The Wolf Willow Site: A Geoarchaeological Perspective

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Abstract

The Wolf Willow site is a multi-component archaeological site located within the Opimihaw Creek Valley at Wanuskewin Heritage Park, which lies approximately three kilometres northeast of Saskatoon, Saskatchewan. Excavation of the site began in 2010 by the University of Saskatchewan Department of Archaeology and Anthropology field school, with the participation of the Saskatchewan Archaeological Society field school. A Master of Arts thesis examining the outcome of the first two field seasons is currently being completed by M. Mampé.

An analysis of the assemblage from the 2012 and 2013 field seasons comprises this thesis. Four distinct cultural levels are denoted by unique corresponding projectile point complexes and series. The absence of lithic materials in Level 5 has led to it being described as "non-cultural". The four projectile point complexes and series found at the site include: Plains Side-Notched, Prairie Side-Notched, McKean Series, and Oxbow complex. Due to the significant gap in occupational progression that exists between the Prairie Side-notched and McKean Series occupation levels, it was decided that a geoarchaeological investigation of the site be undertaken to ascertain the geomorphological reasons for its occupational discontinuity as well as provide an overview of site formation processes at the Wolf Willow site.

The "hiatus" in cultural occupations at the Wolf Willow site spans approximately 1000 years, from 2500 years B.P. to 1200 years B.P., and is manifested by a discrete sedimentary unit comprised mainly of coarse sand and gravel. It is known from research pertaining to other sites within the Opimihaw Creek valley that hillslope activity began at approximately 7000 years B.P. and slowed nearly 4000 years later. Although no regional analog for landscape instability exists for the period between 3000 and 1200 years B.P., climatic proxy data in the form of stable hydrogen isotopes from bison bone and tooth enamel samples effectively bridge the gap. Furthermore, the composition of sediments gleaned from landforms similar to that on which the Wolf Willow site currently lies show little similarity to one another. These gaps in the research record of the Opimihaw Creek valley make climatic, environmental, and sedimentological correlations difficult on a regional scale, and highlight the importance of implementing geoarchaeology in the interpretation of the Wolf Willow site.

Acknowledgements

On a personal note, I would first like to thank Dr. Ernie Walker for his encouragement and guidance throughout these past few years. Had I not been so enthralled by my first field school under his instruction, I am unsure that I would have taken on such a project. I would also like to thank my committee for their patience and help when I needed them most. Especially Dr. Aitken, who not only allowed me unfettered access to his sediment lab, but also made himself available to consult with when I needed help or advice.

To the dozens of students and volunteers who participated in excavations between 2012 and 2014; thank you all so much for your hard work. I could not have collected the immense body of cultural data amassed in this thesis on my own. I would also like to thank those students who also became volunteers when they were needed to help finish excavations, and also to those who helped wash artifacts following the summer field schools.

I would be remiss if I didn't thank all those close friends, family members, and fellow grad students who kept me going over the past few years. Every cup of coffee, every reassuring phone call, and every word of encouragement you shared with me was appreciated more than you know. Finally, thank you to the love of my life, Kathalene Willis; completing a quest is an auspicious start for an adventure.

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Chapter 1: Introduction

1.1: Introduction

Wolf Willow, an archaeological site on which this thesis is focused, is one of 19 identified Precontact sites located within the boundaries of Wanuskewin Heritage Park. It is also the ninth, and most recent, site to be excavated in the park. The Wolf Willow site is defined as a multi-component site due to the presence of four cultural levels. Diagnostic projectile points have also been recovered from each level. Excavation began at the Wolf Willow site in May of 2010 as part of the University of Saskatchewan Department of Archaeology and Anthropology field school.

As of August 2015, 96m^2 units had been excavated. Including this thesis, the Wolf Willow site has formed the basis of three Master's theses from the University of Saskatchewan, the first two being authored by Maria Mampé and Elsa Taylor. However, it is important to note that Elsa Taylor's thesis was only concerned with McKean Series lithics from the site, whereas the works of Mampé and this author were concerned with the cultural material from each cultural level at the site. This thesis also focuses on the relationship between deposition of cultural materials and the deposition or erosion of sediments from the site over time.

1.2: Thesis Objectives

This thesis addresses several objectives through both artifactual and sedimentary analyses of materials gleaned from the 2012 and 2013 excavations at the Wolf Willow site:

1) To analyze and describe artifacts from each cultural level;
2) To examine basic spatial relationships of artifacts and features within the site in order to determine how the site was used by its occupants over time;
3) To determine which lithic types and faunal taxa were used by occupants of the site;
4) To determine the processes responsible for the deposition of a gravel lens between Cultural Level 2 and Cultural Level 3;
5) To determine the processes responsible for the deposition of sedimentary matrices of cultural levels;

6) To compare the depositional chronology of the Wolf Willow site with that of the Thundercloud site, in order to better explain how the Opimihaw Valley has been shaped over the last 6,000 years.

1.3: Thesis Organization

Including this introduction, this thesis has 8 chapters. Chapter 2 provides a more detailed overview of the biophysical environment of the Wolf Willow site; including the history, geology, hydrology, geomorphology, and floral and faunal resources of the study area. Chapter 3 chronicles the cultural chronology of Saskatchewan from the Early Precontact period to the time of European contact. Chapter 4 summarizes the field and laboratory methodologies employed in the collection and analysis of the data presented in this thesis. Chapter 5 presents the Wolf Willow site's stratigraphy as well as radiocarbon dates obtained from those strata. Chapter 6 contains detailed information pertaining to the artifacts that were recovered from the Wolf Willow site and includes artifact photographs and distribution maps. Chapter 7 presents all sedimentary data gleaned from the Wolf Willow site, from the Witness Block profile and unit 25S 16E, respectively. Chapter 8 discusses the sedimentary data in relation to the cultural and natural stratigraphy of the Wolf Willow site and suggests avenues for further study.

Chapter 2: The Biophysical Environment of the Wolf Willow site

2.1 History of the Study Area

The Opimihaw Creek valley, formerly known as the Tipperary Creek valley, is an area of great biological diversity, geological complexity, and archaeological interest. Members of the Saskatoon Archaeological Society first began visiting the area in 1932 when Thad C. Hecker, a representative of the North Dakota State Historical Society, carried out two small excavations in 1946 and 1952. Thomas F. Kehoe conducted an excavation while he was affiliated with the Saskatchewan Museum of Natural History in the 1960s. Z.S. Pohorecky directed a group of students from the University of Saskatchewan for his test excavations in 1965. Dr. Ernie Walker conducted an archaeological survey of the valley in 1982 and 1983, identifying two historic and 19 prehistoric sites (Walker 1988a). The Wolf Willow site was one of the sites identified in this survey (see Figures 2.1, 2.2 below). A long-term research strategy was established in 1984 in order to facilitate the excavation of sites at Wanuskewin in a systematic fashion. Since that time, excavations have been undertaken by University of Saskatchewan students under the direction of Dr. Ernie Walker. The Saskatoon and Saskatchewan Archaeological Societies have also played a recurring role in excavations at Wanuskewin since 1984 on a more limited basis. This long-term research initiative continues to this day and has served as the core of the development of Wanuskewin Heritage Park as a whole.

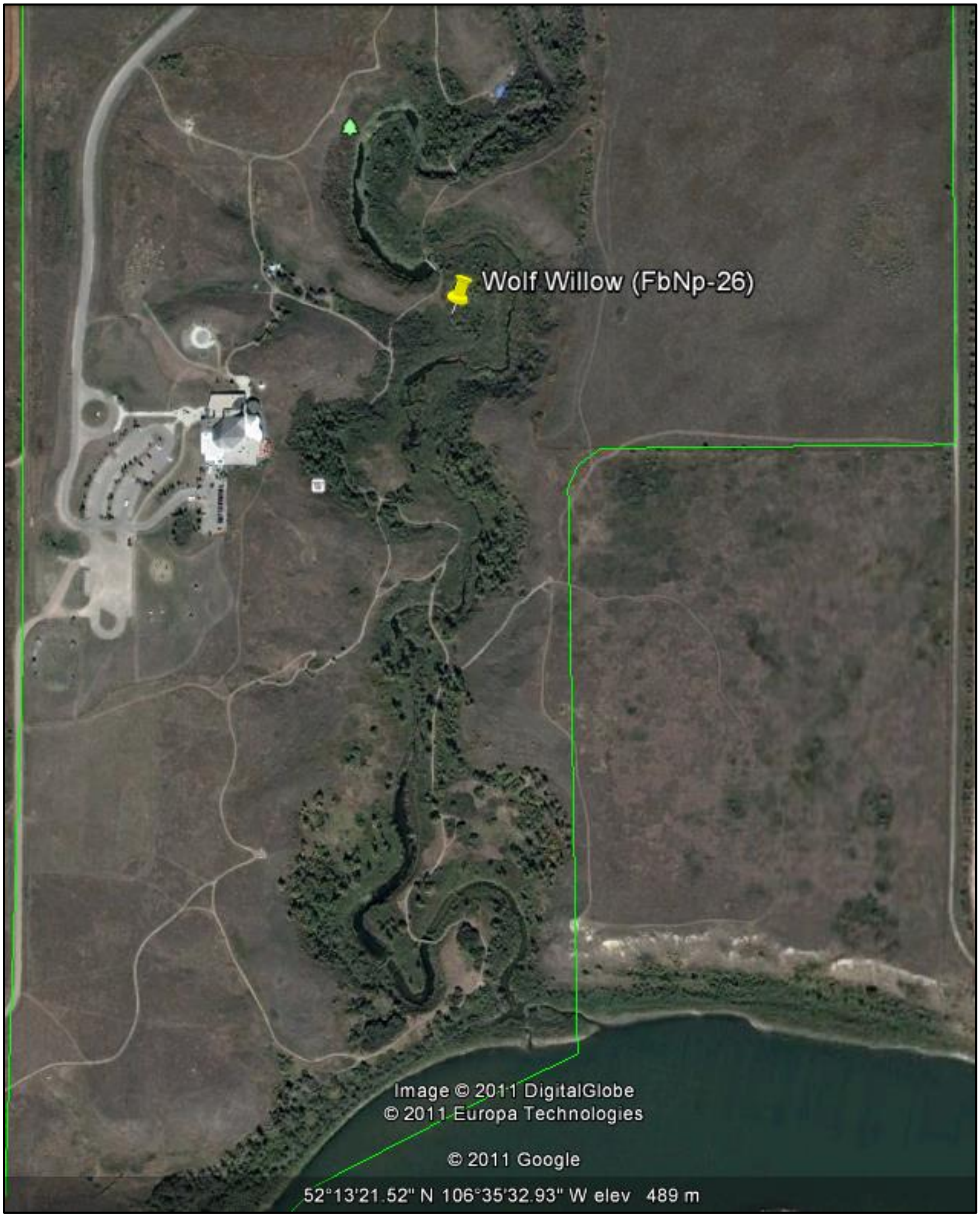

Figure 2.1**:** Location of the Wolf Willow site within the Opimihaw valley.

Figure 2.2: The Wolf Willow site facing northwest before excavations began in May 2010. Note the charred shrubs at right in the photo.

2.2 Geophysical Setting

In order to understand the modern conditions and processes at work in the Opimihaw valley, past processes must first be explained. It has been suggested by Christiansen (1968) that four glaciation events occurred in the Saskatoon area before 12,000 years B.P. Tills from the early and middle Pleistocene, comprised by formations in the Sutherland Group, are overlain by tills belonging to the Saskatoon Group. Formations belonging to the Saskatoon Group include the Floral and Battleford formations, the latter of which was the last till deposited during the last ice age, and is itself overlain by stratified glaciolacustrine deposits and soil (Christiansen 1992). Since the deposition of tills belonging to the Battleford Formation, a suite of processes have altered their original placement and form. As the glaciers receded, vast quantities of water flowed away from their margins creating braided stream channels which drained into ice-dam lakes such as Glacial Lake Saskatchewan and Glacial Lake Agassiz. Sediments associated with braided channels tend to be coarse-grained as smaller particles such as sand, silt and clay are easily swept downstream by the rapidly-flowing rivers. Once these channels entered gathering basins such as Glacial Lake Saskatchewan, their flow regimes shifted from concentrated high flow to expanded flow. This decrease in flow velocity caused the sediments suspended in the moving rivers to settle out and deposit themselves on the bottom of the lake.

