.52	0.96	1.44	0.96	1.44
Bk4	58		8.21		7.65		0.84	1.58		
Bk4			8.29		7.65		0.75	1.28		
Bk4		79	8.37		7.72	7.67	0.74	1.23	0.78	1.36
BCk	79	86	8.32	8.29	7.76	7.76	0.63	1.12	0.63	1.12
Ck1	86		8.43		7.86		0.50	1.02		
Ck1			8.37		7.91		0.47	0.96		
Ck1			8.45		7.84		0.40	0.81		
Ck1			8.35		7.87		0.37	0.97		
Ck1		133	8.45		7.84	7.86	0.37	0.97	0.42	0.95
Ck2	133		8.47	8.41	7.88		0.40	1.02		
Ck2		142	8.54		7.87	7.88	0.35	1.14	0.38	1.08
Ck3	142			8.51						
2Ak1	147		8.54		7.99		0.83	1.20		
2Ak1		157	8.86		8.37	8.18	1.08	1.30	0.96	1.25
2Ak2	157	162	8.83	8.70	8.18	8.18	0.82	1.02	0.82	1.02
2Ak/Bk	162	169	8.85	8.83	8.29	8.29	0.41	0.65	0.41	0.65
2Bk5	169	179	8.67	8.85	8.27	8.27	0.24	0.46	0.24	0.46
2Bk6	179	188	8.73	8.67	8.25	8.25	0.21	0.53	0.21	0.53
2Ck4	188	198	8.81	8.73	8.19	8.19	0.20	0.73	0.20	0.73
2Ck5	198		8.80	8.81	8.07		0.20	0.73		
2Ck5			8.89		8.18		0.21	0.63		
2Ck5		215	8.88		8.30	8.18	0.22	0.71	0.21	0.69
2Ck6	215		8.89	8.86	8.15		0.18	0.79		
2Ck6		230	8.96		8.11	8.13	0.25	0.67	0.22	0.73
2Ck7	230		8.89	8.93	8.23		0.18	0.76		
2Ck7		244	8.96		8.12	8.18	0.25	0.99	0.22	0.88
3Bk7	244			8.93						
4Ck8	258	262	8.28		8.09	8.09	0.10	0.59	0.10	0.59
4Ck9&4Ck10	262	276	8.73	8.28	8.05	8.05	0.16	0.54	0.16	0.54
5Bk/Ck	276	282	8.68	8.73	8.15	8.15	0.17	0.60	0.17	0.60
5Ck11	282	298	8.68	2.76	8.12	8.12	0.16	0.45	0.16	0.45
5Ck12	298		8.50	8.68	8.13		0.19	0.72		
5Ck12		322				8.13			0.19	0.72
6A2	322	325	8.84	8.50	8.14	8.14	0.40	0.75	0.40	0.75
6E	325	326		8.84			0.17	0.43	0.17	0.43
6Bw3	326									
6Bk8	328	331	8.67		8.13	8.13	0.22	0.60	0.22	0.60
6C1	331	333	8.45	8.67	7.94	7.94	0.24	0.54	0.24	0.54
7Bw4	333			8.45						
7Bw4			8.49		7.97	7.97				
7Bw5	345	346	8.67	8.49	7.77	7.77	0.32	0.95	0.32	0.95
7C2	346	368	8.45	8.67	7.86	7.86	0.23	0.69	0.23	0.69

Table B.2 Soil reaction and organic carbon Transect 1, pedon 2

Horizon	Upper Depth cm	Lower Depth cm	Soil pH water	Soil pH salt	Average pH water	Average pH salt	% organic C	120 seconds	Average % organic C	Average 120 seconds
A1	0	4	7.08	6.65	7.08	6.65	5.23		5.23	
A2	4	7	7.54	7.06	7.54	7.06	2.53	2.76	2.53	2.76
A3	7	13	7.78	7.36	7.78	7.36	1.88	1.55	1.88	1.55
Bw	13		7.93	7.50			1.25	1.56		
Bw		26	7.96	7.55	7.95	7.53	1.16	1.45	1.21	1.51
Bk1	26		8.09	7.66			0.94	1.21		
Bk1		36	8.14	7.72	8.12	7.69	0.88	1.16	0.91	1.19
Bk2	36		8.15	7.72			0.82	1.08		
Bk2			8.10	7.59			0.82	1.08		
Bk2		53	8.22	7.65	8.16	7.65	0.71	0.98	0.78	1.05
Bk3	53		8.29	7.70			0.55	0.88		
Bk3			8.32	7.72			0.58	0.86		
Bk3		78	8.35	7.77	8.32	7.73	0.42	0.78	0.52	0.84
Ck1	78		8.42	7.80			0.34	0.68		
Ck1			8.42	7.68			0.33	0.68		
Ck1		102	8.42	7.93	8.42	7.80	0.32	0.68	0.33	0.68
Ck2	102									
Ck2			8.55	7.99			0.34	0.76		
Ck2			8.52	8.01			0.31	0.60		
Ck2			8.52	8.01			0.30	0.60		
Ck2			8.49	8.04			0.34	0.68		
Ck2			8.52	8.06			0.31	0.61		
Ck2			8.55	8.09			0.28	0.55		
Ck2			8.52	8.06			0.25	0.50		
Ck2			8.59	8.09			0.27	0.71		
Ck2			8.66	8.11			0.27	0.58		
Ck2			8.58	8.09			0.28	0.57		
Ck2			8.63	8.12			0.28	0.58		
Ck2			8.62	8.13			0.31	0.62		
Ck2		214	8.63	8.11	8.57	8.07	0.35	0.67	0.30	0.62
2Ak1	214	217	8.56	8.11	8.56	8.11	0.49	0.80	0.49	0.80
2Ck3	217	222	8.55	8.09	8.55	8.09	0.34	0.61	0.34	0.61
3Ak2	222									
3Bk4	230		8.65	8.12			0.35	0.61		
3Bk4		250	8.66	8.13	8.66	8.13	0.33	0.53	0.34	0.57
3Bk5	250		8.71	8.13			0.30	0.51		
3Bk5			8.49	8.20			0.26	0.52		
3Bk5		270	8.56	8.12	8.59	8.15	0.27	0.54	0.28	0.52
3Ck4	270		8.61	8.13			0.24	0.55		
3Ck4			8.68	8.15			0.23	0.48		
3Ck4			8.74	8.14			0.23	0.46		
3Ck4		300	8.77	8.15	8.70	8.14			0.23	0.50
3Ck5	300		8.76	8.17			0.29	0.61		
3Ck5			8.74	8.13			0.25	0.56		
3Ck5		325			8.75	8.15			0.27	0.59
3Ck6	325		8.78	8.14			0.25	0.49		
3Ck6			8.72	8.15			0.17	0.45		
3Ck6		341			8.75	8.15	0.16	0.44	0.19	0.46
4Ck7	341						0.12	0.32		
4Ck7		350	8.67	8.10	8.67	8.10	0.16	0.45	0.14	0.39
5Btk	350									
5Ck8	355	360	8.62	8.09	8.62	8.09	0.29	0.64	0.29	0.64

Table B.3 Soil reaction, organic carbon and carbonates, Transect 1, pedon 3

Horizon	Upper Depth cm	Lower Depth cm	Soil pH water	Soil pH salt	Average pH water	Average pH salt	% organic C	5 minute	average % organic C	average carbonates
Oi										
A1	0	1								
A2	1	3								
Bw	3	8	7.52	7.18	7.52	7.18	6.46		6.46	
Bw	8		7.81	7.37	7.81		2.00	2.53	2.00	2.53
Bw	14		7.95	7.48			1.68	2.49		
Bw	19		7.95	7.47			1.53	2.23		
Bw	19		7.89	7.46			1.27	1.78		
Bk1	26	33	8.04	7.57	7.93	7.47	1.22	1.88		
Bk1	33		8.07	7.61			1.45	1.98	1.43	2.07
Bk1	39		8.10	7.61			1.13	1.97		
Bk1	45		8.07	7.65			0.98	2.05		
Bk1	51		8.16	7.59			0.87	1.89		
Bk2	57	63	8.17	7.60	8.11	7.61	0.85	1.75		
Bk2	63		8.15	7.62			0.80	1.71	0.93	1.87
Bk3	70	77	8.20	7.63	8.18	7.63	0.75	1.87		
Bk3	77		8.16	7.69			0.63	1.89	0.69	1.88
Bk3	84		7.97	7.68			0.61	2.00		
Bk3	91		8.17	7.72			0.59	2.09		
Bk3	98		8.27	7.74			0.50	2.15		
Bk3	105		8.29	7.81			0.46	1.92		
Ck1	112	118	8.21	7.76	8.18	7.73	0.45	1.85		
Ck1	118		8.32	7.82			0.43	1.78	0.51	1.97
Ck1	125		8.19	7.65			0.39	1.84		
Ck1	132		8.25	7.77			0.37	1.83		
Ck1	139		8.38	7.76			0.32	1.82		
Ck1	148		8.28	7.71			0.30	1.70		
Ck1	155		8.33	7.80			0.29	1.59		
Ck1	162		8.39	7.79			0.26	1.59		
Ck1	169		8.39	7.66			0.26	1.60		
Ck1	176		8.33	7.84			0.27	1.54		
Ck1	182		8.41	7.84			0.23	1.22		
Ck2	189	197	8.29	7.89	8.32	7.78	0.29	1.52		
Ck2	197		8.42	7.91			0.28	1.43	0.30	1.61
Ck2	204		8.44	7.91			0.30	1.28		
Ck2	211		8.38	7.73			0.30	1.38		
Ck2	218		8.34	7.88			0.28	1.34		
2Bk4	225	229	8.41	7.97	8.40	7.88	0.29	2.10		
2Bk4	229		8.35	7.77			0.29	2.00	0.29	1.62
2Bk4	235		8.36	7.81			0.31	1.74		
2Bk4			8.37	7.88			0.37	1.97		
2Bk4			8.29	7.90			0.47	1.59		
2Bk4		260	8.28	7.79	8.33	7.83	0.48	0.88		
2Ck3	253						0.52	0.94	0.43	1.42
2Ck3	260						0.72	1.16		
2Ck4	265						1.23	1.61	0.98	1.39
3Ak1	267	277					1.48	1.90	1.48	1.90
3Ak2	275	283	8.35	8.21	8.35	8.21	0.71	1.53	0.71	1.53
3Bk5	277		8.34	7.97			0.61	1.64	0.61	1.64
3Bk5	283						0.43	1.48		
3Bk5	291	305	8.33	7.78	8.34	7.88	0.35	1.49		
3Bk6	298	314	8.34	7.85	8.34	7.85	0.34	1.41	0.37	1.46
3Ck5	305		8.27	7.91			0.30	1.35	0.30	1.35
3Ck5	314		8.36	7.92			0.30	2.28		
3Ck5	319	334	8.27	7.84	8.30	7.89	0.30	2.25		
3Ck6	327		8.30	7.94			0.30	2.23	0.30	2.25
3Ck6	334	347	8.36	7.88	8.33	7.91	0.28	2.05		
3Ck6	339	356					0.23	1.79		
4Ck7	347	360	8.27	7.92			0.25	1.74	0.25	1.86
4Ck7	356	366	8.19	7.87	8.23	7.90	0.25	1.50	0.25	1.50

Table B.4 Soil reaction, organic carbon and carbonates, Transect 1, pedon 4

Horizon	Upper Depth cm	Lower Depth cm	Soil pH water	Soil pH salt	Average pH water	Average pH salt	% organic C	5 minute	Average % organic C	Average 5 minute
Oi	0	2								
A1	2	5	7.28	6.73	7.28	6.73	3.84		3.84	
A2	5		7.76	7.17		7.17	1.34	2.24		
A2		15	7.83	7.37	7.80	7.37	0.97	1.82	1.16	2.03
Bk1	15		8.03	7.50			0.99	1.80		
Bk1			8.12	7.53			1.03	1.72		
Bk1			8.13	7.62			1.11	1.87		
Bk1			8.25	7.65			1.05	1.93		
Bk1		56	8.26	7.64	8.16	7.59	1.02	1.83	1.04	1.83
Bk2	56		8.25	7.69			0.98	1.80		
Bk2		68	8.24	7.73	8.25	7.71	0.93	1.84	0.96	1.82
Bk3	68		8.45	7.89			0.80	2.10		
Bk3			8.62	8.04			0.68	2.07		
Bk3			8.63	8.02			0.62	2.03		
Bk3			8.40	8.06			0.54	1.95		
Bk3		96	8.48	8.07	8.52	8.02	0.49	1.91	0.63	2.01
Ck1	96		8.52	8.01			0.46			
Ck1	101		8.56	8.02			0.44			
Ck1	106		8.53	7.98			0.41			
Ck1	111		8.56	8.03			0.40			
Ck1	117		8.61	8.08			0.52			
Ck1	123		8.58	8.05			0.42			
Ck1	129	131	8.42	8.05	8.54	8.03	0.35		0.43	
Ck2	131		8.45	8.01			0.39			
Ck2										
Ck2			8.55	8.00			0.33			
Ck2			8.60	8.03			0.30			
Ck2			8.59	7.96			0.29		0.33	
Ck2			8.72	7.91						
Ck2			8.56	8.03						
Ck2			8.65	8.06						
Ck2			8.66	8.05						
Ck2		205	8.65	8.05	8.60	8.02				
2A3	205	211	8.61	8.12	8.61	8.12				
2A4	211	215	8.64	8.06	8.64	8.06				
2Bk4	215	225	8.60	8.08	8.60	8.08				
2Ck3	225		8.52	7.99						
2Ck3			8.52	8.00						
2Ck3			8.60	8.01						
2Ck3			8.62	8.01						
2Ck3			8.63	8.00						
2Ck3			8.59	8.03						
2Ck3			8.66	8.04						
2Ck3			8.75	8.06						
2Ck3			8.72	8.04						
2Ck3			8.76	8.10						
2Ck3		305	8.67	8.09	8.64	8.03				
2Ck4	305		8.67	8.11						
2Ck4			8.68	8.08						
2Ck4			8.64	8.08						
2Ck4		331	8.59	8.09	8.65	8.09				
3Ck5	331									
3Ck5		343								

Table B.5 Soil reaction and organic carbon, Transect 1, pedon 5

Horizon	Upper Depth cm	Lower Depth cm	Soil pH water	Soil pH salt	Average pH water	Average pH salt	% organic C	120 seconds	Average % organic C	Average 120 seconds
A										
Bw1	0	6	7.23	6.92	7.23	6.92	4.41	4.41	4.41	4.41
Bw2	6	12	7.89	7.45	7.89	7.45	1.34	1.57	1.34	1.57
Bk1	12	18	8.03	7.61	8.03	7.61	1.99	2.41	1.99	2.41
Bk1	18		8.14	7.68			1.23	2.49		
Bk2		27	8.15	7.65	8.15	7.67	1.30	2.56	1.27	2.53
Bk2	27		8.23	7.73			1.09	1.37		
Bk3		38	8.27	7.76	8.25	7.75	1.07	1.38	1.08	1.38
Bk3	38		8.32	7.78			0.99	1.24		
Bk4		49	8.30	7.77	7.78	7.78	0.86	1.25	0.93	1.25
Bk4	49		8.35	7.80			0.81	1.19		
Bk4			8.41	7.86			0.68	1.10		
Bk4			8.47	7.88			0.60	1.12		
Bk5		76	8.46	7.95	8.42	7.87	0.52	0.93	0.65	1.09
Bk5	76		8.61	8.02			0.47	0.87		
BCk		89	8.68	8.06	8.65	8.04	0.45	0.81	0.46	0.84
BCk	89		8.71	8.10			0.40	0.82		
BCk			8.75	8.15			0.36	0.70		
BCk			8.78	8.15			0.36	0.71		
CBk		107	8.77	8.16	8.14	8.14	0.34	0.72	0.37	0.74
CBk	107		8.83	8.20			0.35	0.78		
CBk			8.80	8.22			0.39	0.74		
Ck1		123	8.84	8.24	8.82	8.22	0.29	0.64	0.34	0.72
Ck1	123		8.77	8.21			0.38	0.69		
Ck1			8.86	8.24			0.34	0.67		
Ck1			8.84	8.24			0.32	0.67		
Ck1			8.84	8.21			0.31	0.63		
Ck1			8.65	7.98			0.31	0.66		
Ck2		162	8.67	8.01	8.77	8.15	0.35	0.65	0.34	0.66
Ck2	162		8.68	8.03			0.37	0.64		
2Ak1		177	8.70	8.02	8.69	8.03	0.47	0.74	0.42	0.69
2Bk6	177	184	8.74	8.06	8.74	8.06	0.48	0.83	0.48	0.83
2Bk6	184		8.77	8.03			0.45	0.76		
2Bk6			8.78	8.10			0.44	0.73		
2Bk6			8.80	8.08			0.46	0.74		
2Bk6			8.73	8.13			0.47	0.77		
3Ak2		223	8.86	8.18	8.79	8.10	0.43	0.74	0.45	0.75
3Ak3	223	228	8.76	8.16	8.76	8.16	0.55	0.77	0.55	0.77
3Bk7	228	232	8.75	8.17	8.75	8.17	0.39	0.61	0.39	0.61
3Bk7	232		8.76	8.19			0.29	0.55		
3Bk7			8.76	8.19			0.23	0.44		
3Bk8		256	8.79	8.23	8.77	8.20	0.23	0.41	0.25	0.47
3Ck3	256	263	8.88	8.26	8.88	8.26	0.26	0.51	0.26	0.51
3Ck3	263		8.95	8.30			0.18	0.39		
3Ck3			8.88	8.27			0.26	0.49		
3Ck4		286	9.00	8.29	8.94	8.29	0.24	0.52	0.23	0.47
3Ck4	286		9.05	8.29			0.19	0.44		
3Ck4			9.01	8.32			0.24	0.47		
4Ck5		307	9.00	8.31	9.02	8.31	0.15	0.40	0.19	0.44
4Ck5	307		8.99	8.32			0.15	0.40		

Table B.6 Soil reaction and organic carbon, Transect 1, pedon 6

Horizon	Upper Depth cm	Lower Depth cm	Soil pH water	Soil pH salt	Average pH water	Average pH salt	% organic C	120 seconds	Average % organic C	Average 120 seconds
Oe	0	1.5								
A1	1.5	7	7.80	7.36	7.80	7.36	2.18	2.46	2.18	2.46
A2	7	16	7.95	7.57	7.95	7.57	1.40	1.67	1.40	1.67
Bk1	16		8.08	7.66			1.23	1.47		
Bk1			8.21	7.69			1.20	1.42		
Bk1		34	8.21	7.73	8.17	7.69	1.18	1.40	1.20	1.43
Bk2	34	42	8.25	7.73		7.73	1.24	1.48	1.24	1.48
Bk3	42		8.30	7.77			1.15	1.45		
Bk3			8.32	7.79			1.07	1.37		
Bk3		66	8.37	7.81	8.33	7.79	1.01	1.22	1.08	1.35
Bk4	66	73	8.38	7.87		7.87	0.92	1.25	0.92	1.25
Bk5	73		8.46	7.89			0.80	1.22		
Bk5			8.52	7.95			0.70	1.04		
Bk5		95	8.55	7.98	8.51	7.94	0.61	1.02	0.70	1.09
Ck1	95		8.36	7.93			0.58	0.91		
Ck1			8.63	8.04			0.51	0.83		
Ck1			8.69	8.10			0.49	0.83		
Ck1			8.83	8.17			0.43	0.83		
Ck1			8.69	8.14			0.37	0.69		
Ck1			8.88	8.18			0.31	0.74		
Ck1			8.89	8.19			0.31	0.77		
Ck1			8.91	8.20			0.26	0.61		
Ck1							0.28	0.65		
Ck1			8.93	8.23			0.25	0.55		
Ck1			8.88	8.25			0.25	0.54		
Ck1							0.27	0.52		
Ck1		185	8.90	8.28	8.78	8.16	0.30	0.55	0.35	0.69
Ck2	185						0.30	0.54		
Ck2			8.90	8.28			0.30	0.61		
Ck2			8.92	8.31			0.31	0.60		
Ck2							0.33	0.59		
Ck2			8.74	8.20			0.33	0.56		
Ck2							0.37	0.62		
Ck2			8.77	8.22						
Ck2		264			8.83	8.25			0.32	0.59
2Ak1	252									
2Ak2	258						0.45	0.71	0.45	0.71
2Bk6	266		8.70	8.22			0.31	0.57		
2Bk6		276	8.77	8.24	8.74	8.23	0.32	0.51	0.32	0.54
2Bk7	276		8.78	8.24			0.35	0.59		
2Bk7			8.83	8.27			0.32	0.67	0.34	0.63
2Bk7			8.84	8.26						
2Bk7		302	8.90	8.27	8.84	8.26				
2Ck3	302		8.89	8.30						
2Ck3		314			8.89	8.30				
3Ck4	314	321	8.91	8.27	8.91	8.27				
3Ck5	321		8.94	8.29			0.26	0.54		
3Ck5			8.88	8.25			0.29	0.58		
3Ck5			8.94	8.25			0.20	0.44		
3Ck5		360	8.91	8.29			0.19	0.46		
3Ck5		367			8.92	8.27	0.17	0.43	0.22	0.49

Table B.7 Soil reaction, organic carbon and carbonates (5 minute reading), Transect 1, pedon 7

Horizon	Upper Depth cm	Lower Depth cm	Soil pH water	Soil pH salt	Average pH water	Average pH salt	% organic C	5 minute	Average % organic C	Average 5 minute
A	0	3	7.17	7.08	7.17	7.08	3.20	3.47	3.20	3.47
Bw	3	7	7.71	7.21	7.71	7.21	1.30	2.08	1.30	2.08
Bk1	7	15	7.87	7.46	7.87	7.46	1.23	1.89	1.23	1.89
Bk2	15		7.93	7.63			1.28	1.74		
Bk2			7.99	7.64			1.26	1.59		
Bk2		33	8.02	7.64	7.98	7.64	1.25	1.51	1.26	1.61
Bk3	33		8.01	7.74			1.18	1.46		
Bk3		46	7.83	7.76	7.92	7.75	1.23	1.57	1.21	1.52
Bk4	46		8.04	7.71			1.19	1.69		
Bk4		56	8.12	7.76	8.08	7.74	1.22	1.70	1.21	1.70
Krotovina	56	62	8.02	7.75	8.02	7.75	1.18	1.63	1.18	1.63
Ck1	62		8.11	7.61			1.04	1.73		
Ck1		73	8.19	7.68	8.15	7.65	0.96	1.86	1.00	1.80
Ck2	73		8.19	7.81			0.84	2.13		
Ck2		80	8.26	7.75						
Ck2			8.33	7.84						
Ck2			8.42	7.88						
Ck2			8.52	8.08						
Ck2			8.56	8.05						
Ck2			8.59	8.25						
Ck2			8.72	8.10						
Ck2			8.73	8.01						
Ck2			8.65	8.06						
Ck2			8.59	8.11						
Ck2			8.63	7.97						
Ck2			8.70	8.02						
Ck2			8.78	8.10						
Ck2		168	8.71	8.14	8.56	8.01	0.32	1.47	0.58	1.80
Ck3	168		8.70	8.12			0.33	1.36		
Ck3			8.71	8.08						
Ck3			8.67	8.21			0.33	1.39		
Ck3			8.59	7.89						
Ck3		202	8.65	7.95	8.66	8.05	0.36	1.44	0.34	1.40
Ck4	202		8.71	7.98			0.41	1.45		
Ck4			8.64	7.99						
Ck4			8.50	7.96						
Ck4		228	8.59	8.02	8.61	7.99	0.46	1.52	0.44	1.49
Ck/Ak	228	234	8.62	8.00	8.62		0.54	1.22	0.54	1.22
2Ak	234	246	8.61	8.04			0.79	1.22	0.79	1.22
2Ak			8.57	8.01	8.59	8.03	0.75	1.12	0.75	1.12
2Bk5	246	252	8.49	7.95	8.49	7.95	0.56	0.90	0.56	0.90
2Ck5	252		8.63	7.98						
2Ck5		266	8.60	8.02	8.62	8.00				

Table B.8 Soil reaction, organic carbon and carbonates, Transect 1, pedon 8

Horizon	Upper Depth cm	Lower Depth cm	Soil pH water	Soil pH salt	Average pH water	Average pH salt	% organic C	5 minute	Average % organic C	Average 5 minute
A1	0	3	6.26	5.98	6.26	5.98		7.57		7.57
Bw1	3	8	7.68	7.31	7.68	7.31	1.41	2.14	1.41	2.14
Bw2	8	16	7.99	7.56	7.99	7.56	0.89	1.92	0.89	1.92
Bw3	16	24	8.05	7.63	8.05	7.63	0.98	1.79	0.98	1.79
2A2	24	27	8.14	7.70	8.14	7.70	0.98	1.71	0.98	1.71
2Bw4	27	33	8.23	7.75	8.23	7.75	0.81	1.75	0.81	1.75
2Bk1	33		8.19	7.73			0.97	1.74		
2Bk1		49	8.23	7.73	8.21	7.73	0.99	1.71	0.98	1.72
2Bk2	49		8.19	7.79			0.79	1.74		
2Bk2			8.30	7.79			0.76	1.76		
2Bk2		67	8.31	7.77	8.27	7.78	0.75	1.86	0.77	1.79
3Ak1	67	72	8.27	7.83	8.27	7.83	0.67	1.59	0.67	1.59
3Bk3	72		8.43	7.95			0.66	1.97		
3Bk3			8.53	8.00			0.58	2.08		
3Bk3			8.58	8.03			0.54	2.03		
3Bk3		100	8.66	8.03	8.55	8.00	0.55	1.94	0.58	2.00
3Ck1	100		8.68	8.09			0.48	2.00		
3Ck1			8.67	8.08						
3Ck1			8.70	8.09			0.42	1.96		
3Ck1			8.70	8.14						
3Ck1			8.68	8.15						
3Ck1		139	8.71	8.15	8.69	8.12	0.44	1.78	0.45	1.91
4Bk4	139		8.78	8.20			0.43	1.70		
4Bk4		152	8.77	8.20	8.78	8.20	0.41	1.56	0.42	1.63
5Bk5	152		8.73	8.05			0.32	1.56		
5Bk5			8.74	8.05			0.30	1.53		
5Bk5		173	8.72	8.10	8.73	8.07	0.30	1.47	0.31	1.52
4Ck3	173		8.73	8.11			0.31	1.44		
4Ck3			8.72	8.09			0.35	1.38		
4Ck3			8.73	8.13			0.33	1.37		
4Ck3		199	8.77	8.15	8.74	8.12	0.36	1.41	0.34	1.40
4Ck4	199		8.76	8.20			0.38	1.37		
4Ck4		213	8.86	8.23	8.81	8.22	0.42	1.40	0.40	1.38
4Ck5	213		8.86	8.24			0.46	1.47		
4Ck5			8.81	8.24			0.49	1.47		
4Ck5			8.93	8.26			0.50	1.50		
4Ck5		239	8.85	8.22	8.86	8.24	0.54	1.48	0.50	1.48
4Ck6	239		8.76	8.25			0.57	1.52		
4Ck6		246	8.80	8.29	8.78	8.27	0.63	1.53	0.60	1.52
4Ck7	246		8.85	8.32			0.67	1.56		
4Ck7			8.84	8.27			0.65	1.55		
4Ck7		259	8.77	8.28	8.82	8.29	0.76	1.57	0.69	1.56
5Ak2	259		8.80	8.33			1.24	1.83		
5Ak2		269	8.77	8.23	8.79	8.28	1.67	2.10	1.46	1.97
5Ak3	269	275	8.64	8.23	8.64	8.23	0.98	1.29	0.98	1.29
5Bk5	275		8.41	7.91			0.67	2.03		
5Bk5			8.41	7.84			0.63	1.96		
5Bk5			8.51	7.97			0.55	1.95		
5Bk5		288	8.56	8.01	8.47	7.93	0.48	1.88	0.58	1.95
A (in filled)			8.32	7.82	8.32	7.82	0.86	1.81	0.86	1.81
6Ck8	288		8.74	8.19			0.34	0.64		
6Ck8			8.77	8.25			0.25	0.45		
6Ck8		298	8.72	8.18	8.74	8.21	0.26	0.44	0.28	0.51

Table B.9 Soil reaction, organic carbon and carbonates, Transect 1, pedon 9

Horizon	Upper Depth cm	Lower Depth cm	Soil pH water	Soil pH salt	Average pH water	Average pH salt	% organic C	5 minutes	Average % organic C	Average 5 minutes
A1	0	4	6.87	6.72	6.87	6.72		4.37		4.37
A2	4	8	7.54	7.30	7.54	7.30	1.74	2.09	1.74	2.09
Bw1	8	13	7.72	7.49	7.72	7.49	1.11	1.85	1.11	1.85
Bw2	13	19	7.86	7.57	7.86	7.57	1.27	1.81	1.27	1.81
Bk1	19		7.99	7.64			1.40	1.74		
Bk1		35	8.02	7.66	8.01	7.65	1.40	1.63	1.40	1.69
Bk2	35		8.06	7.69			1.20	1.46		
Bk2			8.10	7.69			1.15	1.54		
Bk2		51	8.14	7.71	8.10	7.70	0.98	1.56	1.11	1.52
Bk3	51		8.19	7.71			1.01	1.57		
Bk3			8.18	7.78			0.92	1.65		
Bk3		71	8.29	7.79	8.22	7.76	0.73	1.74	0.89	1.65
Bk4	71		8.29	7.82			0.75	1.95		
Bk4		81	8.34	7.84	8.32	7.83	0.69	1.97	0.72	1.96
Ck1	81		8.35	7.83			0.59	2.06		
Ck1			8.36	7.81						
Ck1		102	8.41	7.85	8.37	7.83	0.54	2.06	0.57	2.06
Ck2	102		8.44	7.89			0.45	2.03		
Ck2			8.44	7.92						
Ck2			8.51	7.98			0.40	2.11		
Ck2			8.53	8.02						
Ck2			8.58	7.96			0.36	1.88		
Ck2			8.43	7.80						
Ck2			8.49	7.85			0.31	1.69		
Ck2			8.53	7.88						
Ck2			8.48	7.87			0.32	1.61		
Ck2			8.46	7.88						
Ck2			8.46	7.91			0.31	1.57		
Ck2		178	8.58	7.92	8.49	7.91	0.31	1.39	0.35	1.75
Ck3	178		8.49	7.96			0.29	1.36		
Ck3			8.47	7.95						
Ck3			8.46	7.94			0.31	1.40		
Ck3			8.58	8.07						
Ck3			8.59	8.02			0.36	1.63		
Ck3			8.54	7.94						
Ck3			8.55	8.02			0.45	1.57		
Ck3		216	8.60	7.94	8.54	7.98	0.48	1.60	0.38	1.51
Ck/Ak	216	220					0.56	1.40	0.56	1.40
2Ak1	220		8.57	8.11			0.77	1.27		
2Ak1		230	8.60	8.14	8.59	8.13	0.68	1.21	0.73	1.24
2Ak2	230	235	8.58	8.12		8.12	0.70	1.17	0.70	1.17
2Bk5	235	247	8.64	8.12	8.64	8.12	0.48	0.95	0.48	0.95
2Ck4	247		8.70	8.17			0.35	0.73		
2Ck4			8.77	8.16						
2Ck4		268	8.77	8.19	8.75	8.17	0.33	0.89	0.34	0.81
2Ck5	268		8.82	8.24			0.29	1.32		
2Ck5			8.72	8.15						
2Ck5			8.74	8.25			0.45	1.49		
2Ck5			8.74	8.12						
2Ck5		301	8.73	8.17	8.75	8.19	0.18	1.28	0.31	1.36
2Ck6	301		8.66	8.15			0.19	1.37		
2Ck6			8.64	8.12						
2Ck6			8.69	8.10			0.18	1.32		
2Ck6		331	8.75	8.14	8.69	8.13	0.16	1.18	0.17	1.29
2Ck7	331	337	8.71	8.09	8.71	8.09	0.16	1.04	0.16	

Table B.10 Soil reaction, organic carbon and carbonates, Transect 1, pedon 10

Horizon	Upper Depth cm	Lower Depth cm	Soil pH water	Soil pH salt	Average pH water	Average pH salt	% organic C	5 minutes	Average % organic C	Average 5 minutes
A1	0	4	6.58	6.18	6.58	6.18		5.22		5.22
Bw1	4	12	7.54	7.24	7.54	7.24	1.55	2.09	1.55	2.09
Bw2	12	17	7.77	7.91	7.77	7.91	1.35	1.71	1.35	1.71
2A2	17	21	7.88	7.50	7.88	7.50	1.41	1.69	1.41	1.69
2A3	21		7.96	7.52			1.33	1.52		
2A3			7.99	7.60			1.38	1.54		
2A3		37	8.03	7.62	7.99	7.58	1.34	1.52	1.35	1.53
2Bk1	37		8.13	7.67			1.32	1.56		
2Bk1		49	8.15	7.72	8.14	7.70	1.26	1.51	1.29	1.54
3Ak1	49		8.17	7.65			1.25	1.51		
3Ak1			8.12	7.65			1.44	1.74		
3Ak1		72	8.10	7.66	8.13	7.65	1.17	1.47	1.29	1.57
3Bk2	72	81	8.28	7.83	8.28	7.83	0.63	2.18	0.63	2.18
3Bk3	81		8.24	7.80		7.80	0.58	2.13		
3Bk3			8.38	7.85			0.60	2.22	0.59	2.18
3Bk3		94	8.38	7.85	8.33	7.85	0.54	1.97		
3Ck1	94		8.42	7.87			0.47	2.27		
3Ck1			8.48	7.91			0.40	2.25		
3Ck1			8.52	7.93			0.41	2.22		
3Ck1			8.48	7.97			0.34	2.30	0.43	2.20
3Ck1		125	8.55	7.96	8.49	7.93	0.32	1.84		
3Ck2	125		8.59	8.02						
3Ck2			8.59	7.99						
3Ck2			8.56	8.00			0.32	1.65	0.32	1.75
3Ck2		153	8.63	7.99	8.59	8.00	0.31	1.55		
3Ck3	153		8.66	8.04						
3Ck3			8.67	8.04						
3Ck3			8.62	8.05						
3Ck3			8.67	8.06						
3Ck3			8.64	8.07						
3Ck3			8.66	8.06						
3Ck3			8.64	8.04			0.37	1.58	0.34	1.57
3Ck3		208	8.65	8.06	8.65	8.05	0.46	1.43	0.46	1.43
3Ck/4Ak	208	210	8.58	8.05	8.58	8.05	0.65	1.14	0.65	1.14
4Ak2	210	221	8.70	8.07	8.70	8.07	0.49	0.94		
4Bk4	221	242					0.38	0.90		
4Ck4	242	257					0.34	0.96	0.40	0.93
							0.32	1.49		
							0.31	1.48	0.32	1.49

Table B.11 Soil reaction, organic carbon and carbonates, Transect 1, pedon 11

Horizon	Upper Depth cm	Lower Depth cm	Soil pH water	Soil pH salt	Average pH water	Average pH salt	% organic C	5 minutes	Average % organic C	Average 5 minutes
A1	0	3	7.35	6.77	7.35	6.77		3.87		3.87
Bw1	3	9	7.46	7.11	7.46	7.11	1.51	2.11	1.51	2.11
Bw2	9	18	7.79	7.28	7.79	7.28	1.35	1.81	1.35	1.81
2A2	18		7.98	7.51			1.44	1.76		
2A2		26	8.23	7.49	8.11	7.50	1.33	1.73	1.39	1.75
2A3	26		8.20	7.47			1.24	1.67		
2A3		38	8.22	7.46	8.21	7.47	1.27	1.67	1.26	1.67
2Ak1	38	44	8.28	7.55	8.28	7.55	1.32	1.74	1.32	1.74
2Bk1	44	52	8.34	7.72	8.34	7.72	1.15	1.65	1.15	1.65
3Ak2	52	58	8.31	7.68	8.31	7.68	1.15	1.73	1.15	1.73
3Bk2	58		8.62	7.70			0.87	2.15		
3Bk2			8.40	7.67			0.75	2.39		
3Bk2			8.46	7.74			0.68	2.35		
3Bk2			8.42	7.83			0.63	2.28		
3Bk2		91	8.44	7.85	8.47	7.76	0.56	2.19	0.70	2.27
3Ck1	91		8.63	7.79			0.43	2.13		
3Ck1			8.63	7.82						
3Ck1		105	8.66	7.82	8.64	7.81	0.42	2.18	0.43	2.16
3Ck2	105		8.69	7.94			0.38	2.17		
3Ck2		117	8.69	7.95	8.69	7.95	0.33	1.97	0.36	2.07
3Ck3	117		8.71	7.98			0.32	1.81		
3Ck3			8.79	7.85						
3Ck3			8.77	8.01			0.33	1.59		
3Ck3			8.79	7.98						
3Ck3		148	8.80	8.01	8.77	7.97	0.30	1.48	0.32	1.63
3Ck4	148		8.79	7.92			0.28	1.56		
3Ck4			8.79	8.01						
3Ck4		172	8.78	7.96	8.79	7.96	0.37	1.55	0.33	1.56
3Ck5	172		8.63	7.98			0.37	1.48		
3Ck5		186	8.77	8.08	8.70	8.03	0.36	1.44	0.37	1.46
3CkAk	186	192	8.77	8.07	8.77	8.07	0.42	1.36	0.42	1.36
4Ak3	192		8.72	8.02			0.59	1.17		
4Ak3		205	8.69	8.05	8.71	8.04	0.59	1.11	0.59	1.14
4Bk3	205		8.70	8.18			0.35	0.72		
4Bk3			8.68	8.20			0.28	0.64		
4Bk3			8.76	8.05			0.25	0.54		
4Bk3		230	8.79	8.23	8.73	8.17	0.26	0.80	0.29	0.68
4Ck6	230		8.78	8.05			0.27	1.22		
4Ck6		240	8.90	8.18	8.84	8.12	0.25	1.31	0.26	1.27
5Ck7	240		8.80	7.96			0.30	1.35		
5Ck7			8.80	7.91						
5Ck7		257	8.87	7.96	8.82	7.94	0.25	1.42	0.28	1.39
5Ck8	257		8.85	7.97			0.25	1.50		
5Ck8			8.85	8.06						
5Ck8		277	8.83	7.98	8.84	8.00	0.29	1.57	0.27	1.54
6Ck9	277	285	8.82	8.02	8.82	8.02	0.24	1.50	0.24	1.50
6C	285	288	8.77	8.03	8.77	8.03	0.16	1.16	0.16	1.16

Table B.12 Soil reaction, organic carbon and carbonates, Transect 1, pedon 12

Horizon	Upper Depth cm	Lower Depth cm	Soil pH water	Soil pH salt	Average pH water	Average pH salt	% organic C	5 minutes	Average % organic C	Average 5 minutes
A1	0	3	6.88	6.50	6.88	6.50		3.55		3.55
Bw1	3		7.53	7.09			1.33	1.97		
Bw1		13	7.69	7.23	7.61	7.16	1.28	1.75	1.31	1.86
2A2	13	18	7.77	7.30	7.77	7.30	1.40	1.61	1.40	1.61
2A3	18	24	7.99	7.40	7.99	7.40	1.38	1.56	1.38	1.56
2A4	24		7.95	7.43			1.44	1.58		
2A4		36	8.07	7.52	8.01	7.48	1.12	1.80	1.28	1.69
2Bk1	36		8.02	7.46			1.30	1.77		
2Bk1		46	8.07	7.53	8.05	7.50	1.15	1.59	1.23	1.68
3Ak1	46	51	7.72	7.56	7.72	7.56	1.22	1.40	1.22	1.40
3Bk2	51		7.86	7.59			1.17	1.47		
3Bk2		60	7.96	7.54	7.91	7.57	1.20	1.55	1.19	1.51
3BkCk	60	68	8.08	7.61	8.08	7.61	1.08	1.67	1.08	1.67
3Ck1	68		8.09	7.62			0.99	1.86		
3Ck1		79	8.14	7.66	8.12	7.64	0.84	2.07	0.92	1.97
3Ck2	79		8.16	7.69			0.79	2.27		
3Ck2			8.15	7.71						
3Ck2			8.31	7.90			0.67	2.44		
3Ck2			8.19	7.85						
3Ck2			8.38	7.86			0.48	2.30		
3Ck2			8.55	7.98						
3Ck2			8.58	8.02			0.40	2.14		
3Ck2			8.62	7.96						
3Ck2		142	8.57	7.97	8.39	7.88	0.32	1.91	0.53	2.21
4Ak2	142	145	8.60	7.96	8.60	7.96	0.30	1.69	0.30	1.69
4Bk3	145		8.61	7.99			0.32	1.63		
4Bk3			8.53	7.97			0.32	1.57		
4Bk3			8.61	8.04			0.31	1.49		
4Bk3			8.55	7.91			0.33	1.43		
4Bk3			8.59	8.10			0.37	1.46		
4Bk3		185	8.62	8.17	8.59	8.03	0.36	1.43	0.34	1.50
4Bk4	185		8.61	8.20			0.43	1.52		
4Bk4			8.64	8.07			0.44	1.53		
4Bk4			8.56	8.03			0.46	1.41		
4Bk4		210	8.63	8.08	8.61	8.10	0.47	1.45	0.45	1.48
4C	210	217	8.55	8.19	8.55	8.19	0.43	1.35	0.43	1.35
5A5	217	221	8.46	8.09	8.46	8.09	0.49	1.21	0.49	1.21
5Ak3	221	225	8.56	8.10	8.56	8.10	0.76	1.25	0.76	1.25
5Ak4	225	232	8.48	8.09	8.48	8.09	0.45	0.78	0.45	0.78
5Bk5	232	242	8.57	8.13	8.57	8.13	0.28	0.68	0.28	0.68
5Bk6	242		8.64	8.09			0.29	1.27		
5Bk6		258	8.58	8.08	8.61	8.09	0.30	1.38	0.30	1.33
6Ck3	258		8.65	8.09			0.26	1.34		
6Ck3			8.72	8.12						
6Ck3		266	8.72	8.13	8.70	8.11	0.21	1.35	0.24	1.35