Due to the fact that the Saskatchewan Rivers Plain lies above the current level of the river and because certain areas of these uplands contain sediments indicative of glaciolacustrine environments, such as silts associated with lakebeds and sands associated with river deltas flowing into lakes (Skwara 1988), it is evident that the South Saskatchewan River experienced a period of incision following the draining of Glacial Lake Saskatchewan.

The Opimihaw valley lies within the physiographic region known as the Saskatchewan Rivers Plain. More specifically, it is incised into a sub-section of that region known as the Warman Plain. This region is characterized by "undulating, eroded till plains and gravelly glacio-fluvial plains" (Acton & Ellis 1978: 5). The Opimihaw valley began its formation approximately 12,000 years ago following the retreat of Glacial Lake Saskatchewan to the north. As previously mentioned, the base level of the South Saskatchewan River decreased in elevation as it incised into what had once been the bottom of a glacial lake. From the sedimentary analysis carried out by Acton and Ellis (1978), it is known that a glacio-fluvial channel once existed parallel to the modern South Saskatchewan River. This channel deposited coarse gravels, which still litter the uplands surrounding the Opimihaw valley. A low-lying area to the northwest of the Opimihaw valley, known as the Hudson Bay slough, formed following the abandonment of this alternate channel of the glacial spillway phase of the South Saskatchewan River and has served as a water collection area since that time as evidenced by the presence of a well-established wetland. During times of intense precipitation or spring runoff, excess water in this area flows toward the Opimihaw valley and into Opimihaw Creek. In times of drought, the geology of the area allows groundwater to continue to support the creek by way of gravity springs which emerge from the hills at the head of the valley. As the base level of the South Saskatchewan River lowered, water from the surrounding upland areas had to travel further vertically in order to drain. As can be seen in the case of the Opimihaw valley, the forces involved in the downward transportation of water can effect significant changes on landscapes.

As mentioned, the sediments around the margins of the valley reflect a glacial past as matrix-supported gravels generally comprise the parent material of the valley slopes. In the valley bottom, fluvial and alluvial processes have sculpted numerous landforms which were attractive areas for human occupation in the last 6,000 years. Chief among these landforms are point bar deposits created by the migration of the Opimihaw Creek's channel over the last 7000 years. As a result of this mixture of erosional and depositional processes, there is an interesting progression of sediments in the valley bottom. At the Wolf Willow site for example, which is situated on such a point bar, there are alternating layers of sand, clay, sorted gravel and debris, alluding to radical changes in stream morphology and flow regime over time. Poorly-rounded clast shapes in some of the layers (see Figure 2.3) may indicate the inclusion of hillslope sediments into this profile either directly through mass wasting processes, or indirectly through erosion and fluvial transport from further up the valley. Intensive analysis of these sediments will follow in the later sections of this thesis in order to determine their true nature.

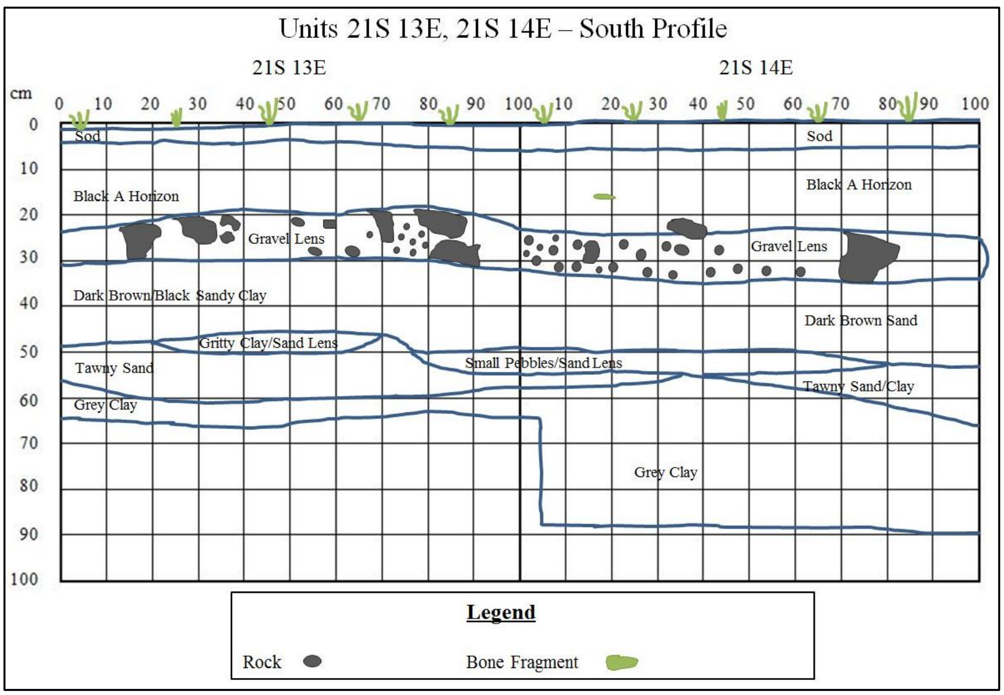

Figure 2.3: Stratigraphic profile of the south wall of units 21S 13E and 21S 14E at the Wolf Willow site. Note the gravel lens between approximately 20 and 35cm below the surface.

2.3 Climate

According to the Köppen system, the Saskatoon area falls on the border between two climate regimes (Strahler & Strahler 2002). The first of these is a semiarid climate (Köppen designation Bsk) which is characterized by a water deficit where average evaporation exceeds average precipitation on a yearly basis. Semiarid climatic zones are also characterized by the presence of grasslands and relatively cold mean annual temperatures.

The second climate regime bordering the Saskatoon area is the moist snowy-forest climate (Köppen designation Dfb). This regime is characterized by warm summers and the absence of a dry season as precipitation levels are adequate year-round. The presence of a forest biome is also required for this designation. Due to the fact that the Saskatoon area is situated near the aspen parkland zone where forested areas and grasslands lie beside one another, it is logical to suggest that the climate regime is a blend of semiarid grassland and moist forest tendencies. The average yearly precipitation for the Saskatoon area from 1981 to 2010 has been calculated at 353.7mm (Environment Canada 2016), while the summer months receive the highest precipitation amounts; a defining characteristic of a dry midlatitude climate regime (Strahler & Strahler 2002). That being said, the climate of the Saskatoon area is intensely variable. On June 24, 1983, 99mm of rain fell on the city of Saskatoon, exceeding the current 30-year average for that month by 39mm, which underlines the unpredictable nature of the region's weather patterns.

2.4 Fauna

The fauna of the Opimihaw valley are typical of the Canadian prairie grassland and parkland ecological zones. While evidence of these animals is not always apparent in excavation data, many species are observed today at Wanuskewin which can reasonably be expected to have inhabited the valley contemporaneously with human occupations over the past 6,000 years. Several species have distinct impacts on archaeological site visibility in the valley, and will be discussed and explained in this section.

2.4.1 Mammals

Three species belonging to the Order Lagomorpha can be found on the northern Plains near Saskatoon. These include Nuttall's cottontail (*Sylvilagus nuttallii*), the snowshoe hare (*Lepus americanus*), and the white-tailed jack rabbit (*Lepus townsendii*). These lagomorph species are active year-round (Banfield 1974).

Several species of the Order Rodentia also reside in and around the Opimihaw valley. These include the Least chipmunk (*Eutamias minimus*), American beaver (*Castor canadensis*), Richardson's ground squirrel (*Spermophilus richarsonii*), Thirteen-Lined ground squirrel (*Spermophilus tridecemlineatus*), Franklin's ground squirrel (*Spermophilus franklinii*), Northern Pocket gopher (*Thomomys talpoides*), Deer mouse (*Peromyscus maniculatus*), Gapper's red-backed vole (*Clethrionomys gapperi*), Muskrat (*Ondatra zibethicus*), Prairie vole (*Microtus ochrogaster*), Meadow vole (*Microtus pennsylvanicus*), and the American porcupine (*Erethizon dorsatum*) (Banfield 1974). Ground squirrels and pocket gophers are conspicuous residents of Wanuskewin Heritage Park as they dig burrows within and around the Opimihaw Creek valley. While this behaviour can pose problems for archaeologists (such as displacing artifacts from their primary contexts and mixing soil strata), it can also be beneficial as the earth and artifacts these animals move to construct their burrows is placed on the ground surface where it can be seen during surface surveys. Soil formation processes are impacted by the feeding habits of these animals as well, especially on hillslopes. In periods of low precipitation, grasses in these areas are unable to regrow quickly enough to keep up with the rate at which they are eaten by ground squirrels. Beavers have also had an impact within the valley due to the fact that they construct dams. These dams create ponds behind them, flooding the banks of the creek along with archaeological sites that lie upon them. However, beavers can also be a help to archaeologists as they clear trees from the land to build their dams and lodges. With the exception of mice, voles, and porcupines, rodents on the Northern Plains hibernate in the winter, and all are quite active in the warmer months.

Many diverse species of carnivores can also be found to inhabit the Opimihaw valley. These include the Red fox (*Vulpes vulpes*), Coyote (*Canis latrans*), Long-Tailed weasel (*Mustela frenata*), Least weasel (*Mustela nivalis*), Ermine (*Mustela ermine*), American badger (*Taxidea taxus*), Striped skunk (*Mephitis mephitis*), and the Raccoon (*Procyon lotor*). Carnivorous species which are known to have once inhabited the valley but are now extirpated from the area include the River otter (*Lontra canadensis*), Swift fox (*Vulpes velox*), Wolf (*Canis lupus*), American black bear (*Ursus americanus*), Grizzly bear (*Ursus arctos*), and the Cougar (*Felis concolor*), although there have been several unconfirmed sightings of the latter in the Saskatoon area in recent years. It should also be mentioned that badgers are burrowing predators, digging large holes in search of prey like ground squirrels and gophers. This behaviour can also lead to the disturbance of archaeological sites (Banfield 1974).

Cloven-hoofed mammals make up a significant portion of the faunal record of the Opimihaw valley. Most significant among these species is the American bison (*Bison bison*), which was relied upon by Native peoples on the Northern Plains as a major source of food, clothing, construction material, and material used in the manufacture of tools. Other members of the order Artiodactyla which have resided in the valley include Mule deer (*Odocoileus hemionus*), White-Tailed deer (*Odocoileus virginianus*), Moose (*Alces alces*), Wapiti (*Cervus canadensis*), and Pronghorn (*Antilocapra americana*). Bison are currently absent from this part of their former range as are elk and pronghorn (Banfield 1974).

2.4.2 Birds

Many avian species visit the Opimihaw valley during the year. Migratory waterfowl species include the Canada goose (*Branta canadensis*), the snow goose (*Chen caerulescens*), northern pintail duck (*Anas acuta*), blue-winged teal (*Anas discors*), mallard duck (*Anas platyrhynchos*), and great blue heron (*Ardea herodias*). Other birds which have been known to inhabit or visit the valley include the sharp-tailed grouse (*Tympanuchus phasianellus*), red-tailed hawk (*Buteo jamaicensis*), ferruginous hawk (*Buteo regalis*), bald eagle (*Haliaeetus leuco*), golden eagle (*Aquila chrysaetos*), black-billed magpie (*Pica pica*), great horned owl (*Bubo virginianus*), and the great grey owl (*Strix nebulosa*) (McGill University 2011). The work of Pletz (2010) at the Dog Child site revealed that several members of these species were represented in the archaeological record, indicating that avian species were utilized by the original inhabitants of the Opimihaw valley.

2.4.3 Reptiles

Few reptile species live as far north as Saskatoon due to the fact that they are cold-blooded requiring heat from the ambient environment to regulate their own body temperatures. However, there is one species of snake able to survive the extreme climate regime of the Northern Plains. Subspecies of the common garter snake (*Thamnophis sirtalis*) hibernate during the winter in large underground colonies known as hibernaculums. In fact, these colonies are “the greatest gathering of reptiles in the world” (BBC 2009). As these snakes are relatively small and possess no venom glands, they present no threat to animals which are larger than ground squirrels. Mice and voles make up the bulk of the garter snake’s diet.

2.4.4 Amphibians

Amphibian species inhabiting the wetter areas of the Opimihaw valley include the northern leopard frog (*Rana pipiens*) and the tiger salamander (*Ambystoma tigrinum*). As these species are also cold-blooded, they hibernate during the winter months in the mud around ponds or streams (McGill University 2011).

2.4.5 Fish

Several species of fish may have inhabited the Opimihaw Creek during a time when it had a steadier flow regime, but are now absent from the living faunal assemblage of the valley. These species include yellow perch (*Perca flavescens*), walleye (*Sander vitreus*), sauger (*Sander canadense*), northern pike (*Esox Lucius*), and lake sturgeon (*Acipenser fulvescens*). All of these species currently live in the South Saskatchewan River which is located at the south end of the valley (Saskatchewan Ministry of Environment 2011).

2.5 Flora

A myriad of plant species have colonized the valley following deglaciation approximately 12,000 years ago. Some of these were important dietary components for people in Pre-contact times.

Native species of grass cover the valley slopes, including blue grama grass (*Bouteloua gracilis*), spear grass (*Stipa richardsonii*) and rough fescue (*Festucata hallii*). The herb pasture sage (*Artemisia frigida*), shrubs like wolf willow (*Elaeagnus commutata*) and sagebrush (*Aster brachyatis*), and flowering plants such as the low prairie rose (*Rosa arkansana*) can also be found on the upland slopes around the Opimihaw valley. Further downslope where there is more moisture, grasses such as sweet grass (*Hierochloe odorata*) and tall manna grass (*Glyceria grandis*) thrive, as do fruiting plants such as saskatoonberry (*Amelanchier alnifolia*), buffaloberry (*Shepherdia canadensis*), chokecherry (*Prunus virginiana melanocarpa*), and wild red raspberry (*Rubus idaeus aculeatissimus*) (Agriculture Canada Research Branch 1987).

Trees prefer the cooler, wetter environment of the valley floor and are mainly represented at Wanuskewin by the beaked willow (*Salix bebbiana*) and aspen poplar (*Populus tremuloides*). Irritating plants such as the stinging nettle (*Urtica dioica*) can also be found in the sheltered areas of the valley floor (Agriculture Canada Research Branch 1987). Interestingly, Canada thistle recently became more prevalent in the valley, intensely colonizing areas which were ravaged by fire in the spring of 2010. Bordering the banks of the creek and beaver ponds are common cattails (*Typha latifolia*) which thrive in the water-saturated soils of those areas. Fruits like the saskatoonberry, chokecherry (see Figure 2.4), buffaloberry, and wild raspberry are present.

Figure 2.4: Looking southeast toward the Wolf Willow site from the walking path. Note the chokecherries at right in the photo.

Chapter 3: Cultural Chronology

3.1 Introduction

The Plains of North America have been occupied by Native peoples for at least 12,000 years. There is an established spatial and temporal sequence of unique archaeological cultures on this continent, and as the work of archaeologists like Peck (2001) illustrate, this cultural sequence is dynamic as new diagnostic tool types are discovered or the established sequence is revised.

Before delving further into cultural chronology, it is pertinent to first define some of the terms that will be employed in this thesis. First, an *archaeological culture* is defined as "[a] constantly recurring *assemblage* of artifacts assumed to be representative of a particular set of behavioural activities carried out at a particular time and place (Renfrew & Bahn 2007: 290)." An assemblage is "[a] group of artifacts recurring together at a particular time and place, and representing the sum of human activities (Renfrew & Bahn 2007: 290)."

Many other terms are used by archaeologists to further describe cultural sequences, including *tradition, phase, focus, component, complex*, and *series*. A *tradition* is defined as "a (primarily) temporal continuity represented by persistent configurations in single technologies or other systems of related forms (Willey & Phillips 1958: 37)." A phase is described by Willey and Phillips (1958) as:

> "an archaeological unit possessing traits sufficiently characteristic to distinguish it from all other units similarly conceived, whether of the same or other cultures or civilizations, spatially limited to the order of magnitude of a locality or region and chronologically limited to a relatively brief interval of time (Willey & Phillips 1958: 22)."

A *focus* is defined by McKern (1939) as "that class of culture exhibiting characteristic peculiarities in the finest analysis of cultural detail (McKern 1939: 308)," while a *component* is "[t]he manifestation of any given focus at a specific site (McKern 1939: 308)." The terms *focus* and *component* as defined above belong to the Midwestern Taxonomic scheme. A *complex*, as it pertains to an archaeological culture, is defined in Dyck (1983) as:

> "…a large composite archaeological unit. It consists of interconnected sites, features, and artifacts, tied together by similarities in function, style, technology, and subsistence-settlement system. The parts of a complex are found within a common geographical distribution and within a common segment of time. The change in terms from culture to

> complex reflects the notion that an archaeological complex is not necessarily equivalent to an ethnological tribe or culture. It may be equivalent, but it may also spread across ethnological groupings (Dyck 1983: 69)."

A *series*, also defined by Dyck (1983), is described as:

> "…a sequence of archaeological components sharing a common geographical space (sometimes within a single site, sometimes within a region), but belonging within separate segments of time. A series is a crude unit of archaeological analysis used for convenience before sites, features, and artifacts are ready for reclassification into complexes and traditions (Dyck 1983: 69)."

Dyck's (1983) taxonomic system, which is tailored for Saskatchewan, is adapted from Mulloy's (1958) Northern Plains Taxonomic system.

Seriation, another key term pertaining to the discipline of archaeology, is "[a] relative dating technique based on the archaeological ordering of a group of artifacts or assemblages, where the most similar are placed adjacent to each other in the series (Renfrew & Bahn 2007: 294)."

Due to the fact that organic materials decompose fairly quickly in most depositional situations, they are therefore rarely found in the archaeological record, Plains cultural chronology is primarily based on the seriation of inorganic stone projectile points, which, "in combination with radiocarbon dates are usually the best temporal indicators in site components of preceramic age (Kornfeld et al. 2010: 48)." As this statement implies, ceramics also play a role in the cultural chronology of the Northern Plains. However, as ceramic technology did not appear in the region until the Late Precontact period and pottery is normally found in fragments in archaeological sites, ceramic typology plays a much smaller role than that of projectile points in the culture history of the Northern Plains.

The first culture history for the Northern Plains was proposed by Mulloy (1958), and laid the groundwork for subsequent culture histories by archaeologists such as Frison (1978), Dyck (1983), Walker (1992), and Cyr (2006), as seen in figure 3.1. This thesis will use the terminology and chronology proposed by Cyr (2006), wherein the "Historic" period was replaced by the "Contact" period in reference to the cultural contact experienced by Plains peoples when European explorers and settlers arrived in the region. However, the beginning of the Late Precontact period has been placed at 2000 years B.P. in this thesis to better delineate the technological differences between the Middle and Late Precontact periods. The chronology proposed by Kornfeld et al. (2010), as seen in figure 3.2, will also be taken into consideration in this thesis, as it reflects the tendencies of projectile point types and styles to temporally overlap between periods, rather than adhere to a rigid timeline (Kornfeld et al. 2010: 48).

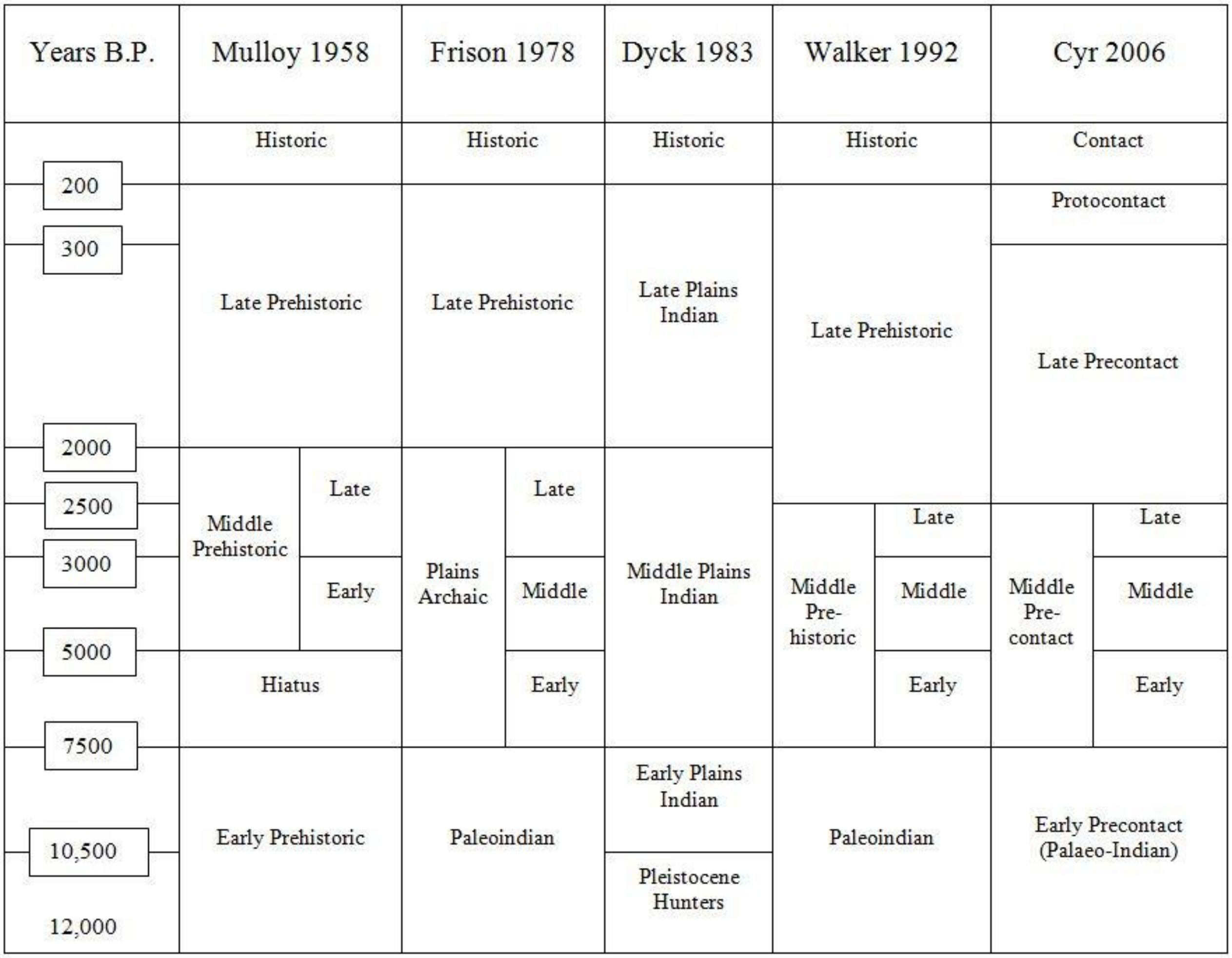

Figure 3.1**:** Cultural chronology proposed by Cyr (2006: 17).