Table B.13 Soil reaction, organic carbon and carbonates, Transect 2, pedon 1

Horizon	Upper Depth cm	Lower Depth cm	Soil pH water	Soil pH salt	Average pH water	Average pH salt	% organic C	5 minutes	Average % organic C	Average 5 minutes
Oi	0	3								
Oe	3	4								
A1	4	9	6.02	5.83	6.02	5.83		3.48		3.48
A2	9	16	7.46	7.12	7.46	7.12	1.52	1.80	1.52	1.80
Bw	16		7.70	7.33			1.45	1.63		
Bw		36	7.82	7.42	7.76	7.38	1.45	1.63	1.45	1.63
2Bk1	36	43	7.81	7.46	7.81	7.46	1.43	1.65	1.43	1.65
2Bk2	43		7.98	7.56			1.21	1.51		
		58.5	7.94	7.51	7.96	7.54	1.21	1.30	1.21	1.41
2Bk3	58.5	71	7.96	7.53	7.96	7.53	1.23	1.37	1.23	1.37
2Bk4	71	84	8.01	7.57	8.01	7.57	1.16	1.65	1.16	1.65
2Bk5	84									
2Bk6	94.5		8.15	7.56			0.80	2.51		
		114	8.19	7.66	8.17	7.61	0.67	2.30	0.74	2.41
2Btk1	114		8.30	7.68			0.65	2.42		
			8.33	7.73			0.55	2.35		
		139	8.43	7.85	8.35	7.75	0.48	2.24	0.56	2.34
2BCk1	139	149	8.44	7.87	8.44	7.87	0.39	2.06	0.39	2.06
2BCk2	149	158	8.49	7.92	8.49	7.92	0.34	1.85	0.34	1.85
2Ck1	158		8.53	7.93			0.29	1.75		
			8.55	7.94						
		179	8.59	8.01	8.56	7.96	0.28	1.68	0.29	1.72
2Ck2	179	186	8.54	7.96	8.54	7.96	0.28	1.60	0.28	1.60
3Bk7	186		8.62	8.07			0.33	1.63		
			8.53	8.03			0.38	1.76		
		205			8.58	8.05	0.45	1.89	0.39	1.76
3Btk2	205		8.57	8.04			0.48	1.48		
		221	8.54	8.07	8.56	8.06	0.43	1.54	0.46	1.51
3Bk8	221	231	8.37	7.93	8.37	7.93	0.40	1.52	0.40	1.52
3Ck3	231		8.52	7.98			0.49	1.45		
		252	8.52	7.99	8.52	7.99	0.51	1.43	0.50	1.44
4Ak1	251	254	8.45	8.00	8.45	8.00	0.68	1.57	0.68	1.57
4Bk9	254	268	8.46	8.00	8.46	8.00	0.54	1.44	0.54	1.44
4Ak'	268	272	8.37	7.95	8.37	7.95	0.73	1.56	0.73	1.56
4Bk'	272	282	8.47	8.00	8.47	8.00	0.61	1.36	0.61	1.36
4Ak"	282	286	8.41	7.99	8.41	7.99	0.81	1.49	0.81	1.49
4Bk"	286	294	8.43	7.97	8.43	7.97	0.80	1.52	0.80	1.52
5Ak2	294									
5Ak3	297									
5Ak3		309	8.30	7.94	8.30	7.94	2.03	2.44	2.03	2.44
5Bk10	309		8.33	7.91			0.84	1.06		
		321	8.37	7.94	8.35	7.93	0.56	0.76	0.70	0.91
5Ck4	321		8.40	7.93			0.50	1.08		
			8.44	7.94			0.41	1.45		
			8.43	8.00			0.38	1.84		
			8.51	8.03			0.24	1.54		
		356	8.44	8.02	8.44	7.98	0.27	1.46	0.36	1.47
5Ck5	356		8.41	7.93			0.27	1.34		
			8.42	7.85						
		380			8.42	7.89			0.27	1.34

Table B.14 Soil reaction and organic carbon, Transect 2, pedon 2

Horizon	Upper Depth cm	Lower Depth cm	Soil pH water	Soil pH salt	Average pH water	Average pH salt	% organic C	120 seconds	Average % organic carbon	Average 120 seconds
Oi/Oe	0	2								
A1	2	6	6.89	6.65	6.89	6.65	3.66	3.69	3.66	3.69
A2	6		7.60	7.24			1.65	1.90		
A2		16.5	7.71	7.41	7.66	7.33	1.30	1.66	1.48	1.78
Bk1	16.5		7.78	7.49			1.32	1.50		
Bk1			7.95	7.54			1.40	1.65		
Bk1		35	7.93	7.58	7.89	7.54	1.39	1.57	1.37	1.57
Bk2	35		8.02	7.65			1.15	1.42		
Bk2		45	7.97	7.63	8.00	7.64	1.17	1.44	1.16	1.43
Bk3	45		8.01	7.65			1.19	1.58		
Bk3		53	8.07	7.68	8.04	7.67	1.20	1.34	1.20	1.46
Bk4	53		8.13	7.70			1.06	1.43		
Bk4			8.12	7.69			0.88	1.26		
Bk4		74	8.12	7.73	8.12	7.71	0.75	1.25	0.90	1.31
Ck1	74		8.22	7.76			0.73	1.06		
Ck1			8.26	7.78			0.54	0.96		
Ck1			8.30	7.86			0.63	1.05		
Ck1			8.29	7.91			0.54	0.98		
Ck1			8.44	7.96			0.47	0.95		
Ck1			8.54	8.00			0.39	1.04		
Ck1			8.64	7.98			0.38	0.80		
Ck1			8.69	8.12			0.29	0.71		
Ck1			8.75	8.05			0.30	0.83		
Ck1		146	8.74	8.06	8.49	7.95	0.29	0.76	0.46	0.91
Ck2	146		8.71	8.09			0.35	0.83		
Ck2			8.71	8.10			0.33	0.77		
Ck2			8.73	8.13			0.34	0.81		
Ck2			8.73	8.63			0.40	0.87		
Ck2		178	8.76	8.15	8.73	8.22	0.38	0.77	0.36	0.81
Ck3	178									
Ck3							0.37	0.77		
Ck3			8.69	8.16			0.36	0.67		
Ck3			8.71	8.19			0.43	0.80		
Ck3			8.77	8.22			0.53	1.11		
Ck3		224	8.83	8.19	8.75	8.19	0.56	0.97	0.45	0.86
2Ak1	224	232	8.80	8.21	8.80	8.21	0.64	1.07	0.64	1.07
2Ak2	232		8.77	8.17			0.92	1.27		
2Ak2		242	8.72	8.17	8.75	8.17	1.05	1.41	0.99	1.34
2Bk5	242	250	8.71	8.14	8.71	8.14	0.78	1.04	0.78	1.04
2Ck4	250	258	8.87	8.19	8.87	8.19	0.38	0.88	0.38	0.88
2Ck5 & 3Ak3	258	264	8.80	8.17	8.80	8.17	0.46	0.92	0.46	0.92
4Ck6	264	271					0.33	0.96	0.33	0.96

Table B.15 Soil reaction and organic carbon, Transect 2, pedon 3

Horizon	Upper Depth cm	Lower Depth cm	Soil pH water	Soil pH salt	Average pH water	Average pH salt	% organic C	120 seconds	Average % organic C	Average 120 seconds
A1	0	2								
A2	2	9.5	7.49	7.46	7.49	7.46	2.01	2.37	2.01	2.37
A3	9.5	15	7.56	7.51	7.56	7.51	1.35	1.69	1.35	1.69
Bw	15	23.5	7.84	7.60	7.84	7.60	1.25	1.58	1.25	1.58
Bk1	23.5		8.00	7.59			1.25	1.81		
Bk1		36	8.12	7.74	8.06	7.67	1.21	1.58	1.23	1.70
Ck1	36		8.25	7.78			0.78	1.39		
Ck1			8.28	7.78			0.61	1.10		
Ck1		56	8.30	7.81	8.28	7.79	0.53	1.03	0.64	1.17
Ck2	56		8.34	7.81			0.50	0.90		
Ck2			8.33	7.94			0.48	1.06		
Ck2			8.45	7.83			0.43	1.09		
Ck2			8.47	7.85			0.54	1.09		
Ck2			8.53	7.89			0.31	0.84		
Ck2			8.57	7.91			0.51	0.90		
Ck2		106	8.57	7.98	8.47	7.89	0.30	0.71	0.44	0.94
Ck3	106		8.60	8.00			0.32	0.71		
Ck3			8.63	7.94			0.36	0.95		
Ck3			8.65	8.05			0.39	0.83		
Ck3		136	8.68	8.12	8.64	8.03	0.36	0.87	0.36	0.84
Ck4	136		8.67	8.00			0.50	1.03		
Ck4		151	8.67	8.00	8.67	8.00	0.51	0.99	0.51	1.01
2A/Bk	151	153	8.59	8.06	8.59	8.06	0.73	1.03	0.73	1.03
2Bk2	153		8.60	8.07			0.48	0.80		
2Bk2		165	8.59	8.06	8.60	8.07	0.53	0.82	0.51	0.81
2Bk3	165		8.60	8.14			0.38	0.62		
2Bk3			8.53	7.89			0.37	0.61		
2Bk3			8.53	7.96			0.32	0.69		
2Bk3			8.59	7.93			0.28	0.68		
2Bk3		195	8.67	8.01	8.58	7.99	0.24	0.64	0.32	0.65
3Ck5	195		8.70	8.00			0.26	0.66		
3Ck5			8.73	8.01			0.20	0.60		
3Ck5			8.79	8.14			0.16	0.69		
3Ck5			8.80	8.08			0.18	0.87		
3Ck5		232	8.76	8.09	8.76	8.06	0.16	0.82	0.19	0.73
3Ck6	232						0.19	0.70		
3Ck6							0.25	0.59	0.22	0.65
3Ck7	244		8.51	8.01			0.28	0.74		
3Ck7			8.53	7.97			0.27	0.74		
3Ck7		262	8.51	7.96	8.52	7.98	0.24	0.65	0.26	0.71
3Ck8	262	272	8.55	7.97	8.55	7.97	0.22	0.65	0.22	0.65
4Ak	272						0.27	1.00	0.27	1.00

Table B.16 Soil reaction and organic carbon, Transect 2, pedon 4

Horizon	Upper Depth cm	Lower Depth cm	Soil pH water	Soil pH salt	Average pH water	Average pH salt	% organic C	120 seconds	Average % organic C	Average 120 seconds
Oi	0	2								
A1	2	6	7.11	6.90	7.11	6.90	NA	4.63		4.63
A2	6	15	7.71	7.30	7.71	7.30	1.65	1.98	1.65	1.98
Bk1	15		7.94	7.52			1.15	1.52		
Bk1			8.03	7.56			1.19	1.54		
Bk1		33	8.07	7.60	8.01	7.56	1.14	1.34	1.16	1.47
Bk2	33		8.08	7.64			1.06	1.32		
Bk2			8.26	7.71			0.90	1.21		
Bk2		50	8.23	7.76	8.19	7.70	0.58	0.90	0.85	1.14
Bk3	50		8.36	7.83			0.42	0.84		
Bk3			8.45	7.82			0.35	0.80		
Bk3		71	8.49	7.82	8.43	7.82	0.37	0.72	0.38	0.79
Bk4	71		8.51	7.85			0.38	0.73		
Bk4			8.48	7.79			0.36	0.78		
Bk4			8.49	7.83			0.36	0.75		
Bk4			8.45	7.82			0.37	0.68		
Bk4			8.46	7.84			0.41	0.78		
Bk4		109	8.44	7.84	8.47	7.83	0.40	0.70	0.38	0.74
Ck1	109	112	8.40	7.85	8.40	7.85	0.54	0.86	0.54	0.86
2Ak	112	116	8.33	7.82	8.33	7.82	0.64	1.05	0.64	1.05
2Bk5	116	121	8.36	7.85	8.36	7.85	0.59	0.85	0.59	0.85
2Ck2	121	133	8.43	7.87	8.43	7.87	0.44	0.67	0.44	0.67
2Ck3	133		8.48	7.81			0.32	0.48		
2Ck3		147	8.45	7.86	8.47	7.84	0.27	0.43	0.30	0.46
3Ck4	147		8.52	7.87			0.24	0.61		
3Ck4			8.53	7.89			0.33	0.67		
3Ck4			8.54	7.89			0.35	0.70		
3Ck4			8.52	7.86			0.33	0.62		
3Ck4		181	8.53	7.92	8.53	7.89	0.33	0.58	0.32	0.64

Table B.17 Soil reaction and organic carbon, Transect 2, pedon 5

Horizon	Upper Depth cm	Lower Depth cm	Soil pH water	Soil pH salt	Average pH water	Average pH salt	% organic C	120 seconds	Average % organic C	Average 120 seconds
A	0	3	6.80	6.61	6.80	6.61	6.49	80.00	6.49	80.00
Bw1	3	7	7.48	7.15	7.48	7.15	2.19	2.45	2.19	2.45
Bw2	7		7.83	7.49			1.29	1.50		
Bw2		17	7.90	7.55	7.87	7.52	1.27	1.57	1.28	1.54
Bw3	17		8.10	7.70			0.99	1.21		
Bw3			8.10	7.71			0.97	1.36		
Bw3			8.24	7.70			0.70	1.03		
Bw3		46	8.24	7.72	8.17	7.71	0.65	0.98	0.83	1.15
Bk1	46		8.35	7.80			0.54	0.96		
Bk1		56	8.40	7.79	8.38	7.80	0.53	0.88	0.54	0.92
2Ak	56	63	8.38	7.86		7.86	0.74	1.03	0.74	1.03
2Bk2	63		8.36	7.82			0.57	0.86		
2Bk2		72	8.41	7.83	8.39	7.83	0.57	0.85	0.57	0.86
2Bk3	72		8.22	7.56			0.45	0.69		
2Bk3		83	8.32	7.57	8.27	7.57	0.34	0.56	0.40	0.63
2Bk4	83		8.38	7.66			0.35	0.69		
2Bk4		97	8.40	7.72	8.39	7.69	0.30	0.63	0.33	0.66
2Bk5	97		8.41	7.74			0.29	0.61		
2Bk5			8.40	7.72			0.27	0.60		
2Bk5		114	8.37	7.76	8.39	7.74	0.29	0.61	0.28	0.61
2Ck1	114		8.49	7.85			0.28	0.60		
2Ck1		137	8.50	7.85	8.50	7.85	0.28	0.67	0.28	0.64
3Ck2	137		8.48	7.86			0.30	0.62		
3Ck2			8.51	7.86			0.25	0.55		
3Ck2		157	8.57	7.94	8.52	7.89	0.25	0.61	0.27	0.59
3Ck3	157	166	8.48	7.86		7.86	0.32	0.74	0.32	0.74
3Ck4	166		8.45	7.90			0.24	0.55		
3Ck4		176	8.47	7.77	8.46	7.84	0.25	0.52	0.25	0.54
4C1	176	182	8.11	7.61	8.11	7.61	0.22	0.45	0.22	0.45
4C2	182		8.26	7.67			0.22	0.44		
4C2		198	8.29	7.66	8.28	7.67	0.25	0.57	0.24	0.51
5C3	198		8.35	7.71			0.19	0.46		
5C3			8.33	7.70			0.22	0.59		
5C3		215	8.30	7.76	8.33	7.72	0.21	0.50	0.21	0.52
5C4	215	222					0.19	0.43	0.19	0.43

Table B.18 Soil reaction and organic carbon, Transect 2, pedon 6

Horizon	Upper Depth cm	Lower Depth cm	Soil pH water	Soil pH salt	Average pH water	Average pH salt	% organic C	120 seconds	Average % organic C	Average 120 seconds
Oi	0	2								
A1	2	4	6.54	6.33	6.54	6.33				
fill 1	4	10	7.46	7.11	7.46	7.11	1.63	1.99	1.63	1.99
fill 2	10	19.5	7.83	7.50	7.83	7.50	1.53	1.84	1.53	1.84
fill 3	19.5	23.5	7.89	7.61	7.89	7.61	1.72	1.96	1.72	1.96
fill 4	23.5	32	8.10	7.74	8.10	7.74	1.05	1.34	1.05	1.34
fill 5	32	39	8.12	7.70	8.12	7.70	0.99	1.46	0.99	1.46
fill 6	39		8.18	7.75			1.11	1.53		
fill 6		49	8.31	7.86	8.25	7.81	1.18	1.67	1.15	1.60
fill 7	49		8.20	7.77			0.82	1.29		
fill 7			8.16	7.73			0.76	1.18		
fill 7			8.30	7.82			0.63	1.05		
fill 7			8.36	7.87			0.61	1.06		
fill 7			8.42	7.93			0.61	0.90		
fill 7			8.53	7.97			0.56	0.98		
fill 7			8.66	8.04			0.48	0.81		
fill 7		102	8.64	7.95	8.41	7.89	0.45	0.91	0.62	1.02
fill 8	102		8.57	8.06			0.48	0.85		
fill 8		116.5	8.49	8.04	8.53	8.05	0.47	0.79	0.48	0.82
2Ak1	116.5	123	8.33	7.95	8.33	7.95	0.68	0.84	0.68	0.84
2Ak2	123	128.5	8.30	8.00	8.30	8.00	0.47	0.84	0.47	0.84
2Bk1	128.5		8.24	7.96			0.49	0.89		
2Bk1			8.15	7.94			0.46	0.78		
2Bk1			8.06	7.90			0.43	0.72		
2Bk1		158	8.02	7.90	8.12	7.93	0.49	0.91	0.47	0.83
2Bk2	158	166	7.92	7.80	7.92	7.80	0.52	0.81	0.52	0.81
2Ck1	166	173	8.27	8.02	8.27	8.02	0.55	0.87	0.55	0.87
2Ck2	173		7.90	7.77			0.61	0.97		
2Ck2			7.87	7.73			0.55	0.89		
2Ck2		191	7.87	7.77	7.88	7.76	0.60	0.88	0.59	0.91
2Ck3	191	196	7.83	7.70	7.83	7.70	0.76	1.04	0.76	1.04
3Ak3	196	202	7.74	7.61	7.74	7.61	1.35	1.65	1.35	1.65
3Ak4	202	212	7.71	7.58	7.71	7.58				
3Ak5	212	222	7.81	7.70	7.81	7.70				
3Ak/Bk	222	228	7.85	7.72	7.85	7.72				
3Bk3	228		7.88	7.72						
3Bk3			7.96	7.71						
3Bk3		254	7.99	7.75	7.94	7.73				
slough	254									
3Ck4	259		8.05	7.76						
3Ck4			8.15	7.79						
3Ck4		278	8.18	7.75	8.13	7.77				
4C	278	281	8.08	7.73	8.08	7.73				

Table B.19 Soil reaction and organic carbon, Transect 2, pedon 7

Horizon	Upper Depth cm	Lower Depth cm	Soil pH water	Soil pH salt	Average pH water	Average pH salt	% organic C	120 seconds	Average % organic C	Average 120 seconds
A1	0	5	7.04	6.87	7.04	6.87				
A2	5	8	7.61	7.37	7.61	7.37	1.20	1.59	1.20	1.59
fill 1	8		7.85	7.60			1.08	1.43		
fill 1		20	7.99	7.66	7.92	7.63	0.97	1.33	1.03	1.38
fill 2	20		7.41	7.47			1.18	1.50		
fill 2			8.27	7.80			1.15	1.41		
fill 2		38	7.53	7.27	7.74	7.51	1.06	1.37	1.13	1.43
fill 3	38		8.32	7.83			0.86	1.36		
fill 3			8.04	7.68			0.70	1.18		
fill 3			8.31	7.79			0.60	0.95		
fill 3			8.08	7.68			0.60	1.01		
fill 3			8.27	7.80			0.57	1.06		
fill 3			8.37	7.90			0.56	0.95		
fill 3			8.34	7.93			0.45	0.77		
fill 3			8.28	7.95			0.43	0.73		
fill 3			8.30	7.98			0.43	0.90		
fill 3		105	8.28	7.99	8.26	7.85	0.58	0.94	0.58	0.99
fill 4	105	110	8.10	7.95	8.10	7.95	1.15	1.46	1.15	1.46
fill 5	110		8.02	7.92			1.07	1.34		
fill 5			7.96	7.87			1.14	1.43		
fill 5			7.81	7.67			1.31	1.56		
fill 5			7.72	7.61			1.10	1.33		
fill 5			7.77	7.63			1.17	1.40		
fill 5			7.74	7.48			1.19	1.42		
fill 5			7.94	7.57			1.14	1.35		
fill 5		166	8.13	7.67	7.89	7.68	1.17	1.39	1.16	1.40
fill 6	166	168	7.73	7.49	7.73	7.49	1.13	1.38	1.13	1.38
2Ck1	168	176	7.93	7.55	7.93	7.55	0.67	1.03	0.67	1.03
3Ak1	176	182	8.28	7.72	8.28	7.72	1.19	1.46	1.19	1.46
3Ak2	182	190	8.24	7.78	8.24	7.78	0.60	0.86	0.60	0.86
3Bk1	190		8.33	7.85			0.30	0.49		
3Bk1			8.34	7.88			0.28	0.49		
3Bk1		216	8.38	7.87	8.35	7.87	0.27	0.55	0.28	0.51
3Ck2	216	224	8.40	7.86	8.40	7.86	0.26	0.51	0.26	0.51
4Ck3	224		8.45	7.90			0.22	0.51		
4Ck3			8.48	7.84			0.20	0.44		
4Ck3		250	8.46	7.89	8.46	7.88	0.18	0.42	0.20	0.46
4Ck4	250		8.55	7.92			0.22	0.66		
4Ck4			8.33	7.83			0.19	0.56		
4Ck4		280	8.36	7.85	8.41	7.87	0.20	0.57	0.20	0.60
5Ck5	280		8.21	7.79			0.21	0.57		
4Ck5		298	8.40	7.91	8.31	7.85	0.17	0.55	0.19	0.56

Table B.20 Soil reaction and organic carbon, Transect 2, pedon 8

Horizon	Upper Depth cm	Lower Depth cm	Soil pH water	Soil pH salt	Average pH water	Average pH salt	% organic C	120 seconds	Average % organic C	Average 120 seconds
Oi/Oe	0	2								
A	2	6.5	6.58	6.31	6.58	6.31	3.10	3.31	3.10	3.31
Bw1	6.5	13	7.54	7.23	7.54	7.23	1.29	1.70	1.29	1.70
Bw2	13	22	7.83	7.52	7.83	7.52	1.16	1.55	1.16	1.55
Bk1	22		7.86	7.59			1.12	1.51		
Bk1		34	7.97	7.65	7.92	7.62	1.01	1.44	1.07	1.48
Bk2	34		8.07	7.68			0.75	1.22		
Bk2			7.99	7.67			0.75	1.26		
Bk2			8.09	7.77			0.69	1.15		
Bk2		62	8.08	7.74	8.06	7.72	0.44	0.94	0.66	1.14
Bk3	62		8.12	7.76			0.44	0.95		
Bk3			8.18	7.69			0.42	0.99		
Bk3			8.17	7.74			0.40	0.85		
Bk3		91	8.19	7.77	8.17	7.74	0.38	0.81	0.41	0.90
Bk4	91		8.12	7.73			0.38	0.84		
Bk4			8.26	7.78			0.40	0.90		
Bk4			8.23	7.76			0.44	0.90		
Bk4		114	8.11	7.72	8.18	7.75	0.37	0.79	0.40	0.86
Ck1	114		8.22	7.76			0.37	0.81		
Ck1			8.23	7.78			0.39	0.74		
Ck1			8.13	7.79			0.40	0.81		
Ck1			8.14	7.79			0.38	0.88		
Ck1			8.22	7.78			0.43	0.83		
Ck1		151	8.26	7.82	8.20	7.79	0.44	0.81	0.40	0.81
2Ak1	151	159	8.17	7.80	8.17	7.80	0.69	1.04	0.69	1.04
2Ak2	159	166	8.15	7.77	8.15	7.77	1.00	1.33	1.00	1.33
2Ak/Bk	166	170	8.20	7.81	8.20	7.81	0.53	0.84	0.53	0.84
2Bk5	170		8.28	7.73			0.31	0.59		
2Bk5			8.27	7.82			0.29	0.52		
2Bk5		189	8.30	7.78	8.28	7.78	0.28	0.57	0.29	0.56
3Ck2	189	194	8.27	7.77	8.27	7.77	0.20	0.48	0.20	0.48
3Ck3	194		8.30	7.78			0.24	0.59		
3Ck3		203	8.21	7.79	8.26	7.79	0.24	0.69	0.24	0.64
3Ck4	203		8.25	7.76			0.28	0.86		
3Ck4			8.15	7.78			0.28	0.63		
3Ck4			8.27	7.81			0.25	0.72		
3Ck4			8.31	7.80			0.28	0.71		
3Ck4			8.33	7.79			0.23	0.61		
3Ck4			8.25	7.76			0.20	0.58		
3Ck4			8.27	7.71			0.18	0.51		
3Ck4			8.32	7.78			0.22	0.57		
3Ck4			8.27	7.79			0.21	0.58		
3Ck4		284	8.29	7.82	8.27	7.78	0.24	0.65	0.24	0.64

Table B.21 Soil reaction and organic carbon, Transect 2, pedon 9

Horizon	Upper Depth cm	Lower Depth cm	Soil pH water	Soil pH salt	Average pH water	Average pH salt	% organic C	120 seconds	Average % organic C	Average 120 seconds
A1	0	2	7.90	7.54	7.90	7.54				
A2	2	7.5	8.24	7.79	8.24	7.79				
2A3	7.5	15	8.21	7.72	8.21	7.72	1.50	1.91	1.50	1.91
2A4	15	21	8.29	7.87	8.29	7.87	1.15	1.64	1.15	1.64
2Bw1	21	27	8.49	7.93	8.49	7.93	1.19	1.54	1.19	1.54
3A5	27	35	8.58	8.01	8.58	8.01	1.25	1.63	1.25	1.63
3Bk1	35		8.59	8.02			1.11	1.45		
3Bk1			8.55	7.93			1.12	1.49		
3Bk1		57	8.52	7.93	8.55	7.96	1.05	1.43	1.09	1.46
4A6	57	63	8.33	7.86		7.86	1.47	1.84	1.47	1.84
4Bw2	63		8.38	7.89			1.08	1.44		
4Bw2		76	8.41	7.89	8.40	7.89	0.78	1.33	0.93	1.39
4Ck1	76		8.43	7.90			0.68	1.28		
4Ck1			8.44	7.92			0.65	1.21		
4Ck1			8.40	7.91			0.63	1.24		
4Ck1			8.40	7.92			0.59	1.21		
4Ck1			8.20	7.95			0.57	1.09		
4Ck1			8.23	7.97			0.51	1.07		
4Ck1		117	8.15	7.97	8.32	7.93	0.48	1.02	0.59	1.16
4Ck2	117		8.12	7.99			0.38	0.91		
4Ck2			8.11	8.02			0.42	1.08		
4Ck2			8.10	7.94			0.40	0.82		
4Ck2			8.10	7.97			0.38	0.81		
4Ck2		155	8.11	8.01	8.11	7.99	0.39	0.83	0.39	0.89
4Ck3	155		8.05	7.96			0.38	0.81		
4Ck3			8.03	7.93			0.37	0.84		
4Ck3		176	7.96	7.71	8.01	7.87	0.35	0.82	0.37	0.82
4Ck4	176		7.79	7.79			0.35	0.92		
4Ck4			7.83	7.82			0.36	0.73		
4Ck4			7.85	7.79			0.36	0.89		
4Ck4			7.93	7.84			0.35	0.78		
4Ck4			7.94	7.80			0.37	0.75		
4Ck4			7.95	7.85			0.43	0.72		
4Ck4		225	7.95	7.84	7.89	7.82	0.43	0.87	0.38	0.81
4Ck5	225	231	7.95	7.85	7.95	7.85	0.61	0.97	0.61	0.97
5A7	231	239	7.93	7.83	7.93	7.83	1.09	1.40	1.09	1.40
5A8	239	244	7.92	7.82	7.92	7.82	0.97	1.27	0.97	1.27
5Bk2	244	253	7.93	7.84	7.93	7.84	0.41	0.73	0.41	0.73

Table B.22 Soil reaction and organic carbon, Transect 2, pedon 10

Horizon	Upper Depth cm	Lower Depth cm	Soil pH water	Soil pH salt	Average pH water	Average pH salt	% organic C	120 seconds	Average % organic C	Average 120 seconds
A1	0	4	6.76	6.60	6.76	6.60				
A2	4	7	7.32	7.04	7.32	7.04	1.91	2.27	1.91	2.27
Bw1	7	16	7.61	7.32	7.61	7.32	1.40	1.87	1.40	1.87
Bk1	16	24	7.89	7.53	7.89	7.53	1.19	1.63	1.19	1.63
fill 1	24		8.09	7.71			1.03	1.45		
fill 1		36	8.15	7.79	8.12	7.75	1.21	1.73	1.12	1.59
ash	36	50	8.22	7.80	8.22	7.80	1.25	1.92	1.25	1.92
Ck1	50		8.34	7.85			0.65	1.22		
Ck1			8.26	7.82			0.58	1.10		
Ck1			8.31	7.81			0.54	1.28		
Ck1		79	8.29	7.80	8.30	7.82	0.48	1.02	0.56	1.16
pit fill 2	79	120								
Ck2	120		8.50	7.88			0.36	0.75		
Ck2			8.51	7.97			0.35	0.77		
Ck2			8.54	7.98			0.35	0.77		
Ck2			8.57	7.92			0.36	0.83		
Ck2			8.56	8.04			0.36	0.79		
Ck2			8.64	8.03			0.37	0.80		
Ck2			8.67	8.00			0.38	0.80		
Ck2			8.63	8.04			0.39	0.80		
Ck2		184	8.66	8.05	8.59	7.99	0.43	0.88	0.37	0.80
Ck3	184	195	8.69	8.03	8.69	8.03	0.38	0.72	0.38	0.72
2Ak1	195	203	8.71	8.05	8.71	8.05	0.55	0.97	0.55	0.97
2Ak2	203	211	8.68	7.98	8.68	7.98	0.87	1.29	0.87	1.29
2Ak3	211	215	8.68	8.07	8.68	8.07	0.67	0.98	0.67	0.98
2Bk2	215		8.78	8.12			0.38	0.67		
2Bk2			8.84	8.16			0.32	0.57		
2Bk2		231	8.85	8.15	8.82	8.14	0.34	0.57	0.35	0.60
2Ck4	231		8.93	8.22			0.26	0.63		
2Ck4		247	8.95	8.18	8.94	8.20	0.28	0.62	0.27	0.63

Table B.23 Soil reaction and organic carbon, Transect 2, pedon 11

Horizon	Upper Depth cm	Lower Depth cm	Soil pH water	Soil pH salt	Average pH water	Average pH salt	% organic C	120 seconds	Average % organic C	Average 120 seconds
A1	0	3	6.61	6.34	6.61	6.34				
fill 1	3	10.5	7.67	7.27	7.67	7.27	1.39	1.83	1.39	1.83
fill 2	10.5		7.84	7.47			1.46	1.82		
fill 2			8.02	7.63			1.34	1.75		
fill 2		30	8.12	7.74	7.99	7.61	1.46	1.83	1.42	1.80
fill 3	30	33.5	8.31	7.88	8.31	7.88	0.86	1.27	0.86	1.27
fill 4	33.5	37	8.27	7.78	8.27	7.78	1.27	1.66	1.27	1.66
fill 5	37	41	8.36	7.90	8.36	7.90	0.79	1.17	0.79	1.17
fill 6	41	48	8.32	7.88	8.32	7.88	0.95	1.21	0.95	1.21
Bk1	48		8.39	7.95			1.03	1.34		
Bk1		60	8.41	7.98	8.40	7.97	1.04	1.43	1.04	1.39
Ck1	60	69	8.48	8.03	8.48	8.03	0.96	1.34	0.96	1.34
Ck2	69		8.50	8.05			0.88	1.25		
Ck2			8.51	8.08			0.93	1.49	0.91	1.37
Ck2		87	8.58	8.13	8.53	8.09				
Akb1	87	92	8.46	8.04	8.46	8.04	1.33	1.82	1.33	1.82
Akb2	92	100	8.30	8.01	8.30	8.01	1.11	1.53	1.11	1.53
Bkb	100	107	8.26	8.00	8.26	8.00	0.86	1.29	0.86	1.29
Akb/Bkb/Ckb	107		8.31	8.02			0.76	1.16		
Akb/Bkb/Ckb		116	8.47	8.08	8.39	8.05	0.51	0.93	0.64	1.05
2A2	116	121	7.88	7.76	7.88	7.76	1.37	1.79	1.37	1.79
2Ak/Ck	121	126	8.08	7.92	8.08	7.92	0.80	1.21	0.80	1.21
3Ak2	126	135	7.92	7.77	7.92	7.77	1.08	1.43	1.08	1.43
3Ak/Ck	135		7.95	7.78			1.00	1.35		
3Ak/Ck		148	7.80	7.70	7.88	7.74	0.94	1.34	0.97	1.35
3Ck3	148		8.01	7.86			0.55	1.00		
3Ck3			8.02	7.87			0.32	0.77		
3Ck3		166	7.96	7.80	8.00	7.84	0.33	0.82	0.40	0.86
3Ck4	166		7.84	7.78			0.35	0.81		
3Ck4			7.84	7.77			0.34	0.84		
3Ck4		186	7.82	7.76	7.83	7.77	0.34	0.84	0.34	0.83
3Ck5	186		7.88	7.77			0.34	0.74		
3Ck5			7.89	7.78			0.32	0.77		
3Ck5			7.91	7.78			0.32	0.72		
3Ck5			7.91	7.77			0.33	0.86		
3Ck5			7.95	7.78			0.31	0.85		
3Ck5			7.94	7.79			0.32	0.76		
3Ck5		232	7.93	7.77	7.92	7.78	0.33	0.77	0.32	0.79
4Ak3	232	242	7.93	7.76	7.93	7.76	0.39	0.78	0.39	0.78
4Ak4	242		7.90	7.75			0.77	1.05		
4Ak4		250	7.86	7.36	7.88	7.56	0.54	0.84	0.66	0.95

Table B.24 Soil reaction and organic carbon, Transect 2, pedon 12

Horizon	Upper Depth cm	Lower Depth cm	Soil pH water	Soil pH salt	Average pH water	Average pH salt	% organic C	120 seconds	Average % organic C	Average 120 seconds
A1	0	4.5	6.80	6.57	6.80	6.57				
Bw1	4.5	9	7.93	7.51	7.93	7.51	1.91	2.45	1.91	2.45
Bw2	9		8.30	7.80			1.69	2.21		
Bw2		21	8.51	7.97	8.41	7.89	1.55	1.97	1.55	1.97
Bw3	21	28	8.57	8.07	8.57	8.07	1.31	1.83	1.31	1.83
fill 1 (ash)	28	34.5	8.57	8.25	8.57	8.25	1.93	2.66	1.93	2.66
fill 2 (ash)	34.5	39	8.14	8.02	8.14	8.02	3.63	4.39	3.63	4.39
fill 3	39	46	7.96	7.88	7.96	7.88	4.05	4.56	4.05	4.56
fill 4	46		8.32	8.17			1.47	1.97	1.47	1.97
fill 4		60	8.08	8.00	8.20	8.09	1.38	1.76	1.38	1.76
2Bk1	60		8.10	8.05			0.88	1.25		
2Bk1		69	8.08	8.02	8.09	8.04	0.82	1.27	0.85	1.26
2Ck1	69		8.03	7.94			0.74	1.16		
2Ck1			8.02	7.90			0.69	1.13		
2Ck1			8.11	7.98			0.71	1.18		
2Ck1			8.25	8.15			0.68	1.15		
2Ck1			8.32	8.22			0.65	1.10		
2Ck1		112	8.33	8.19	8.18	8.06	0.66	1.09	0.69	1.14
2Ck2	112		8.31	8.25			0.53	1.17		
2Ck2			8.18	8.16			0.43	0.89		
2Ck2		127	8.19	8.08	8.23	8.16	0.52	0.90	0.49	0.99
3A2	127		7.94	7.82			1.59	2.03		
3A2			7.96	7.86			2.34	3.83		
3A2		144	8.00	7.92	7.97	7.87	2.53	3.03	2.15	2.96
3Ck3	144		8.06	7.99			0.63	1.07		
3Ck3			8.07	7.96			0.33	0.76		
3Ck3			8.03	7.93			0.30	0.65		
3Ck3		175	7.99	7.91	8.04	7.95	0.35	0.75	0.40	0.81
3Ck3/4Ak1	175	181	7.88	7.80	7.88	7.80	0.43	0.88	0.43	0.88
4Ak1	181		7.78	7.71			0.79	1.19		
4Ak1		194	7.77	7.70	7.78	7.71	0.87	1.42	0.83	1.31
4Ak2	194		7.73	7.66			0.83	1.25		
4Ak2			7.66	7.59			0.97	1.32		
4Ak2		206	7.68	7.58	7.69	7.61	1.01	1.41	0.57	1.33
4Ck4	206		7.89	7.76			0.61	0.99		
4Ck4			7.90	7.81			0.34	0.74		
4Ck4		226	7.91	7.79	7.90	7.79	0.32	0.74	0.42	0.82
slough							2.68	3.16		
4Ck5	226		7.93	7.81			0.40	0.82		
4Ck5		235	7.95	7.80	7.94	7.81	0.53	0.90	0.47	0.86
5Ak3	235		7.85	7.71			0.84	1.18		
5Ak3		246	7.83	7.69	7.84	7.70	0.93	1.24	0.89	1.21
5Ak4	246	254	7.82	7.73	7.82	7.73	0.53	0.85	0.53	0.85
5Bk2	254		7.90	7.76			0.32	0.59		
5Bk2			8.01	7.82			0.28	0.56		
5Bk2			7.98	7.81			0.32	0.62		
5Bk2			7.93	7.85			0.37	0.70		
5Bk2		286	7.95	7.79	7.95	7.81	0.34	0.74	0.33	0.64
5Ck6	286	294	7.95	7.78	7.95	7.78	0.32	0.67	0.32	0.67

Table B.25 Soil reaction and organic carbon, Transect 2, pedon 13

Horizon	Upper Depth cm	Lower Depth cm	Soil pH water	Soil pH salt	Average pH water	Average pH salt	% organic C	120 seconds	Average % organic C	Average 120 seconds
A1	0	3	6.80	6.65	6.80	6.65				
A2	3	7	7.04	6.73	7.04	6.73	3.05	3.40	3.05	3.40
Bw1	7	11	7.40	7.13	7.40	7.13	1.50	1.93	1.50	1.93
2Bw2	11		7.39	7.08			1.31	1.69		
2Bw2		20	7.52	7.27	7.46	7.18	1.24	1.64	1.28	1.67
2Bw3	20	28	7.67	7.39	7.67	7.39	1.12	1.63	1.12	1.63
2Bk1	28		7.76	7.43			1.02	1.41		
2Bk1			7.79	7.47			1.00	1.43		
2Bk1		46	7.90	7.49	7.82	7.46	0.95	1.34	0.99	1.39
2Bk2	46		7.86	7.51			0.88	1.35		
2Bk2			7.91	7.50			0.86	1.31		
2Bk2		62	7.92	7.55	7.90	7.52	0.81	1.22	0.85	1.29
3Ak1	62		7.89	7.49			0.93	1.32		
3Ak1		77	7.96	7.59	7.93	7.54	0.74	1.25	0.84	1.29
3Bk3	77		8.15	7.68			0.38	0.84		
3Bk3			8.13	7.67			0.33	0.80		
3Bk3			8.14	7.66			0.32	0.72		
3Bk3			8.15	7.68			0.31	0.77		
3Bk3			8.19	7.67			0.30	0.70		
3Bk3		115	8.03	7.63	8.13	7.67	0.42	0.82	0.34	0.78
3Ck1	115		8.22	7.68			0.31	0.75		
3Ck1			8.21	7.69			0.32	0.71		
3Ck1			8.19	7.72			0.29	0.71		
3Ck1			8.13	7.74			0.31	0.69		
3Ck1			8.25	7.78			0.30	0.69		
3Ck1			8.28	7.81			0.31	0.74		
3Ck1			8.23	7.76			0.33	0.77		
3Ck1			8.28	7.80			0.33	0.78		
3Ck1			8.24	7.77			0.30	0.74		
3Ck1			8.25	7.83			0.31	0.83		
3Ck1			8.27	7.77			0.34	0.76		
3Ck1		200	8.32	7.79	8.24	7.76	0.37	0.77	0.32	0.75
4Ak/3Ck	200		8.27	7.73			0.51	0.88		
4Ak/3Ck		207	8.28	7.75	8.28	7.74	0.65	0.99	0.58	0.94
4Ak2	207	209	8.25	7.73	8.25	7.73	0.83	1.15	0.83	1.15
4Bk4	209		8.24	7.77			0.46	0.73		
4Bk4			8.25	7.83			0.28	0.48		
4Bk4		225	8.22	7.76	8.24	7.79	0.25	0.45	0.33	0.55
4Bk5	225		8.30	7.81			0.29	0.56		
4Bk5		239	8.28	7.72	8.29	7.77	0.28	0.72	0.29	0.64
4Ck2	239		8.31	7.84			0.27	0.71		
4Ck2		253	8.39	7.87	8.35	7.86	0.24	0.81	0.26	0.76
5Ck3	253		8.40	7.89			0.20	0.56		
5Ck3		267	8.44	7.88	8.42	7.89	0.18	0.58	0.19	0.57
5Ck4	267		8.36	7.86			0.19	0.58		
5Ck4			8.42	7.90			0.17	0.49		
5Ck4			8.39	7.84			0.22	0.56		
5Ck4			8.40	7.83			0.20	0.52		
5Ck4		295	8.36	7.72	8.39	7.83	0.22	0.55	0.20	0.54

Table B.26 Soil reaction and organic carbon, Transect 3, pedon 1 (continued below)