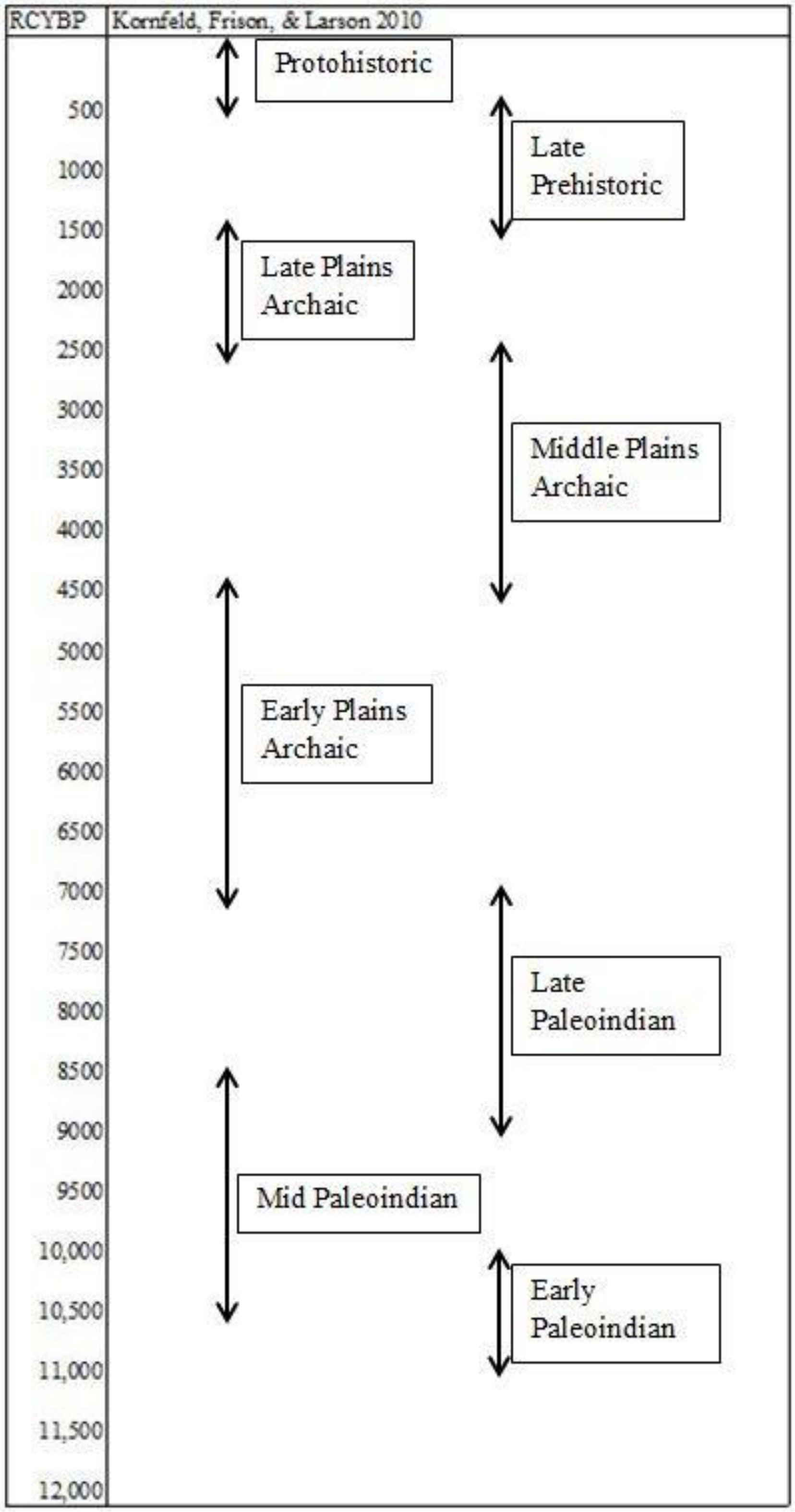

Figure 3.2: Cultural chronology proposed by Kornfeld et al. (2010: 48).

3.2: Early Precontact (Paleoindian) Period (12,000 to 7500 Years B.P.)

While the body of evidence for earlier occupation of the Northern Plains continues to grow at sites like Wally's Beach in southern Alberta (Kooyman et al. 2001), the earliest accepted culture to occupy the Northern Plains at this time is still Clovis. Evidence of this culture, while sparse compared to that from cultures of later ages, can be found all over North America in contemporaneously unglaciated areas (Hamilton & Buchanan 2007: 15627). Sites such as the Colby site in northern Wyoming and the Dent site in northern Colorado reveal that these first North Americans hunted mammoths (Kornfeld et al. 2010: 73). Further, it has been argued by some that Clovis people may have had some role to play in the ultimate demise of several other Pleistocene megafaunal species. A North American horse known as *Equus conversidens,* as well as a musk ox *Bootherium bombifrons,* among several other species, may also have been hunted or scavenged on the Northern Plains by Clovis people as evidenced by the presence of proteins from these animals on several Clovis tools from the Wally's Beach site in southern Alberta (Kooyman et al. 2001).

Clovis points are large, lanceolate-shaped objects that required a high degree of craftsmanship to manufacture. Lengths of Clovis points vary greatly depending on functionality, but can be anywhere between seven and twenty centimetres long (Kooyman 2000: 108). One major defining characteristic of the Clovis point is the presence of two large "flutes" from the base of either face of the tool which runs approximately one-third up the length of the point. This feature made the point thinner at its base which in turn made hafting the point onto a bone or wooden shaft easier. Once they were hafted, Clovis points were formidable weapons. At the business end of a long thrusting spear, they would have been able to penetrate the hide and rib cage of a mammoth, as archaeological experiments carried out on African elephants have shown (Kornfeld et al. 2010: 143). Dates for Clovis fall within a narrow window at the beginning of the Early Precontact, or Paleoindian, period. A range from 11,500 to 11,000 radiocarbon years before present, or 13,700 to 12,600 calendar years ago is fairly widely accepted by Plains archaeologists, although it may extend later (Kooyman 2000: 107).

Goshen-Plainview points are easily distinguished from those of the Clovis culture by the lack of flutes and the presence of more general thinning at their bases (Kooyman 2000: 110-111). Animal procurement on the Northern Plains seems to have shifted away from extinct Pleistocene megafauna immediately following the rapid colonization of the region by Clovis peoples. However, it is apparent at sites like the Mill Iron site in Montana that Goshen people were accomplished communal hunters of a now-extinct species of bison, *B. antiquus* (Kornfeld et al. 2010: 217-218). While there has been considerable debate regarding the placement of Goshen-Plainview in northern Plains cultural chronology, the dating of bone collagen from several sites has placed the date range to between 10,450 and 10,175 radiocarbon years B.P., or from 12,500 to 11,800 calendar years B.P. (Waters & Stafford 2014: 546-547).

Folsom points, the last of the Early Paleoindian period, have flutes similar to those of the Clovis culture. However, flutes on Folsom points sometimes run almost their entire length and can also be nearly as wide as the points themselves (Kooyman 2000: 111). Folsom points also tend to be much smaller on average than Clovis, between about three and seven centimetres in length (Kooyman 2000: 111). As is the case with Goshen-Plainview, Folsom is also associated with bison kills. These kills tend to contain small numbers of individuals which is likely a reflection of the difference in behaviour between modern bison, which tend to be gregarious, and *Bison antiquus* which appears to have lived in smaller herds than its modern-day descendants (Kornfeld et al. 2010: 225). Folsom is dated to between 10,900 and 10,200 radiocarbon years B.P. (Kornfeld et al. 2010: 80).

The Middle Early Precontact period began with the Agate Basin complex. Agate Basin points are long and lanceolate in form, but they have much narrower bases than the points of the Clovis, Goshen-Plainview, or Folsom complexes (Kooyman 2000: 113). Agate Basin falls between 10,500 and 10,000 radiocarbon years B.P. Immediately following Agate Basin was the Hell Gap cultural complex, which lasted from 10,000 years B.P. to 9500 years B.P. (Kornfeld et al. 2010: 86). Hell Gap points are similar to Agate Basin points, but they have a widely-set "shoulder" near the tip (Kooyman 2000: 114). As yet, Saskatchewan has had no Early Paleoindian period artifacts found *in situ*, although points from Clovis to Hell Gap have been recovered as surface finds (Walker 1999: 25).

Cody complex points come in three distinct morphologies: Alberta, Scottsbluff, and Eden points. Alberta points, dating from 9500 to 9000 radiocarbon years B.P., have an even more abrupt or almost angular shoulder than Agate Basin points do which creates a stemmed base (Kooyman 2000: 115). This basic stemmed and shouldered outline was once considered to be a standalone complex, but it has since been argued by some archaeologists that Alberta points have too much in common with other point styles from the Cody complex to be considered separately from Cody (Holliday 2000: 269). Scottsbluff I and II, and Eden points exhibit a flaking technique known as "comedial flaking" which is a process by which flakes are removed from either side of a point, thereby creating a centre-line ridge (Kooyman 2000: 116-117). In Eden points, this ridge is so defined that it produces a diamond-shaped cross-section. Of further interest in describing the Cody complex is the distinctive Cody knife, an asymmetrical biface that is often found in association with Cody points. The "classic" Cody complex points, Eden and the two variants of Scottsbluff, date from 9400 to 8800 years B.P. (Holliday 2000: 269). It should be noted that there are intact Cody components at sites like Niska (Meyer 1985) and Heron-Eden (Corbeil 1995) in Saskatchewan.

Point styles at the end of the Early Precontact period, like their predecessors, also exhibit several unique attributes. A poorly-defined complex of parallel-oblique-flaked projectile points, being drastically different than those of the earlier Cody complex, defines the terminal Early Precontact. Frederick/James Allen points are lanceolate in form, but lack a stem. Instead, hafting was facilitated by a variably concave base; less concave for Frederick, more concave for James Allen (Kooyman 2000: 118). Parallel-oblique flaking in Frederick/James Allen points tends to have a symmetrical, mirrored appearance, with flakes originating on the edges nearer to the tip, and terminating in the middle nearer to the base. This creates a faint mid-line ridge (Kooyman 2000: 118-119). Lusk points are much narrower at their bases than Frederick/James Allen, but still retain the basal concavity. Several other parallel-oblique-flaked types, such as Pryor-Stemmed and Angostura, comprise the remainder of the types for this complex. Dates for this parallel-oblique complex generally range from approximately 9000 to 8000 years B.P. (Kooyman 2000: 118), but Pryor-stemmed extends to as late as 7800 years B.P. (Kornfeld et al. 2010: 102). Until recently, the only points from the Early Precontact recovered in Saskatchewan were merely surface finds (Walker 1999: 25). However, work conducted by Nathalie Cahill (2012) on an assemblage from the Camp Rayner site on Lake Diefenbaker in southern Saskatchewan revealed an intact component from the terminal Early Precontact. Three points of a style similar to those belonging to the Lusk Complex, and one point reminiscent of the Lovell Constricted point type were recovered in Culture Zone 7, the deepest level at the site (Cahill 2012: 138-139).

3.3: Middle Precontact Period (7500 to 2000 Years B.P.)

Little is known about the Early Middle Precontact period. Unfavourable climatic conditions during the Hypsithermal, which lasted from approximately 7700 to 5000 years B.P. (Sauchyn 1990: 1508), were once believed to have led to the complete abandonment of the Northern Plains (Mulloy 1958). As it turns out, however, this period of increased temperatures and aridity may have merely pushed people to live in oasis-like areas on the Plains, or “refugia”. Increased hillslope activity caused by a decrease in vegetation during the Hypsithermal had an impact on site visibility, often burying occupations under deep alluvial or colluvial deposits (Otelaar 2004). However, it is becoming clear at sites such as Mummy Cave in Wyoming, the Stampede site in Alberta, and the Gowen sites in Saskatoon, Saskatchewan, that Plains peoples were able to adapt to a time of great biotic stress.

Radiocarbon dates from the Mummy Cave site in Wyoming place the beginning of the Middle Precontact period somewhere between 8000 and 7500 years B.P. and the end at approximately 5000 years B.P., correlating the culture history succinctly with the Hypsithermal climatic episode. Projectile point styles of the “Mummy Cave Series” such as Bitterroot and Gowen represent some of the first side-notched point types on the Northern Plains. They may also be some of the first points to tip a type of throwing spear known as an atlatl in this region. Gowen points, named for the Gowen sites at which they were first discovered (Walker 1988b), tend to be fairly nondescript, and are often mistaken in surface find contexts for side-notched points of later periods. Radiocarbon dates from the Gowen sites range from 6150 to 5780 years B.P., placing them in the last half of the Early Middle Precontact period (Walker 1992). At the Dog Child site in Wanuskewin Heritage Park, the Gowen component dated to 6000 radiocarbon years B.P. (Pletz 2010: 67), representing the earliest cultural component in the Park.

The Middle Middle Precontact period is of particular interest in regard to this thesis, as the cultural chronology for the Wolf Willow site begins with Oxbow. Oxbow points, which have side notches as well as a deep basal concavity, seem to represent the result of a typological evolution of Gowen points (Walker 1992), and therefore a transition from the Early Middle Precontact period to the Middle Middle Precontact period. Named for the Oxbow Dam site in southeast Saskatchewan, this culture may represent the first *in situ* development of a culture for the geographic area now known as Saskatchewan, due to the fact that radiocarbon date sequences from sites in Saskatchewan tend to start earlier than those from states like Wyoming (Kornfeld et al. 2010: 113-114). Evidence supporting this theory comes from the Gray site 13km northwest of Swift Current, Saskatchewan, where 304 individuals were recovered from 99 burial units, from an estimated 60 percent of the site's total area (Millar 1981: 104).

Middle Middle Precontact period assemblages are characterized mainly by the three point styles of the McKean Series: McKean lanceolate, Duncan, and Hanna. McKean lanceolate points appear earliest, and are distinguishable from Duncan and Hanna by their deeply concave bases and lack of side notches. The Duncan point follows a similar outline to its predecessor, maintaining the basal concavity, but adding broad, shallow side notches. Hanna points have exaggerated side notches and constricted bases, giving the tip of the point an inflated appearance. Dates for the McKean series range from approximately 5000 to 3000 years B.P. According to work conducted by Yvonne Fortin (2015: 124) at the University of Saskatchewan, "…McKean would have been present later in the southern region, indicating a smaller, localized region of origin in the northwestern part of Wyoming and southwestern Montana." Fortin (2015: 126) further notes that "there was a spread north, east, and southeast[,]" and that "[t]he introduction of the McKean Complex into the north likely occurred by 4300 – 4140 B.P." This means that peoples belonging to the McKean Complex were intrusive on the Northern Plains, from the perspective of Oxbow Complex peoples who already occupied the area.

The Late Middle Precontact period is comprised of two point types: Pelican Lake and Besant. Pelican Lake points are very angular in appearance, having deep corner notches and barbed shoulders. Several variants of Pelican Lake points have been determined, but whether the bases are straight, convex, or constricted, the corner notches remain a consistent, defining characteristic of the type. Besant points are very different from those of the Pelican Lake type, having side notches instead of corner notches. Another telling attribute of Besant points is the persistent use of Knife River Flint in their manufacture. Besant points recovered from the Fitzgerald site near Saskatoon, Saskatchewan, show that 97% of the material used in their manufacture was Knife River Flint (Hjermstad: 1996). Since the source for this material type is typically considered to be northwestern North Dakota, the tendency for Besant points to be manufactured so preferentially from Knife River Flint is of particular interest to Plains archaeologists. Radiocarbon dates for Pelican Lake sites are typically from between 1800 and

3300 years ago. This range overlaps with Besant, which ranges from approximately 1150 to 2000 years B.P. (Kooyman 2000: 124). Pelican Lake and Besant projectile points are transitional between the Middle and Late Precontact periods, as each started out as atlatl dart tips, but transitioned to arrow points following the introduction of bow and arrow technology to the Northern Plains (Kooyman 2000: 122-123). Due to their stylistic and compositional similarity, Besant points are considered to be in the same complex as Sonota points.

3.4: Late Precontact Period (2000 to 300 Years B.P.)

There are a number of "hallmarks" of the Late Precontact period that can be seen in the archaeological record on the Northern Plains. These include: bow and arrow technology, large communal bison kills, ceramic technology, horticulture, and an increase in human population that led to, in some areas, a rise in the instance of both communicable disease and civil strife (Holliman & Owsley 1994, Walker 1983).

Besant and Pelican Lake points are arguably the first styles that existed during the Late Precontact period, although due to their origins as atlatl dart tips during the Late Middle Precontact and diminished association with large communal kills, they each fit better as transitional styles between the Middle and Late Precontact periods. The first distinctive point style of the Late Precontact that is consistently found as an arrow point termed Avonlea. Avonlea points are characterized by their slim cross-section, longitudinal symmetry, low side notches, and concave bases with rectangular lateral margins. Avonlea points are named for a single-component site near Avonlea, Saskatchewan, and date to between approximately 1350 and 1100 years B.P. (Bubel et al. 2012: 69). As has been previously mentioned and demonstrated, projectile points are good diagnostic cultural indicators. However, pottery also plays a significant diagnostic role during the Late Precontact period. Avonlea pottery is often found in association with projectile points of the same culture and is typically globular in shape with three main ware types: net/fabric-impressed, parallel-grooved, and cord-roughened (Meyer & Walde 2009).

The Old Women's Phase includes three main projectile point types: Prairie Side-Notched, Plains Side-Notched, and Plains Triangular. Prairie Side-Notched points are triangular in outline with very deep notches placed at or very near the base. It is argued by some archaeologists that Prairie Side-Notched points are in the same cultural continuum as Besant (Greiser 1994), and others contend further that both Prairie and Plains Side-Notched points belong in a cultural progression known as the Cayley Series (Peck 2001). In contrast to Prairie Side-Notched points, Plains Side-Notched points have deep notches placed much higher on the blade, with a distinctively rectangular base. Plains Triangular points are, as their name suggests, triangular in outline. They are thinned slightly at their base to facilitate hafting, but lack notches of any description. Date ranges of approximately 1100 to 600 years B.P. and 600 to 250 years B.P. have been suggested for Prairie and Plains Side-Notched points, respectively. Plains Triangular points are believed to belong to the Cayley Series, but it has yet to be determined if they are indeed finished points or merely un-notched preforms (Bubel et al. 2012: 72).

Pottery of the Old Women's Phase consists of globular-shaped vessels with flat bottoms, pronounced shoulders, and thick walls comprised of poorly-consolidated paste (Walde et al. 1995: 28). Mortlach pottery, on the other hand, is generally much thinner, and its decoration appears to have been influenced by other cultures which shared its borders (Walde et al. 1995: 41). One problem that pottery often poses to archaeologists is its tendency to shatter into small pieces, making stylistic identification and thus cultural affiliation difficult to determine.

It is important to note that many of the "hallmarks" of the Late Precontact period, briefly discussed above, were influenced at least in part by climatic conditions. Between approximately 650 and 1150 A.D., the climate of the Northern hemisphere warmed significantly, even allowing the Vikings to establish a colony in Greenland (Kump et al. 2010: 297-298). In North America, this period of increased temperature and precipitation provided Mississippian agriculturalists with food surpluses, allowing them to focus on building the Precontact city of Cahokia (Benson et al. 2009). However, the onset of the Little Ice Age around the sixteenth century A.D. had an immensely negative impact on inflated human populations around the Northern hemisphere. It has been suggested by some researchers that a massacre of nearly 550 individuals at Crow Creek, South Dakota in 1325 A.D. was motivated by competition for scarce resources between groups of Plains horticulturalists (Pringle 1998). Paleoclimatic relationships will be discussed further in the chapters that follow.

Chapter 4: Methodology and Radiocarbon Dating

4.1 Site Recovery and Assessment

Along with 18 other Precontact sites, the multi-component Wolf Willow site was initially identified following a survey of the Opimihaw valley in 1983. Four cultural levels were identified, and due to the presence of 15 stone cairns located on the upland to the west of the site, it was initially believed to have been associated with a bison kill (Walker 1988a). In May of 2010, a 10m x 10m excavation block was established, and excavation of the site began.

4.2 Excavation Methodology

In order to ascertain the spatial and occupational extent of the Wolf Willow site, it was decided that a 1m x 10m trench running from west to east be opened. This trench was widened to a 3m x 10m pit the following year. In 2012, an effort was made to determine the northern extent of the site, and so a 1m wide trench was put in on the eastern side of the 10m x 10m site area, and the 3m x 10m pit was expanded by another metre on its northern side. In 2013, following the discovery of an intriguing gravel lens in the northeast corner of the site, it was decided that the western and eastern sides of the site be linked in the hopes that the extent of the gravel lens would be determined (see Figure 4.1 below).

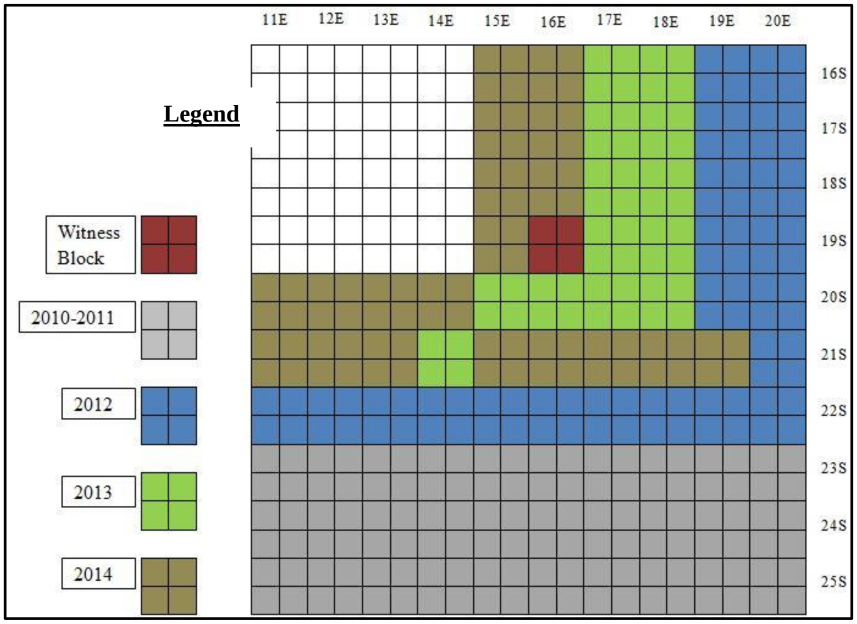

Figure 4.1: Excavated units at the Wolf Willow site, 2010-2014.

Prior to the site being opened, a datum was placed to the northwest of the site area, which has a position of 0m S 0m E. Every 1m x 1m unit likewise had a datum in the northwest corner that was measured south and east of the site datum. Every measurement taken to provenience artifacts was taken from each unit's datum, and every unit was further divided into 50cm x 50cm quadrants so that artifacts not found *in situ* could at least be traced back to a quadrant (see Figure 4.2 below).