Horizon	Upper Depth cm	Lower Depth cm	Soil pH water	Soil pH salt	Average pH water	Average pH salt	% organic C	120 seconds	Average % organic C	Average 120 seconds
A1	0	3.5	7.38	7.21	7.38	7.21				
A2	3.5	6	7.37	7.06	7.37	7.06				
A3	6	9	7.52	7.20	7.52	7.20	1.95	2.32	1.95	2.32
Bw1	9	17	7.66	7.33	7.66	7.33	1.04	1.45	1.04	1.45
2Bw2	17		7.66	7.49			1.30	1.68		
2Bw2		26	7.83	7.56	7.75	7.53	1.38	1.68	1.34	1.68
2Bk1	26		7.78	7.48			1.34	1.66		
2Bk1			8.08	7.57			1.26	1.60		
2Bk1			7.86	7.70			1.29	1.65		
2Bk1		53	8.08	7.46	7.95	7.55	1.22	1.58	1.28	1.62
2Bk2	53		8.06	7.69			1.23	1.52		
2Bk2			8.08	7.55			1.19	1.48		
2Bk2			8.05	7.69			1.18	1.50		
2Bk2			7.78	7.59			1.20	1.55		
2Bk2			7.68	7.51			1.23	1.51		
2Bk2			7.96	7.56			1.17	1.48		
2Bk2			8.22	7.55			1.11			
2Bk2		113	7.99	7.75	7.98	7.61	1.22	1.56	1.19	1.51
2Ak/Ck	113	121	7.91	7.58	7.91	7.58	1.06	1.44	1.06	1.44
2Ck/Ak	121		8.27	7.76			0.71	1.14		
2Ck/Ak			7.90	7.74			0.59	1.09		
2Ck/Ak			8.19	7.79			0.52	0.96		
2Ck/Ak			8.31	7.68			0.61	1.02		
2Ck/Ak			8.11	7.71			0.53	0.98		
2Ck/Ak			8.22	7.70			0.37	0.78		
2Ck/Ak		170	8.18	7.69	8.17	7.72	0.41	0.90	0.53	0.98
3Ck1	170		8.37	7.73			0.32	0.76		
3Ck1			8.53	7.72			0.29	0.76		
3Ck1			8.26	7.78			0.28	0.86		
3Ck1			8.52	7.78			0.28	0.75		
3Ck1			8.41	7.94			0.28	0.70		
3Ck1			8.26	7.76			0.26	0.66		
3Ck1			8.33	7.69			0.27	0.67		
3Ck1			8.57	7.96			0.29	0.71		
3Ck1			8.38	7.81			0.32	0.73		
3Ck1		239	8.56	7.73	8.42	7.79	0.27	0.66	0.29	0.73
3Ck2	239		8.44	7.88			0.32	0.70		
3Ck2			8.65	7.71			0.35	0.81		
3Ck2			8.45	8.00			0.31	0.71		
3Ck2			8.21	8.06			0.33	0.74		
3Ck2			8.45	7.73			0.32	0.69		
3Ck2		280	8.39	7.98	8.43	7.89	0.35	0.72	0.33	0.73
3Ck3	280		8.40	7.85			0.36	0.72		
3Ck3		296	8.35	7.55	8.38	7.70	0.42	0.82	0.39	0.77
4Ck4	296		8.33	7.91			0.38	0.80		
4Ck4			8.44	7.71			0.46	0.87		
4Ck4			8.42	7.77			0.48	0.87		
4Ck4			8.46	7.78			0.45	0.85		
4Ck4		330	8.49	7.72	8.43	7.78	0.45	0.85	0.44	0.85
5Ak1	330		8.47	7.92			0.66	1.04		
5Ak1		343	8.27	7.71	8.37	7.82	0.95	1.23	0.81	1.14
5Ak2	343	349	8.41	7.75	8.41	7.75	1.24	1.61	1.24	1.61
5Ak3	349		8.41	7.92			2.02	2.44		
5Ak3		359	8.23	7.63	8.32	7.78	1.85	2.19	1.94	2.32
5Ak/Bk	359	369	8.20	7.75	8.20	7.75	0.73	0.94	0.73	0.94

Table B.26 (continued) Soil reaction and organic carbon, Transect 3, pedon 1

Horizon	Upper Depth cm	Lower Depth cm	Soil pH water	Soil pH salt	Average pH water	Average pH salt	% organic C	120 seconds	Average % organic C	Average 120 seconds
5Bk3	369		8.21	7.80			0.48	0.71		
5Bk3			8.59	7.93			0.45	0.68		
5Bk3			8.33	7.77			0.40	0.72		
5Bk3		395	8.21	7.68	8.34	7.80	0.35	0.72	0.42	0.71
6Ck5	395		8.34	7.69			0.25	0.58		
6Ck5			8.35	7.74			0.21	0.50		
6Ck5			8.22	7.67			0.26	0.60		
6Ck5			8.44	7.69			0.23	0.56		
6Ck5			8.39	7.63			0.24	0.60		
6Ck5			8.37	7.68			0.28	0.78		
6Ck5		442	8.44	7.80	8.36	7.70	0.26	0.70	0.25	0.62

Table B.27 Soil reaction and organic carbon, Transect 3, pedon 2

Horizon	Upper Depth cm	Lower Depth cm	Soil pH water	Soil pH salt	Average pH water	Average pH salt	% organic C	120 seconds	Average % organic C	Average 120 seconds
A1	0	2	6.87	6.53	6.87	6.53				
A2	2	6	7.40	7.09	7.40	7.09				
Bw1	6	10	7.50	7.16	7.50	7.16	1.29	1.67	1.29	1.67
Bw2	10	14.5	7.65	7.27	7.65	7.27	1.16	1.54	1.16	1.54
Bk1	14.5		7.74	7.31			1.02	1.43		
Bk1			7.79	7.35			1.13	1.51		
Bk1		33	7.85	7.36	7.79	7.34	1.12	1.54	1.09	1.49
Bk2	33		7.80	7.25			1.01	1.48		
Bk2			7.91	7.39			0.91	1.50		
Bk2		52	7.95	7.43	7.89	7.36	0.81	1.31	0.91	1.43
Ck1	52		7.85	7.46			0.68	1.28		
Ck1			7.84	7.51			0.64	1.18		
Ck1			7.85	7.63			0.61	1.25		
Ck1		75	7.96	7.51	7.88	7.53	0.56	1.10	0.62	1.20
Ck/Ak1	75		7.71	7.43			1.11	1.47		
Ck/Ak1			7.92	7.42			0.63	1.20		
Ck/Ak1			7.82	7.70			1.36	1.50		
Ck/Ak1			7.85	7.51			0.86	1.32		
Ck/Ak1			7.88	7.41			1.01	1.47		
Ck/Ak1			8.08	7.62			0.40	0.88		
Ck/Ak1		115	7.94	7.54	7.89	7.52	0.64	1.10	0.86	1.28
Ck1'	115		8.02	7.58			0.31	0.77		
Ck1'			8.06	7.57			0.33	0.90		
Ck1'			7.69	7.61			0.35	0.79		
Ck1'			8.07	7.65			0.37	0.88		
Ck1'			8.05	7.57			0.35	0.79		
Ck1'		163	7.89	7.58	7.96	7.59	0.33	0.76	0.34	0.82
Ck'/Ak'	163	170	7.84	7.54	7.84	7.54	0.54	0.94	0.54	0.94
Ck2	170		8.15	7.59			0.47	0.88		
Ck2			8.16	7.66			0.35	0.80		
Ck2			8.24	7.76			0.36	0.75		
Ck2			8.26	7.64			0.37	0.77		
Ck2			8.19	7.64			0.35	0.78		
Ck2		210	8.15	7.91	8.19	7.70	0.38	0.84	0.38	0.80
2Ak2	210	214	8.22	7.74	8.22	7.74	0.65	1.06	0.65	1.06
2Ak3	214		8.22	7.68			0.89	1.19		
2Ak3		224	8.21	7.61	8.22	7.65	0.99	1.30	0.94	1.25
2Bk3	224		8.20	7.72			0.51	0.76		
2Bk3		235	8.22	7.83	8.21	7.78	0.30	0.56	0.41	0.66
2Bk4	235		8.04	7.70			0.25	0.63		
2Bk4			8.10	7.69			0.27	0.61		
2Bk4		256	8.31	7.69	8.15	7.69	0.28	0.65	0.27	0.63
2Ck3	256		8.02	7.66			0.24	0.65		
2Ck3			8.25	7.66			0.25	0.64		
2Ck3		283	8.02	7.71	8.10	7.68	0.25	0.67	0.25	0.65
2Ck4	283	296	8.21	7.64	8.21	7.64	0.25	0.63	0.25	0.63

Table B.28 Soil reaction and organic carbon, Transect 3, pedon 3

Horizon	Upper Depth cm	Lower Depth cm	Soil pH water	Soil pH salt	Average pH water	Average pH salt	% organic C	120 seconds	Average % organic C	Average 120 seconds
A1	0	2.5	6.69	5.90	6.69	5.90				
A2	2.5	6	7.23	6.80	7.23	6.80	2.23	2.63	2.23	2.63
fill 1	6	13	7.57	7.00	7.57	7.00	1.06	1.47	1.06	1.47
fill 2	13	18	7.62	7.24	7.62	7.24	1.18	1.60	1.18	1.60
fill 3	18		7.77	7.34			1.30	1.67		
fill 3		29	7.81	7.37	7.79	7.36	1.24	1.68	1.27	1.68
fill 4	29	38	7.89	7.56		7.56	1.21	1.64	1.21	1.64
fill 5	38		7.86	7.53			1.31	1.66		
fill 5		52	7.97	7.49	7.92	7.51	1.17	1.50	1.24	1.58
fill 6	52		7.98	7.45			1.28	1.64		
fill 6		64	8.04	7.53	8.01	7.49	1.12	1.52	1.20	1.58
fill 7	64	70	8.10	7.63	8.10	7.63	1.17	1.57	1.17	1.57
Ck1	70		8.06	7.56			0.62	1.15		
Ck1			8.21	7.57			0.42	0.97		
Ck1			8.23	7.64			0.36	0.81		
Ck1			8.19	7.57			0.35	0.77		
Ck1		108	8.25	7.69	8.19	7.61	0.42	0.81	0.43	0.90
Ck2	108		8.26	7.70			0.36	0.77		
Ck2			8.30	7.67			0.34	0.74		
Ck2			8.24	7.72			0.36	0.79		
Ck2			8.33	7.81			0.40	0.82		
Ck2			8.26	7.79			0.45	0.91		
Ck2			8.38	7.93			0.38	0.84		
Ck2			8.43	7.87			0.36	0.74		
Ck2			8.49	7.86			0.38	0.80		
Ck2			8.57	7.82			0.41	0.82		
Ck2		185	8.56	7.98	8.38	7.82	0.41	0.83	0.39	0.81
2Ak1	185	190	8.47	7.97	8.47	7.97	0.57	0.97	0.57	0.97
2Ak2	190		8.44	7.88			0.86	1.22		
2Ak2		200	8.45	7.94	8.45	7.91	1.17	1.56	1.02	1.39
2Ak/Bk	200	206	8.51	7.99	8.51	7.99	0.68	1.02	0.68	1.02
2Bk1	206		8.40	7.88			0.42	0.74		
2Bk1			8.41	7.78			0.35	0.59		
2Bk1		227	8.53	7.87	8.45	7.84	0.33	0.60	0.37	0.64
2Bk2	227	235	8.53	7.82	8.53	7.82	0.31	0.68	0.31	0.68
2Ck3	235		8.57	7.74			0.32	0.71		
2Ck3			8.46	7.82			0.28	0.67		
2Ck3		258	8.47	7.80	8.50	7.79	0.29	0.70	0.30	0.69

Table B.29 Soil organic carbon, Transect 4, pedon 29

Horizon	Upper Depth cm	Lower Depth cm	Soil pH water	Soil pH salt	Average pH water	Average pH salt	% organic C	120 seconds	Average % organic C	Average 120 seconds
A1	0	3								
fill 1	3	8.5					1.36	1.97	1.36	1.97
fill 2	8.5	14					1.21	1.04	1.21	1.04
fill 3	14						1.30	1.77		
fill 3							1.31	1.82		
fill 3							1.19	1.72		
fill 3		37					1.13	1.52	1.23	1.71
fill 4	37						1.87	2.29		
fill 4		51					1.55	1.99	1.71	2.14
fill 5	51						1.07	1.52		
fill 5							1.05	1.52		
fill 5		74					1.17	1.60	1.10	1.55
fill 6	74						1.09	1.59		
fill 6		90					0.92	1.29	1.01	1.44
fill 7	90						1.30	1.66		
fill 7		100					1.35	1.89	1.33	1.78
fill 8	100						1.54	1.96		
fill 8							1.21	1.64		
fill 8		124					1.15	1.61	1.30	1.74
fill 9	124	133					0.78	1.14	0.78	1.14
fill 10	133						1.11	1.48		
fill 10							1.51	1.85		
fill 10							1.23	1.56		
fill 10							1.18	1.52		
fill 10							1.03	1.54		
fill 10		176					1.35	1.77	1.24	1.62
fill 11	176						0.44	0.90		
fill 11		188					0.46	0.86	0.45	0.88
Ck1	188	196					0.27	0.63	0.27	0.63
2Ck2	196						0.24	0.61		
2Ck2		213					0.21	0.56	0.23	0.59
2Ck3	213						0.22	0.57		
2Ck3							0.18	0.55		
2Ck3		233					0.18	0.51	0.19	0.54
3Ck4	233						0.18	0.52		
3Ck4							0.21	0.54		
3Ck4							0.20	0.52		
3Ck4							0.18	0.52		
3Ck4							0.15	0.51		
3Ck4							0.14	0.53		
3Ck4							0.14	0.45		
3Ck4							0.15	0.53		
3Ck4							0.16	0.51		
3Ck4							0.19	0.58		
3Ck4		310					0.15	0.51	0.17	0.52

Table B.30 Soil organic carbon, Transect 4, pedon 30b

Horizon	Upper Depth cm	Lower Depth cm	Soil pH water	Soil pH salt	Average pH water	Average pH salt	% organic C	120 seconds	Average % organic C	Average 120 seconds
A1	0	3								
A2	3	5.5					2.81	3.19	2.81	3.19
Bw1	5.5	10					1.71	2.11	1.71	2.11
Bw2	10						1.18	1.71		
Bw2		20					1.12	1.53	1.15	1.62
2A3	20	23					1.38	1.74	1.38	1.74
2Bw3	23						1.28	1.73		
2Bw3		35					1.15	1.58	1.22	1.66
2Bk1	35						1.11	1.53		
2Bk1		50					1.09	1.53	1.10	1.53
2Ck1	50						0.58	1.18		
2Ck1							0.50	1.05		
2Ck1							0.45	0.93		
2Ck1							0.42	0.91		
2Ck1							0.40	0.87		
2Ck1		92					0.37	0.95	0.45	0.98
2Ck2	92						0.35	0.79		
2Ck2							0.35	0.79		
2Ck2							0.34	0.72		
2Ck2							0.34	0.79		
2Ck2							0.33	0.74		
2Ck2		135					0.36	0.78	0.35	0.77
2Ck3	135						0.50	0.95		
2Ck3							0.68	1.27		
2Ck3							0.41	0.78		
2Ck3							0.35	0.78		
2Ck3		170					0.34	0.77	0.46	0.91
2Ck4	170						0.38	0.80		
2Ck4							0.41	0.87		
2Ck4		185					0.42	0.75	0.40	0.81
3Ak1	185						0.57	0.88		
3Ak1		203					0.55	0.90	0.56	0.89
3Bk2	203						0.28	0.58		
3Bk2							0.24	0.52		
3Bk2		224					0.24	0.52	0.25	0.54
3Ck5	224						0.22	0.52		
3Ck5							0.18	0.50		
3Ck5							0.19	0.57		
3Ck5							0.20	0.57		
3Ck5		259					0.21	0.67	0.20	0.57

Table B.31 Soil organic carbon, Transect 4, pedon 31

Horizon	Upper Depth cm	Lower Depth cm	Soil pH water	Soil pH salt	Average pH water	Average pH salt	% organic C	120 seconds	Average % organic C	Average 120 seconds
Oi/Oe	0	2								
A1	2	5								
A2	5	10.5					1.72	2.14	1.72	2.14
fill 1	10.5						1.10	1.51		
fill 1							1.11	1.51		
fill 1							1.09	1.46		
fill 1		36					1.15	1.54	1.11	1.51
fill 2	36						1.16	1.53		
fill 2							1.13	1.48		
fill 2							1.16	1.46		
fill 2		55					1.23	1.58	1.17	1.51
2Ck1	55						0.82	1.35		
2Ck1							0.70	1.20		
2Ck1							0.64	1.30		
2Ck1							0.52	1.11		
2Ck1							0.43	0.91		
2Ck1							0.37	0.77		
2Ck1							0.36	0.78		
2Ck1							0.34	0.78		
2Ck1							0.63	1.01		
2Ck1		141					0.37	0.74	0.52	1.00
2Ck2	141						0.35	0.73		
2Ck2							0.36	0.80		
2Ck2							0.34	0.76		
2Ck2							0.36	0.77		
2Ck2		178					0.36	0.79	0.35	0.77
2Ck3	178						0.35	0.78		
2Ck3		189					0.28	0.66	0.32	0.72
2Ck4	189						0.31	0.71		
2Ck4							0.39	0.80		
2Ck4		207					0.39	0.79	0.36	0.77
2Ck5	207	212					0.51	0.91	0.51	0.91
3Ak1	212	219					0.89	1.24	0.89	1.24
3Ak2	219	224					0.81	1.14	0.81	1.14
3Bk	224						0.35	0.66		
3Bk							0.33	0.60		
3Bk		243					0.32	0.68	0.33	0.65
3Ck6	243						0.29	0.83		
3Ck6							0.26	0.75		
3Ck6		264					0.28	0.78	0.28	0.79
4Ck7	264	269					0.24	0.68	0.24	0.68

Table B.32 Soil organic carbon, Transect 4, pedon 32

Horizon	Upper Depth cm	Lower Depth cm	Soil pH water	Soil pH salt	Average pH water	Average pH salt	% organic C	120 seconds	Average % organic C	Average 120 seconds
Oi/Oe	0	2								
A1	2	5								
A2	5	10					2.12	2.44	2.12	2.44
fill 1	10	13					1.55	1.91	1.55	1.91
fill 2	13	19					0.88	1.26	0.88	1.26
fill 3	19	26					1.11	1.50	1.11	1.50
fill 4	26						1.42	1.81		
fill 4							1.61	1.99		
fill 4							1.84	2.36		
fill 4							1.35	1.85		
fill 4							1.17	1.51		
fill 4		65					1.23	1.66	1.44	1.86
fill 5	65						1.18	1.59		
fill 5							1.23	1.53		
fill 5		88					1.03	1.53	1.15	1.55
fill 6	88						0.88	1.35		
fill 6							0.77	1.23		
fill 6							0.88	1.33		
fill 6							0.77	1.20		
fill 6							0.75	1.18		
fill 6							0.80	1.18		
fill 6		134					1.30	1.78	0.88	1.32
fill 7	134						1.39	1.74		
fill 7		150					1.40	1.79	1.40	1.77
2Ck1	150						0.70	1.34		
2Ck1							0.30	0.86		
2Ck1		169					0.28	0.76	0.43	0.99
2Ck2	169						0.33	0.81		
2Ck2							0.34	0.78		
2Ck2		199					0.33	0.83	0.33	0.81
2Ck3	199						0.33	0.76		
2Ck3							0.33	0.75		
2Ck3							0.33	0.75		
2Ck3							0.36	0.94		
2Ck3							0.37	0.81		
2Ck3							0.39	0.81		
2Ck3		241					0.44	0.86	0.36	0.81
3Ak1	241						0.57	0.93		
3Ak1		263					0.85	1.18	0.71	1.06
3Ak2	263	277					1.11	1.48	1.11	1.48
3Bk1	277						0.28	0.55		
3Bk1							0.28	0.51		
3Bk1							0.34	0.63		
3Bk1		303					0.28	0.68	0.30	0.59
3Bk2	303						0.27	0.70		
3Bk2							0.24	0.79		
3Bk2		319					0.25	0.75	0.25	0.75
3Ck4	319	327					0.25	0.72	0.25	0.72
3Ck5	327	338					0.29	0.87	0.29	0.87

Table B.33 Soil organic carbon, Transect 4, pedon 33

Horizon	Upper Depth cm	Lower Depth cm	Soil pH water	Soil pH salt	Average pH water	Average pH salt	% organic C	120 seconds	Average % organic C	Average 120 seconds
Oi/Oe	0	2								
A1	2	5								
A2	5	10					2.02	2.31	2.02	2.31
fill 1	10	17					1.31	1.71	1.31	1.71
fill 2	17						1.20	1.57		
fill 2		32					1.21	1.58	1.21	1.58
fill 3	32						1.04	1.49		
fill 3		47					1.01	1.47	1.03	1.48
2Ck1	47						0.59	1.11		
2Ck1							0.50	1.15		
2Ck1							0.44	1.03		
2Ck1							0.42	0.93		
2Ck1		82					0.45	0.95	0.48	1.03
2Ck2	82						0.55	1.04		
2Ck2							0.37	0.82		
2Ck2							0.37	0.90		
2Ck2							0.38	0.86		
2Ck2							0.34	0.89		
2Ck2		117					0.39	0.88	0.40	0.90
2Ck3	117						0.39	0.80		
2Ck3							0.44	0.90		
2Ck3							0.36	0.85		
2Ck3		145					0.35	0.83	0.39	0.85
2Ck4	145						0.38	0.84		
2Ck4							0.38	0.77		
2Ck4							0.42	0.90		
2Ck4							0.43	0.89		
2Ck4							0.44	0.86		
2Ck4							0.42	0.89		
2Ck4							0.45	0.93		
2Ck4		195					0.53	1.03	0.43	0.89
2Ck5	195						0.64	1.14		
2Ck5							0.55	1.03		
2Ck5		213					0.56	1.07	0.58	1.08
3Ak1	213	219					1.01	1.40	1.01	1.40
3Ak2	219						1.31	1.60		
3Ak2		236					1.67	2.01	1.49	1.81
3Bk	236						0.51	0.77		
3Bk							0.30	0.49		
3Bk							0.32	0.49		
3Bk		263					0.36	0.54	0.37	0.57

Table B.34 Soil organic carbon, Transect 4, pedon 34

Horizon	Upper Depth cm	Lower Depth cm	Soil pH water	Soil pH salt	Average pH water	Average pH salt	% organic C	120 seconds	Average % organic C	Average 120 seconds
A1	0	5.5								
A2	5.5						1.82	2.16		
A2		17					1.27	1.69	1.55	1.93
Bw1	17						1.16	1.57		
Bw1		27					1.14	1.64	1.15	1.61
Bw2	27						1.12	1.55		
Bw2		41					0.83	1.30	0.98	1.43
Ck1	41						0.65	1.16		
Ck1		53					0.61	1.11	0.63	1.14
Ck2	53						0.57	1.16		
Ck2							0.55	1.05		
Ck2							0.47	0.99		
Ck2		81					0.43	0.98	0.51	1.05
Ck3	81						0.40	0.95		
Ck3							0.37	0.89		
Ck3							0.35	0.79		
Ck3							0.34	0.86		
Ck3							0.34	0.84		
Ck3							0.32	0.82		
Ck3							0.33	0.81		
Ck3							0.32	0.79		
Ck3							0.33	0.73		
Ck3							0.33	0.76		
Ck3		155					0.35	0.77	0.34	0.82
Ck4	155						0.37	0.79		
Ck4							0.37	0.83		
Ck4							0.39	0.81		
Ck4							0.40	0.87		
Ck4							0.38	0.81		
Ck4							0.40	0.82		
Ck4							0.41	0.84		
Ck4		210					0.35	0.86	0.38	0.83
Ck5	210						0.43	0.91		
Ck5							0.45	0.84		
Ck5							0.51	0.97		
Ck5		249					0.57	1.01	0.49	0.93
2Ak	249						1.04	1.46		
2Ak		264					1.12	1.46	1.08	1.46
2Bk	264	272					0.41	0.66	0.41	0.66

Table B.35 Soil reaction and organic carbon, Transect 4, pedon 35

Horizon	Upper Depth cm	Lower Depth cm	Soil pH water	Soil pH salt	Average pH water	Average pH salt	% organic C	120 seconds	Average % organic C	Average 120 seconds
Oi/Oe	0	3								
A	3	8	7.45	7.12	7.45	7.12				
Bw1	8	16	8.05	7.67	8.05	7.67	1.32	1.89	1.32	1.89
Bw2	16		8.04	7.74			1.16	1.65		
Bw2		28	8.07	7.73	8.06	7.74	1.13	1.57	1.15	1.61
Bk1	28	36	8.08	7.73	8.08	7.73	0.92	1.55	0.92	
Ck1	36		8.12	7.83			0.74	1.28		
Ck1			8.26	7.89			0.52	1.17		
Ck1			8.28	7.89			0.41	0.96		
Ck1			8.40	7.91			0.37	0.85		
Ck1		71	8.38	7.90	8.29	7.88	0.33	0.81	0.55	1.10
Ck2	71		8.41	7.92			0.34	0.79		
Ck2			8.36	7.91			0.36	0.83		
Ck2			8.41	7.92			0.36	0.89		
Ck2			8.40	7.93			0.35	0.82		
Ck2			8.33	7.91			0.34	0.82		
Ck2			8.42	7.94			0.36	0.84		
Ck2			8.48	8.00			0.37	0.84		
Ck2		125	8.49	7.98	8.41	7.94	0.36	0.89	0.36	0.84
2Ak/Ck	125	129	8.47	8.00	8.47	8.00	0.42	0.80	0.42	0.80
2Ak	129	136	8.41	8.00	8.41	8.00	0.66	1.04	0.66	1.04
2Bk2	136		8.43	8.02			0.37	0.72		
2Bk2			8.47	8.04			0.30	0.60		
2Bk2			8.48	8.05			0.28	0.56		
2Bk2			8.51	8.08			0.26	0.70		
2Bk2			8.60	8.08			0.26	0.85		
2Bk2		175	8.58	8.08	8.51	8.06	0.25	0.68	0.29	0.69
2Ck3	175		8.56	8.08			0.25	0.63		
2Ck3			8.66	8.06			0.28	0.65		
2Ck3			8.63	8.08			0.22	0.66		
2Ck3		202	8.59	8.10	8.61	8.08	0.21	0.60	0.24	0.64
3Ck4	202		8.61	8.05			0.25	0.66		
3Ck4			8.63	8.05			0.28	0.73		
3Ck4		227	8.56	8.05	8.60	8.05	0.28	0.72	0.27	0.68
3Ck5	227		8.69	8.06			0.20	0.70		
3Ck5		247	8.69	8.04	8.69	8.05	0.20	0.59	0.20	0.65

Table B.36 Soil reaction and organic carbon, Transect 4, pedon 36

Horizon	Upper Depth cm	Lower Depth cm	Soil pH water	Soil pH salt	Average pH water	Average pH salt	% organic C	120 seconds	Average % organic C	Average 120 seconds
Oi/Oe	0	2.5								
A	2.5	6	7.08	6.92	7.08	6.92				
Bw1	6	12	7.92	7.57	7.92	7.57	1.52	1.86	1.52	1.86
Bw2	12	16	8.13	7.75	8.13	7.75	1.15	1.55	1.15	1.55
Bw3	16		8.15	7.73			1.06	1.48		
Bw3		27	8.27	7.81	8.21	7.77	1.12	1.54	1.09	1.51
Bk1	27		8.38	7.93			0.97	1.41		
Bk1		43	8.42	7.93	8.40	7.93	0.96	1.44	0.97	1.43
Ck1	43		8.49	8.02			0.58	1.12		
Ck1			8.48	8.02			0.52	1.02		
Ck1			8.57	8.01			0.44	0.92		
Ck1			8.62	8.02			0.36	0.78		
Ck1		76	8.56	8.00	8.54	8.01	0.35	0.88	0.45	0.94
Ck2	76		8.66	8.01			0.35	0.76		
Ck2			8.49	8.03			0.34	0.77		
Ck2			8.62	8.04			0.35	0.82		
Ck2			8.56	7.99			0.36	0.80		
Ck2			8.49	8.00			0.36	0.80		
Ck2			8.50	8.07			0.37	0.83		
Ck2		123	8.58	8.11	8.56	8.04	0.37	0.81	0.36	0.80
Ck3	123	131	8.61	8.17	8.61	8.17	0.49	0.89	0.49	0.89
2Ak	131	135	8.62	8.06	8.62	8.06	0.50	0.84	0.50	0.84
2Bk2	135		8.52	8.13			0.30	0.59		
2Bk2			8.57	8.17			0.29	0.56		
2Bk2			8.67	8.21			0.31	0.82		
2Bk2		161	8.71	8.15	8.62	8.17	0.25	0.65	0.29	0.66
2Ck4	161		8.67	8.15						
2Ck4		169	8.69	8.27	8.68	8.21	0.26	0.69	0.26	0.69
3Ck5	169		8.77	8.32			0.25	0.64		
3Ck5			8.85	8.28			0.16	0.43		
3Ck5			8.76	8.24			0.23	0.67		
3Ck5			8.86	8.25			0.22	0.58		
3Ck5			8.83	8.36			0.21	0.61		
3Ck5			8.94	8.29			0.22	0.60		
3Ck5			8.86	8.31			0.36	0.69		
3Ck5		228	8.89	8.27	8.85	8.29	0.27	0.59	0.24	0.60
3C1	228	238	8.83	8.31	8.83	8.31	0.41	0.68	0.41	0.68
3C2	238						0.21	0.75		
3C2							0.19	0.56		
3C2		268					0.17	0.54	0.19	0.62

Table B.37 Soil reaction and organic carbon, Transect 4, pedon 37

Horizon	Upper Depth cm	Lower Depth cm	Soil pH water	Soil pH salt	Average pH water	Average pH salt	% organic C	120 seconds	Average % organic C	Average 120 seconds
A1	0	7	7.27	7.20	7.27	7.20				
A2	7	12	8.02	7.67	8.02	7.67	1.83	2.07	1.83	2.07
A3	12		8.09	7.69			1.46	1.71		
A3		26	8.18	7.76	8.14	7.73	1.41	1.66	1.44	1.69
A4	26	32	8.25	7.79	8.25	7.79	1.31	1.59	1.31	1.59
Bk/Ak	32	40	8.38	7.88	8.38	7.88	1.09	1.41	1.09	1.41
Ak1	40	48	8.36	7.88	8.36	7.88	1.13	1.43	1.13	1.43
Bk1	48		8.40	7.93			1.00	1.42		
Bk1			8.49	7.92			0.97	1.45		
Bk1		66	8.50	7.88	8.46	7.91	0.88	1.42	0.95	1.43
Ck1	66		8.40	7.89			0.79	1.34		
Ck1		81	8.49	7.93	8.45	7.91	0.71	1.37	0.75	1.36
Ck2	81		8.49	8.00			0.60	1.19		
Ck2			8.57	8.02			0.51	1.10		
Ck2			8.63	8.11			0.43	0.92		
Ck2			8.68	8.08			0.39	0.90		
Ck2			8.70	8.10			0.36	0.91		
Ck2			8.67	8.09			0.35	0.83		
Ck2			8.66	8.12			0.35	0.79		
Ck2			8.67	8.09			0.36	0.79		
Ck2		142	8.66	8.08	8.64	8.08	0.35	0.76	0.41	0.91
Ck3	142		8.72	8.12			0.34	0.80		
Ck3			8.60	8.06			0.39	0.83		
Ck3			8.73	8.26			0.39	0.84		
Ck3			8.71	8.15			0.39	0.83		
Ck3		173	8.71	8.18	8.69	8.15	0.50	0.92	0.40	0.84
2Ak2	173	181	8.67	8.17	8.67	8.17	0.88	1.21	0.88	1.21
2Bk2	181		8.72	8.19			0.48	0.79		
2Bk2			8.81	8.23			0.39	0.81		
2Bk2		198	8.77	8.23	8.77	8.22	0.34	0.73	0.40	0.78
2Ck4	198	209	8.85	8.30	8.85	8.30	0.29	0.69	0.29	0.69
3Ck5	209		8.90	8.34			0.24	0.65		
3Ck5		228	8.85	8.26	8.88	8.30	0.24	0.75	0.24	0.70

Table B.38 Soil reaction and organic carbon, Transect 4, pedon 38

Horizon	Upper Depth cm	Lower Depth cm	Soil pH water	Soil pH salt	Average pH water	Average pH salt	% organic C	120 seconds	Average % organic C	Average 120 seconds
A1	0	3	6.29	6.14	6.29	6.14				
A2	3	6.5	7.16	6.93	7.16	6.93				
A3	6.5	9	7.64	7.29	7.64	7.29	2.16	2.57	2.16	2.57
A4	9	13	7.81	7.34	7.81	7.34	2.13	2.51	2.13	2.51
A5	13	21	7.95	7.48	7.95	7.48	1.76	2.09	1.76	2.09
A6	21	27	7.91	7.47	7.91	7.47	1.71	2.02	1.71	2.02
A7	27		8.02	7.59			1.59	1.82		
A7			8.04	7.61			1.58	1.88		
A7			8.13	7.70			1.44	1.60		
A7		52	8.17	7.74	8.09	7.66	1.36	1.57	1.49	1.72
A8	52		8.09	7.77			1.38	1.58		
A8			8.24	7.82			1.29	1.49		
A8		74	8.31	7.82	8.21	7.80	1.21	1.38	1.29	1.48
Bk1	74		8.29	7.84			1.17	1.41		
Bk1		85	8.32	7.85	8.31	7.85	1.08	1.32	1.13	1.37
Bk2	85		8.36	7.88			0.98	1.27		
Bk2		100	8.38	7.91	8.37	7.90	0.86	1.33	0.92	1.30
Bk3	100		8.46	7.97			0.80	1.37		
Bk3			8.55	7.99			0.75	1.34		
Bk3			8.61	8.04			0.70	1.29		
Bk3		128	8.64	8.04	8.57	8.01	0.61	1.10	0.72	1.28
Ck1	128		8.35	8.00			0.50	1.07		
Ck1		142	8.57	7.97	8.46	7.99	0.48	0.97	0.49	1.02
Ck2	142		8.57	7.97			0.39	0.91		
Ck2			8.62	8.03			0.38	0.95		
Ck2			8.61	8.00			0.33	0.88		
Ck2			8.69	8.04			0.32	0.82		
Ck2			8.67	8.02			0.32	0.81		
Ck2			8.69	8.03			0.33	0.77		
Ck2		181	8.70	8.04	8.65	8.02	0.34	0.78	0.34	0.85
Ck3	181		8.58	8.02			0.36	0.91		
Ck3			8.61	8.05			0.35	0.84		
Ck3			8.60	8.03			0.34	0.74		
Ck3			8.65	7.96			0.40	0.81		
Ck3			8.64	8.00			0.40	0.88		
Ck3			8.62	8.03			0.38	0.80		
Ck3			8.41	7.94			0.41	0.88		
Ck3			8.56	7.98			0.46	0.97		
Ck3		239	8.59	7.96	8.58	8.00	0.49	0.96	0.40	0.87
Ck/2Ak	239	244	8.62	7.94	8.62	7.94	0.73	1.19	0.73	1.19
2Ak1	244		8.57	7.98			0.97	1.40		
2Ak1		263	8.52	7.79	8.55	7.89	1.21	1.60	1.09	1.50
2Ak2	263		8.54	7.99			0.95	1.37		
2Ak2		271	8.52	8.00	8.53	8.00	0.66	1.10	0.81	1.24
2Bk4	271	277	8.56	8.04	8.56	8.04	0.48	0.93	0.48	0.93
2Bk5	277		8.61	8.03			0.36	0.83		
2Bk5			8.64	8.13			0.31	0.76		
2Bk5		297	8.70	8.07	8.65	8.08	0.28	0.71	0.32	0.77
2Ck4	297		8.71	8.13			0.23	0.83		
2Ck4			8.67	8.07			0.20	0.62		
2Ck4			8.73	8.11			0.19	0.57		
2Ck4		318	8.71	8.14	8.71	8.11	0.18	0.54	0.20	0.64

Table B.39 Soil reaction and organic carbon, Transect 4, pedon 39

Horizon	Upper Depth cm	Lower Depth cm	Soil pH water	Soil pH salt	Average pH water	Average pH salt	% organic C	120 seconds	Average % organic C	Average 120 seconds
A1	0	2	6.48	5.49	6.48	5.49				
A2	2	5	7.01	6.79	7.01	6.79				
fill 1	5		7.47	7.15			1.53	1.86		
fill 1		14	7.77	7.38	7.62	7.27	1.46	1.82	1.50	1.84
fill 2	14		8.07	7.52			1.36	1.67		
fill 2							1.32	1.64		
fill 2							1.28	1.58		
fill 2		41					1.33	1.65	1.32	1.64
fill 3	41						1.44	1.82		
fill 3							1.29	1.61		
fill 3			8.40	7.83			1.26	1.55		
fill 3		72	8.39	7.84	8.40	7.84	1.34	1.57	1.33	1.64
2Ak1	72		8.33	7.81			1.56	1.68		
2Ak1			8.28	7.79			1.57	1.68		
2Ak1			8.22	7.80			1.49	1.62		
2Ak1		98	8.28	7.79	8.28	7.80	1.42	1.58	1.51	1.64
2Ak2	98		8.22	7.80			1.24	1.41		
2Ak2		113	8.20	7.77	8.21	7.79	1.25	1.40	1.25	1.41
2Bw1	113		8.14	7.83			1.16	1.31		
2Bw1			8.13	7.80			1.06	1.27		
2Bw1		136	8.11	7.78	8.13	7.80	1.01	1.30	1.08	1.29
2Bk1	136	143	8.12	7.82	8.12	7.82	0.81	1.28	0.81	1.28
2Ck1	143		8.14	7.79			0.72	1.19		
2Ck1			8.05	7.74			0.66	1.14		
2Ck1			8.15	7.85			0.62	1.15		
2Ck1			8.20	7.72			0.57	1.11		
2Ck1			8.27	7.70			0.50	1.07		
2Ck1			8.25	7.70			0.44	1.01		
2Ck1			8.23	7.70			0.43	0.98		
2Ck1			8.26	7.75			0.43	0.96		
2Ck1			8.28	7.74			0.45	0.95		
2Ck1			8.29	7.78			0.40	0.94		
2Ck1			8.31	7.79			0.41	1.08		
2Ck1			8.39	7.77			0.42	0.91		
2Ck1			8.35	7.79			0.43	0.97		
2Ck1			8.34	7.80			0.43	0.96		
2Ck1			8.38	7.78			0.42	0.96		
2Ck1			8.43	7.78			0.43	0.95		
2Ck1		266	8.40	7.80	8.28	7.76	0.45	0.90	0.48	1.01
2Ck2	266		8.48	7.82			0.47	0.91		
2Ck2			8.48	7.84			0.48	0.95		
2Ck2			8.57	7.69			0.49	0.97		
2Ck2			8.54	7.76			0.48	0.92		
2Ck2		300	8.54	7.78	8.52	7.78	0.50	0.95	0.48	0.94
2Ck3	300		8.51	7.75			0.59	1.23		
2Ck3			8.56	7.81			0.59	1.13		
2Ck3		318	8.56	7.81	8.54	7.79	0.66	1.15	0.61	1.17
3Ak3	318	322	8.48	7.82	8.48	7.82	0.99	1.45	0.99	1.45
3Ak4	322	330	8.47	7.85	8.47	7.85	1.36	1.82	1.36	1.82
3Bk2	330	339	8.39	7.79	8.39	7.79	0.91	1.31	0.91	1.31
3Bk3	339		8.41	7.81			0.61	1.00		
3Bk3		352	8.44	7.79	8.43	7.80	0.46	0.89	0.54	0.95
3Bk4	352		8.46	7.80			0.33	0.80		
3Bk4			8.48	7.83			0.25	0.66		
3Bk4			8.47	7.85			0.25	0.65		
3Bk4		380	8.41	7.80	8.46	7.82	0.25	0.67	0.27	0.70
3C1	380		8.43	7.78			0.22	0.61		
3C1		392	8.42	7.79	8.43	7.79	0.22	0.51	0.22	0.56
4C2	392	402	8.37	7.79	8.37	7.79	0.27	0.83	0.27	0.83

APPENDIX C

HORIZON	DEPTH CM		% OF TOTAL			% SILT		% SAND						TEXTURE
			CLAY	SILT	SAND	FINE	COARSE	VERY FINE	FINE	MEDIUM	COARSE	V. COARSE	> V. FINE	
A	0	3	12.8	64.8	22.4	13.3	51.5	20.2	1.3	0.2	0.3	0.4	2.2	SIL
Bw1	3	12	9.7	64.1	26.2	11.2	52.7	24.7	1.1	0.1	0.1	0.2	1.5	SIL
Bk1	12	22	11.8	57	31.2	12.9	44.1	27.1	2.9	0.5	0.4	0.3	4.1	SIL
Bk2	22	27	15.8	57.8	26.4	15.4	42.4	22.6	3	0.3	0.2	0.3	3.8	SIL
Bk3	32	39	13.8	62.9	23.3	18.3	44.6	20.9	1.8	0.2	0.2	0.1	2.3	SIL
Bk4	47	58	14.1	62.1	23.8	19.7	42.4	20.6	2.5	0.4	0.2	0.1	3.2	SIL
Bk5	65	72	14.4	60.9	24.7	18.7	42.2	20.8	3.2	0.4	0.2	0.1	3.9	SIL
BCk	79	86	15.5	61.7	22.8	15.9	45.8	19.8	2.5	0.2	0.2	0.1	3	SIL
Ck1	86	96	14.6	63	22.4	15.7	47.3	20.3	1.8	0.2	0.1	0	2.1	SIL
Ck1	118	124	12.3	63	24.7	16.7	46.3	22.9	1.6	0.1	0.1	0	1.8	SIL
Ck2	133	137	11.9	68.8	19.3	16.4	52.4	17.7	1.4	0.1	0.1	0	1.6	SIL
Ck2	137	142	12	67.7	20.3	17.5	50.2	18.3	1.8	0.2	0	0	2	SIL
2Ak1	147	152	14.2	60.9	24.9	18.4	42.5	19.5	4.6	0.7	0.1	0	5.4	SIL
2Ak2	157	162	13.9	64.1	22	21.2	42.9	18.5	3.1	0.3	0.1	0	3.5	SIL
2Ak/Bk	162	169	16.5	64.8	18.7	23.6	41.2	16.4	2	0.2	0.1	0	2.3	SIL
2Bk6	169	179	16.3	47.3	36.4	13.7	33.6	32.1	4	0.2	0.1	0	4.3	L
2Bk7	179	188	11.2	39	49.8	8.4	30.6	38.4	9.8	1.4	0.2	0	11.4	L
3Bk8	188	198	9.6	34.3	56.1	7.6	26.7	40.1	14.4	1.3	0.3	0	16	VFSL
3Bk9	204	210	9.4	36.3	54.3	9.4	26.9	45.2	8.4	0.6	0.1	0	9.1	VFSL
3Bk10	215	222	10.1	30	59.9	7.4	22.6	39.6	17.6	2.3	0.4	0	20.3	VFSL
3BCk	230	237	9.8	24.6	65.6	6.5	18.1	33.8	26.9	4.3	0.6	0	31.8	VFSL
4C	258	262	3.2	11.4	85.4	3.6	7.8	17.3	53.5	13	1.6	0	68.1	LFS
4Bk/Ck	276	282	8.2	27.8	64	8.5	19.3	38.4	20.3	4.7	0.6	0	25.6	VFSL
4Bk'1	282	298	9.4	37.2	53.4	11.1	26.2	36.7	15.1	1.3	0.2	0.1	16.7	VFSL
4Bk'2	298	310	10.9	40.7	48.4	11.9	28.8	34	12.6	1.6	0.2	0	14.4	L
5A	322	325	8.4	29.4	62.2	9.1	20.3	20.2	19.9	17	5	0.1	42	FSL
5Bk13	328	331	8.7	29.8	61.5	9.6	20.2	30.2	21.6	8.4	1.3	0	31.3	VFSL
5C1	331	333	2.3	5.2	92.5	2	3.2	6	46.7	35.4	4.4	0	86.7	S
6Bw2	339	345	6.5	17.7	75.8	3.9	13.8	43.6	30.2	1.9	0.1	0	32.2	VFSL
6Bw3	345	346	44	35.6	20.5	21.8	13.8	14.6	5.4	0.4	0.1	0	5.9	C
6C2	346	368	6.7	17.6	75.7	4.5	13.1	40.4	30.1	4.5	0.4	0.3	35.3	VFSL