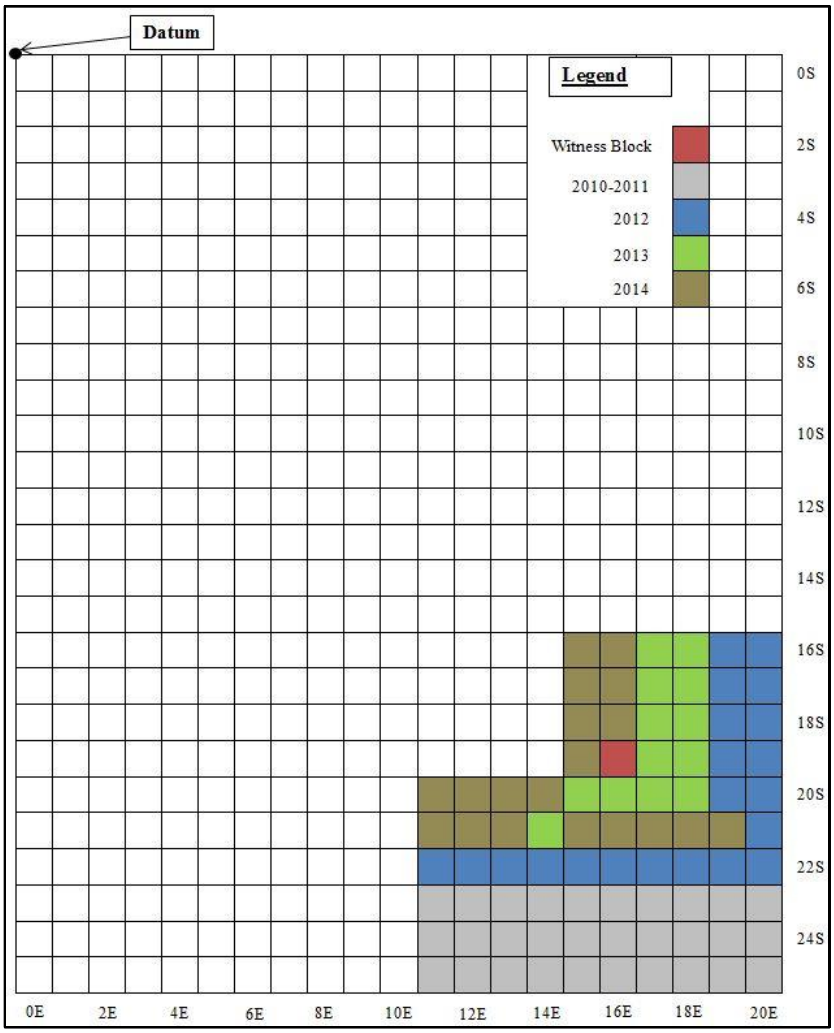

Figure 4.2**:** The Wolf Willow site in its entirety as of August, 2014.

Excavation of each unit was undertaken by pairs of students during the 2010 field school, but by individual students in subsequent field seasons. Due to the academic nature of the excavations, they were executed with small hand tools to prevent any artifacts from being overlooked. Once the sod was removed from the top of each unit, trowels were used to shave off thin layers of sediment. Roots, of which there were many, were carefully clipped as they were uncovered. Artifacts found *in situ*, which included bone or stone tools, identifiable bones or large fragments, were carefully removed after being measured using the 3-point provenience method. The location of each artifact south and east of the unit datum was recorded in centimetres, as was its depth below the same datum. Prior to removal, positions of provenienced artifacts were drawn on a planview map. Artifacts were then placed in bags with identification cards, on which all pertinent qualitative and quantitative information was recorded. Loosened sediment was removed from exposed surfaces with a brush and dust pan, emptied into a bucket, and sifted through a ¼ inch screen so that fragments missed by excavators while digging could be recovered.

Units were excavated in arbitrary levels of 5cm in order to maintain separation of cultural levels, and to ensure that natural levels were identified and not missed. Archaeological materials are typically found on darker, more organic-rich soil horizons, which are indicative of extended periods of landscape stability. At the Wolf Willow site, these stable surfaces were sometimes difficult to discern, as the organic matter from them appeared to have been mixed into other sedimentary strata. However, there are palpable differences in the textures and colours of these strata, and students noted and recorded these changes in their field notes. In layers that were found to be archaeologically sterile, the “shovel shaving” technique was employed to expedite the excavation process.

Reconstruction of the site is of the utmost importance to an archaeological excavation. Excavators at the Wolf Willow site kept track of their progress by writing pertinent details like layers excavated, methodology, excavation depth to date, significant finds, feature description, completed floor plans and profiles, and any other comments on a “Daily Log” form. After a cultural level had been thoroughly excavated, students were also asked to fill out a “Level Record” form, on which the top and bottom depths of each corner of their unit, excavation technique, screen size, matrix description, feature description, artifact description, and samples collected from the unit, as well as any additional comments were to be recorded. Students also took several photographs of significant *in situ* finds, with the assistance of the supervisors. Units at the Wolf Willow site were excavated to a maximum depth of 90cm during the 2012 and 2013 field seasons.

In the fall of 2011, soil auger samples were collected from the surface down to a depth of approximately 20cm, and elevation readings were taken from several points, beginning at the top of the western wall of the valley, down the swale, and terminating at the periphery of the site. Sediment samples gleaned from the Wolf Willow site itself in June of 2014 were taken from the eastern wall of unit number 19S 16E, also known as the Witness Block. The purpose of the Witness Block is to ensure that, should any future comparative analyses of the cultural, paleoenvironmental, or sedimentary attributes of the site need to take place, further samples can be extracted from it, and be considered scientifically valid.

4.3 Laboratory Methodology

All materials gleaned from the excavation were transported back to a laboratory at the University of Saskatchewan. Artifacts were washed with water and soft-bristled toothbrushes, then set out on large baking sheets to dry. At this stage, material types of provenienced lithic artifacts were identified once the sediments which adhered to their surfaces were removed. Bags full of unidentified fragments, dubbed “frag bags”, were left unparsed by students due to time constraints for the six-week course. After the class was over, several identifiable bone, lithic, and pottery specimens from “frag bags” were found and separated out. Unidentifiable or otherwise miscellaneous fragments were separated by material type. Every artifact was then identified, counted, and weighed by the author.

Artifacts were catalogued using *Microsoft Office® Excel 2010*™, and were itemized using a number of qualitative and quantitative criteria. These classified artifacts into four basic categories: faunal, lithic, metallic, and ceramic. Faunal artifacts include intact and fragmentary bones and teeth from vertebrate animals, as well as shells or shell fragments from invertebrate species. Lithic artifacts include flaked stone tools, stones that clearly functioned as tools, by-products of stone tool manufacture or re-shaping, and fragments of fire-cracked rock. Only one metallic artifact was found; a lead musket ball. Ceramic artifacts are comprised of Mortlach and Old Women’s Phase pot sherds.

4.3.1: Faunal Analysis

Faunal artifacts were sorted by element, specimen, side (where applicable), species, and notable taphonomic attributes. A faunal element is defined as an intact bone, while specimens may be intact or fragmentary elements. Identification of faunal elements and specimens was achieved or confirmed by utilizing the extensive comparative faunal collection at the University of Saskatchewan.

Taphonomic analysis was undertaken in a cursory manner for the purposes of this thesis. While the author is not an expert in taphonomic analysis, several artifacts were found to have been modified by apparent taphonomic processes, such as scoring, polishing, carving, cutting, and fracturing. Some faunal specimens were found to have been chewed or digested, presumably by scavengers consuming the scraps from human encampments in the Opimihaw valley.

4.3.2: Lithic Analysis

Lithic artifacts were subdivided based on discernible morphological characteristics. The stone tool assemblage included intact or fragmentary hammerstones, anvils, cores, knives, drills, scrapers, a grinding slab, a grooved maul, a spokeshave, projectile points, bifaces, flakes, and utilized flakes. Other lithic artifacts include primary and secondary flakes, as well as amorphous shatter. Un-utilized flakes were separated into two main categories: primary and secondary. Primary flakes, or decortication flakes, are pieces of lithic debitage that have a clear striking platform, a bulb of percussion, and ripple marks, and also have varying amounts of cortex on their dorsal surfaces. Secondary flakes, however, lack cortex on their dorsal surfaces, having instead dorsal ridges or “arris” created by the prior removal of flakes from the outer layers of a core or other piece of stone.

Many lithic material types are represented at the Wolf Willow site, including: basalt, granite, gneiss, schist, diorite, sandstone, quartz, quartzite, and several varieties of chert, chalcedony, and siltstone. While the vast majority of these types can be found within the province of Saskatchewan, some originate from more distant locations, and would have required a fair degree of effort to acquire, either through trade or personal procurement. Identification of these types was aided by the comparative lithic collection at the University of Saskatchewan, and followed the lithic identification terminology used by Johnson (1986).

Siltstones are present in three main types at the Wolf Willow site: feldspathic siltstone, siltstone pebbles, and Gronlid siltstone. Feldspathic siltstone cobbles are found in gravels in southwest Saskatchewan, having been transported via fluvial processes from Montana (Johnson 1986: 95) during the Eocene and Miocene epochs, when “rivers north of the drainage divide transported gravel and sand north into Canada to be deposited as the Oligocene to Miocene Cypress Hills Formation (Leckie 2006: 139).” Typically, feldspathic siltstone is maroon or purple in colour, with a dull lustre and a fairly coarse texture. Siltstone pebbles, as their name suggests, occur in small pebble form. They are typically black in colour, although grey and green coloured pebbles have also been found at the Wolf Willow site. Silicified siltstone pebbles are present in the glacial till in west-central Saskatchewan, and, in archaeological contexts, are commonly split in a bipolar fashion to form small tools; most commonly unifacial tools like scrapers. Gronlid siltstone can be found in tabular nodules near the town of Gronlid in east-central Saskatchewan. The cortex is light tan to grey in colour and fairly coarse, while the interior layer is black or speckled grey, and amorphous in texture with a waxy lustre.

Two types of quartzite are known to be present in Saskatchewan: Rocky Mountain and Athabasca (Johnson 1986). Rocky Mountain quartzite can be found in a range of colours, from white or tan to pink, and even purple. Lustre tends to be somewhat glassy, while the texture is usually fairly grainy. Sources for Rocky Mountain quartzite are relegated to the southwest corner of Saskatchewan, in the same places where feldspathic siltstone can be found, largely due to the fact that the two types of stone were simultaneously transported by the same fluvial processes (Johnson 1986). By comparison, Athabasca quartzite has a more restricted colour range, having tan, white, and grey in common with the Rocky Mountain type. Lustre and texture are also visually indistinguishable from Rocky Mountain quartzite. If specimens of similar colour from each type were compared, the only difference between Rocky Mountain and Athabasca quartzite would be source area. The former comes from southwestern Saskatchewan, the latter from the north. When explaining how each type of quartzite was named, Johnson (1986) stated that each type “is simply called “quartzite” (Johnson 1986: 64).” Therefore, because the two types are so morphologically similar, all quartzite artifacts from the Wolf Willow site were simply classified as “quartzite”.

Cherts are represented quite well in the assemblage at Wolf Willow. Black chert, Cathead chert, “chert precipitated in limestone” (CPL), “red chert”, Swan River Chert (SRC), jasper, and “tan chert” have all been recovered from the site. Black chert is often indistinguishable from black silicified siltstone, largely due to the fact that it is nearly always found in the same areas, and in the same small pebble form. Cathead chert, also known as Red River chert, is “a banded chert containing varying textures of microcrystalline quartz and chalcedony and replaced fossils

(Saini-Eidukat & Michlovic 2005: 165).” One type of chert seen at the Wolf Willow site was differentiated from other types based on perceived differences in appearance and texture. This unique yet obscure type was descriptively dubbed “chert precipitated in limestone” (CPL). CPL cortex is white and chalky, while the chert itself is typically grey or grey and white in colour, with a slightly coarser texture than Cathead chert. Following inspection of the CPL artifacts from Wolf Willow, raw nodules of the material appear to be pebble-sized or slightly larger.