Figure C.1 Particle Size Distribution (pipette method) for Transect 1, pedon 1

HORIZON	**DEPTH CM**		**% OF TOTAL**			**% SILT**		**% SAND**						**TEXTURE**
			CLAY	SILT	SAND	FINE	COARSE	VERY FINE	FINE	MEDIUM	COARSE	V. COARSE	> V. FINE	
A	2	7	11.6	59.6	28.8	15.5	44.1	22.5	3	0.8	1	1.5	6.3	SIL
E	7	16	10.6	59.6	29.8	13.1	46.5	26.7	1.9	0.2	0.3	0.7	3.1	SIL
Bk1	20	27	11.6	59.1	29.3	15.6	43.5	25.4	2.2	0.3	0.3	1.1	3.9	SIL
Bk2	34	42	12.2	63	24.8	18.8	44.2	21.5	2.3	0.3	0.3	0.4	3.3	SIL
Bk3	42	49	12.4	64.9	22.7	19.6	45.3	19.5	2.2	0.5	0.3	0.2	3.2	SIL
Bk3	56	66	12.5	66.2	21.3	19.3	46.9	19.5	1.3	0.2	0.2	0.1	1.8	SIL
Bk4	66	73	13.3	67.6	19.1	20.2	47.4	17.3	1.4	0.2	0.1	0.1	1.8	SIL
Bk5	73	80	14.1	67.4	18.5	21.9	45.5	17	1.2	0.2	0.1	0	1.5	SIL
Bk5	88	95	14.5	65.4	20.1	20.2	45.2	18.2	1.6	0.2	0.1	0	1.9	SIL
Ck1	95	101	14.3	66.1	19.6	20	46.1	17.7	1.6	0.2	0.1	0	1.9	SIL
Ck1	121	128	11.8	68	20.2	16.9	51.1	18.7	1.3	0.1	0.1	0	1.5	SIL
Ck1	151	158	10.6	68.3	21.1	15.7	52.6	20	1	0.1	0	0	1.1	SIL
Ck1	171	178	10.9	67.4	21.7	17.6	49.8	19.9	1.6	0.2	0	0	1.7	SIL
Ck2	185	192	11.6	61.2	27.2	14.9	46.3	23.9	2.8	0.4	0.1	0	3.3	SIL
Ck2	208	218	11.3	54.3	34.4	15.2	39.1	30.9	2.4	0.4	0.5	0.2	3.5	SIL
Ck2	228	238	11.6	58.8	29.7	15	43.7	26.8	2.2	0.4	0.2	0.1	2.9	SIL
2A2	270	278	17.7	62.1	20.2	24.2	37.9	15.7	3.2	1	0.3	0	4.5	SIL
2Bk6	278	283	17.9	54.2	27.9	19.8	34.4	21	5	1.6	0.3	0	6.9	SIL
2Bk7	288	294	14.3	40.7	45	10.2	30.5	31.7	10.3	2.6	0.4	0	13.3	L
2Bk7	301	308	12.8	37.5	49.8	10.1	27.4	34.5	12.6	2.6	0.3	0.2	15.3	L
2Bk8	314	320	11.8	32.4	55.7	7.9	24.5	37.1	15.8	2.4	0.3	0	18.5	VFSL
3Ck3	333	343	9.3	23.9	66.8	6.5	17.3	26.6	19.7	16.5	3.9	0.1	40.2	FSL
3Ck3	351	361	8.2	17.8	74	5.4	12.4	31	32.3	9.4	1.2	0	42.9	FSL

Figure C.2 Particle Size Distribution (pipette method) for Transect 1, pedon 6

HORIZON	DEPTH CM		% OF TOTAL			% SILT		% SAND						TEXTURE
			CLAY	SILT	SAND	FINE	COARSE	VERY FINE	FINE	MEDIUM	COARSE	V. COARSE	> V. FINE	
A1	0	3	10.9	64.2	24.9	17.2	47	20.8	2.2	0.5	0.8	0.6	4.1	SIL
Bw1	3	9	10	63.3	26.7	13.6	49.7	25	1.2	0.1	0.2	0.2	1.7	SIL
Bw1	9	13	12.1	60.9	27	13.4	47.5	25.1	1.5	0.1	0.1	0.2	1.9	SIL
2A3	18	24	13.3	42.2	44.5	12.4	29.8	40	3.6	0.1	0.2	0.6	4.5	L
2A4	24	30	14	52.8	33.2	14.9	37.9	29.4	2.9	0.3	0.2	0.4	3.8	SIL
3Bk1	36	41	14.8	65.4	19.8	19.6	45.8	17.1	1.9	0.2	0.2	0.4	2.7	SIL
3Bk1	41	46	14.8	65.3	19.9	19.4	45.9	17.7	1.5	0.2	0.2	0.3	2.2	SIL
4A5	46	51	14.2	65.3	20.5	19.9	45.4	18.4	1.4	0.2	0.2	0.3	2.1	SIL
4Bk2	51	55	15.1	66.7	18.2	20.1	46.6	16.4	1.3	0.1	0.2	0.2	1.8	SIL
4BkCk	60	68	15.1	68.5	16.4	21	47.5	14.8	1.2	0.2	0.1	0.1	1.6	SIL
4Ck1	68	74	14.9	69	16.1	21.4	47.6	14.6	1.1	0.2	0.1	0	1.4	SIL
4Ck2	79	86	16.1	67.2	16.7	22.3	44.9	15	1.2	0.2	0.2	0.1	1.7	SIL
4Ck2	93	100	17.4	65.5	17.1	22.3	43.2	15.3	1.4	0.2	0.1	0.1	1.8	SIL
4Ck2	107	114	16.5	66	17.5	19.4	46.6	15.8	1.4	0.1	0.1	0.1	1.7	SIL
4Ck2	121	127	13.9	68.5	17.6	17.9	50.6	16.5	0.9	0.1	0.1	0	1.1	SIL
4Ck2	133	142	11.7	68.4	19.9	17.2	51.2	18.8	0.8	0.1	0.1	0.1	1.1	SIL
5A6	142	145	12.3	67.3	20.4	16.4	50.9	19.3	0.9	0.1	0.1	0.1	1.2	SIL
5Bk3	145	152	12.9	68	19.1	15.5	52.5	18	0.9	0.1	0.1	0	1.1	SIL
5Bk3	159	165	14.1	61.6	24.3	14.5	47.1	21.4	2.6	0.3	0	0	2.9	SIL
5Bk3	170	177	13.2	62.9	23.9	14.7	48.2	22.3	1.4	0.1	0.1	0	1.6	SIL
5Bk3	177	185	12.8	62.8	24.4	15.5	47.3	22.9	1.4	0.1	0	0	1.5	SIL
5Bk4	185	192	13.1	62..2	24.7	14.5	47.7	23.2	1.3	0.1	0.1	0	1.5	SIL
5Bk4	199	206	13.6	66.5	19.9	16.2	50.3	18.2	1.6	0.1	0	0	1.7	SIL
5Bk4	206	210	12.8	66.8	20.4	17.2	49.6	18.4	1.7	0.2	0.1	0	2	SIL
5C	210	223	12.8	66.6	20.6	18.3	48.3	18.4	1.9	0.2	0.1	0	2.2	SIL
6A7	223	230	15.3	62.9	21.8	18.1	44.8	19.1	2.3	0.3	0.1	0	2.7	SIL
6A8	230	239	16.7	60.7	22.6	20.1	40.6	18.7	3.4	0.4	0.1	0	3.9	SIL
6A9	239	253	17.9	60.1	22	21.2	38.9	19.5	2.1	0.3	0.1	0	2.5	SIL
6Bk5	253	273	17.6	55.8	26.6	16	39.8	24.9	1.6	0.1	0	0	1.7	SIL
6Ck3	273	281	12.3	48.4	39.3	10.9	37.5	36.4	2.6	0.2	0.1	0	2.9	L
6Ck3	281	289	12.3	42.6	45.1	9.1	33.5	38.4	5.7	0.9	0.1	0	6.7	L
7Ck4	289	296	11.7	33.9	54.4	8.5	25.4	38.3	12.6	3.2	0.3	0	16.1	VFSL
7Ck4	303	317	9.9	27.4	62.7	7.2	20.2	33.9	22.5	5.7	0.6	0	28.8	VFSL

Figure C.3 Particle Size Distribution (pipette method) for Transect 1, pedon 12

APPENDIX D

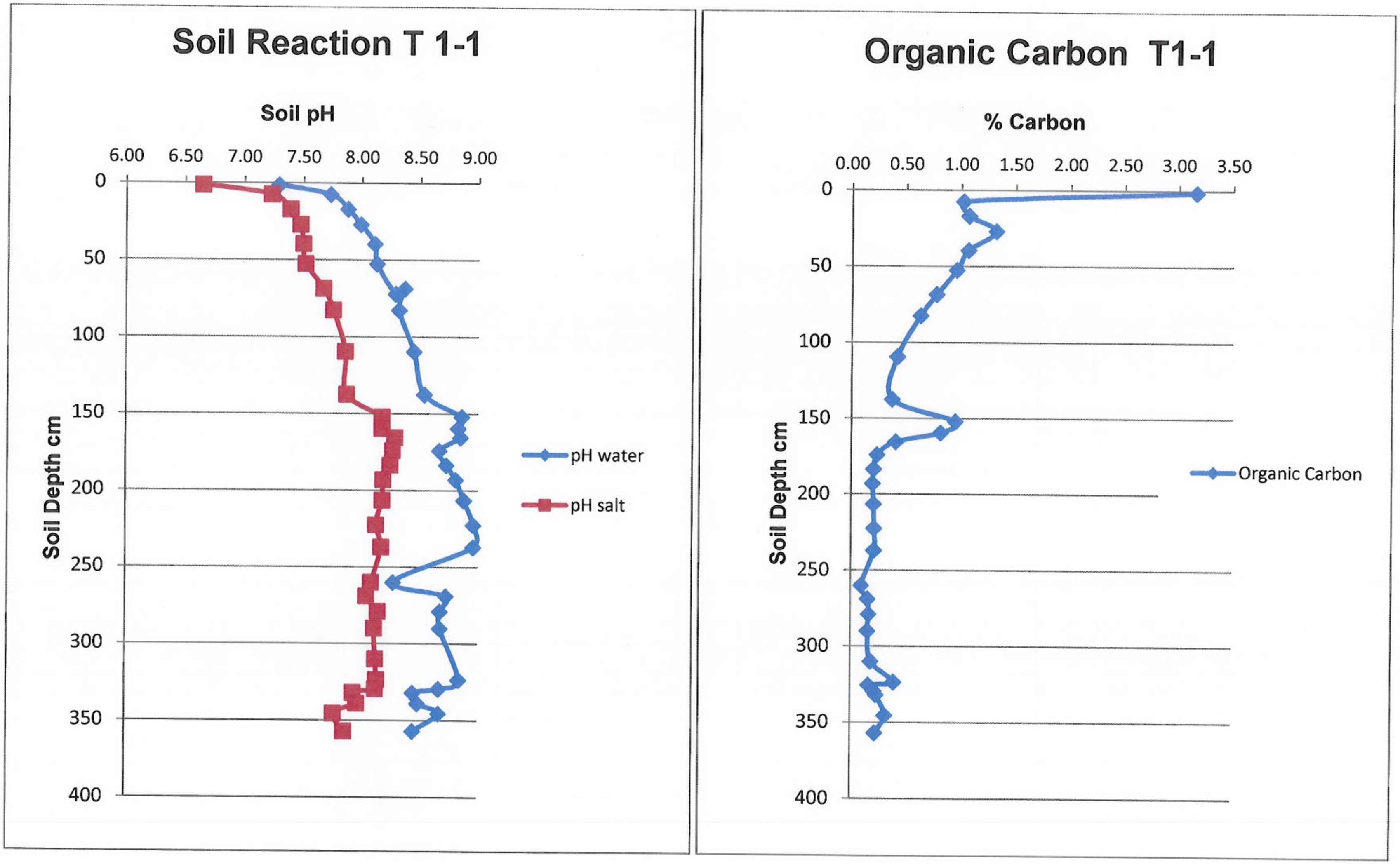


Figure D.1 Depth distribution diagram of soil reaction and organic carbon for Transect 1, pedon 1

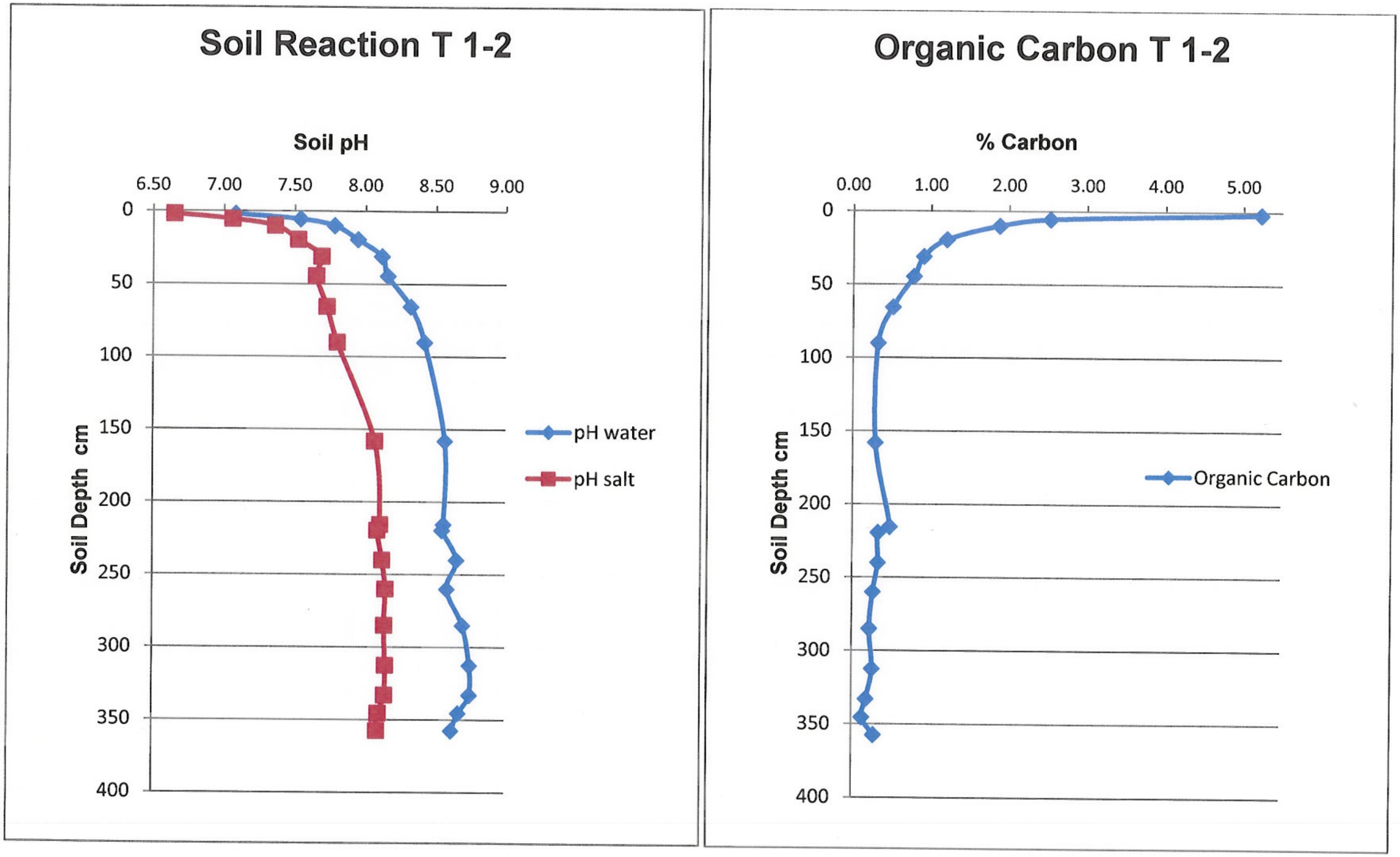


Figure D.2 Depth distribution diagrams of soil reaction and organic carbon for Transect 1, pedon 2

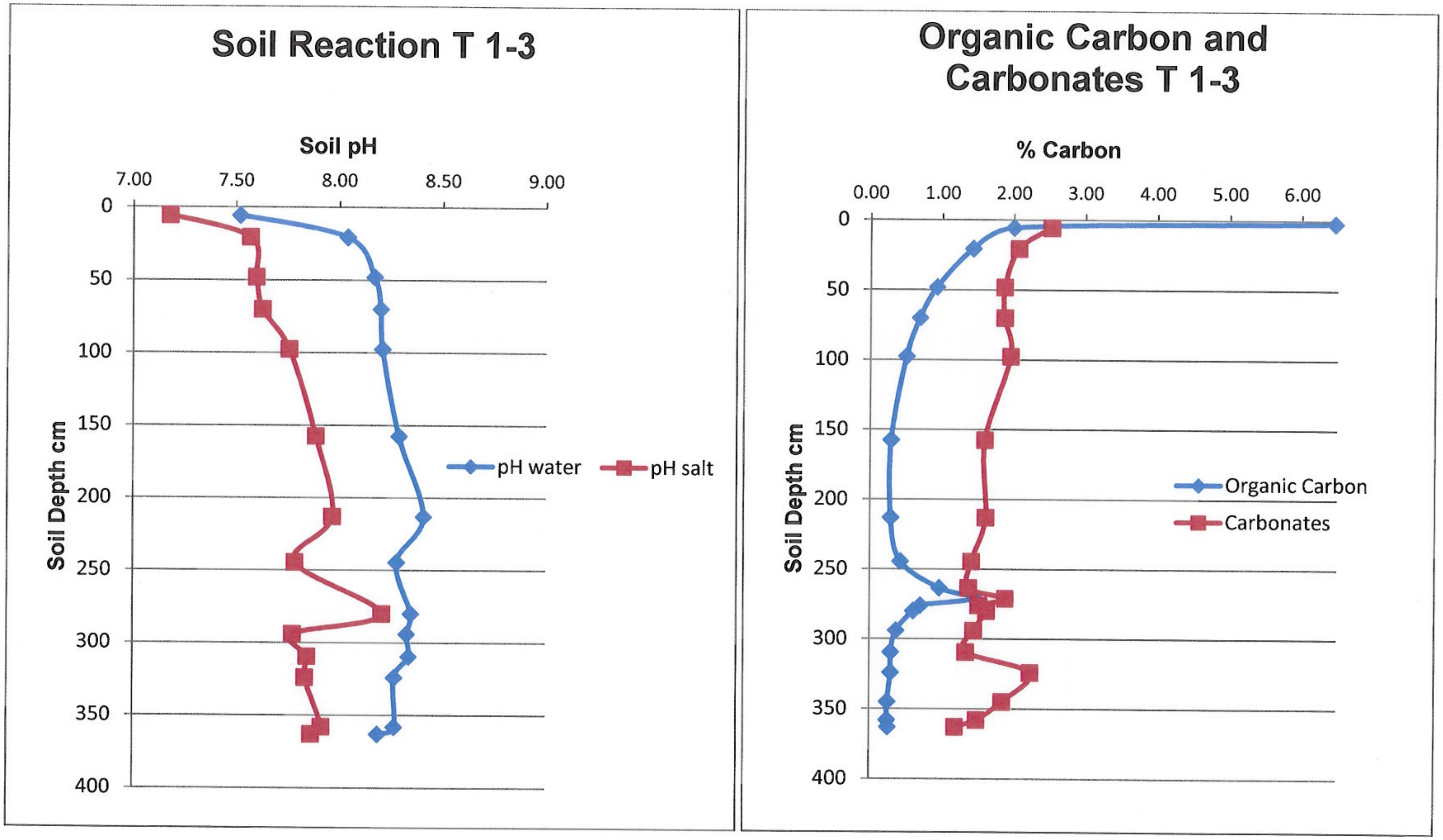
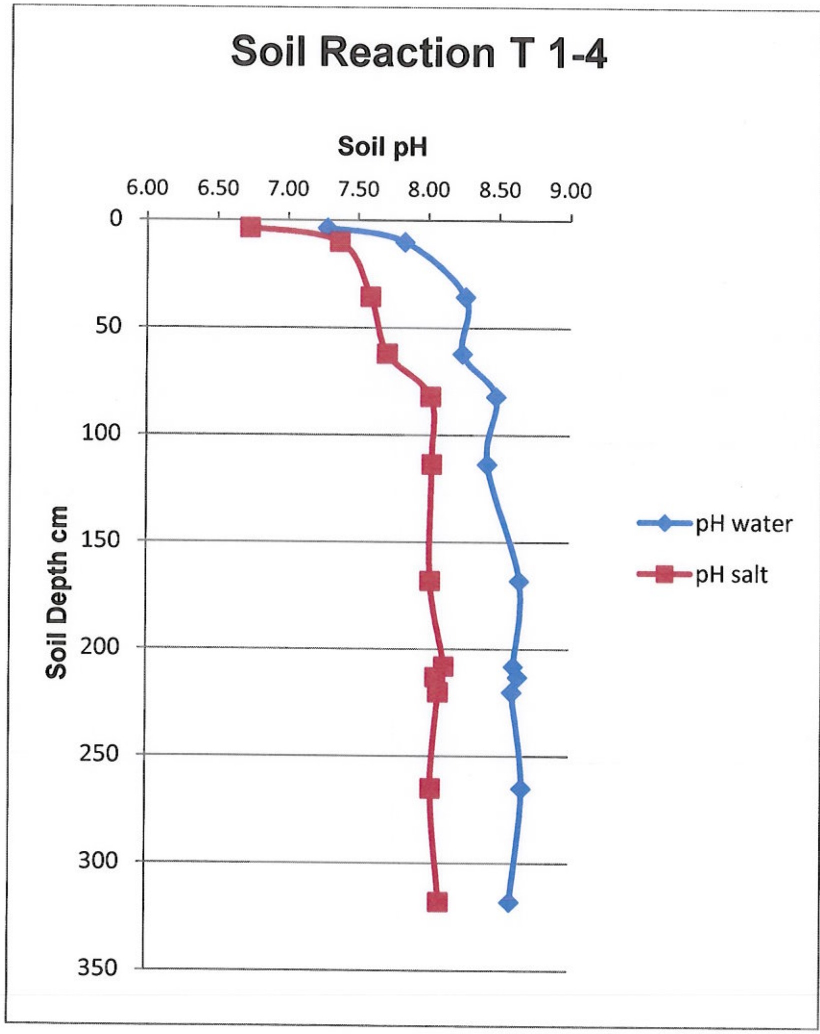


Figure D.3 Depth distribution diagrams of soil reaction, organic carbon and carbonates for Transect 1, pedon 3



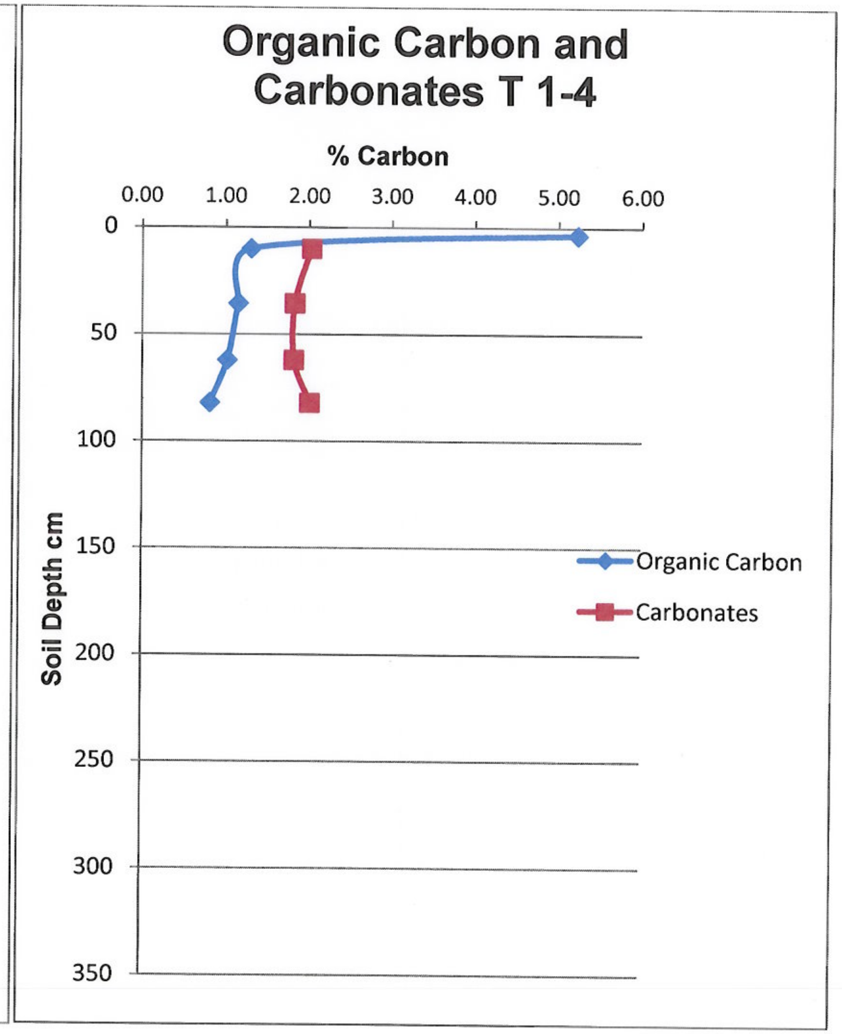


Figure D.4 Depth distribution diagram of soil reaction, organic carbon and carbonates for Transect 1, pedon 4

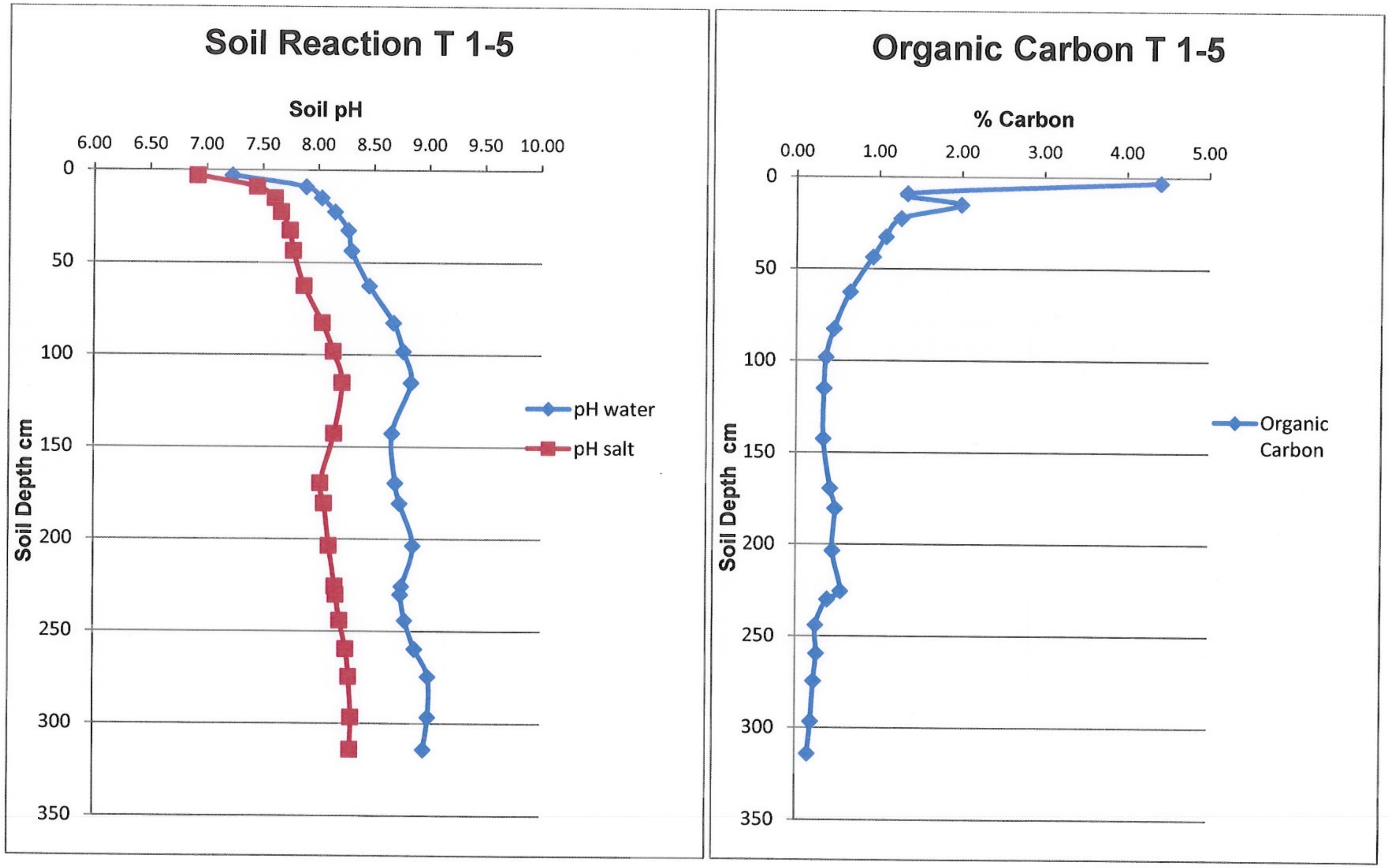


Figure D.5 Depth distribution diagrams of soil reaction and organic carbon for Transect 1, pedon 5

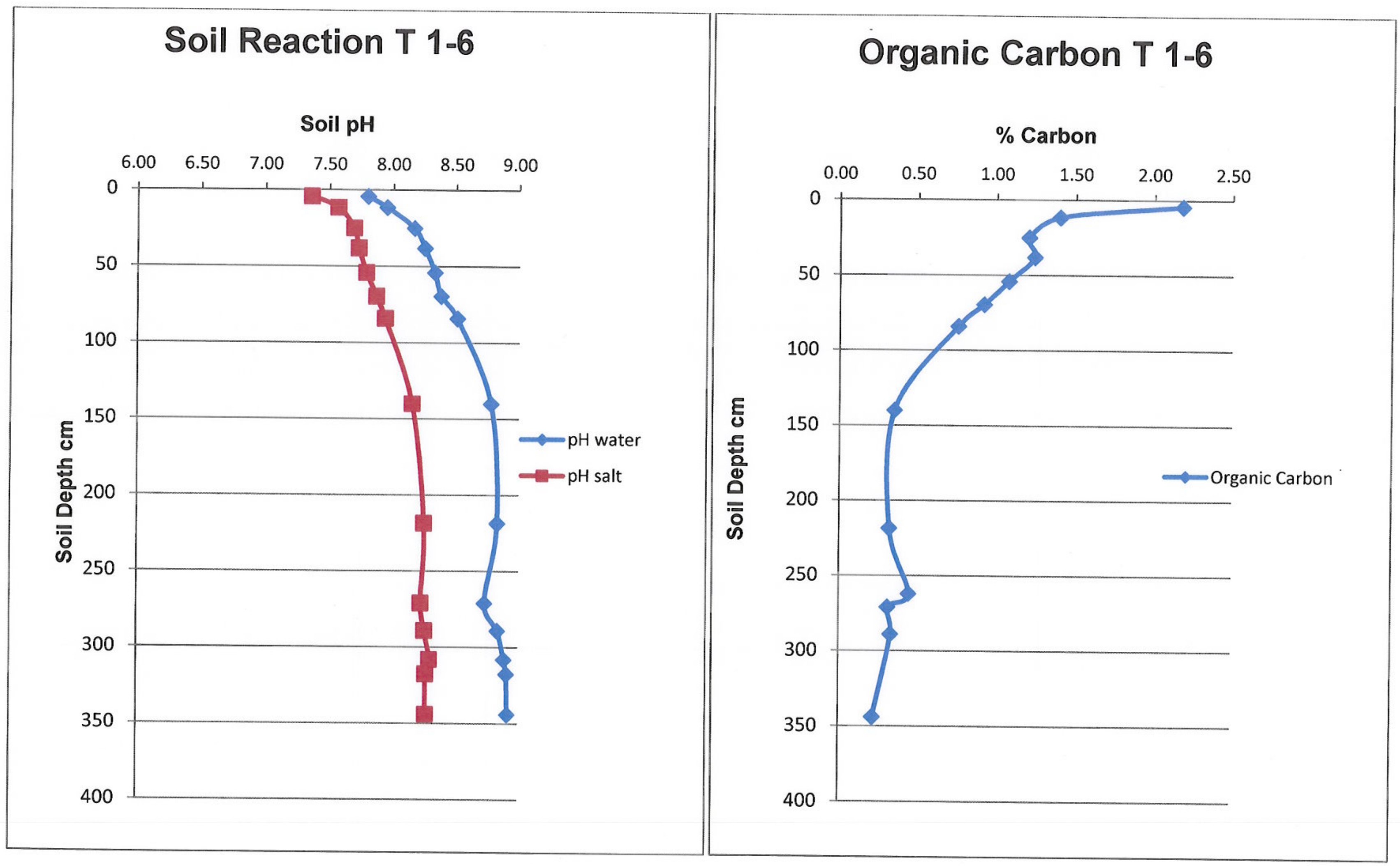
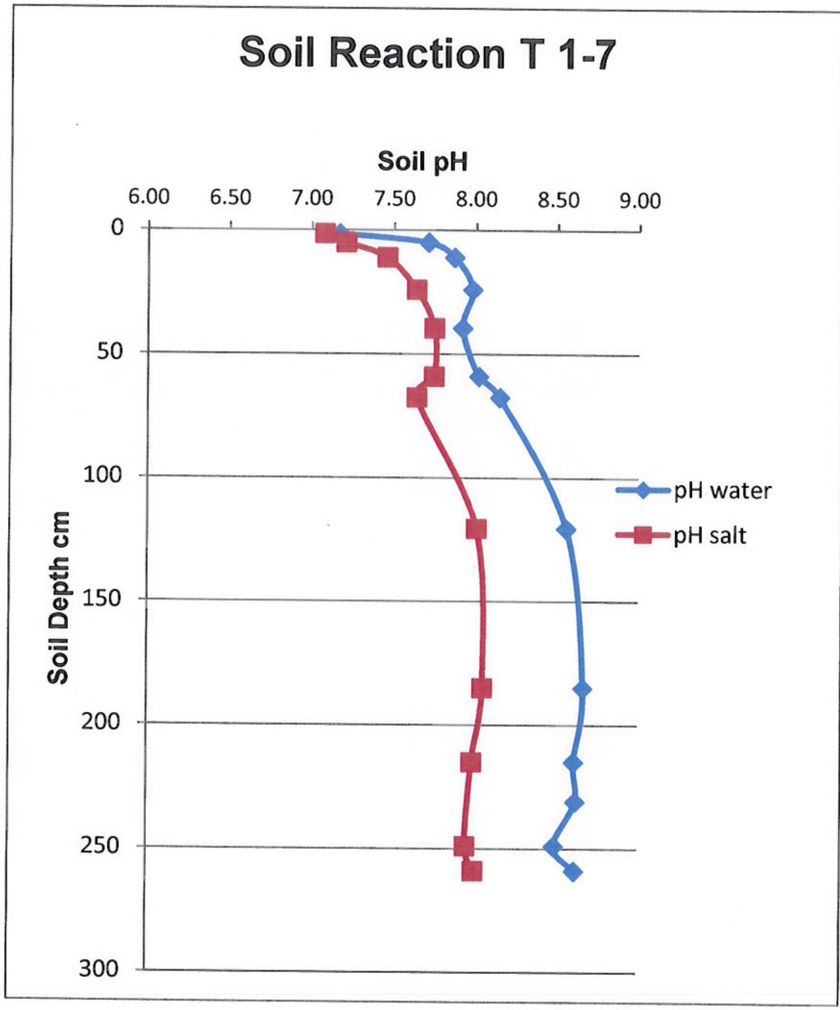


Figure D.6 Depth distribution diagrams of soil reaction and organic carbon for Transect 1, pedon 6



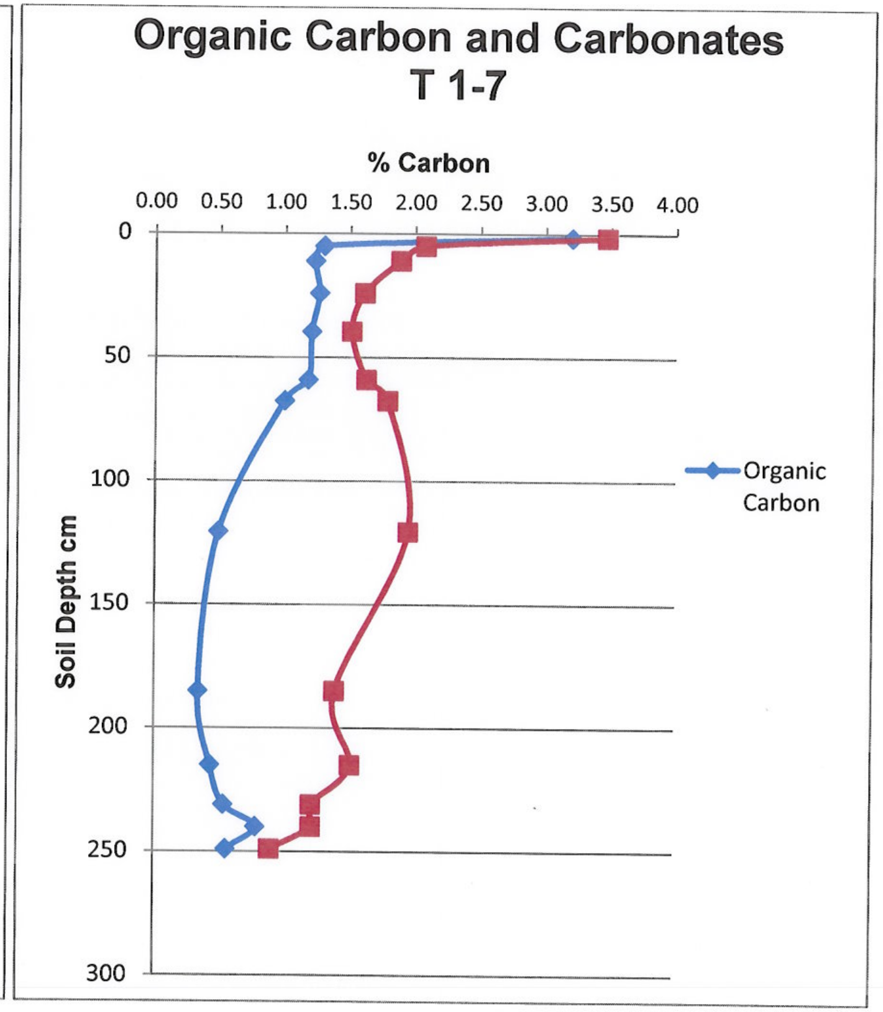


Figure D.7 Depth distribution diagrams of soil reaction, organic carbon and carbonates for Transect 1, pedon 7

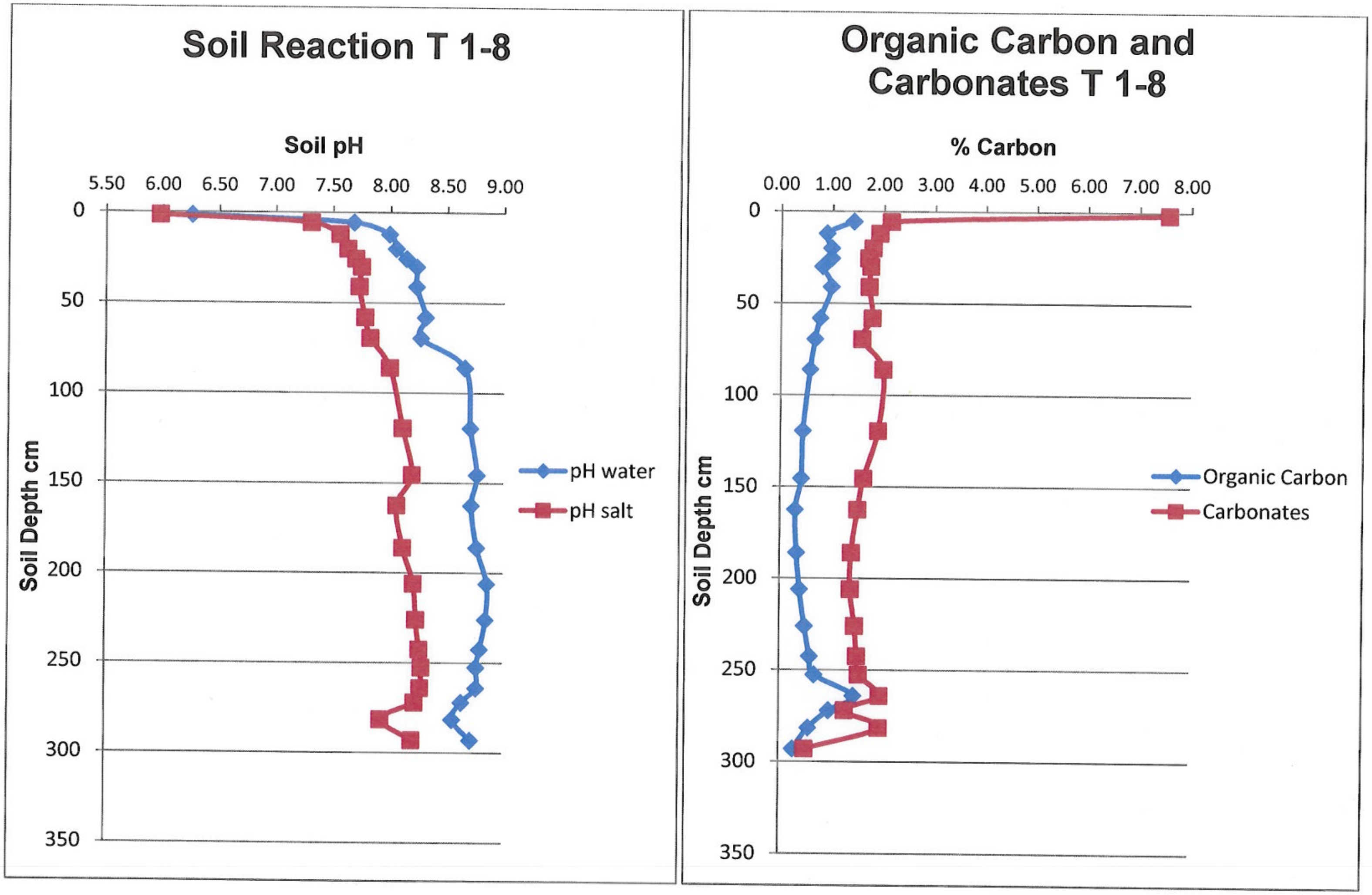


Figure D.8 Depth distribution diagram of soil reaction, organic carbon and carbonates for Transect 1, pedon 8

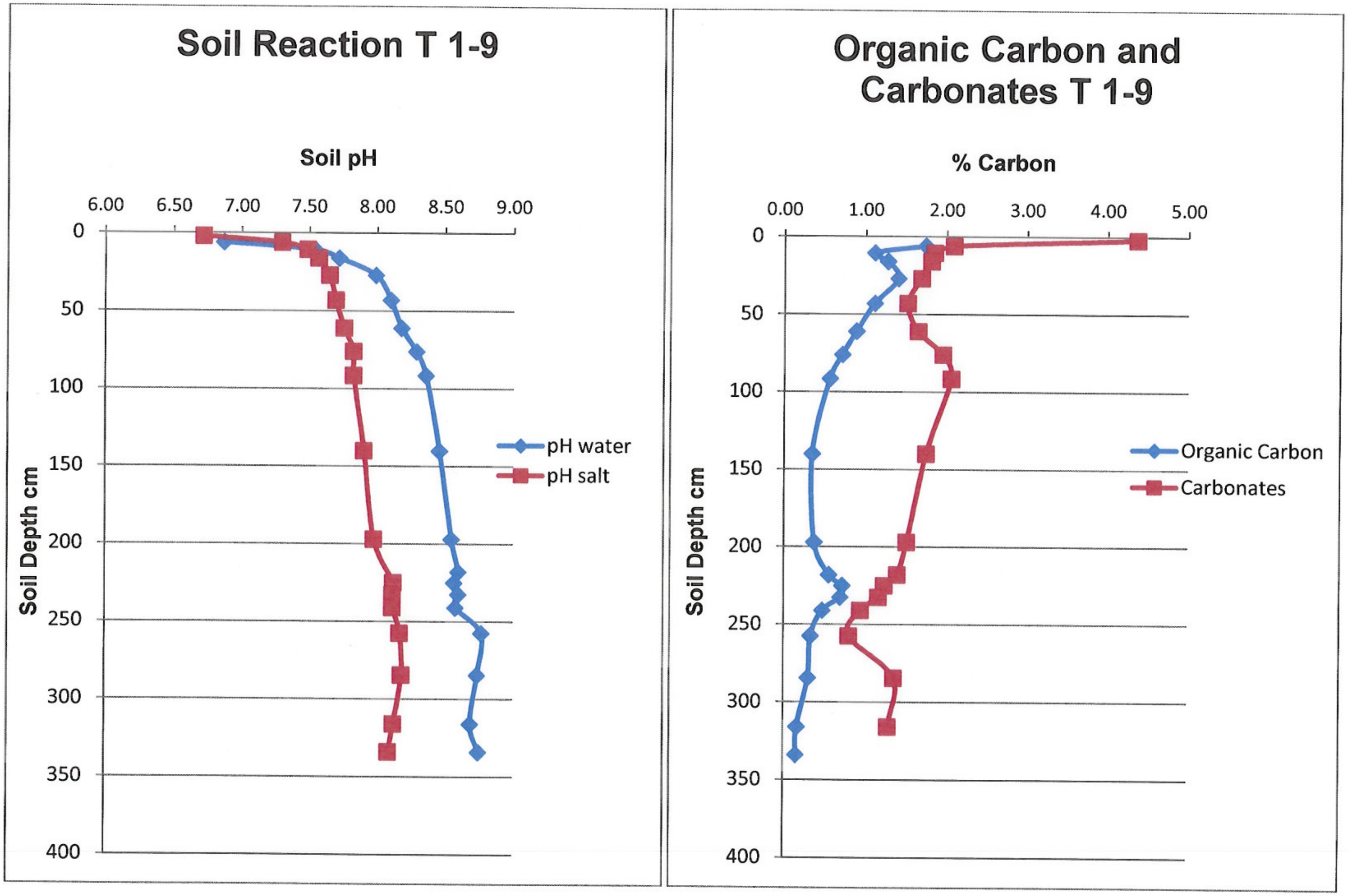


Figure D.9 Depth distribution diagram of soil reaction, organic carbon and carbonates for Transect 1, pedon 9

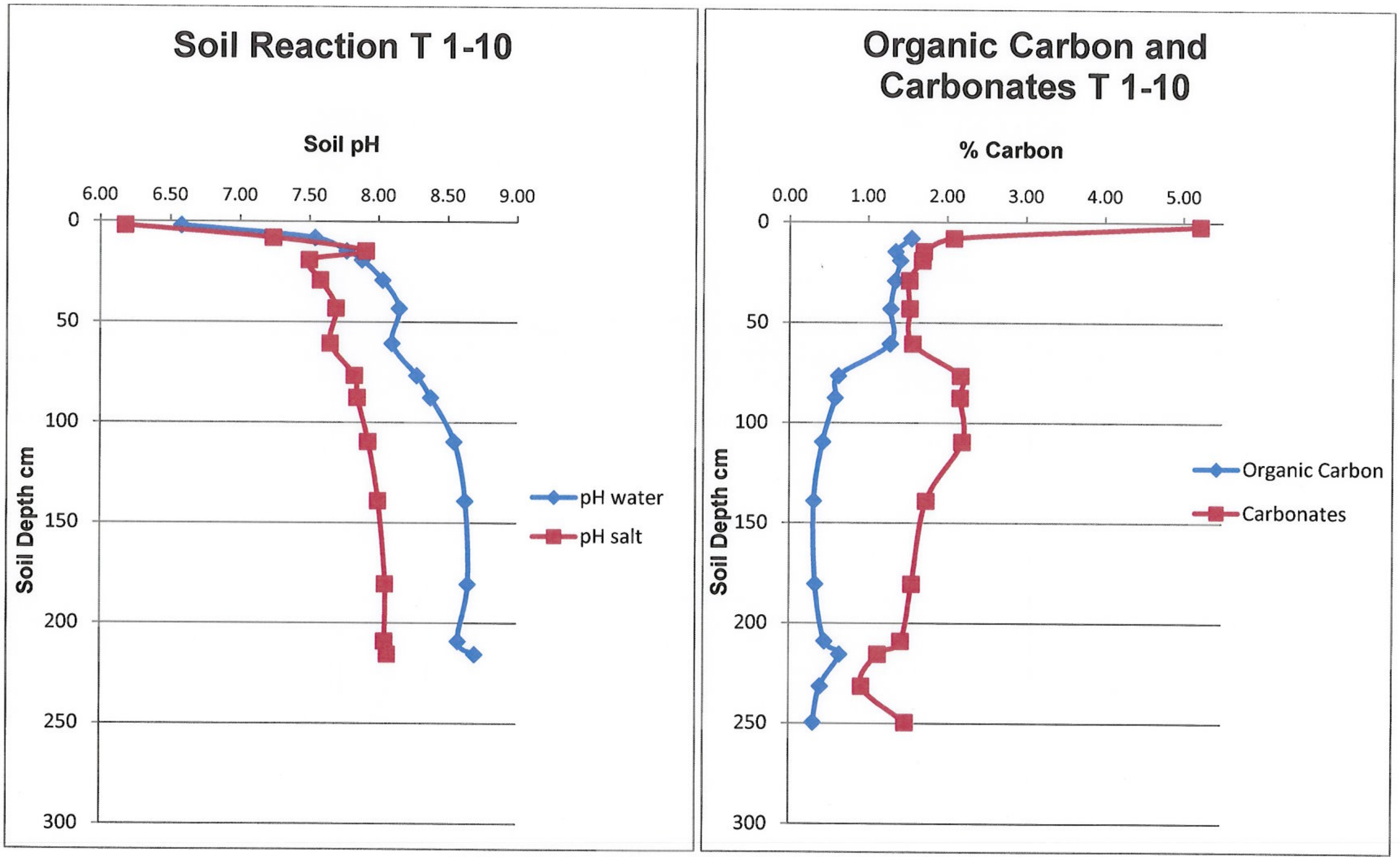
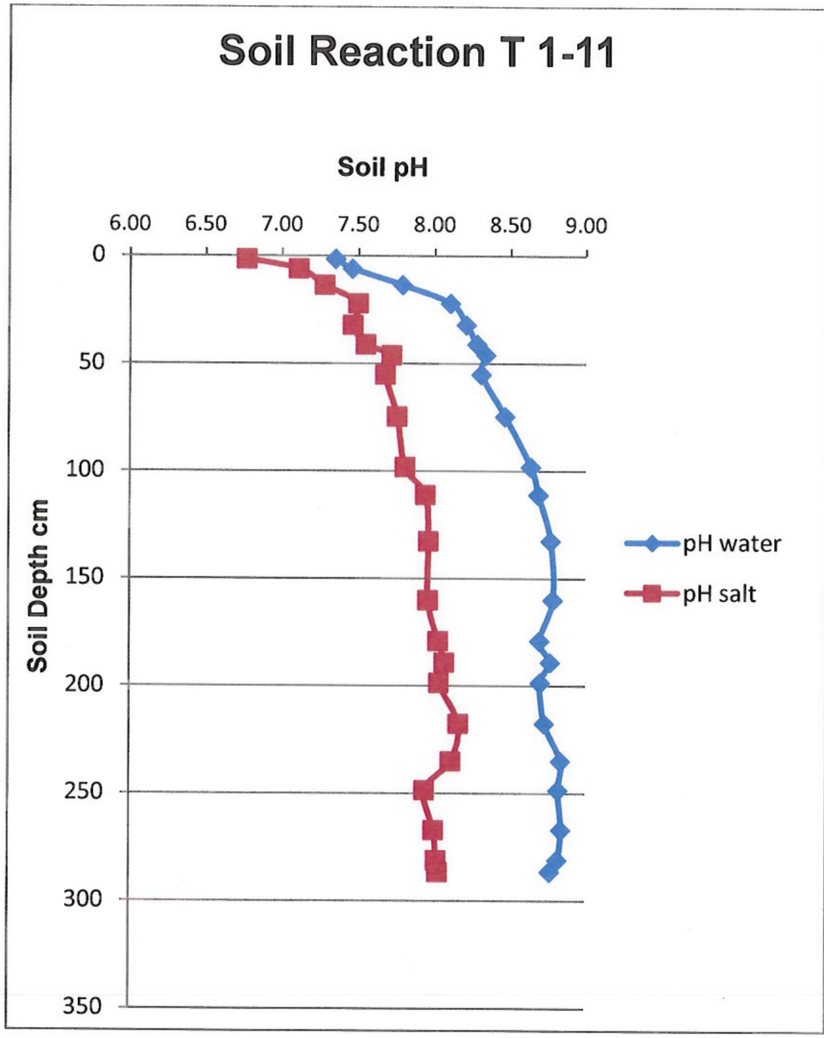


Figure D.10 Depth distribution diagram of soil reaction, organic carbon and carbonates for Transect 1, pedon 10



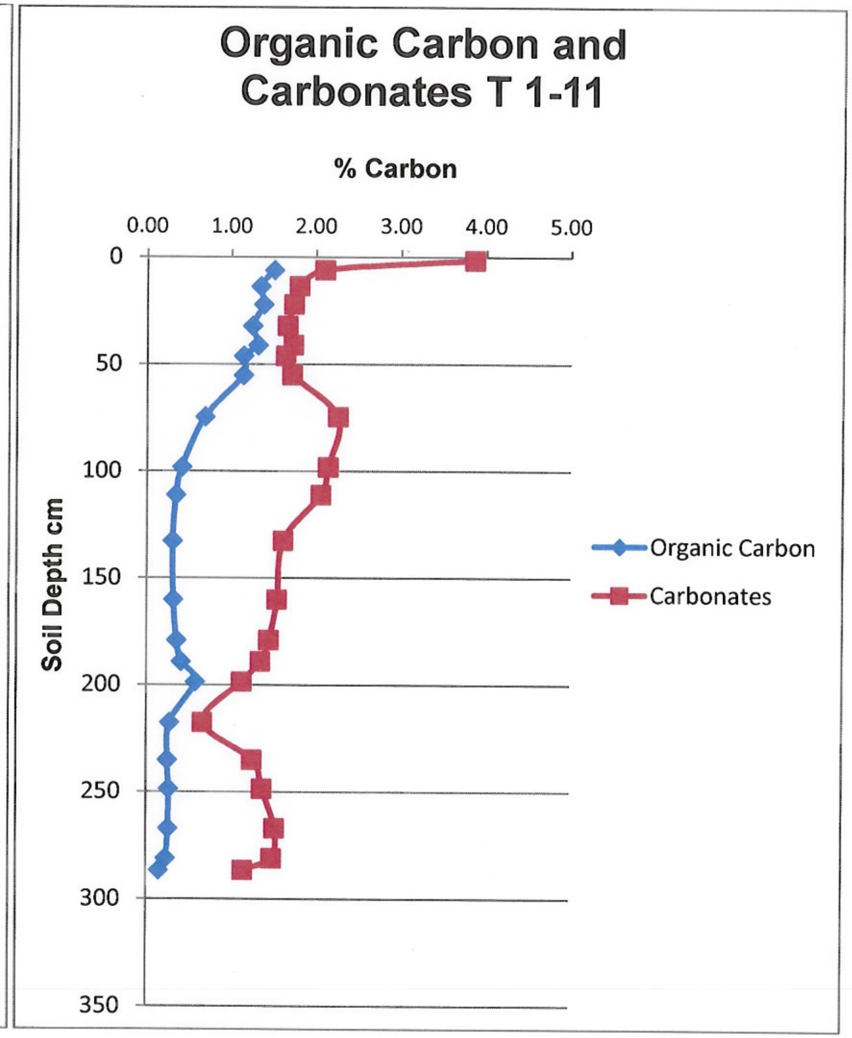


Figure D.11 Depth distribution diagram of soil reaction, organic carbon and carbonates for Transect 1, pedon 11

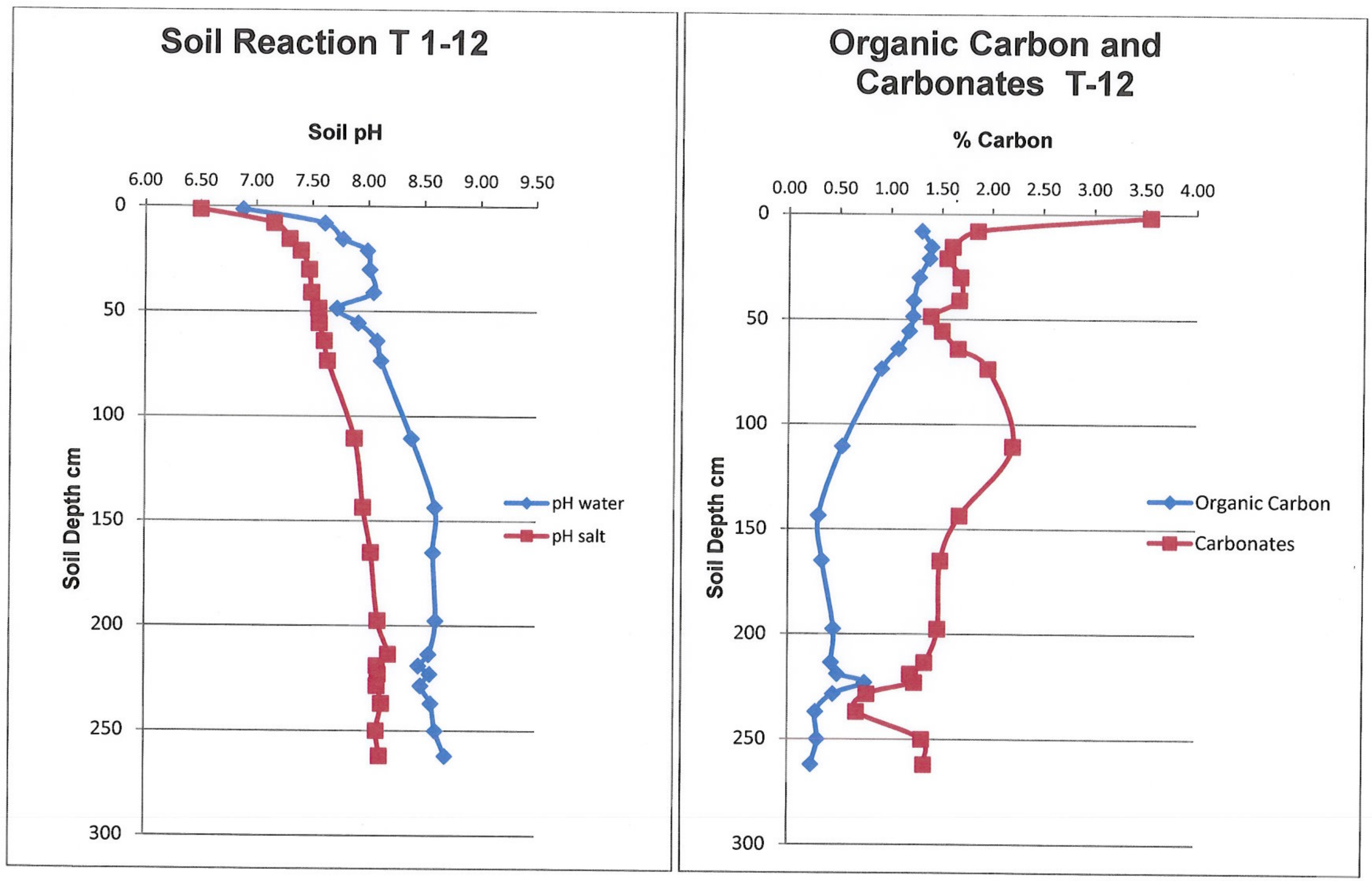
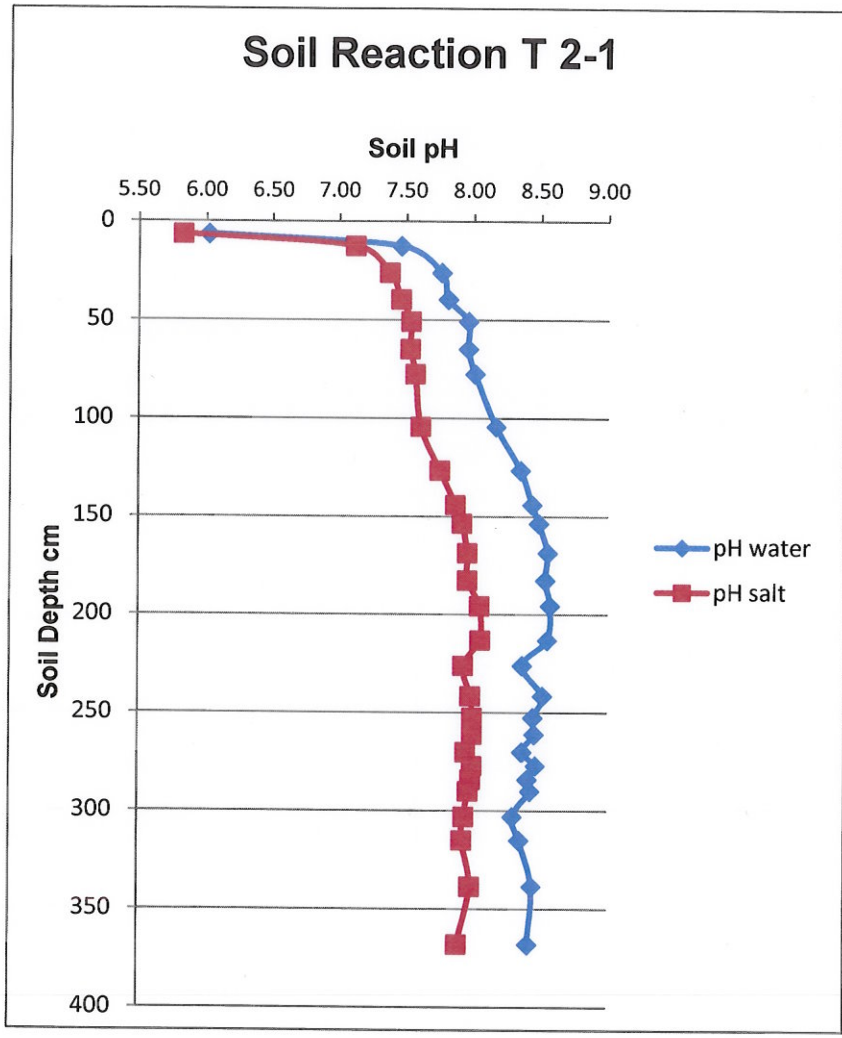


Figure D.12 Depth distribution diagrams of soil reaction, organic carbon and carbonates for Transect 1, pedon 12



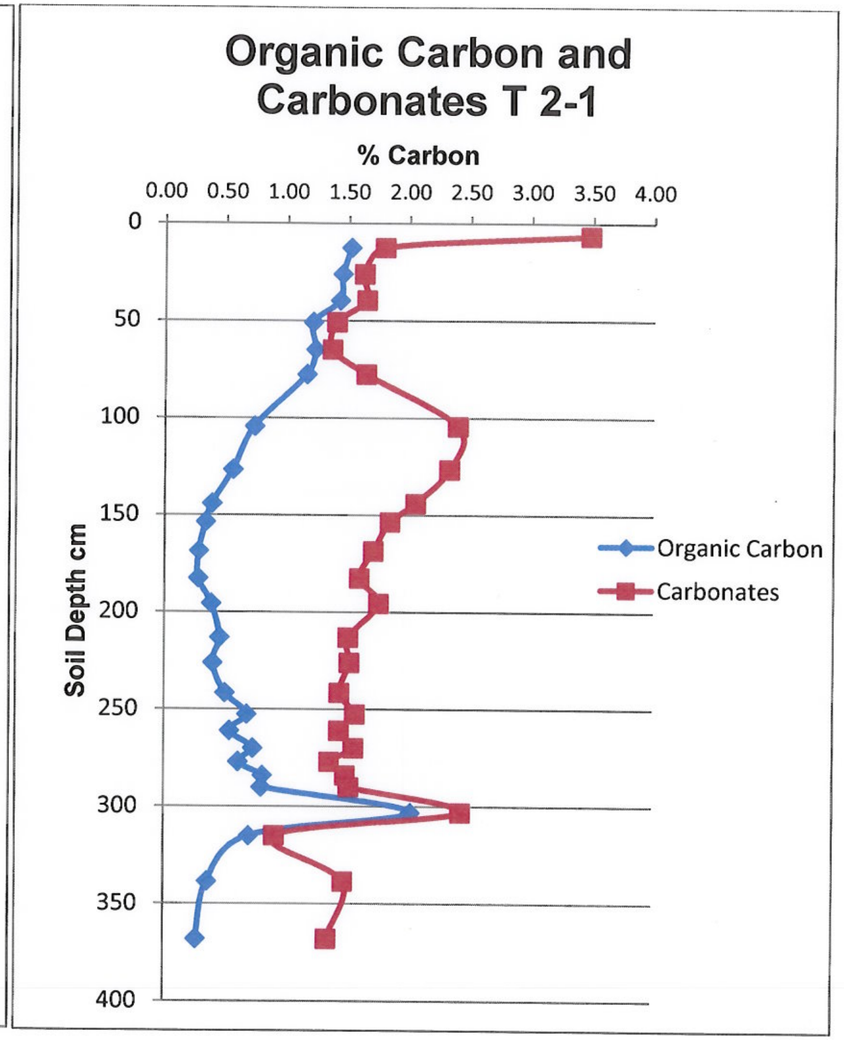


Figure D.13 Depth distribution diagram of soil reaction, organic carbon and carbonates for Transect 2, pedon 1

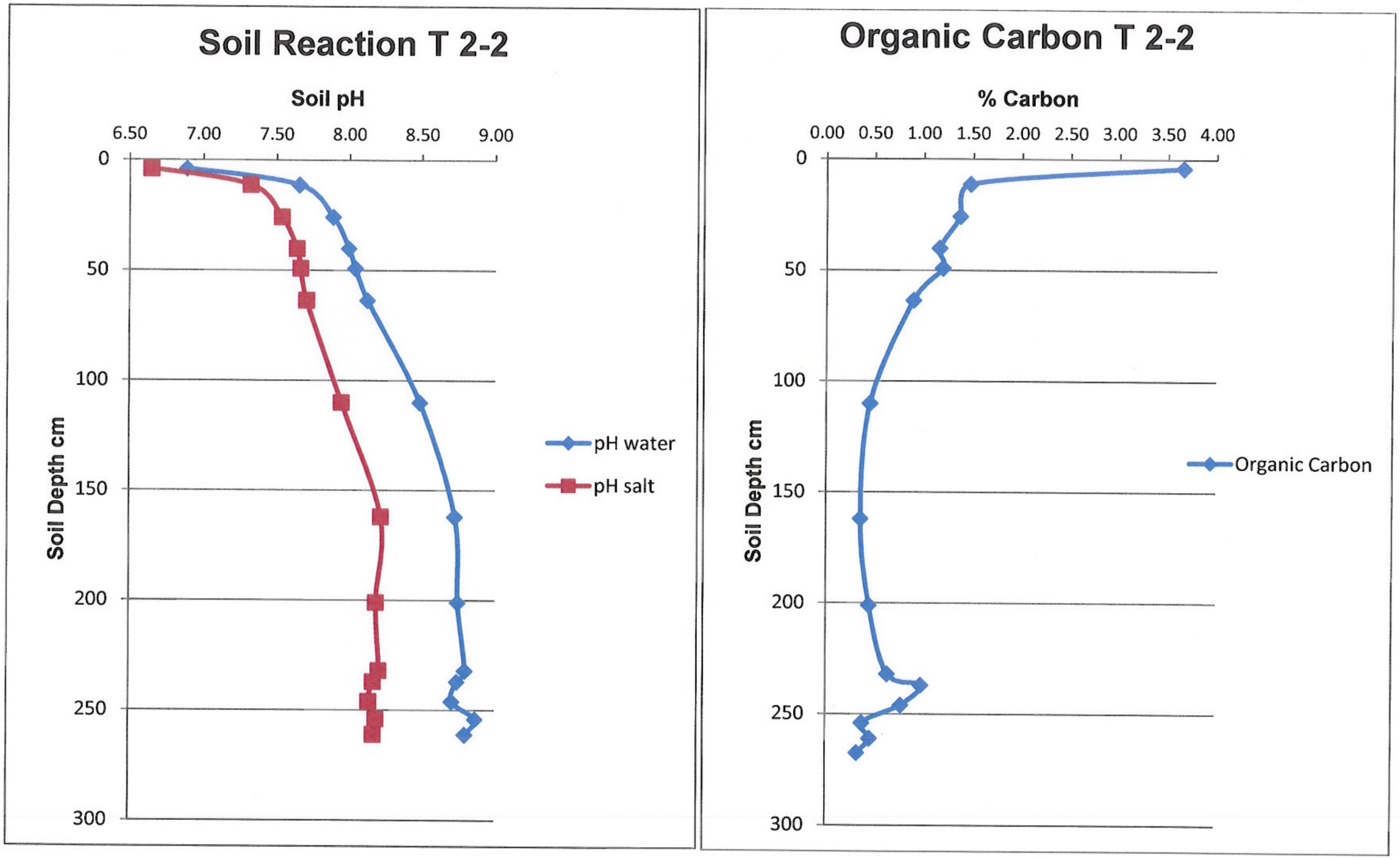


Figure D.14 Depth distribution diagrams of soil reaction and organic carbon for Transect 2, pedon 2

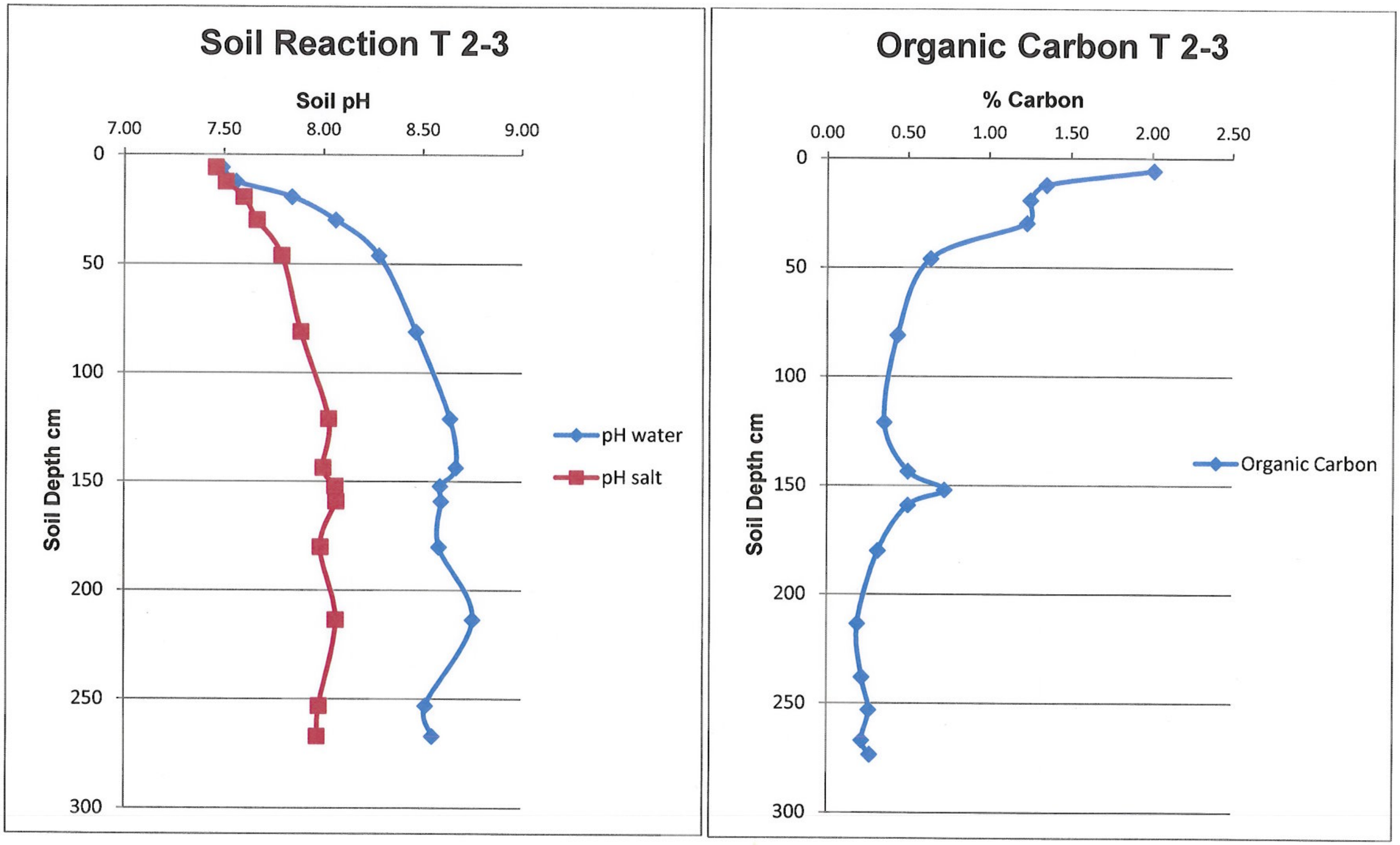


Figure D.15 Depth distribution diagrams of soil reaction and organic carbon for Transect 2, pedon 3

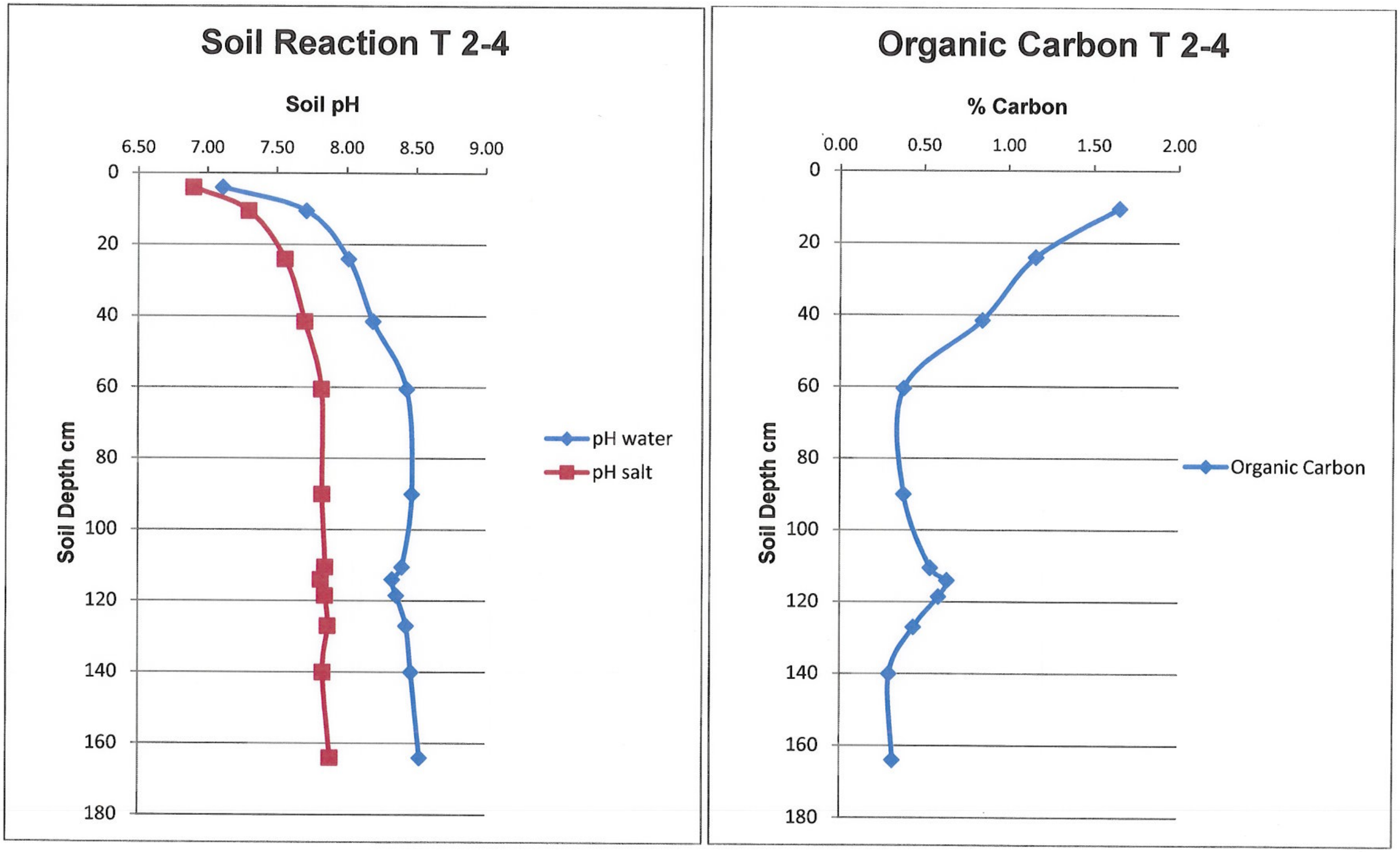
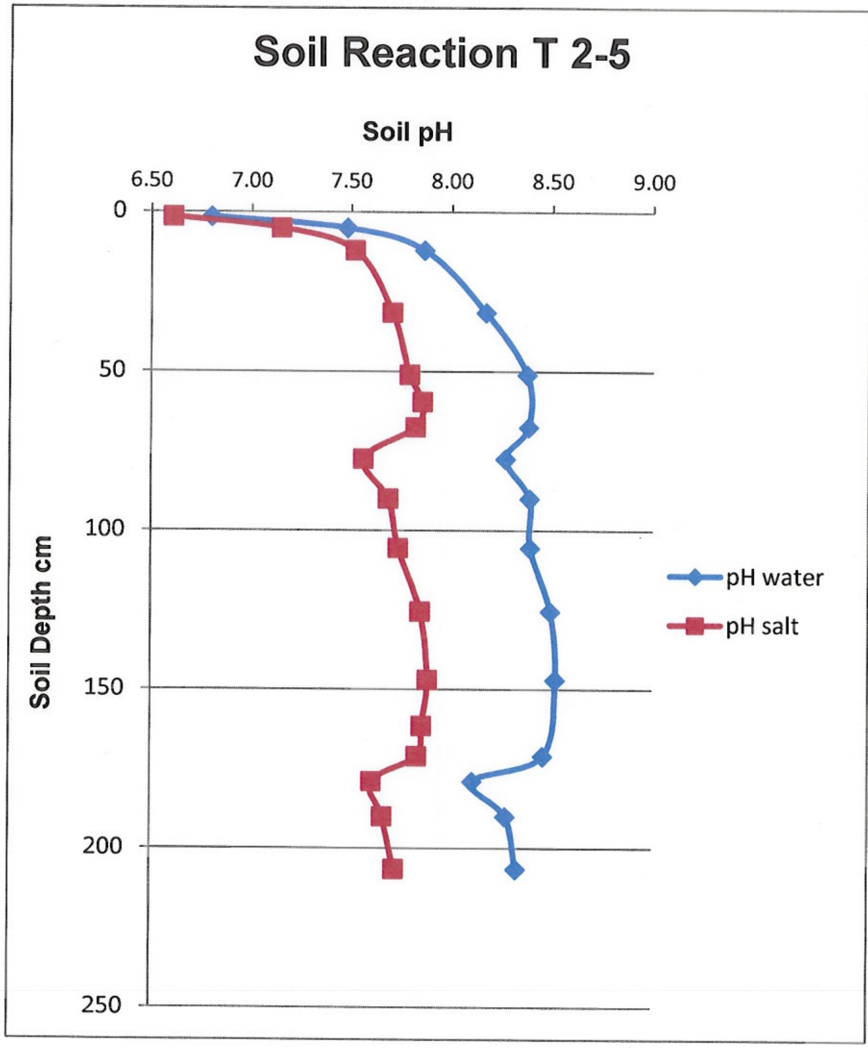


Figure D.16 Depth distribution diagrams of soil reaction and organic carbon for Transect 2, pedon 4



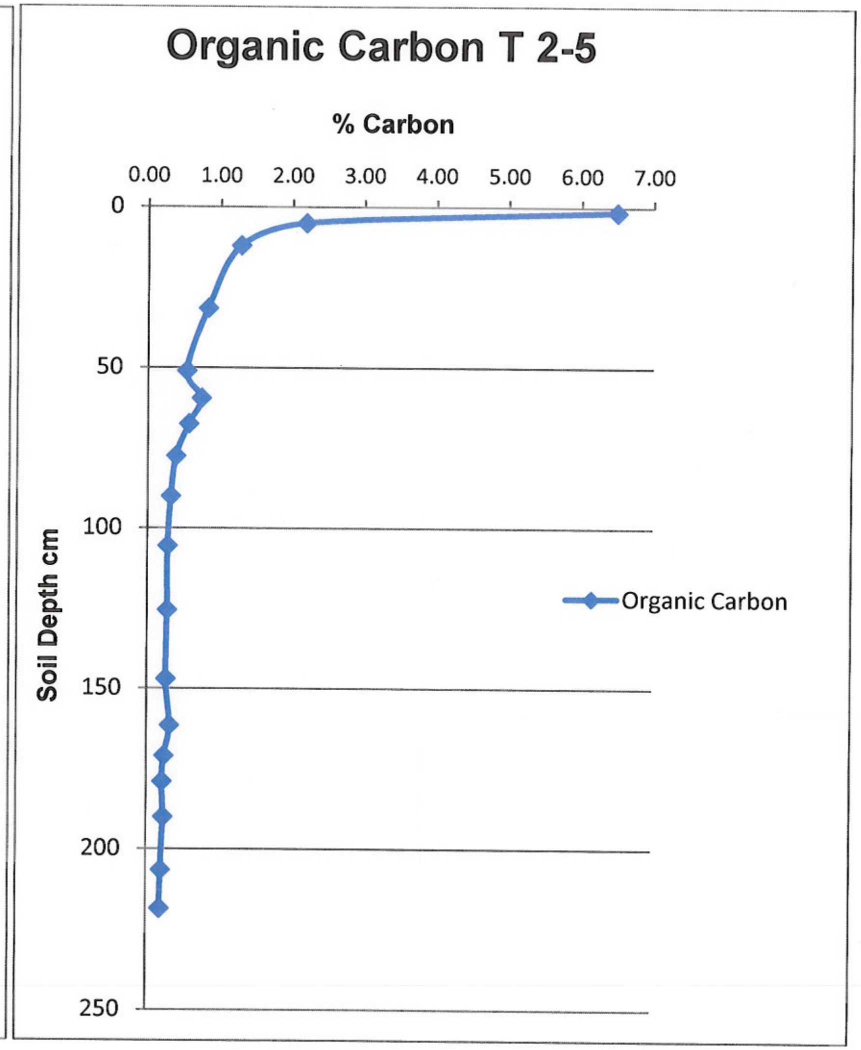


Figure D.17 Depth distribution diagrams of soil reaction and organic carbon for Transect 2, pedon 5