“Red chert” is something of a curiosity at the Wolf Willow site. Occurring only in cultural level II, this material has a distinctive red colour that is accompanied by grey mottling in several specimens. The term “chert”, however, is most likely a misnomer, as the texture and lustre of the material most closely resemble those of Beaver River sandstone from northern Alberta, which is actually an orthoquartzite. Due to the fact that this material type has not been seen, or at least identified, at sites in the Opimihaw valley before, it is the opinion of the author that more study is needed to ascertain exactly what this material is and where it came from.

Swan River Chert (SRC) is arguably the most common archaeologically significant lithic material type in Saskatchewan. In its raw form it is normally mottled white or grey in colour, but can also be pink, orange, or blue. Voids filled with quartz crystals, called vugs, can commonly be found inside nodules of Swan River Chert, and are often responsible for the structural failure of tools made from this material. Moreover, the overall texture of Swan River Chert is far from consistent, as nodules of the material can contain material that is anywhere from nearly amorphous in structure to coarse and quartzite-like. Because of this, it is common to find heat treated Swan River Chert artifacts. Heat treatment improves knappability of certain lithic materials by essentially making them more vitreous, or glass-like. It has been noted that in some lithic types, heat treatment also “reduces tensile strength by about one-half,” and “reduces the frequency of hinge terminations…and step terminations (Kooyman 2000: 65).” The source area for Swan River Chert is in west-central Manitoba, where it is believed to have formed within a formation of limestone (Johnson 1986: 70). Nodules of Swan River Chert were transported by glacial activity during the Pleistocene epoch, as evidenced by the fact that they can be found in a large area extending from east-central Saskatchewan to as far as Coronach in south-central Saskatchewan (Johnson 1986: 71). Several tan-coloured core fragments and flakes were also found, and do not seem to fit with any other types of chert from the site. They are tan or tan and grey in colour, and have a very fine, nearly amorphous texture, and a waxy lustre. Further study, perhaps including chemical analyses, may reveal the nature and source area of this type.

Jasper artifacts from the site include several tools and tool fragments, as well as flakes and pieces of shatter. Jasper is characterized by its range of vibrant colours, from reds and yellows to tan, brown, and even blue. Kooyman notes that “[j]aspers are often banded and may have veins of chalcedony running through them (Kooyman 2000: 30).” Like other types of chert, jasper can occasionally contain vugs, although on a much lesser scale than Swan River Chert. Lustre tends to be waxy or vitreous. It is important to note that what is herein called “jasper” is likely what is known as “Montana chert” (Bubel 2015), as the descriptions of each are identical. Furthermore, the source area, while far enough away to be considered exotic, is close enough to the Opimihaw valley that the idea of procurement from Montana is within the realm of plausibility.

A few types of chalcedony have also been identified at Wolf Willow, including Knife River flint, silicified wood, silicified peat, and agate, as well as a brown chalcedony and a grey chalcedony that are less well-known. Knife River flint (KRF) is well-known across the northern Plains, and is commonly found in components belonging to the Besant culture. KRF is translucent brown in colour with a white or tan-coloured cortex. Patination of KRF artifacts is also known to occur, and is the result of chemical weathering of the cryptocrystalline structure of the material by water. It manifests as a thin white layer on the outer surfaces of artifacts. As noted by Johnson, “[r]ecently exposed nodules of Knife River flint are not patinated, nor are projectile points of it that are of types less than about 2000 years old (Johnson 1986: 54).” Sourcing Knife River flint is quite simple, due to the fact that it can only be found in Dunn and Mercer counties in west-central North Dakota. KRF is therefore considered to be an “exotic” lithic material in Saskatchewan.

Silicified wood has been included in the “chalcedony” group for the purposes of this thesis due to the predominance of chalcedonic silica-replaced wood artifacts within the assemblage of artifacts of this lithic material type. However, it should be noted that several “silicified wood” specimens in this assemblage have wood structures that have instead been replaced by quartz. The difference between the two is that the chalcedonic silica-replaced wood “resembles agate, hence may be called “agatized wood” (Johnson 1986: 79)”, while quartz-replaced wood “is commonly shades of brown or grey, it is usually opaque, annual growth rings are prominent and usually represent planes of weakness. Commonly sparkles from minute subhedral quartz crystals can be discerned (Johnson 1986: 79).” Textures of silicified wood specimens are therefore variable. Chalcedonic silicified wood is very fine to amorphous, while quartzose silicified wood can be medium to fine-grained. Sources of both silicified wood variants can be found near Rockglen in southern Saskatchewan, as well as near Eastend in the southwest corner of the province (Johnson 1986).

Silicified peat, also known as South Saskatchewan River chalcedony, is similar to silicified wood in appearance and texture, but is easily differentiated thanks to its more squamous laminar structure. It is anywhere from fine to amorphous in texture, with the inner material being usually brown or grey in colour with varying degrees of translucence and opacity. Due to the presence of cleavage planes between layers of silicified peat, artifacts made from this material are often found to have been fractured along these lines. There are two main source areas for silicified peat within Saskatchewan according to Johnson (1986): one is near Rockglen in southern Saskatchewan. The other is on the western shore of Lake Diefenbaker in the south-central part of the province.

Agate found at the Wolf Willow site tends to be very fine to amorphous in texture, as well as translucent. Colours range from white and grey to yellow, orange, and even pink. Some agate specimens also have quartz crystal-lined cavities. The exact source area of this material type is unknown. However, it is possible that this agate comes from somewhere in Montana, as its presence in sedimentary bedrock parent material in the Dryhead area of the southeastern corner of the state has been well-documented (Götze et al. 2009).

A brown chalcedony was identified at the site that could be either Knife River flint or South Saskatchewan River chalcedony. Since the true identity of these objects is impossible to ascertain without chemical analyses, it was decided by the author that they be named simply “brown chalcedony.” Artifacts made from “grey chalcedony” could possibly be agate, or from a chalcedonic vein of Cathead chert. Again, due to uncertainty, it was decided that the descriptive term “grey chalcedony” be applied in some cases.

4.3.3: Ceramic and Metallic Analysis

Ceramic and metallic artifacts were too few in number or differentiable attributes to be subdivided by criteria other than the acknowledgement of their presence at the site. However, basic metric analysis of a musketball recovered from Wolf Willow ascertained its calibre and confirmed that it had not been fired, as it was not deformed in any way. Other metallic artifacts recovered from the site include two cut iron nails, which based on their appearance are likely from the 1920s.

4.3.4: Sediment Analysis

Sediment samples were gathered from the Wolf Willow site using a hand trowel, then transported to a laboratory at the University of Saskatchewan. In all, seven samples were taken from the eastern wall of the Witness Block at the following depths: 0 to 14cm, 14 to 24cm, 24 to 35cm, 35 to 44cm, 44 to 52cm, 52 to 68cm, and 68 to 90cm. Analysis of the sediments was carried out by the author, under the supervision of Dr. Alec Aitken.

Sedimentary analysis for the purposes of this thesis consisted of three main methods: loss-on-ignition, particle size analysis, and pipette analysis. “Loss”, as it pertains to “loss-on-ignition,” refers to the loss of carbon from a sediment sample through being heated to prescribed temperatures. There are two such temperatures at which this analysis is typically carried out: 550°C and 1000°C. Samples heated to 550°C get hot enough to completely combust organic carbon, so by weighing a sample before and after it is fired, its organic carbon content can be ascertained. At 1000°C, a sample is hot enough to rid itself of inorganic carbonates. Organic carbon includes remains of plants and animals in various stages of decay, from bone fragments and decaying leaves to charcoal and microscopic organic particles that give sediments or soils a black or brown hue. Inorganic carbon is largely made up of carbonates from carbonate-rich parent material such as limestone or dolostone. Unfortunately, the inorganic carbon content of Wolf Willow site sediments could not be ascertained, due to a malfunction with the oven which prevented it from reaching the necessary temperature.

Particle size analysis involves shaking a sediment sample through a series of 11 screens, for a total of 12 particle sizes. The first screen catches all clasts larger than 2.0mm, while the subsequent 10 filter out successively finer sizes of sand. At the bottom of the stack of sieves, the “pan” catches silt and clay-sized particles, which are smaller than 63μm in diameter (Waters

1992: 20-21). Before they could be sifted, samples from each of the levels were ground with a mortar and pestle to separate any unwanted consolidated sediments, but not too hard so as to crush primary clasts. Samples were then homogenized and weighed out to approximately 30g. Sediments trapped in the screens were carefully weighed, and the resulting particle size ratios for each sample were tabulated.

Pipette analysis was undertaken to determine the percentages of colloidal clay, silt, and clay present in each of the seven samples. Raw sediment samples were placed in beakers with a 3% hydrogen peroxide solution to remove organic carbon. Once it was apparent that the peroxide solution was no longer reacting with any organic matter, 50mL of a 10% Calgon solution was added to the samples. Once the Calgon solution had been added, samples were wet screened using a 63μm sieve to recover silt and clay-sized particles in 1000mL cylinders, which were then filled with distilled water. These samples, now only containing silt and clay in a Calgon solution, were placed in a room temperature water bath and covered with watch glasses. Days later, the samples were agitated, and sampled using a 50mL mouth pipette at prescribed intervals. Unfortunately, due to unknown circumstances, the pipette analysis carried out by the author did not produce viable results, and thus will not be discussed further.

Colours of the sediment samples were also recorded, using the Munsell colour system for comparison. Three criteria are involved in defining a Munsell colour: hue, value (how light or dark a colour is), and chroma (how pure a colour is). Using the Munsell colour seen in the third column of Figure 7.1 as an example, “10YR 7/1” indicates a hue of yellow/red, with a value of 7 or fairly light, and a chroma of 1, indicating a low colour purity. Determining the colour of sediment is important because it can be indicative of the organic or mineral content of a given sample. For example, black or dark brown sediment is indicative of sediment that is high in organic matter; whereas a yellow colour indicates an enrichment of iron or aluminum oxides or hydroxides, and light grey or white sediment is usually enriched in calcium carbonate or salt and likely significantly leached.

Unlike cultural levels which are numbered by the order in which they are uncovered, lithostratigraphic units are numbered by the order in which they were deposited. Or, put more simply, the first cultural level at a site will be at the top of its stratigraphic profile, while the first lithostratigraphic unit will be at the bottom. Therefore, the sections of this chapter will follow an order based on that of the lithostratigraphic units found at the Wolf Willow site. A more detailed discussion of the methods and results of these analyses can be found in Chapter 7.

4.3.5: Radiocarbon Dating

Two bone collagen samples were submitted for analysis to Beta Analytic Inc. in Miami, Florida by Maria Mampé (2015b). Sample number 414920 was gleaned from a depth of 11cm in unit 25S 19E, and corroborates the anticipated relative age of C1 following the discovery of Plains Side-notched points at several locations within the Wolf Willow site since excavations began (see Table 4.1 below). A second bone collagen sample from unit 25S 19E, sample number 414921, was recovered from a depth of 21cm (see Table 4.1 below). This depth is well within the expected range for Cultural Level 2, but resulted in an acceptable date for Cultural Level 3 perhaps due to "…poor stratigraphic control during excavation or mislabeling during the cataloguing process (Mampé 2015a: 42)." Another two samples of bison bone were submitted by the author to Beta Analytic Inc. for analysis. Sample "Beta – 414922" gives Cultural Level 4 a measured radiocarbon age of 4540 +/- 30 years B.P. ($\delta^{13}C$ = -20.1 0/00), or 5317 calibrated years B.P.; while sample "Beta – 414923" gives Level 5 a measured radiocarbon age of 4860 +/- 30 years B.P. ($\delta^{13}C$ = -19.0 0/00), or 5660 calibrated years B.P. Table 4.1 below gives all available radiocarbon dates from the Wolf Willow site. Perhaps the most interesting and unexpected radiocarbon date of those displayed in Table 4.1 is that from sample number 414919. Sample number 414919 was recovered from a hearth feature that was believed during excavation to belong to Cultural Level 3. However, as its date clearly indicates, it cannot be affiliated with any established cultural level at the Wolf Willow site. The only archaeological culture that could fit with a calibrated radiocarbon age of 2750 years B.P. is Pelican Lake, but as no Pelican Lake points have ever been recovered from the site, this possibility was not considered until the sample had been dated. It is apparent, then, that in addition to the four cultural levels already established following 6 years of excavation, the Wolf Willow site also may contain a very sparse Pelican Lake component.