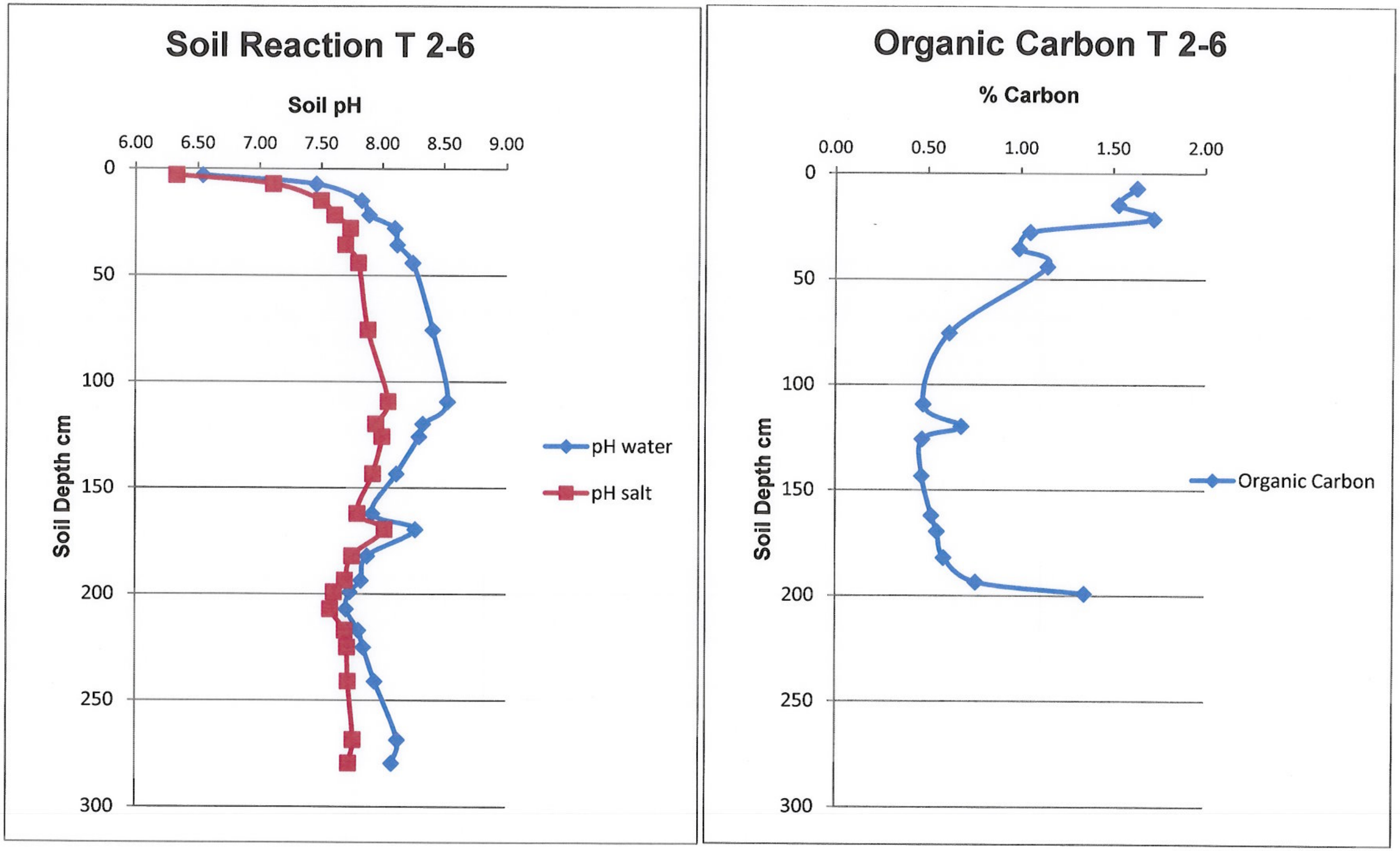
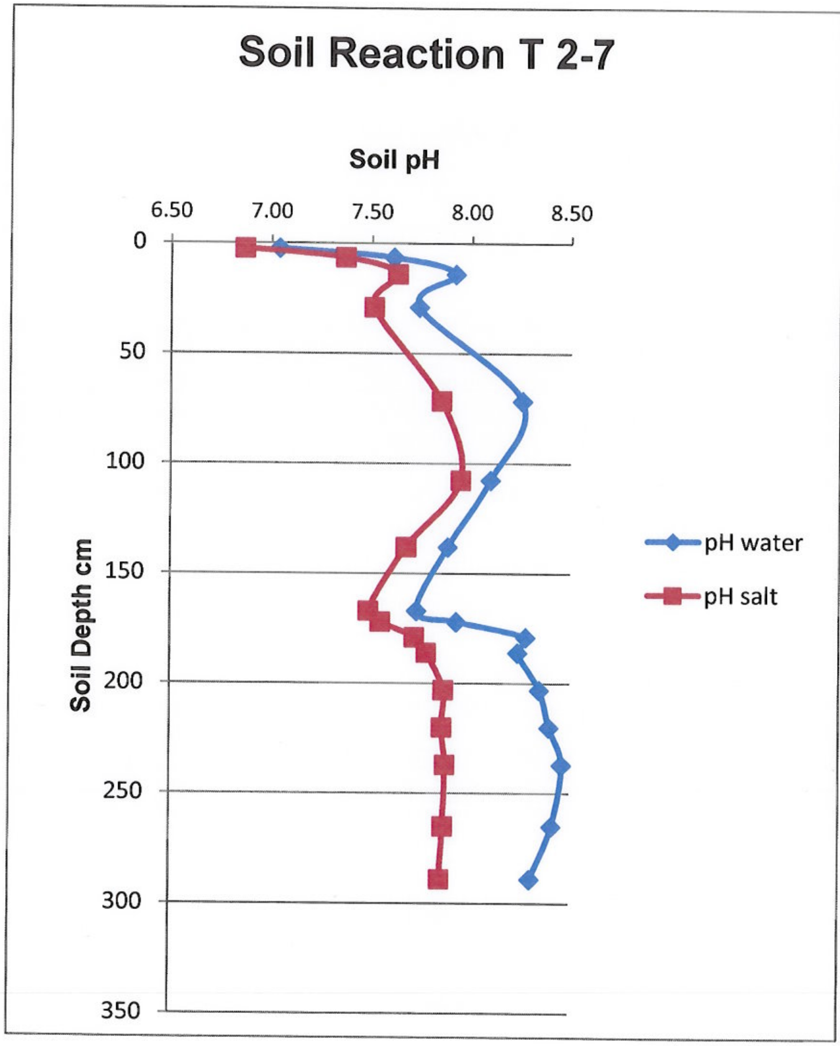


Figure D.18 Depth distribution diagrams of soil reaction and organic carbon for Transect 2, pedon 6



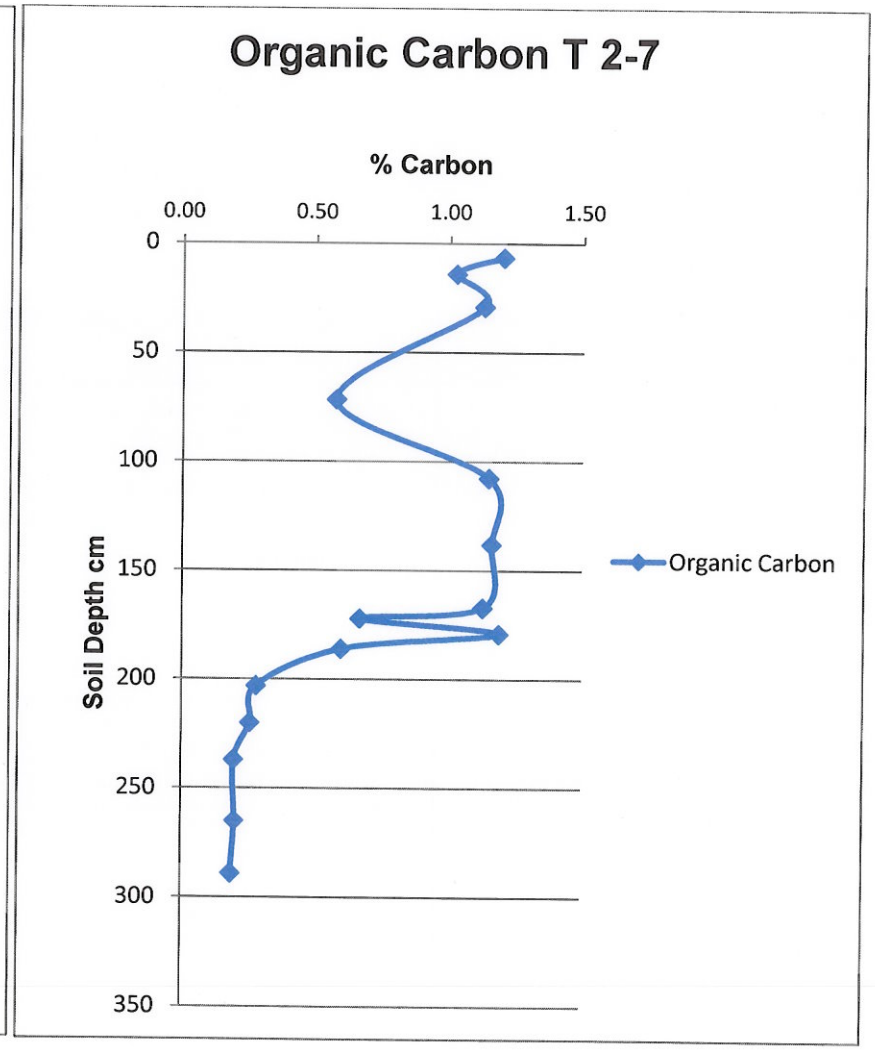


Figure D.19 Depth distribution diagrams of soil reaction and organic carbon for Transect 2, pedon 7

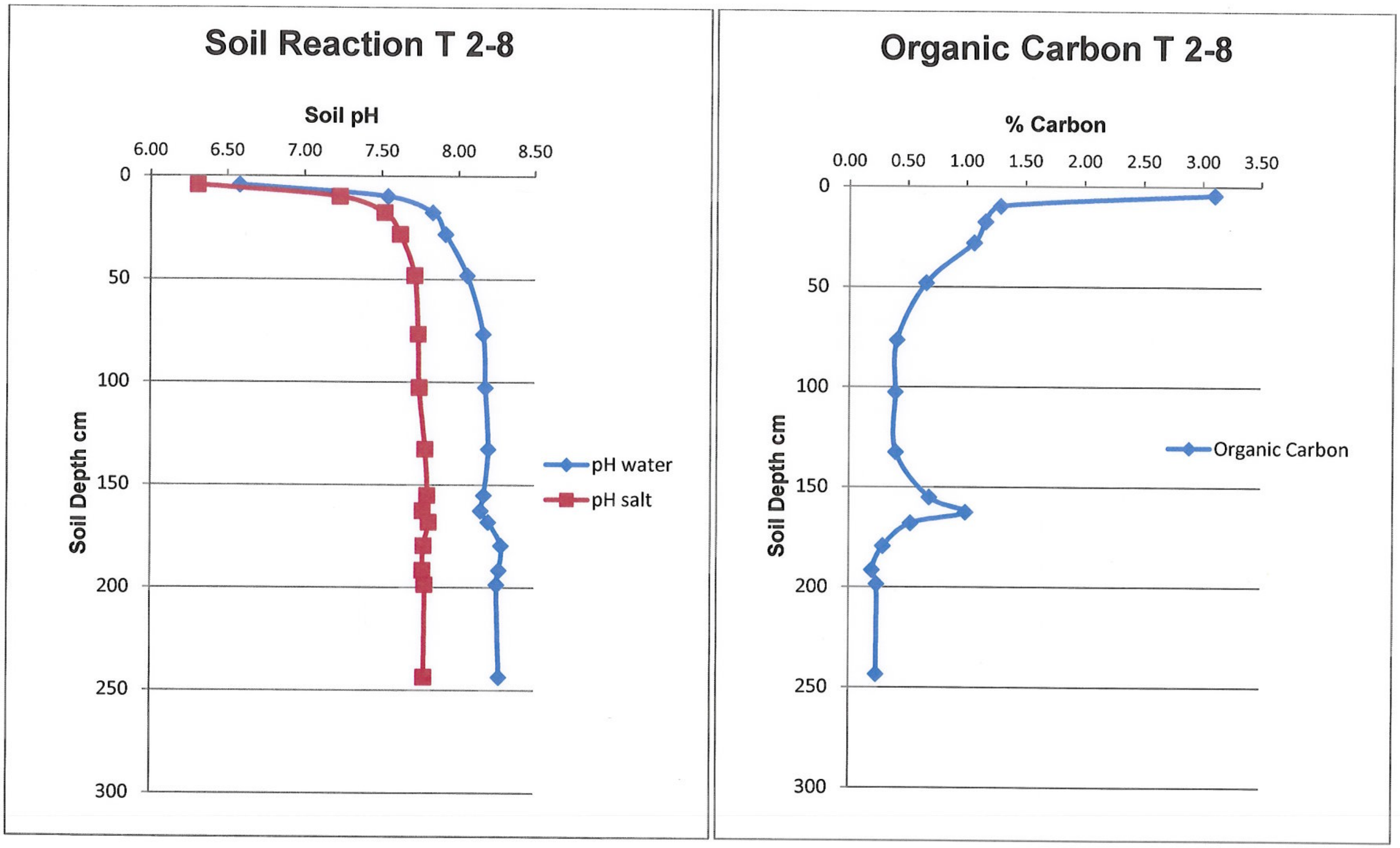


Figure D.20 Depth distribution diagrams of soil reaction and organic carbon for Transect 2, pedon 8

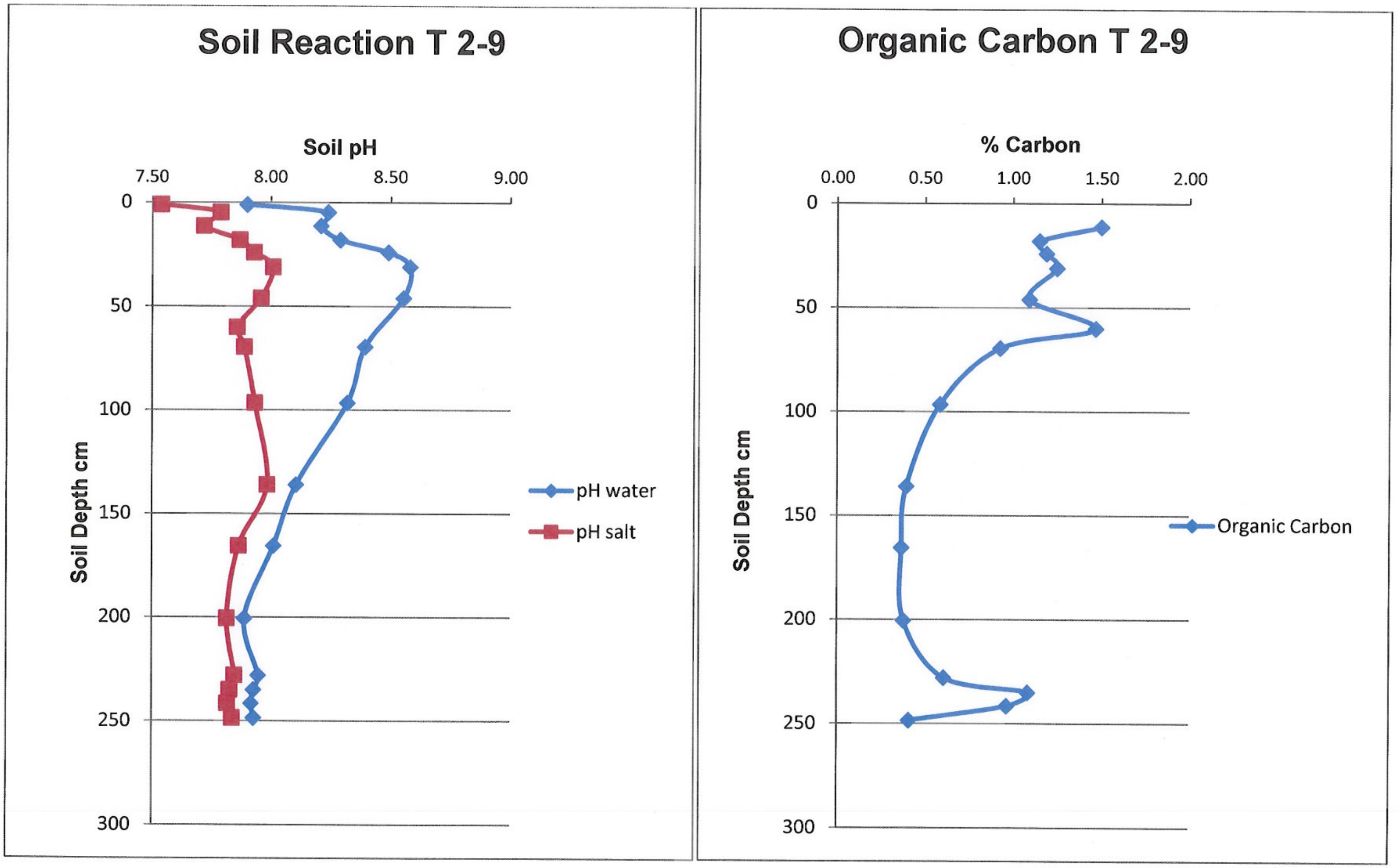


Figure D.21 Depth distribution diagrams of soil reaction and organic carbon for Transect 2, pedon 9

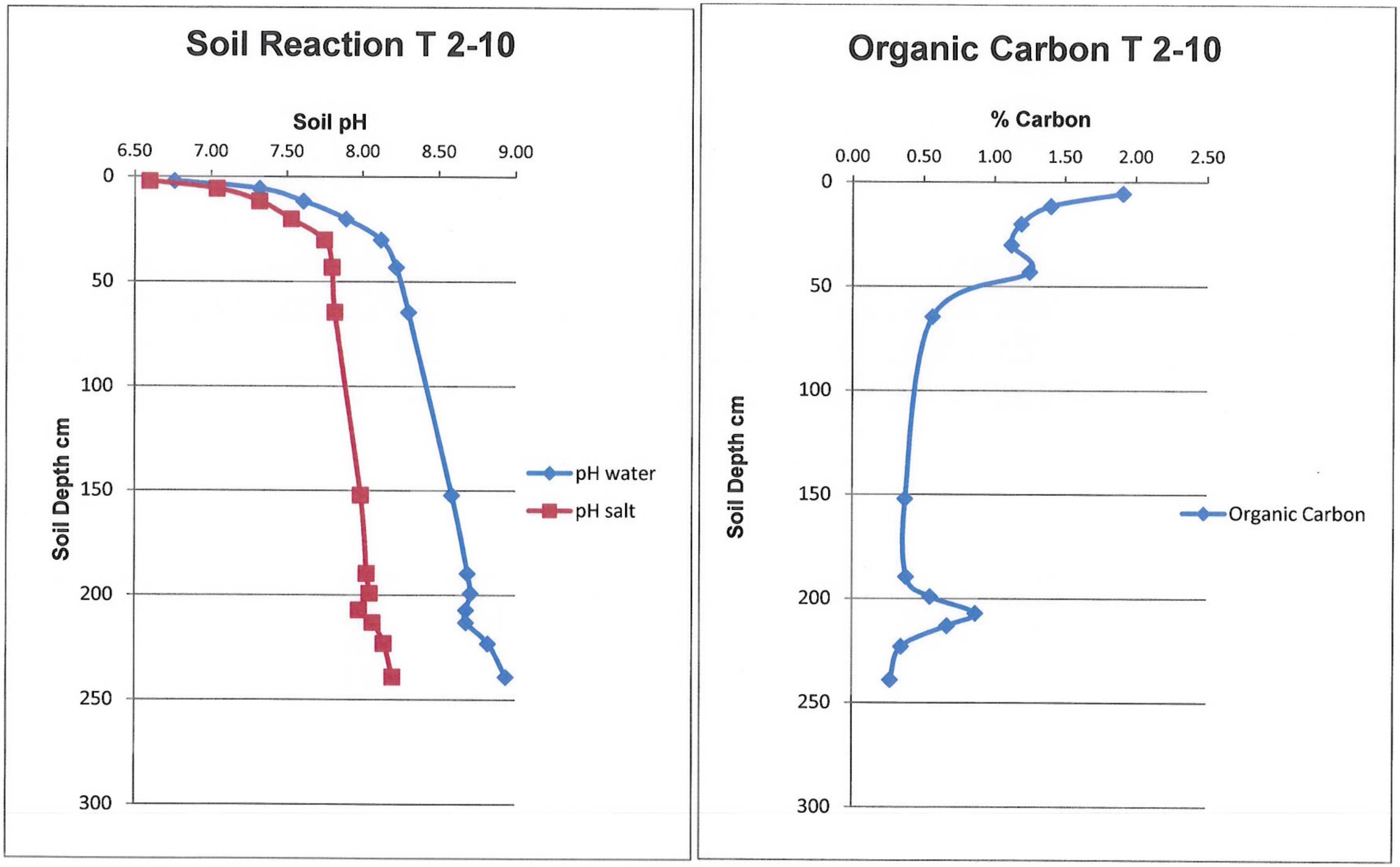
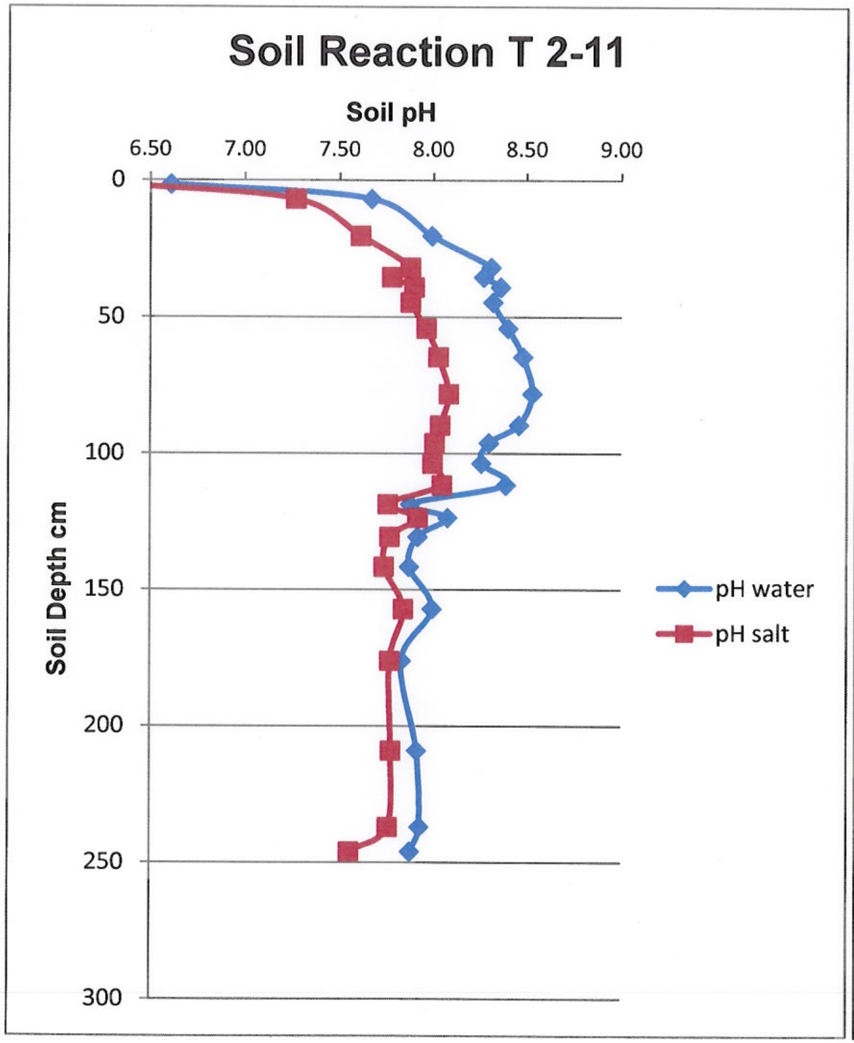


Figure D.22 Depth distribution diagrams of soil reaction and organic carbon for Transect 2, pedon 10



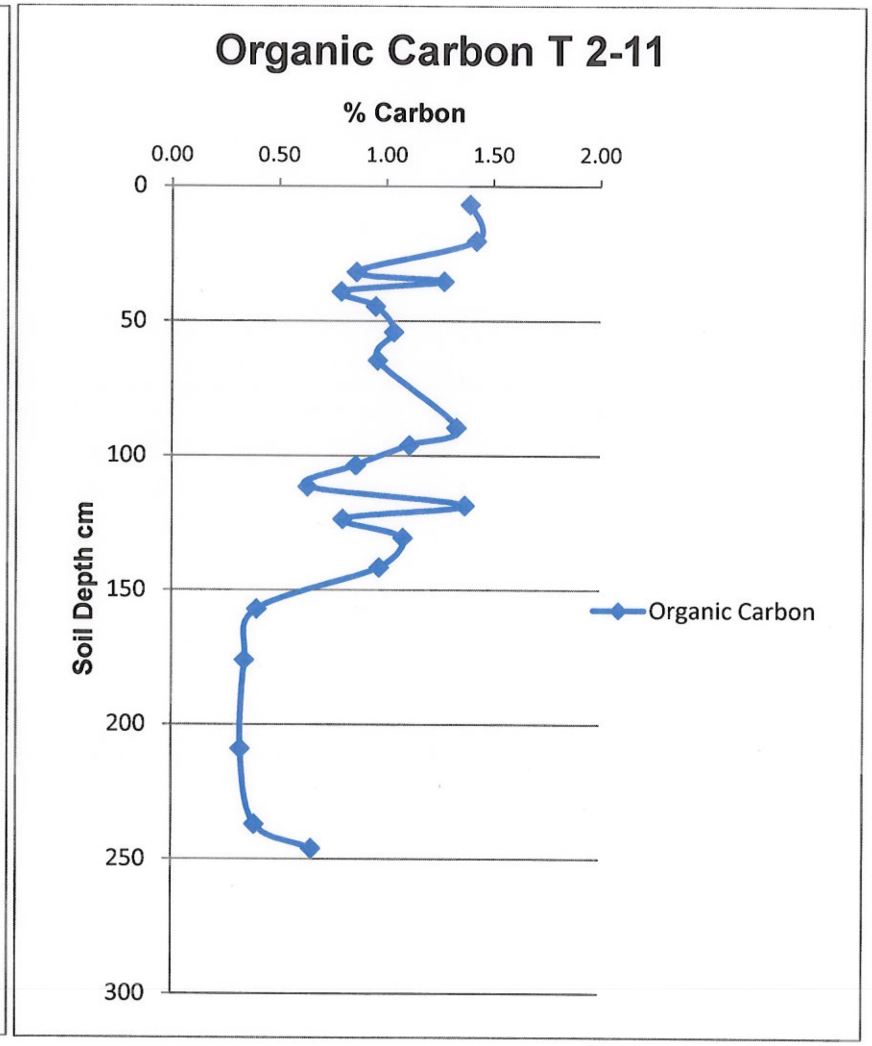
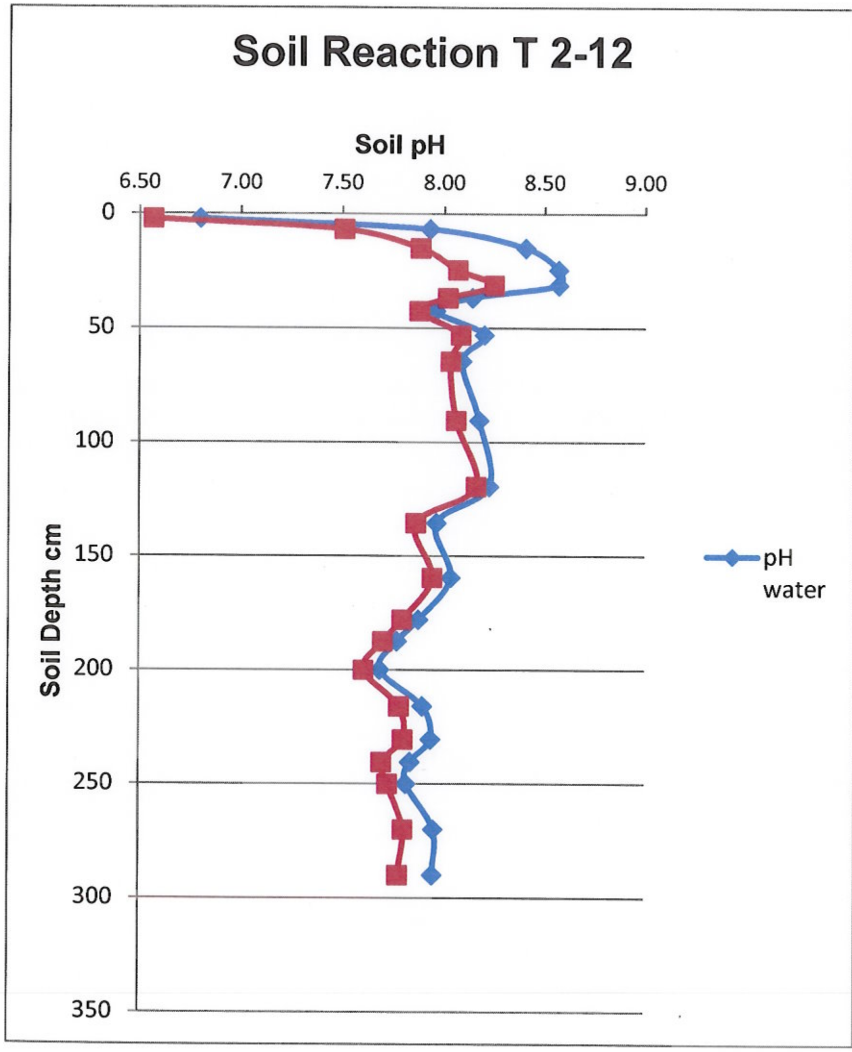


Figure D.23 Depth distribution diagrams of soil reaction and organic carbon for Transect 2, pedon 11



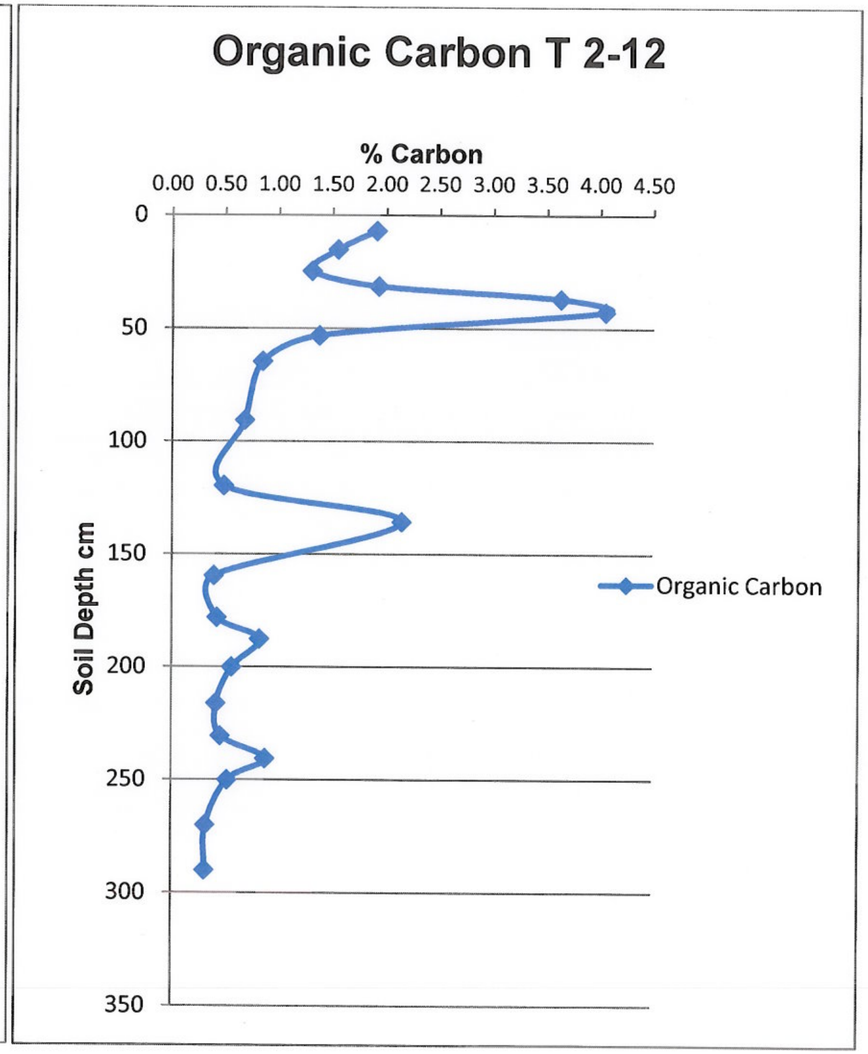


Figure D.24 Depth distribution diagrams of soil reaction and organic carbon for Transect 2, pedon 12

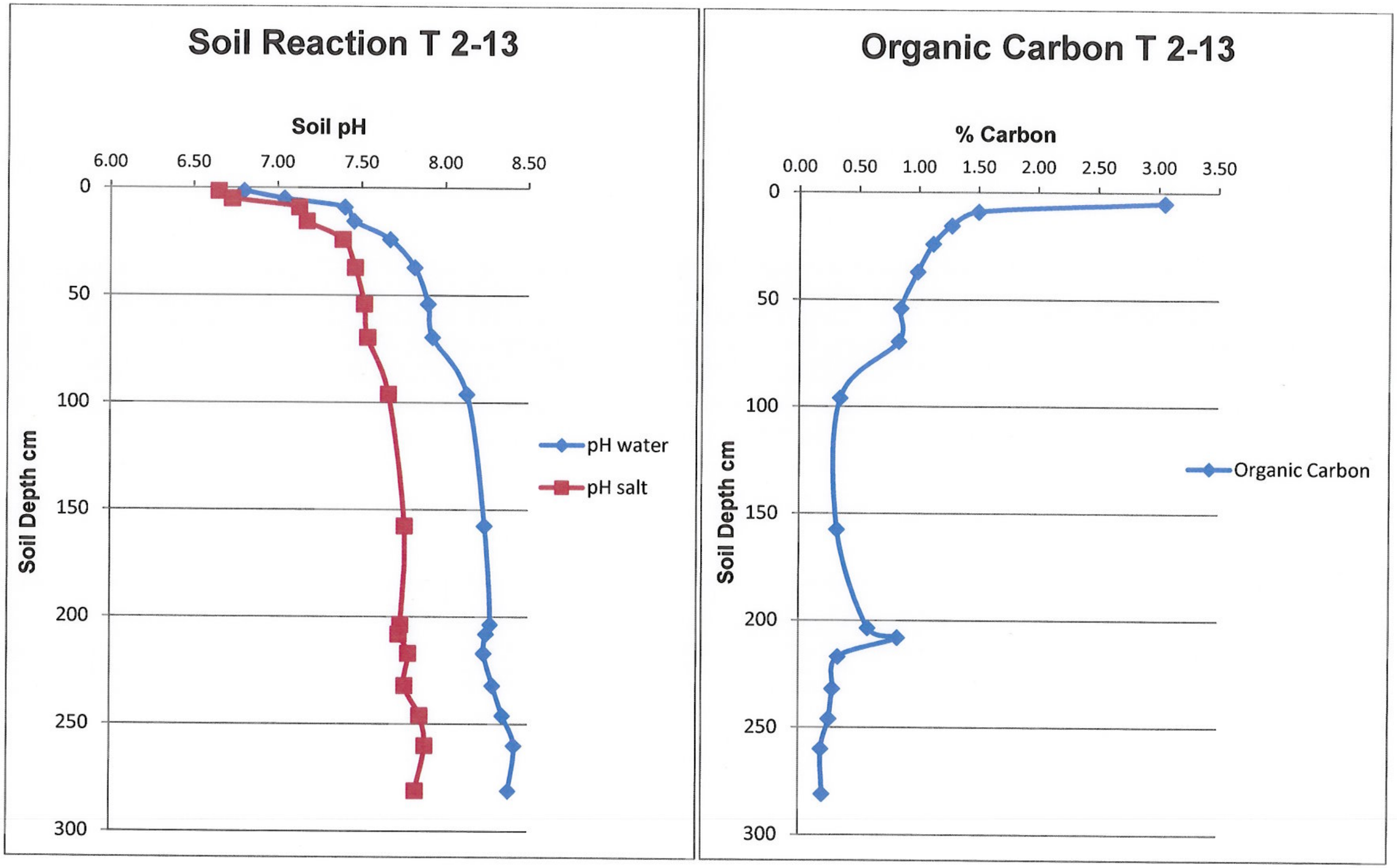
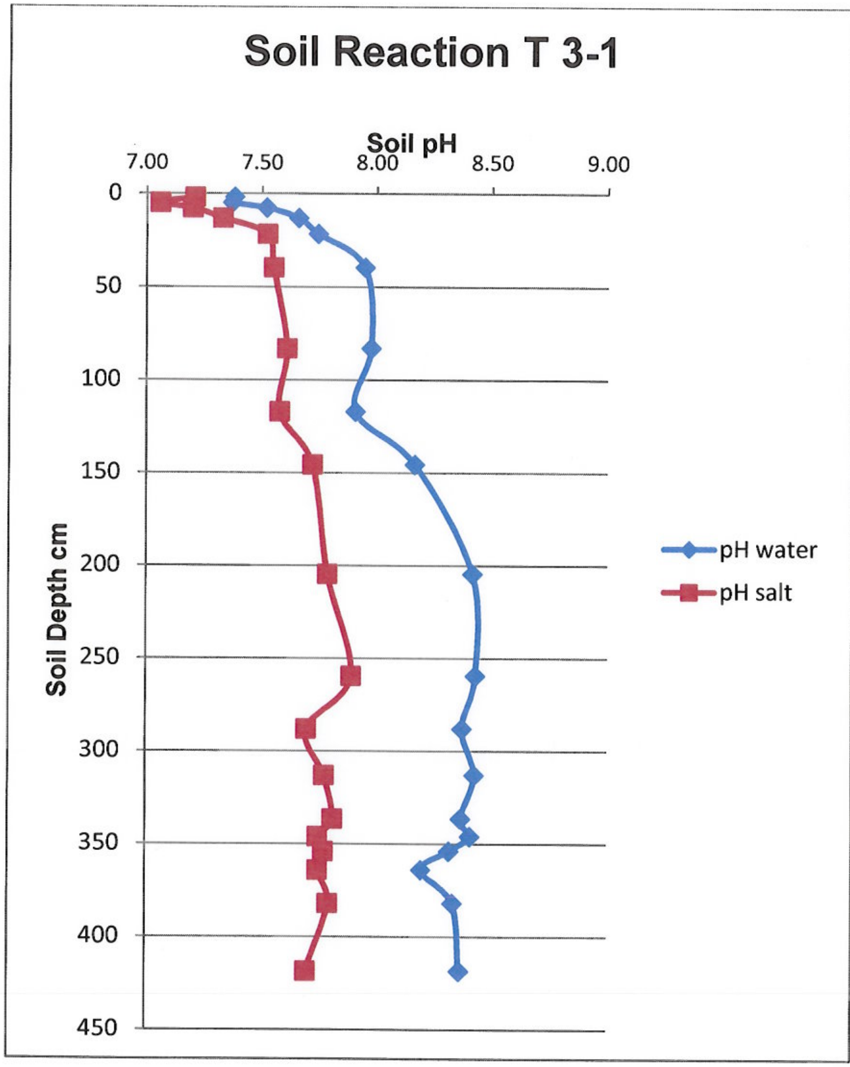


Figure D.25 Depth distribution diagrams of soil reaction and organic carbon for Transect 2, pedon 13



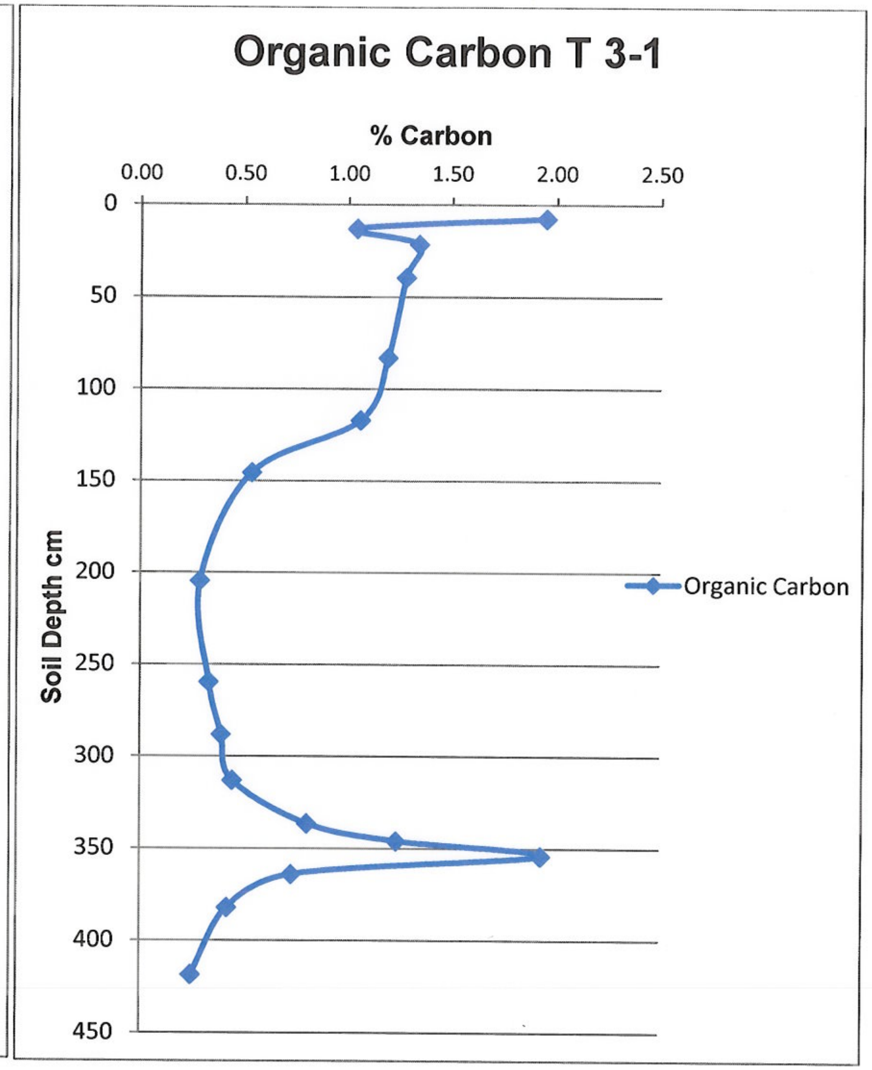


Figure D.26 Depth distribution diagrams of soil reaction and organic carbon for Transect 3, pedon 1

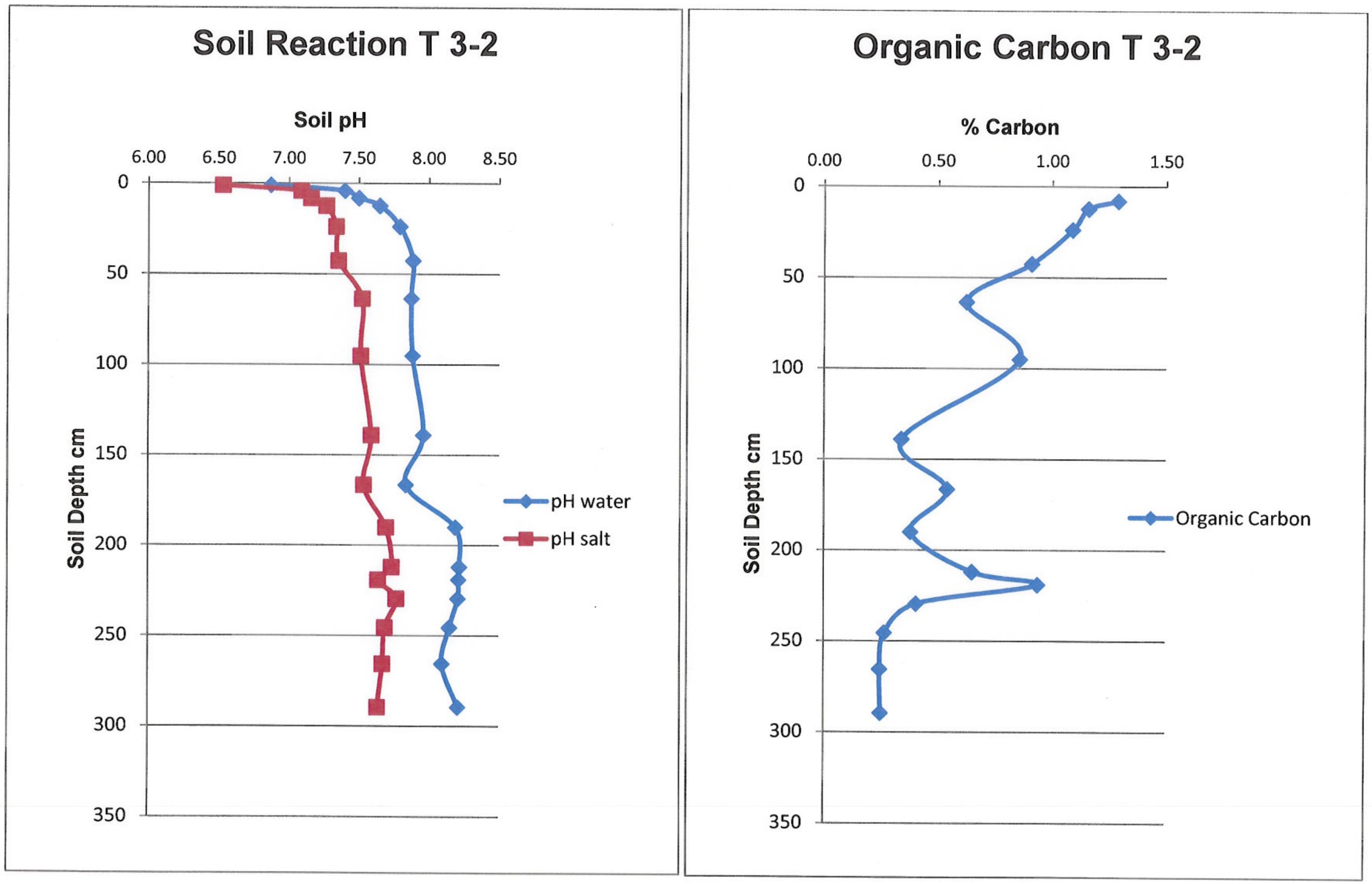


Figure D.27 Depth distribution diagrams of soil reaction and organic carbon for Transect 3, pedon 2

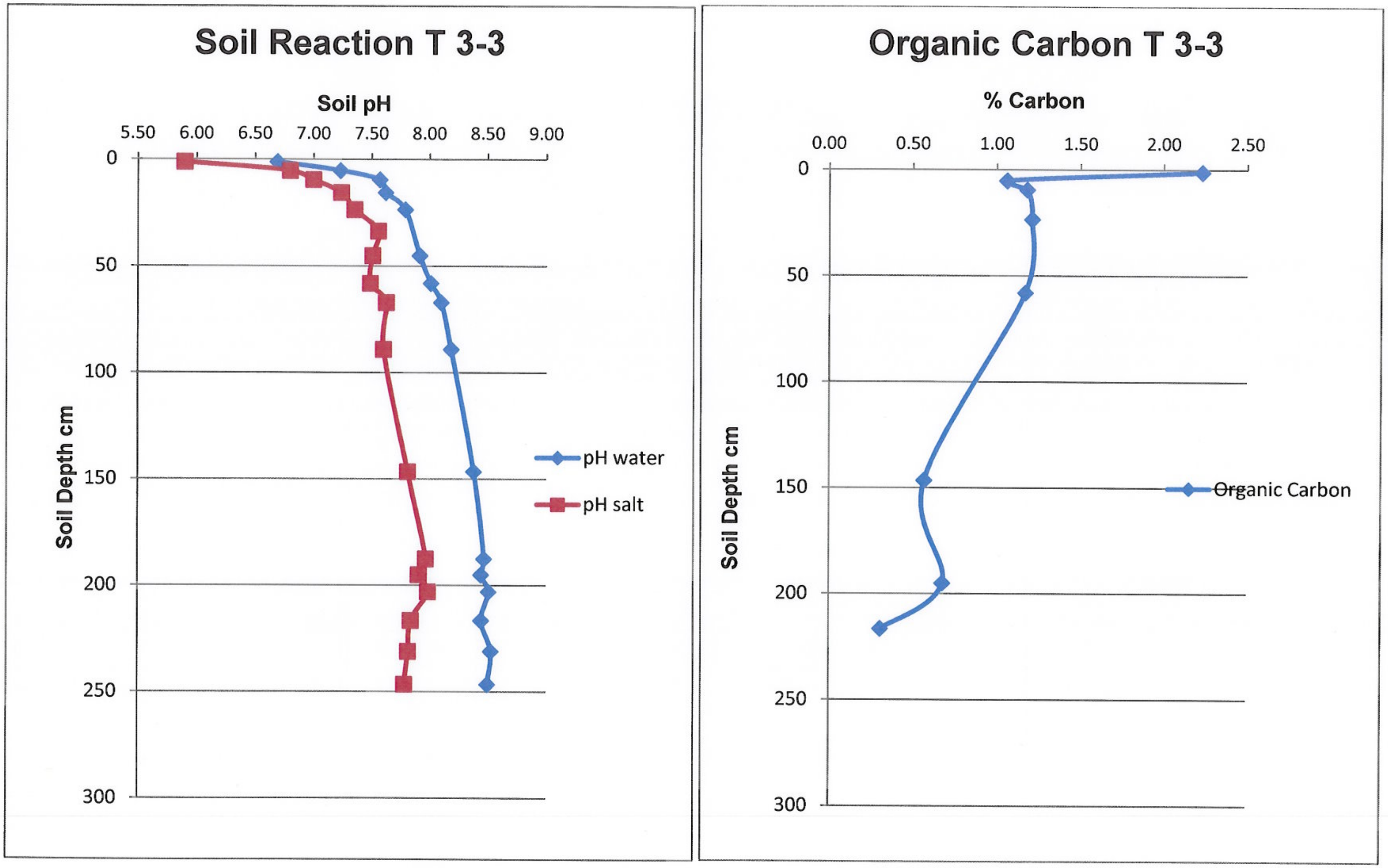


Figure D.28 Depth distribution diagrams of soil reaction and organic carbon for Transect 3, pedon 3

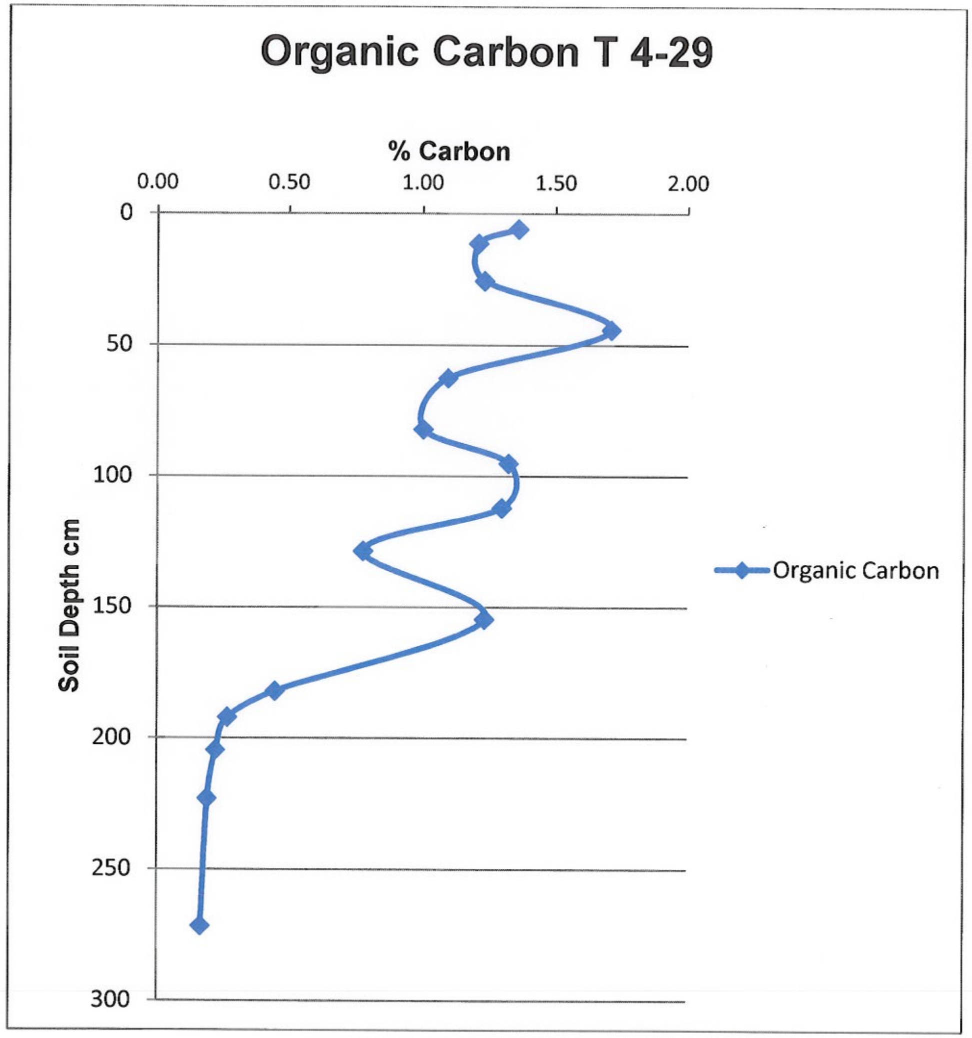


Figure D.29 Depth distribution diagram of organic carbon for Transect 4, pedon 29

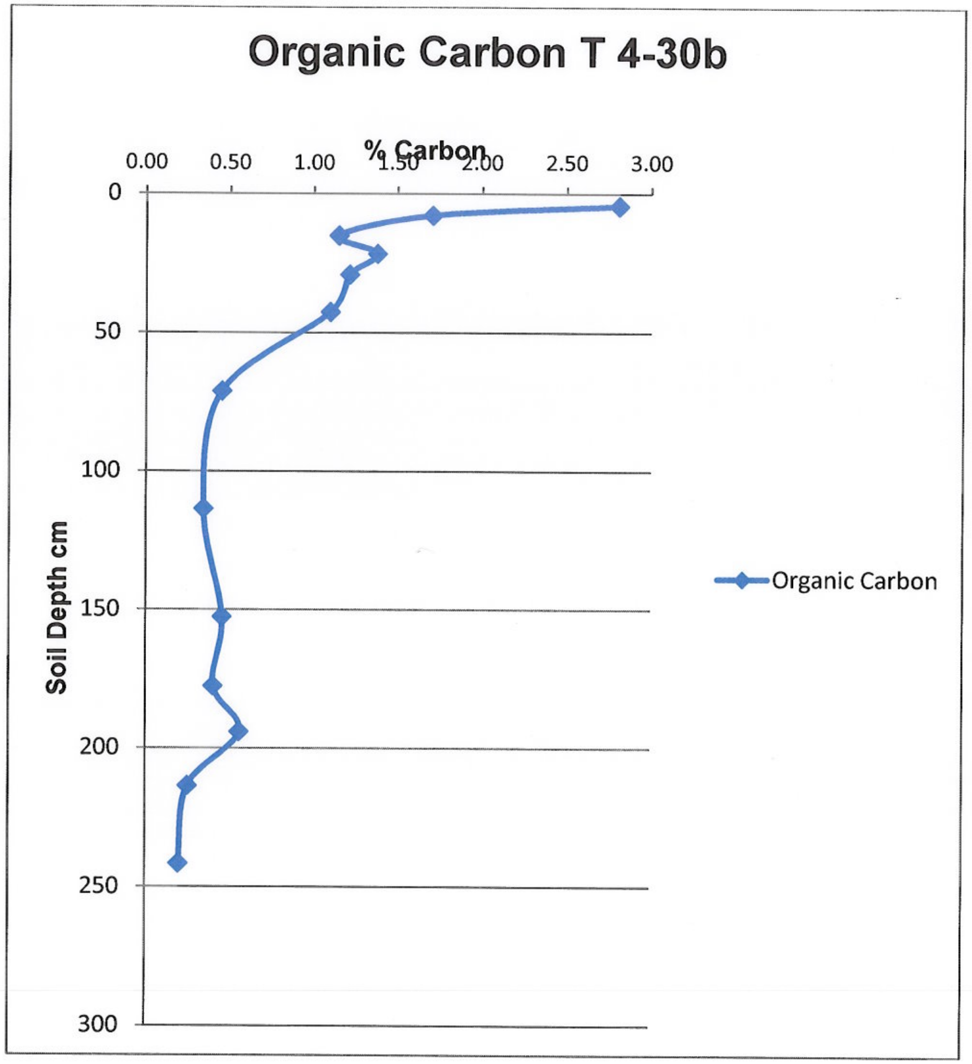


Figure D.30 Depth distribution diagram of organic carbon for Transect 4, pedon 30b

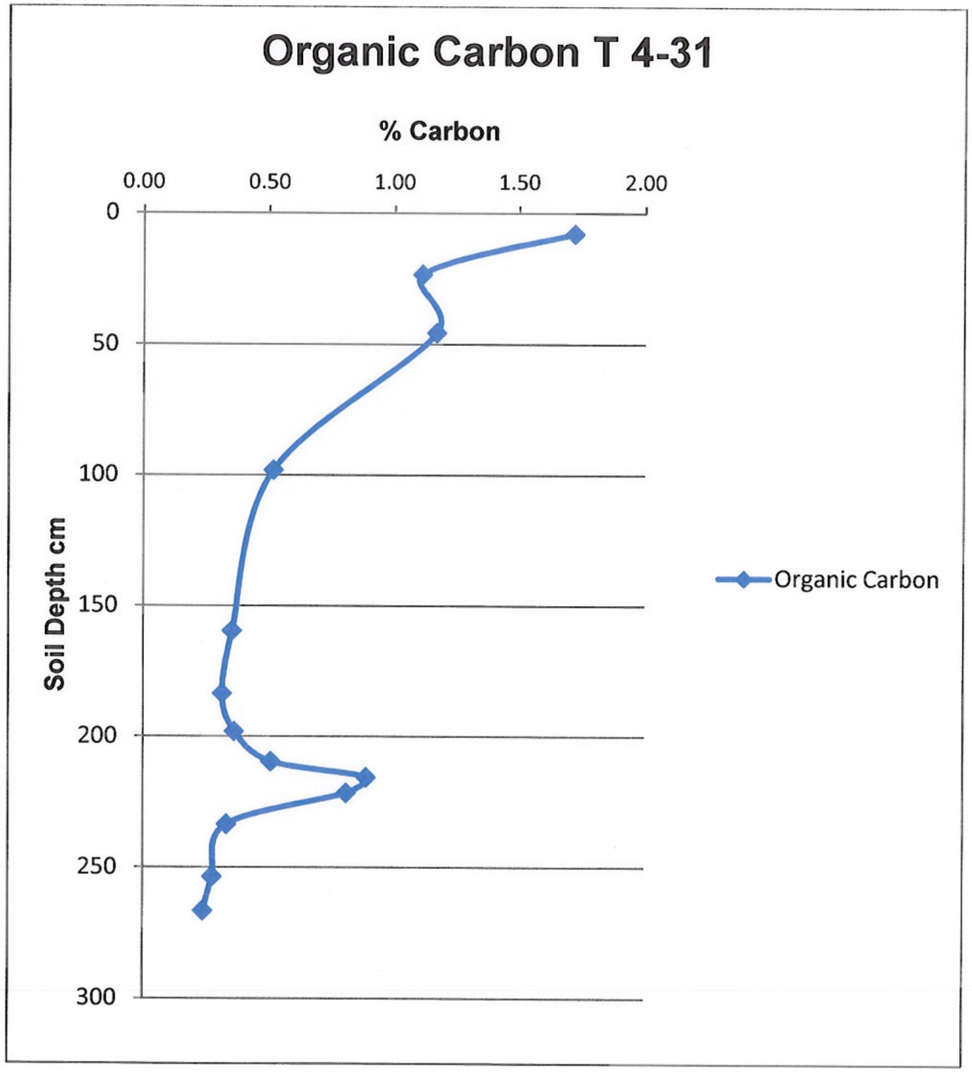


Figure D.31 Depth distribution diagram of organic carbon for Transect 4, pedon 31

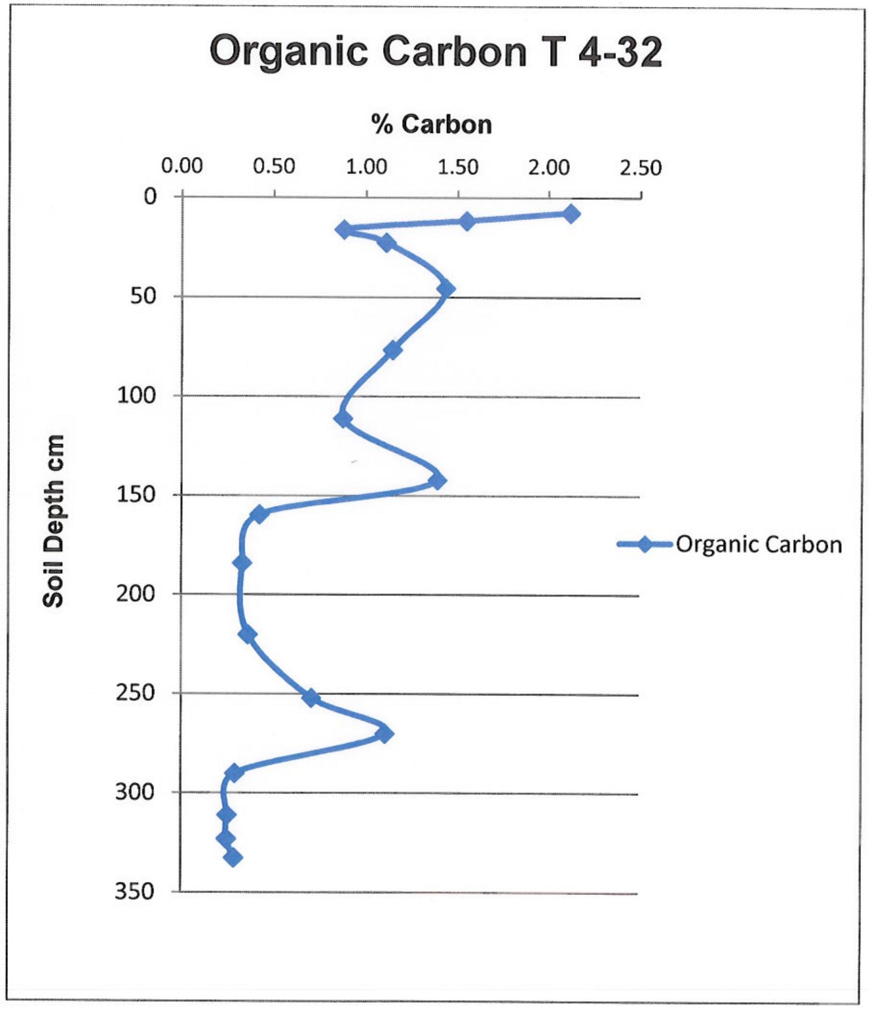


Figure D.32 Depth distribution diagram of organic carbon for Transect 4, pedon 32

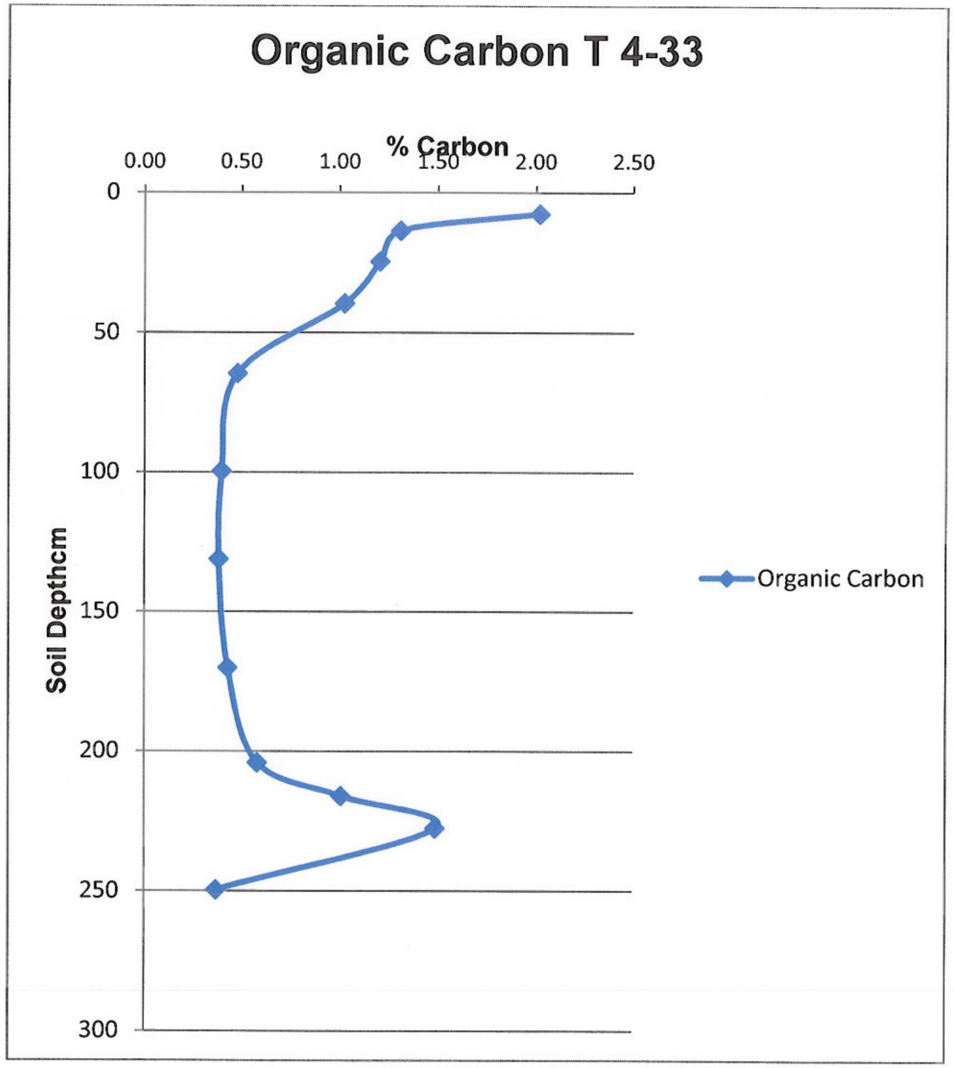


Figure D.33 Depth distribution diagram of organic carbon for Transect 4, pedon 33

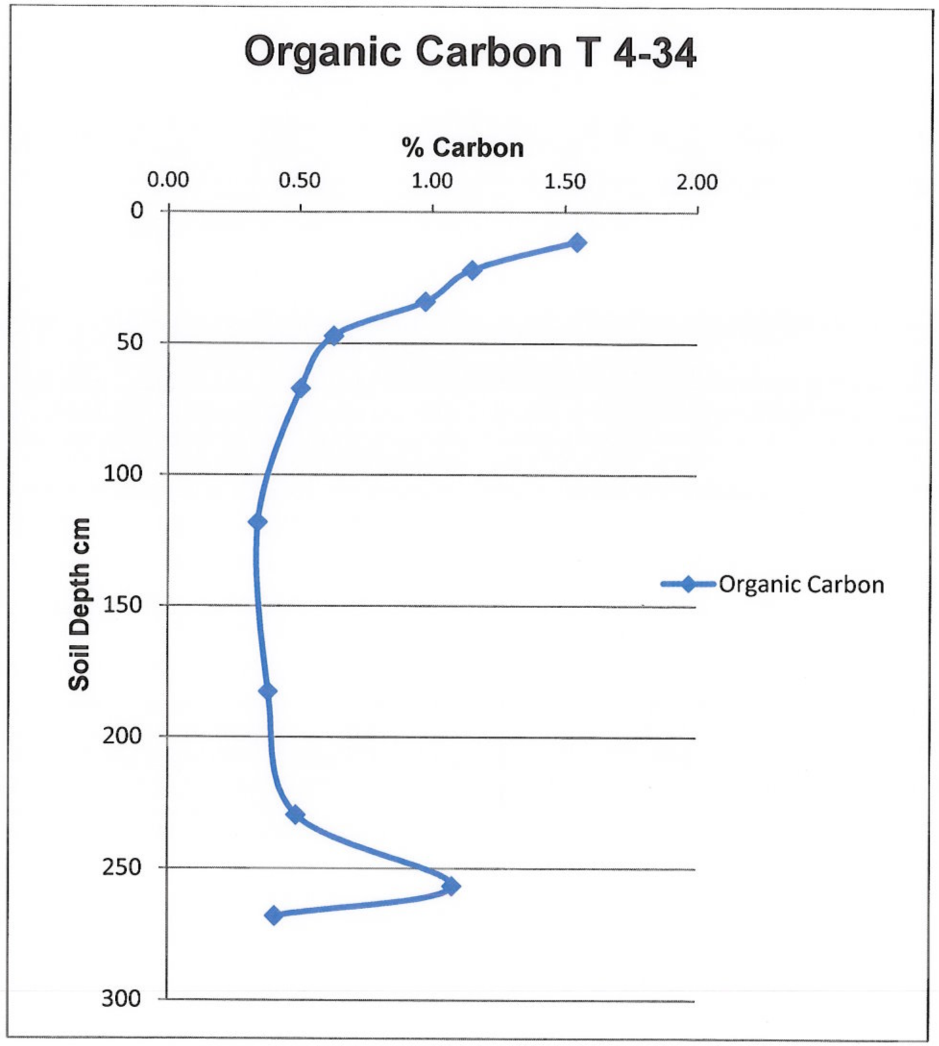
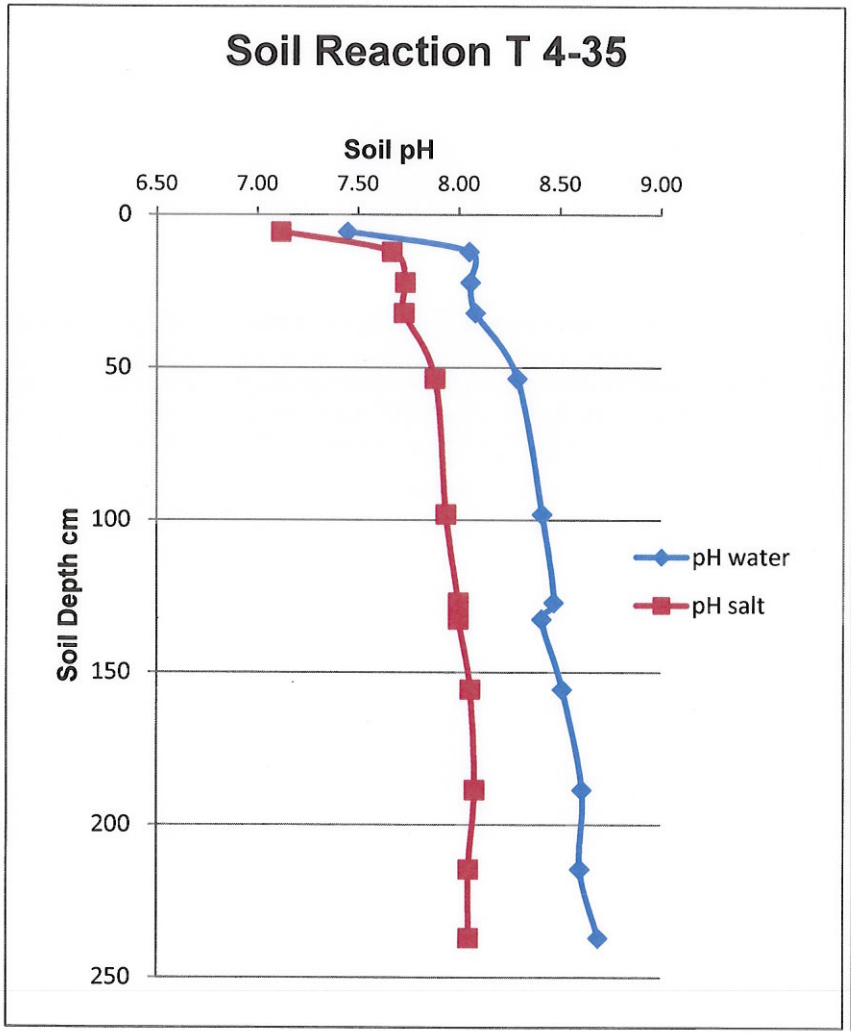


Figure D.34 Depth distribution diagram of organic carbon for Transect 4, pedon 34



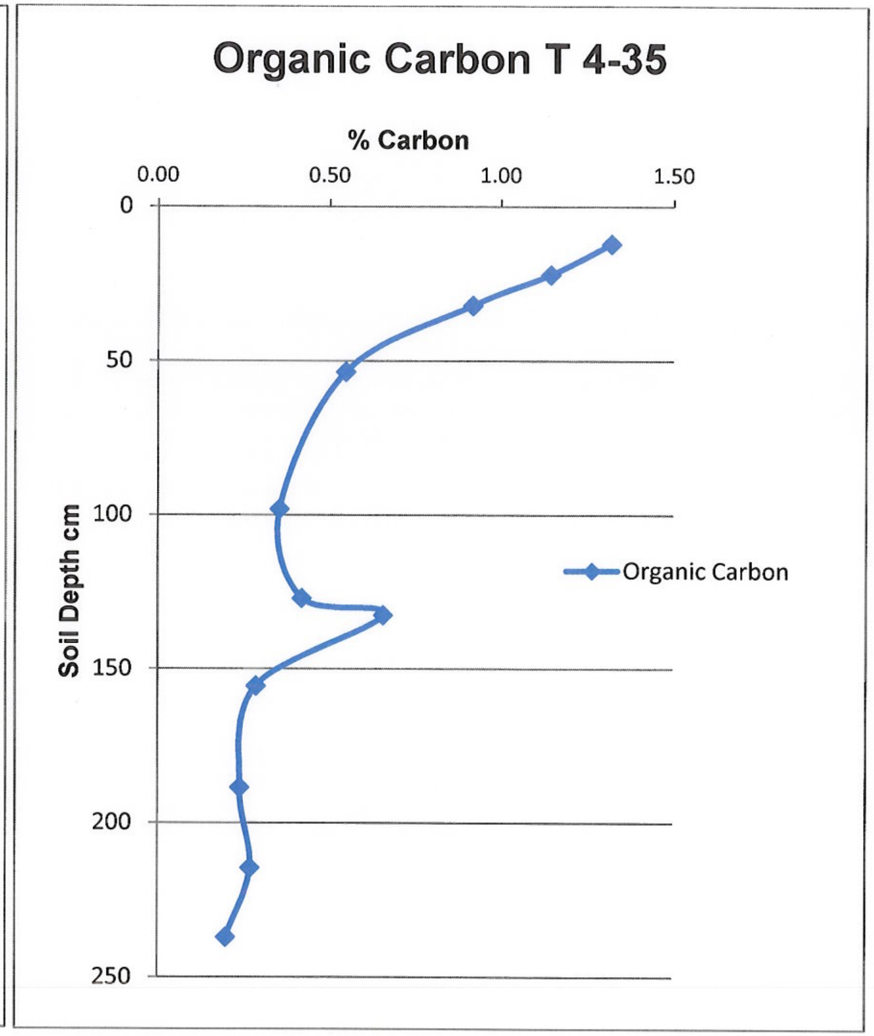


Figure D.35 Depth distribution diagrams of soil reaction and organic carbon for Transect 4, pedon 35

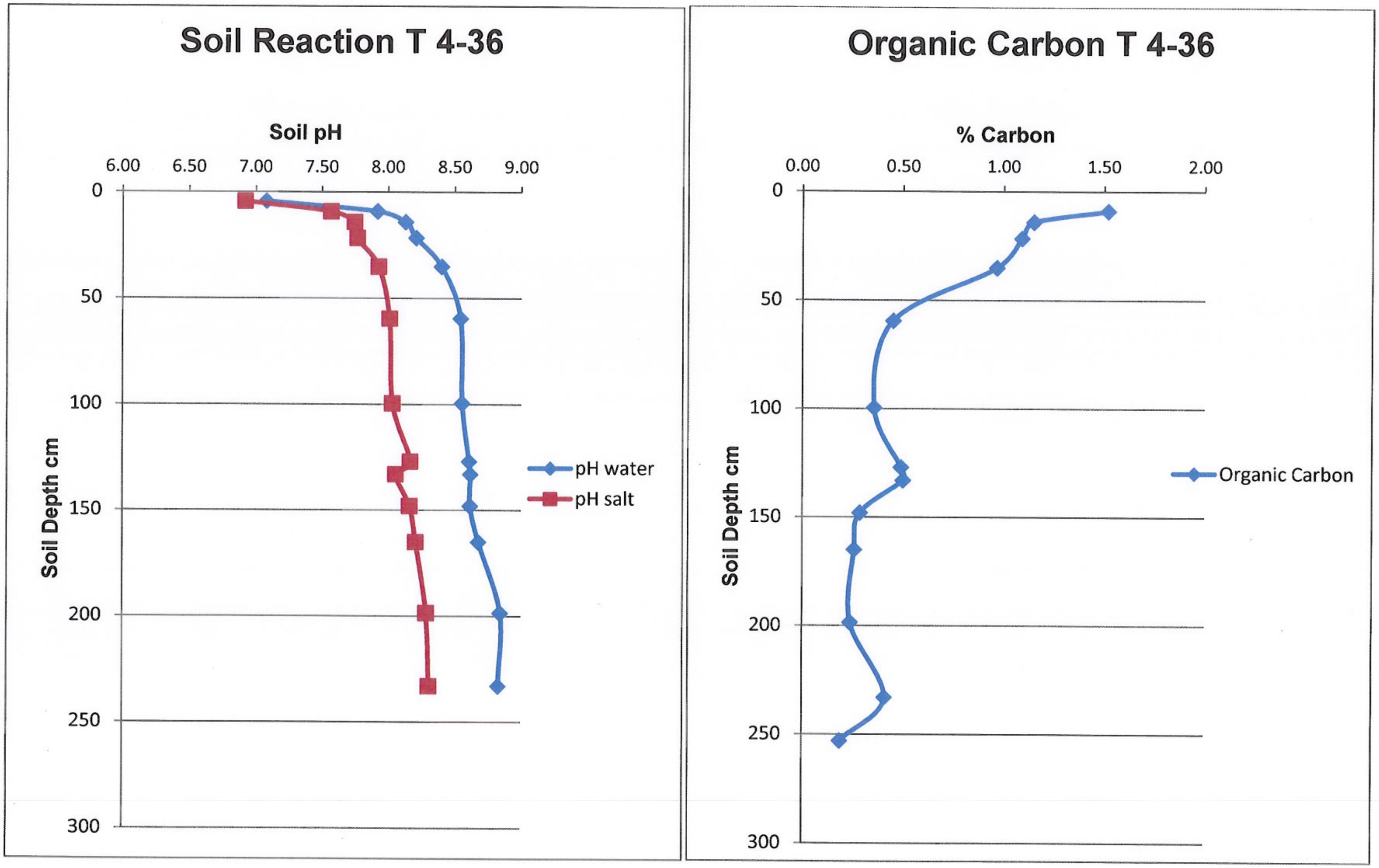
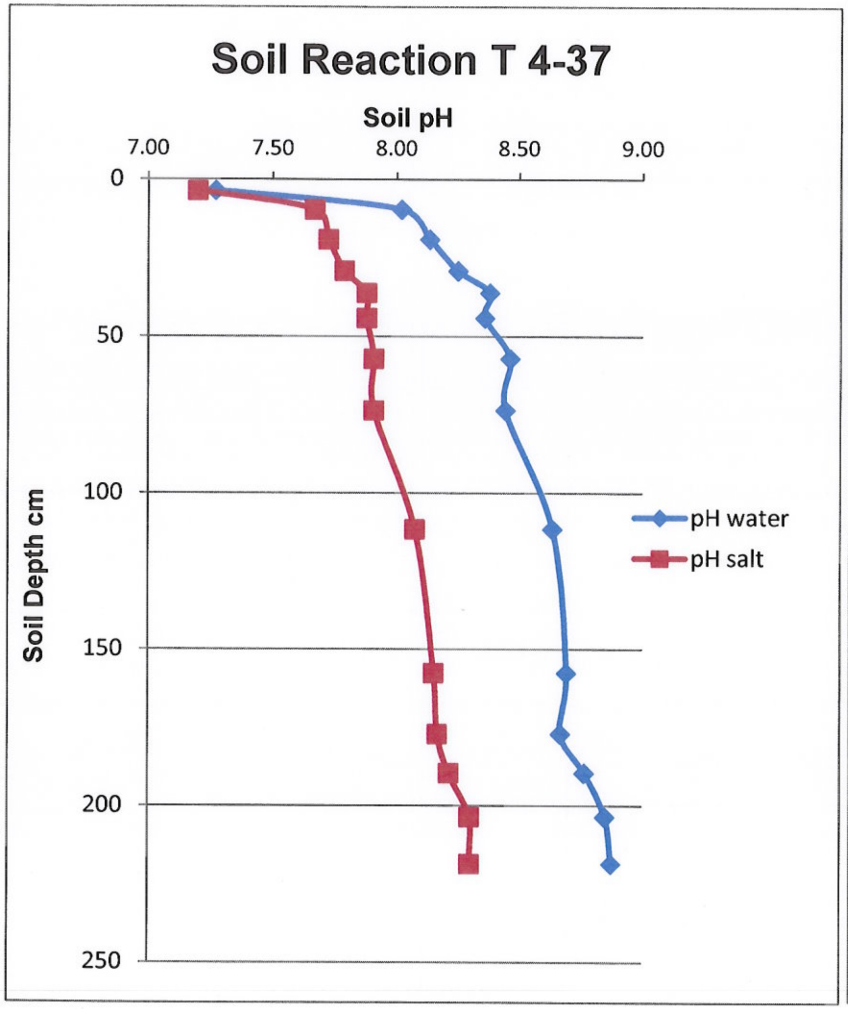


Figure D.36 Depth distribution diagrams of soil reaction and organic carbon for Transect 4, pedon 36



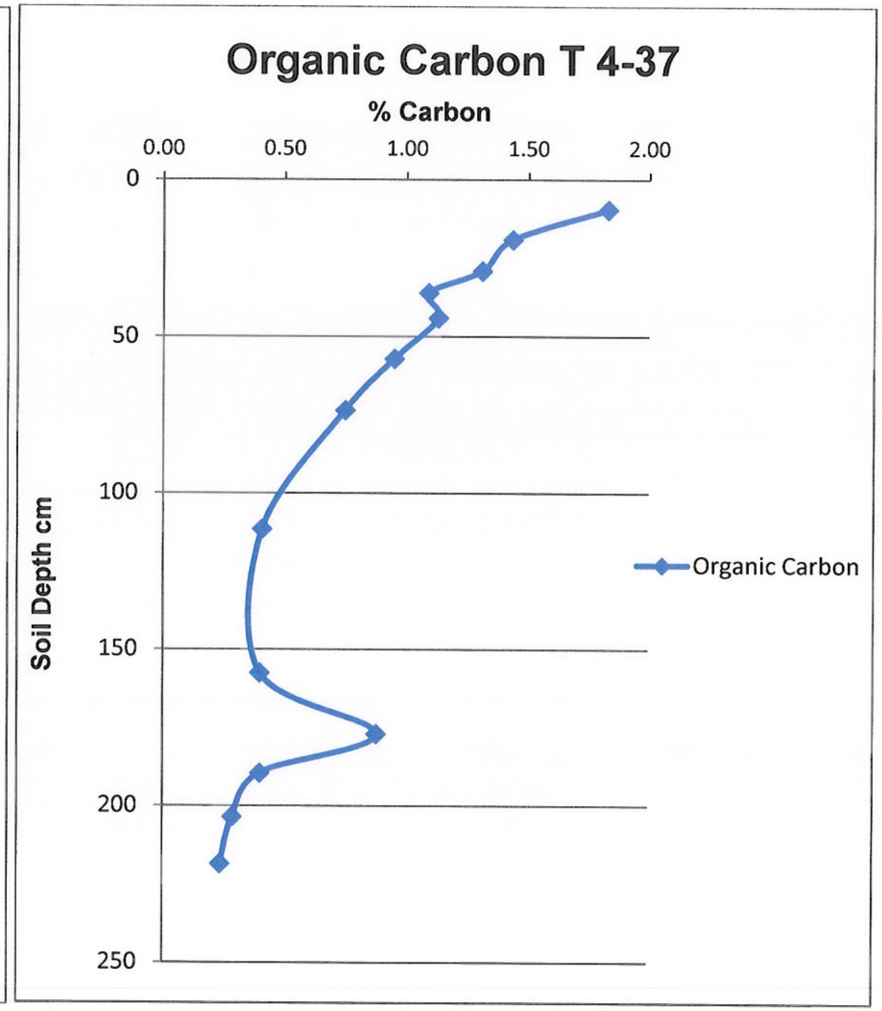


Figure D.37 Depth distribution diagrams of soil reaction and organic carbon for Transect 4, pedon 37

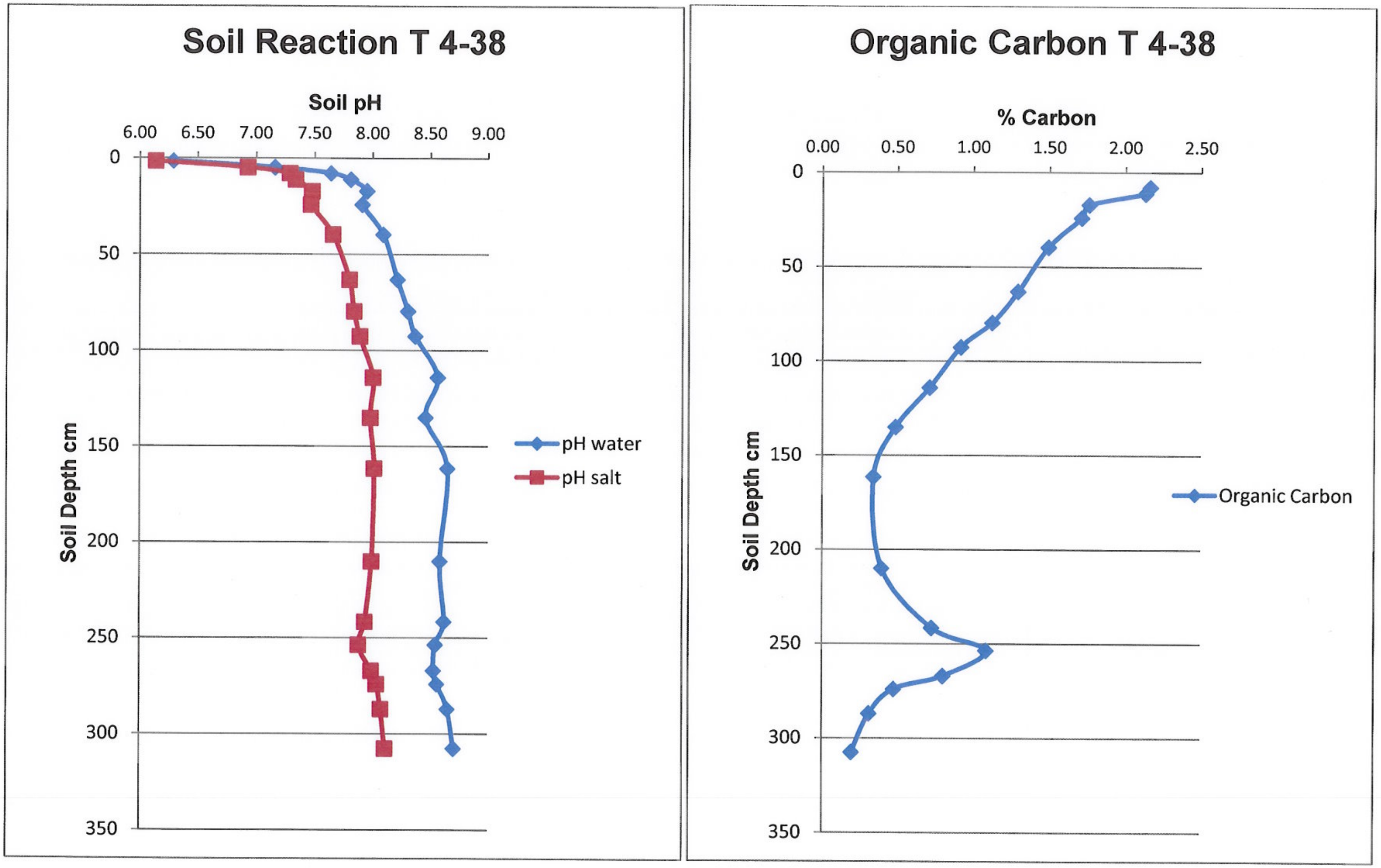
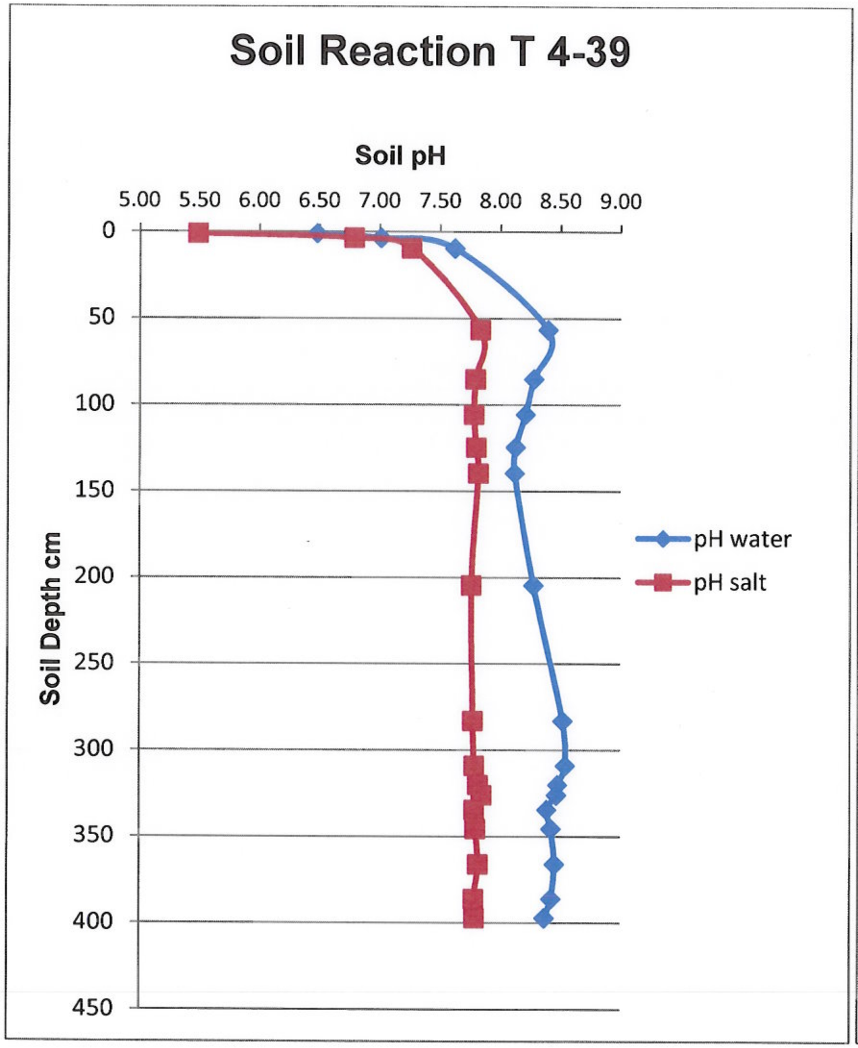


Figure D.38 Depth distribution diagrams of soil reaction and organic carbon for Transect 4, pedon 38



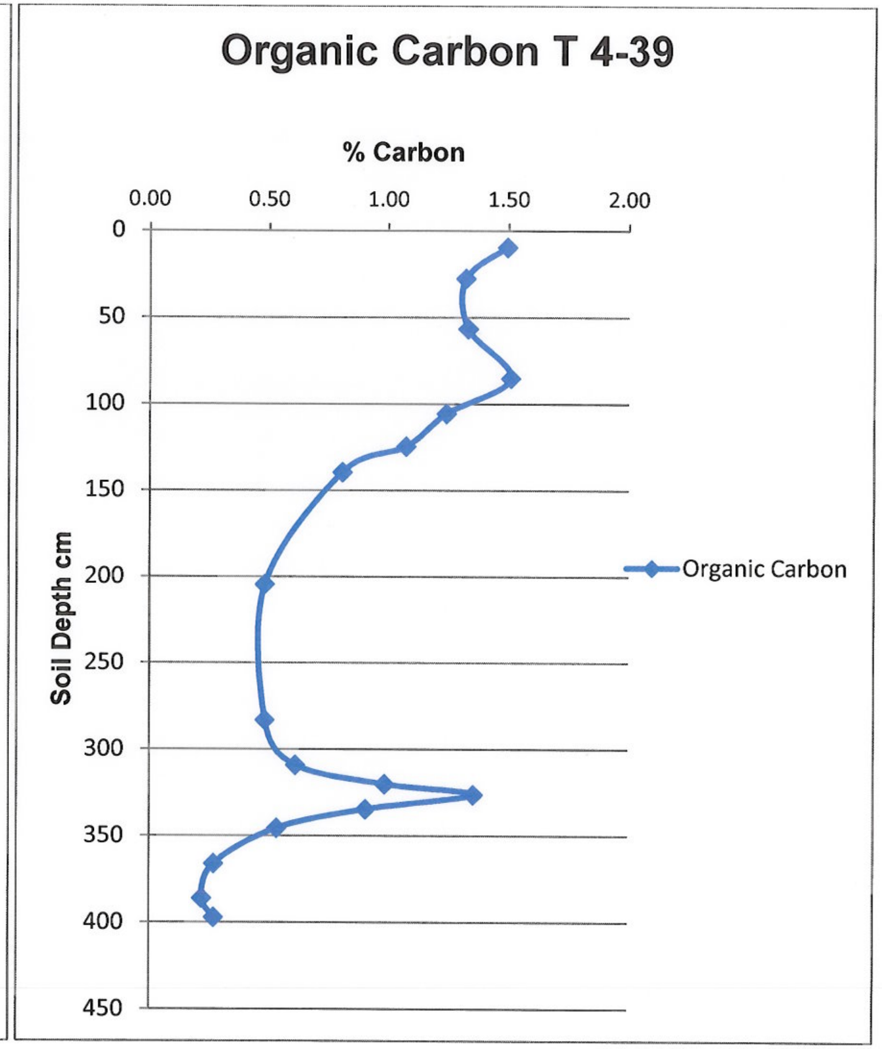


Figure D.39 Depth distribution diagrams of soil reaction and organic carbon for Transect 4, pedon 39

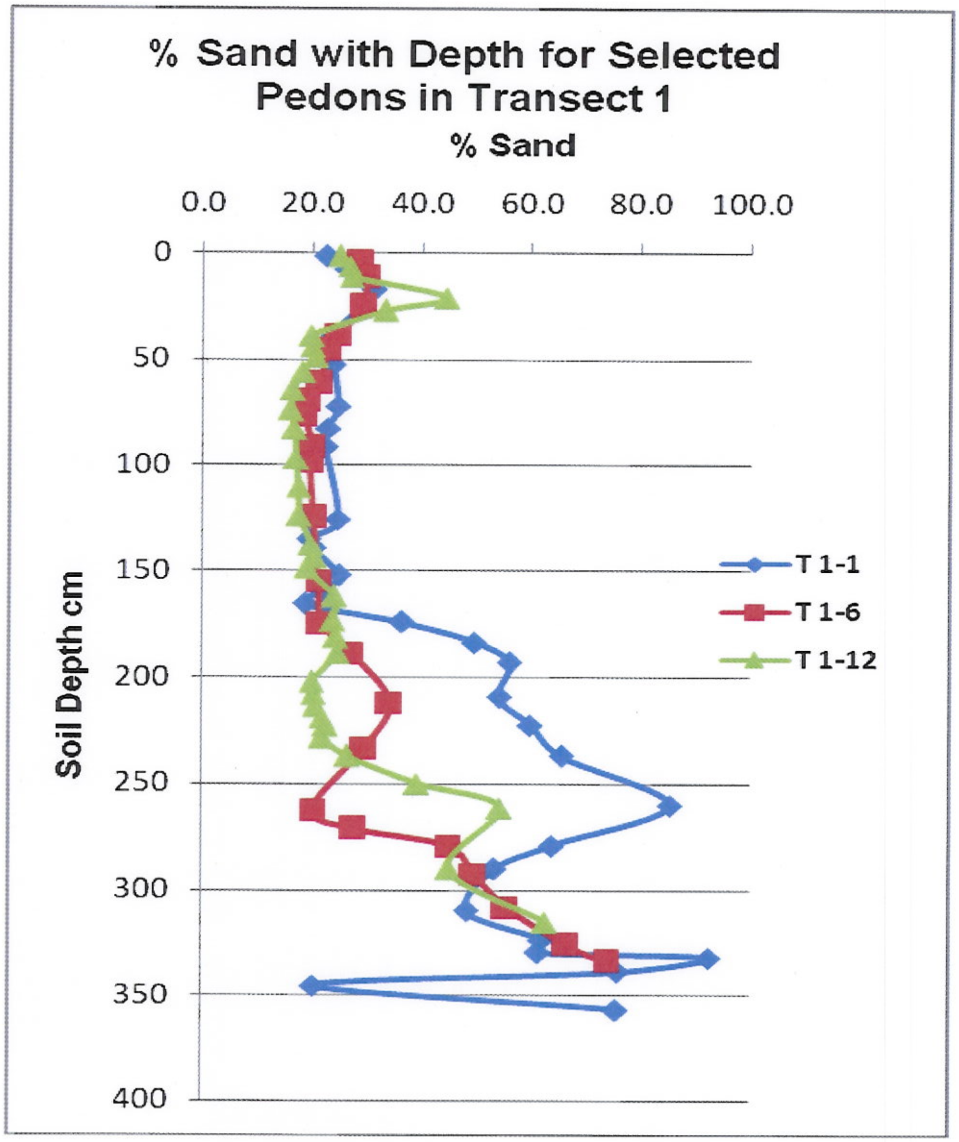


Figure D.40 Depth distribution diagram of percent sand for selected pedons in Transect 1 (pedons 1, 6 and 12)

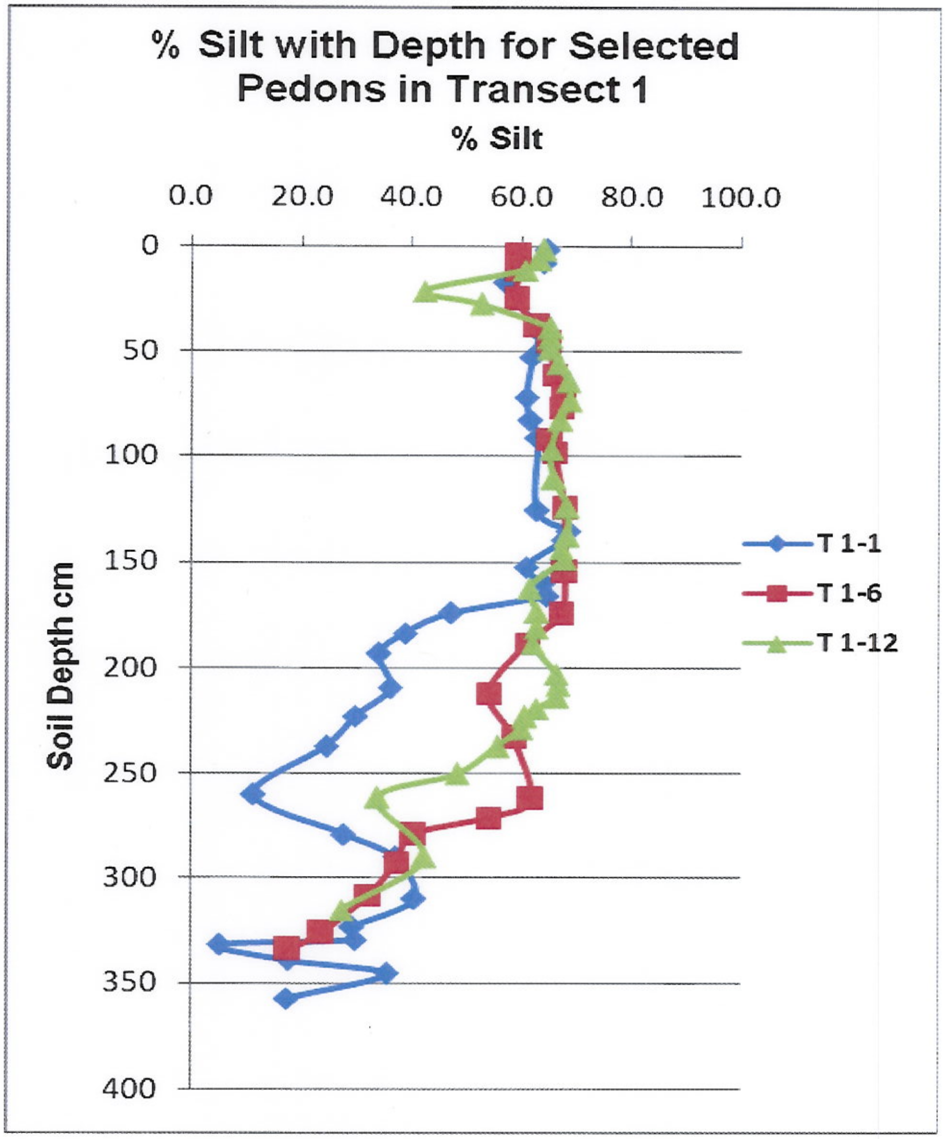


Figure D.41 Depth distribution diagram of percent silt for selected pedons in Transect 1 (pedons 1, 6 and 12)

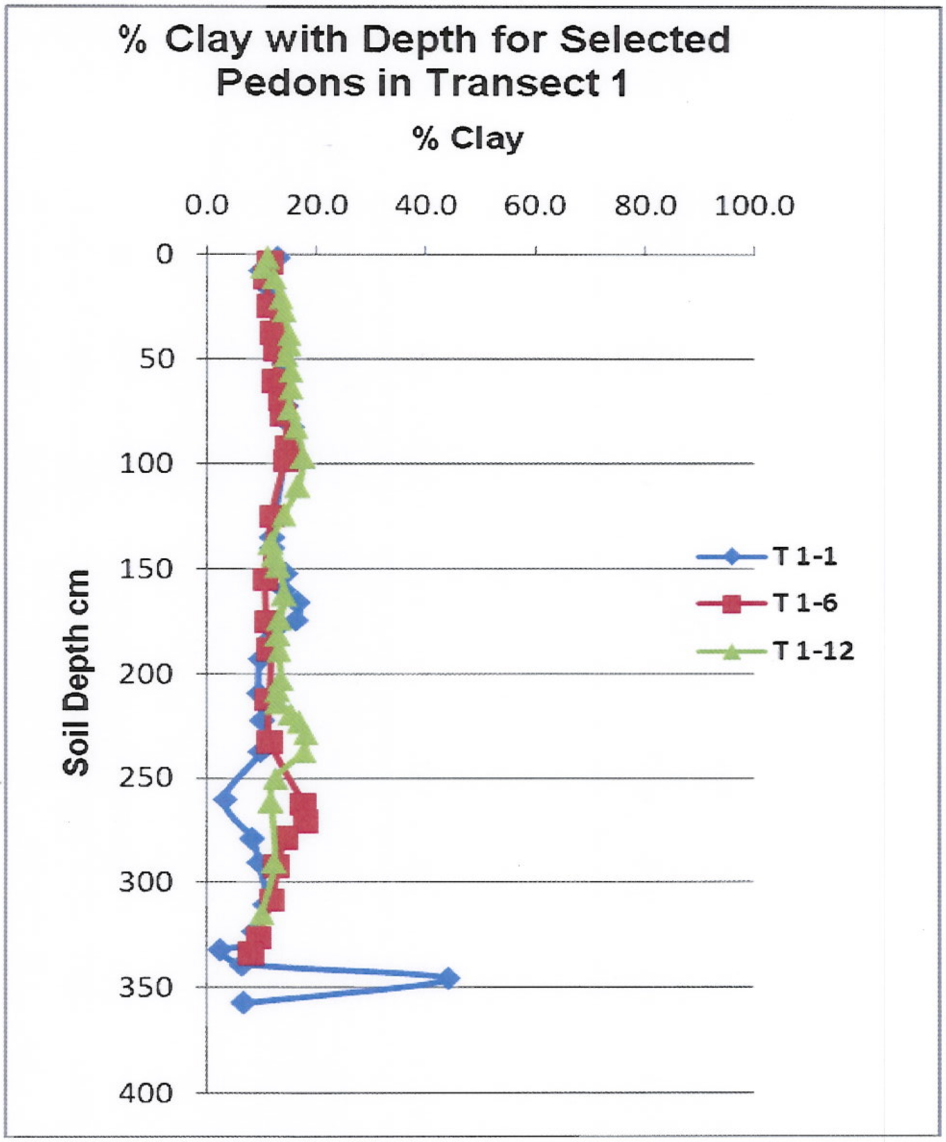


Figure D.42 Depth distribution diagram of percent clay for selected pedons in Transect 1 (pedons 1, 6 and 12)

APPENDIX E

Table E.1 Comparison of Area (m^2) Height (m) and Volume (m^3) for mounds by location. Data from Ahler (2003) and the third iteration model from this study. Mound volume from this study is approximately 60% greater than the volume by Ahler.

			Ahler 2003			Frey 2011		
Size Class	Mound	Location	Area m^2	Height m	Volume m^3	Area m^2	Height m	Volume m^3
small	U	core	201.87	0.596	50.11	218.00	0.72	80.66
small	T	core	169.01	0.765	53.85	171.25	0.93	90.65
TOTAL for Core Residential mounds:					**103.96**			**171.31**
small	II	outer	87.53	0.338	12.32	17.50	0.23	2.07
small	K	outer	200.00	0.260	16.00	251.00	1.10	158.13
small	FF	outer	147.06	0.336	20.58	86.25	0.66	24.79
small	W	outer	116.43	0.496	24.05	111.75	0.47	28.65
small	HH	outer	104.25	0.695	30.18	103.50	1.21	56.07
small	X	outer	135.46	0.630	35.54	125.75	0.51	28.98
small	Z	outer	128.91	0.673	36.13	96.50	0.91	62.29
small	Q	outer	345.54	0.265	38.13	[no longer classified as a mound]		
small	DD	outer	187.17	0.526	41.01	161.00	0.65	45.24
small	P2	outer	254.12	0.410	43.39	271.00	0.90	157.67
small	EE	outer	213.43	0.607	53.96	134.00	0.65	54.28
medium	D2	outer	336.89	0.520	72.96	280.50	0.99	188.78
medium	BB	outer	356.29	0.560	83.10	40.25	0.09	1.90
medium	CC	outer	288.55	0.800	96.14	255.25	0.57	75.42
medium	S	outer	304.62	0.930	117.99	328.50	1.38	241.59
medium	GG	outer	254.50	1.142	121.05	167.00	1.03	84.26
medium	P1	outer	457.82	1.070	204.03	539.25	1.16	562.25
medium	J	outer	666.56	0.840	233.20	439.00	1.32	260.74
large	B	outer	589.38	1.410	346.12	696.75	2.01	701.92
large	I2	outer	507.71	1.710	361.60	547.00	1.91	494.16
large	JJ	outer	570.28	1.595	378.85	690.25	1.87	678.41
medium	D1	outer/periph.	528.92	0.977	215.23	507.75	1.47	435.04
TOTAL for Outer Residential Area mounds:					**2581.56**			**4342.64**
small	M	periphery	118.55	0.113	5.58	156.00	0.31	36.21
small	L	periphery	133.26	0.150	8.33	148.25	.034	32.53
small	AA	periphery	102.81	0.300	12.85	128.00	0.97	52.55
small	O	periphery	139.41	0.350	20.32	116.25	1.16	119.90
small	A2	periphery	101.81	0.570	24.17	120.25	1.43	110.01
small	KK	periphery	198.23	0.392	32.36	165.00	0.70	60.12
small	C2	periphery	292.45	0.290	35.23	243.75	0.61	94.88
small	N	periphery	169.99	0.550	38.94	170.00	0.74	59.15
small	V	periphery	212.90	0.556	49.30	251.00	1.03	155.92
medium	Y	periphery?	213.69	1.140	101.46	211.75	1.75	208.86
medium	F	periphery	300.71	1.250	156.56	431.75	1.51	246.08
medium	H	periphery	327.60	1.357	185.16	309.00	1.72	257.13
large	I1	periphery?	395.89	1.247	205.62	423.25	1.47	300.22
large	A3	periphery	484.92	1.68	339.31	452.25	1.52	389.76
large	G	periphery	693.43	1.45	418.78	694.50	1.57	562.95
large	A1	periphery	688.54	1.770	507.59	709.50	2.66	980.07
large	C1	periphery	967.83	1.806	728.00	1205.00	2.43	1190.95
large	E	periphery	919.84	2.170	831.36	1132.75	2.61	1133.51
TOTAL for mounds located near ditch 2 and outward:					**3700.92**			**5990.80**
GRAND TOTAL					**6386.44**			**10524.75**

Table E.2 Comparison of Area (m^2), Height (m) and Volume (m^3) for mounds, sorted by size class (increasing volume) and location. Comparison of the 3rd iteration paleo-topography data with data generated with final pre-occupation topographic model.

			Frey final iteration			Frey 3rd interation		
Size Class	Mound	Location	Area m^2	Height m	Volume m^3	Area m^2	Height m	Volume m^3
small	U	core	218.50	0.75	81.19	218.00	0.72	80.66
small	T	core	153.25	0.70	55.80	171.25	0.93	90.65
TOTAL for Core Residential Mounds:					**136.99**			**171.31**
small	II	outer	14.75	0.23	1.70	17.50	0.23	2.07
small	K	outer	233.50	0.58	58.65	251.00	1.10	158.13
small	FF	outer	87.25	0.76	33.09	86.25	0.66	24.79
small	W	outer	120.75	0.74	61.06	111.75	0.47	28.65
small	HH	outer	102.25	1.22	56.10	103.50	1.21	56.07
small	X	outer	190.00	1.03	124.89	125.75	0.51	28.98
small	Z	outer	86.25	0.39	15.19	96.50	0.91	62.29
small	Q	outer	[no longer classified as a mound]			[no longer classified as a mound]		
small	DD	outer	95.00	0.41	17.42	161.00	0.65	45.24
small	P2	outer	248.00	0.78	106.75	271.00	0.90	157.67
small	EE	outer	69.25	0.25	8.73	134.00	0.65	54.28
medium	D2	outer	280.75	1.37	294.56	280.50	0.99	188.78
medium	BB	outer	173.25	0.38	32.37	40.25	0.09	1.90
medium	CC	outer	183.75	0.50	42.98	255.25	0.57	75.42
medium	S	outer	297.25	1.00	119.92	328.50	1.38	241.59
medium	GG	outer	196.00	1.40	154.65	167.00	1.03	84.26
medium	P1	outer	538.25	1.71	481.58	539.25	1.16	562.25
medium	J	outer	118.50	0.45	21.93	439.00	1.32	260.74
large	B	outer	599.25	1.56	407.99	696.75	2.01	701.92
large	I2	outer	389.25	1.39	259.35	547.00	1.91	494.16
large	JJ	outer	690.75	2.21	840.93	690.25	1.87	678.41
medium	D1	outer/periph.	508.00	1.84	593.06	507.75	1.47	435.04
TOTAL for Outer Residential Area Mounds:					**3732.90**			**4342.64**
small	M	periphery	156.00	0.31	37.18	156.00	0.31	36.21
small	L	periphery	148.50	0.36	33.94	148.25	.034	32.53
small	AA	periphery	130.00	0.97	68.91	128.00	0.97	52.55
small	O	periphery	115.75	1.22	113.90	116.25	1.16	119.90
small	A2	periphery	112.00	1.13	68.14	120.25	1.43	110.01
small	KK	periphery	165.00	0.68	58.89	165.00	0.70	60.12
small	C2	periphery	244.00	0.78	142.76	243.75	0.61	94.88
small	N	periphery	169.50	0.88	82.11	170.00	0.74	59.15
small	V	periphery	251.00	1.07	158.71	251.00	1.03	155.92
medium	Y	periphery?	186.00	1.11	78.69	211.75	1.75	208.86
medium	F	periphery	431.75	2.10	487.05	431.75	1.51	246.08
medium	H	periphery	214.50	1.16	105.16	309.00	1.72	257.13
large	I1	periphery?	394.00	1.10	172.38	423.25	1.47	300.22
large	A3	periphery	394.00	1.19	224.42	452.25	1.52	389.76
large	G	periphery	693.00	1.81	627.33	694.50	1.57	562.95
large	A1	periphery	701.75	2.56	926.86	709.50	2.66	980.07
large	C1	periphery	1205.00	2.63	1413.97	1205.00	2.43	1190.95
large	E	periphery	1132.00	2.52	1116.99	1132.75	2.61	1133.51
TOTAL for Mounds located near Ditch 2 and outward:					**5799.61**			**5990.80**
GRAND TOTAL					**9669.50**			**10524.75**

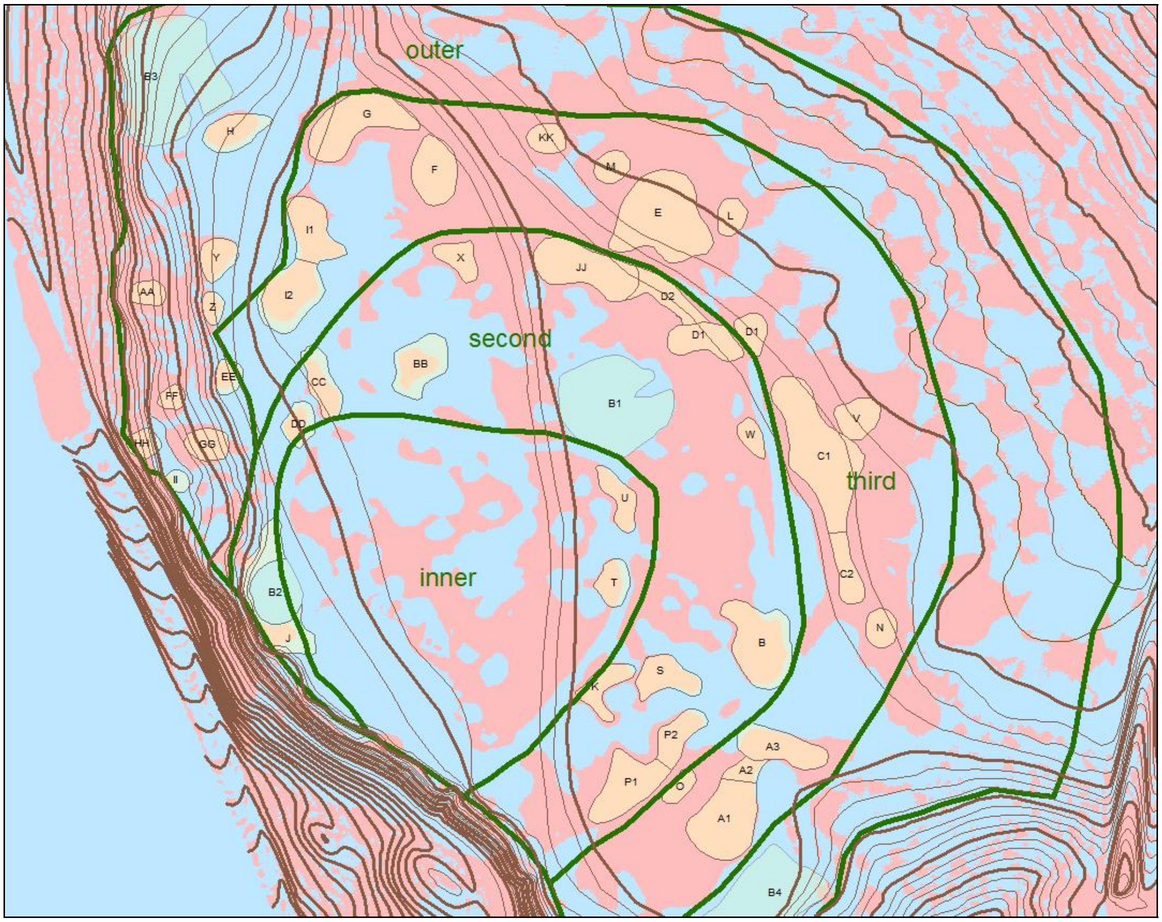


Figure E.1 Areas of borrow and fill relative to grade, where grade is defined as pre-occupation surface elevation minus present-day surface elevation. Borrow areas are light blue; fill areas are pink. Present-day mounds show as light orange and are labeled; present-day borrow basins are light green and are labeled. Paleo-topography 25 cm contour lines are brown. Figure is labeled with Inner, Second, Third and Outer areas as used in this study. Inner corresponds to the Core (or Core Residential) Area; Second corresponds to Outer (or Outer Residential) Area; Third corresponds to the area between Ditch 2 and Ditch 4, all as used for the archaeological investigation by Ahler and Swenson. Outer designates the Area of Interest for this study, designed to capture areas of potential planar borrowing outside the known village perimeter.

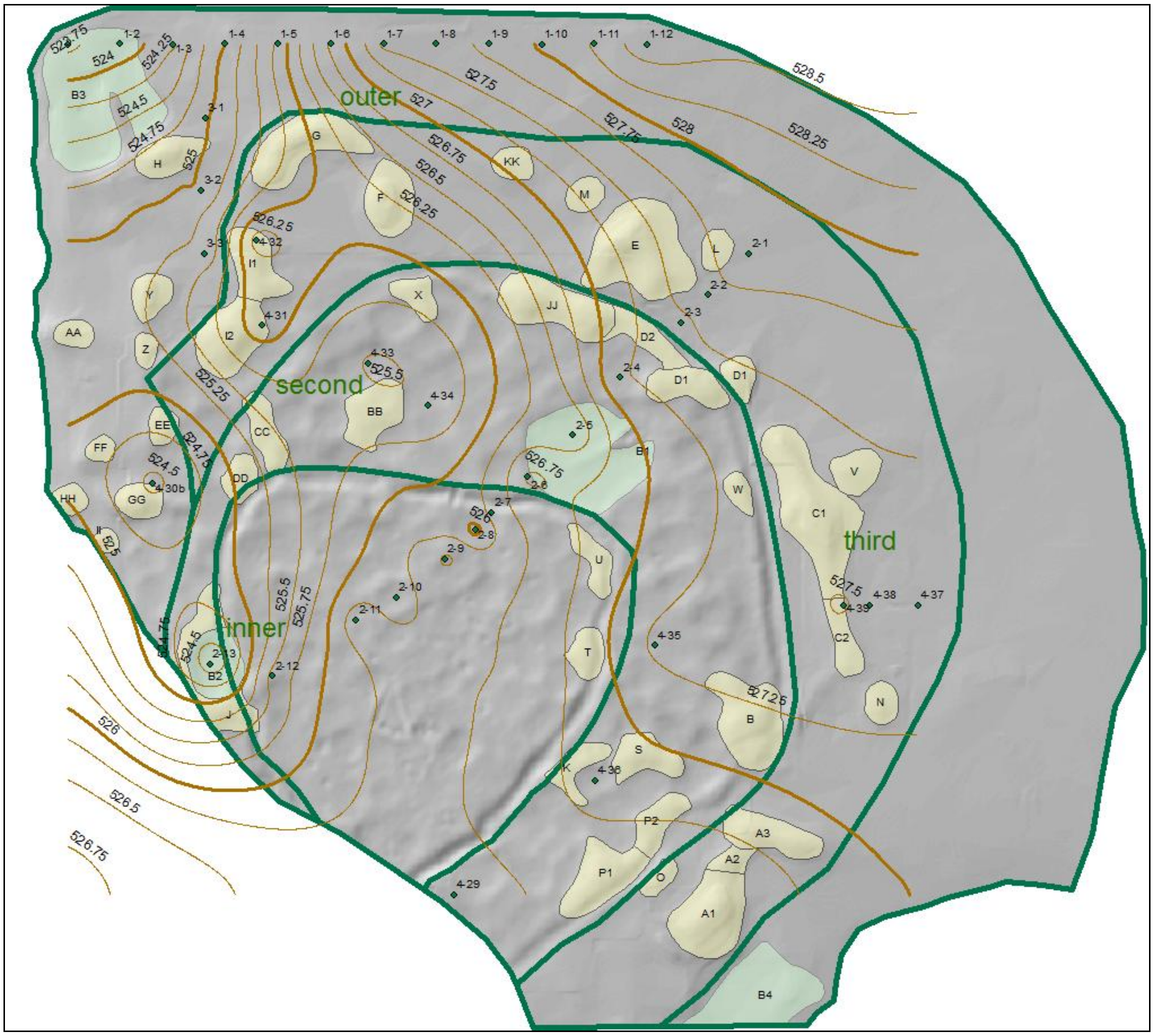


Figure E.2 Paleosol surface elevations with mounds, borrows and soil pedon locations on a hillshade underlay. A 25 cm contour interval map of the modeled elevation of the paleosol surface, as documented in detailed profile descriptions. Contours are more accurate near pedon locations; pedon data was scant in the southern portion of the study area.

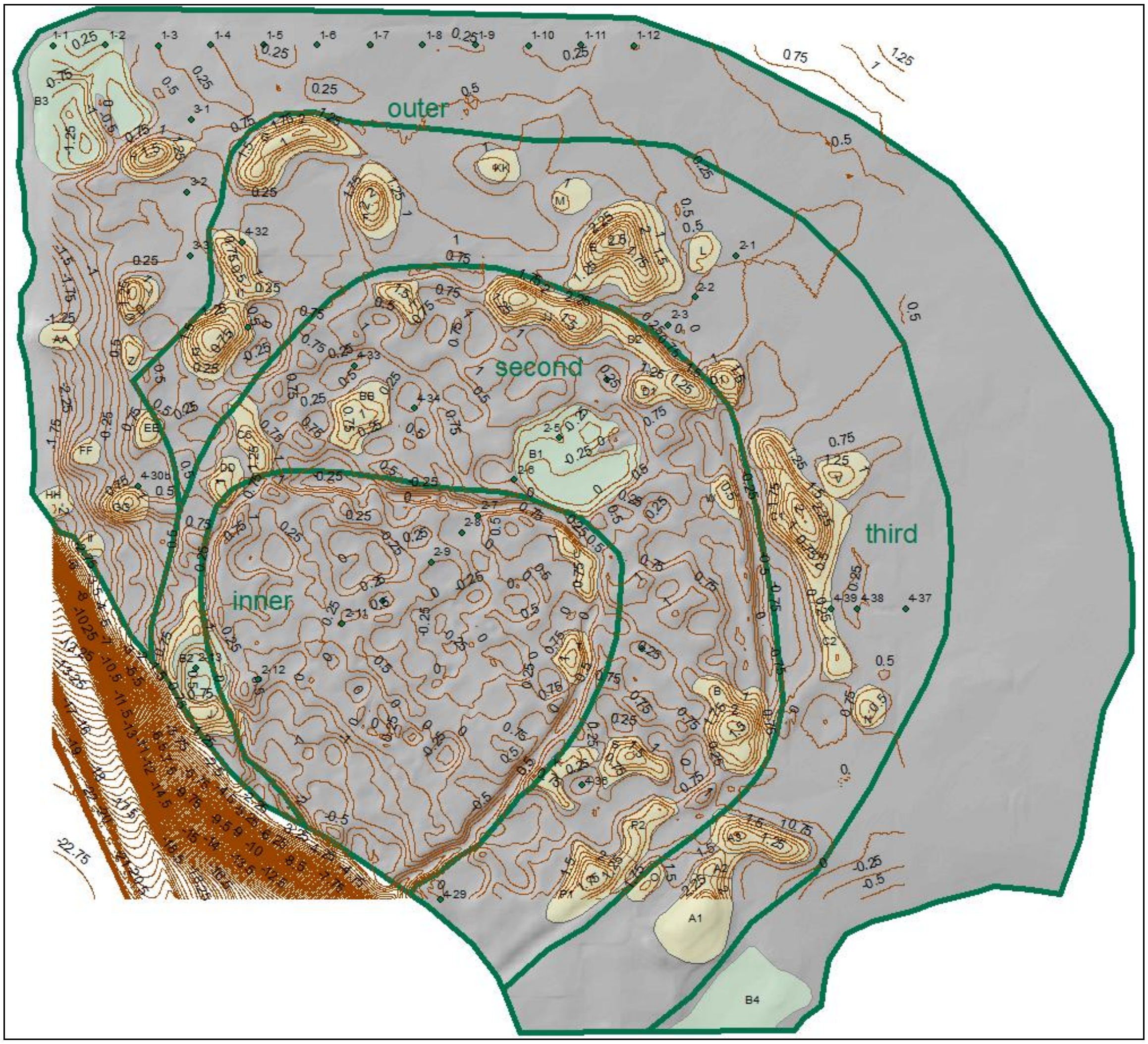


Figure E.3 Elevation difference between the present-day surface and the paleosol surface, as documented in detailed profile descriptions (25 cm contour interval).

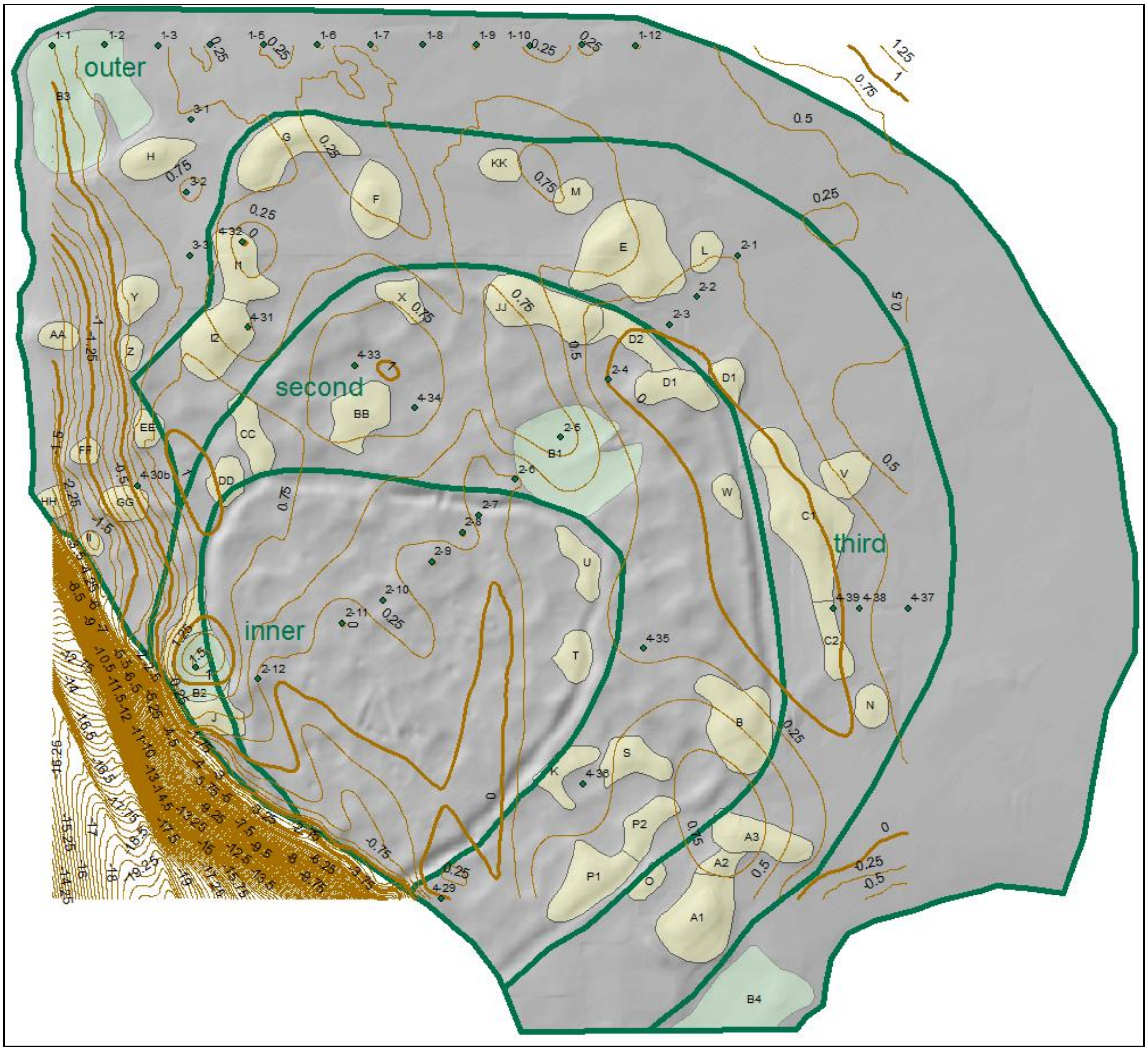


Figure E.4 Elevation difference between the reconstructed pre-occupation surface and the paleosol surface (25 cm contour interval). The zero (0) difference contour lies around or through mounds W, D2, C.

APPENDIX F

Figure E.1 *Threshasaurus northdakotaensis woodii*. The author was fortunate to capture this rare creature on film. Thought to perhaps be a descendant of megafauna that roamed North Dakota in the Late Wisconsinan or Early Holocene, Threshasaurs are solitary creatures who subsist primarily on the seeds of grassy vegetation. Named after Dr. W. R. "Ranger Ray" Wood who has a monograph (unpublished) on the creature's habits and lifeways (W. R. Wood, pers. comm.)