Sample Number	Cultural Level	Depth (cm)	Sample Type	Uncalibrated Age (Years B.P.)	Calibrated Age (Years B.P.)	Calibrated Error (+/-)	Two Sigma Minimum (Years B.P.)	Two Sigma Maximum (Years B.P.)
Beta - 414920	1	11	bone	220	285	30	145	310
Beta - 414919	3*	52	bone	2620	2750	30	2735	2770
Beta - 414921	3	21	bone	3300	3533**	30	3543	3590
Beta - 414922	4	56	bone	4620	5317	30	5303	5447
Beta - 414923	5	74	bone	4960	5660	30	5608	5743
* - indicates non-corroborative date for associated cultural level								
** - indicates *average* calibrated age								

Table 4.1: Radiocarbon dates from the Wolf Willow site. Sample # 414919 is from a hearth feature in what was believed during excavation to have been Cultural Level 3.

The tops of rocks from the topmost extent of the hearth feature found in units 18S 19E and 19S 19E were first seen at a depth of approximately 45cm below datum. Due in part to this depth, and also due to its location far beneath a sterile gravel layer which lay approximately 25cm to 35cm below the datum, the hearth was believed during excavation to belong to Cultural Level 3. Because it was so substantial in size and depth and because it held organic remains such as charcoal and bone fragments, several samples of hearth sediment were taken, and a bone fragment was submitted for radiocarbon dating. It should be noted that the majority of the large hearth stones that lined and filled the feature were not catalogued, but rather were carefully mapped and numbered with the intention that the feature in its entirety be reconstructed and incorporated into an exhibit by curatorial personnel at Wanuskewin Heritage Park. Figure 4.3 below shows a profile of the bottom half of the hearth feature with the top layer of stones removed.

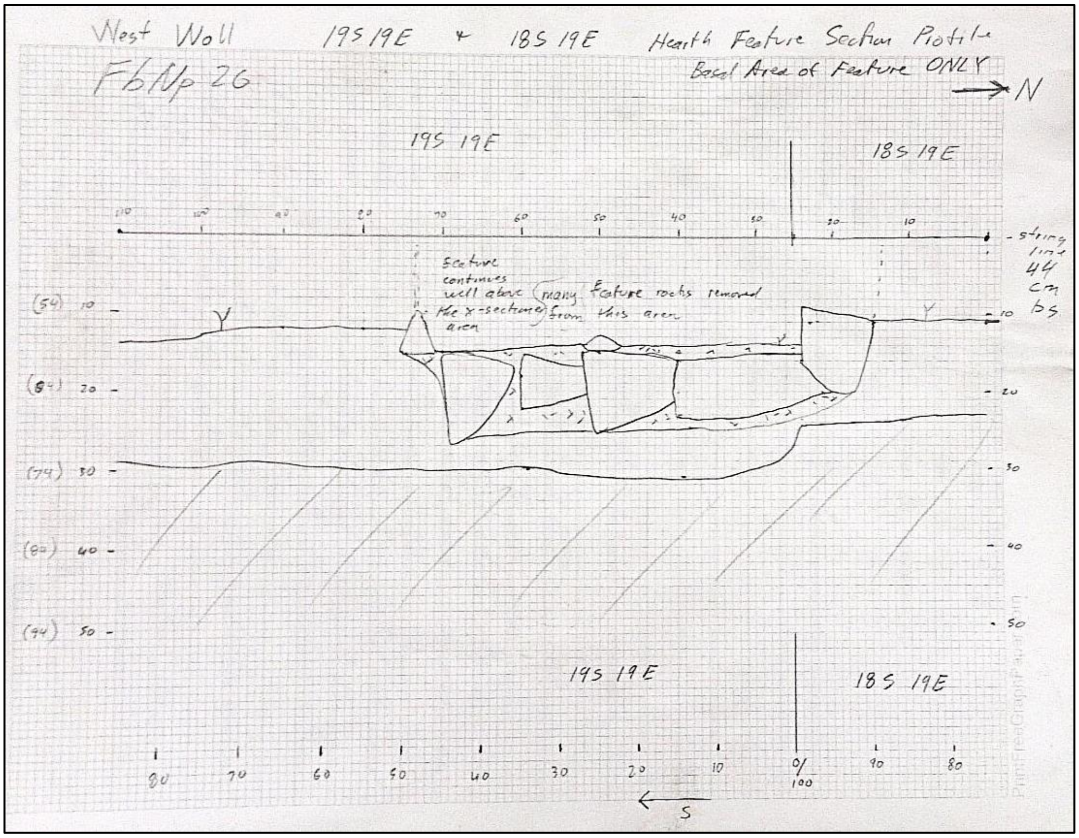

Figure 4.3: Profile of hearth feature in units 18S 19E and 19S 19E from which sample 414919 was taken. Profile is actually of the east wall of the units, not the west.

Unfortunately during the 2013 field season, the vast majority of the photos of the feature were lost due to an incident involving the author's photographic device and a washing machine. However, one photo was taken and posted to social media before the infamous incident occurred, and can be seen in Figure 4.4 (below).

Figure 4.4: Top of hearth feature in units 18S 19E, 19S 19E. Note charcoal staining at bottom in the photo, and how many large, unbroken stones lay atop the feature.

Chapter 5: Wolf Willow Site Stratigraphy

5.1 Introduction

Stratigraphy at the Wolf Willow site is based primarily on its sequence of cultural occupation levels and corresponding radiocarbon dates. However, as the interpretive lens of this thesis is a Geoarchaeological one, discernible attributes like sediment colour, composition, and texture will also be used in the stratigraphic interpretation of the site. Excavations conducted in 2010 determined that there were four cultural levels at the site, confirming Walker's initial assessment (Walker 1983). Depths for artifacts from cultural levels 1 and 2 are generally consistent. However, due to spatial and quantitative variability in deposition of the gravel lenses and sandy sediments separating C2 and C3, the depths of C2 and C3 can vary across the site. Oxbow points from C4, however, were consistently recovered from depths between 44cm and 48cm below unit datum across the site (Mampe 2015b).

5.2 Soil Formation

Soil formation is a particularly important concept with regard to understanding the stratigraphy of an archaeological site. Soils can only form when a surface remains stable long enough for plants to take root and generate a layer of darkly-tinted organic matter as they decay. As stable surfaces are also desirable to humans when choosing a place to spend extended periods of time, occupation levels are usually associated with them. According to Waters (1992), four processes are needed to convert sediments to soils (see Figure 5.1 below). The first of these is the addition of matter from the surface and surrounding atmosphere, which can include dissolved ions or suspended particles in rainwater, as well as organic matter from decaying plants and animals. The second is the transformation of substances in the soil, such as organic matter into humus. Third is the vertical transfer of soluble material within a soil profile. The fourth and final soil formation process is the removal, or "leaching", of soil constituents from a living soil (Waters 1992: 41).

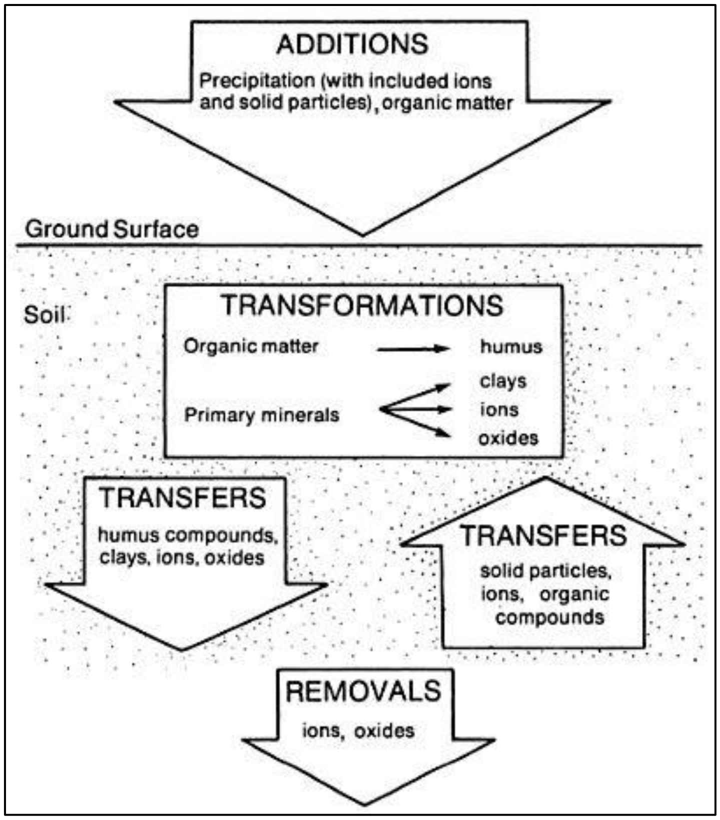

Figure 5.1: Diagram showing the 4 processes of soil formation (Waters 1992: 42).

Because these soil formation processes operate at different depths within a soil profile, horizons are able to develop. Soil horizons "have distinctive physical, chemical, and biological properties that are easily recognized in the field and that are used to subdivide the soil profile (Waters 1992: 45)." There are six "master" soil horizons, designated by six capital letters: O, A, E, B, C, and R. Typically, well-developed soil profiles have an A horizon at the top, a B horizon in the middle, and a C horizon at the bottom (Waters 1992: 45). "A" horizons are typically darkly-coloured, and are characterized by "the accumulation of humified organic matter mixed with solid mineral grains (Waters 1992: 46)." "B" horizons form below A, E, or O horizons, and are characterized by elevated concentrations of clay or other minerals compared to the parent material (Waters 1992: 47). "C" horizons consist of unconsolidated parent material such as sand, silt, or gravel, that is unaltered or slightly altered (Waters 1992: 47). "O" (organic), "E" (eluviated), and "R" (rock) horizons are not present in the stratigraphy of the Wolf Willow site, and therefore will not be discussed. Master horizons can be further subdivided based on observable characteristics such as the presence of clay, carbonates, salts, or other minerals that affect the chemical properties, colour, or texture of a soil horizon. These subdivisions are denoted by lower-case letters (Waters 1992: 47).

5.3 Stratigraphy

Stratigraphy is defined as "the study of the sequence and correlation of sediments and soils (Waters 1992: 4)." Periods of landscape aggradation, stability, and degradation can create, alter, or destroy stratigraphy at any given archaeological site. If the prevailing conditions at a site change from one of these states to another, "an interbedded sequence of sediments, soils, and erosional contacts is created (Waters 1992: 60-61)." Geoarchaeologists should achieve four main objectives when studying stratigraphy at an archaeological site. First, they should parse sediments and soils at a site based on perceived differences in colour or texture, and note the nature of the contacts between sedimentary units. Second, once identified, these stratigraphic units should be numbered from oldest to youngest. Third, they should determine the absolute ages of sedimentary units so that a detailed timeline with every potential period of aggradation, stability, or erosion at the site can be written. Fourth, they should put a site's stratigraphy into a larger regional context, correlating it with other sites in the area (Waters 1992: 61).

5.4 Stratigraphy of the Wolf Willow Site

The Wolf Willow site lies on a relatively flat section of a point bar deposit at the bottom of the Opimihaw Valley. A survey from the top of the western wall of the valley to the modern creek bed found that in the 10 metres between the southwest corner of the excavated area of the Wolf Willow site and the southeast corner, there is an elevation change of only 0.4m. Changes in sediment colour and texture and the lateral extents of any sedimentary anomalies were noted. In addition to this, stratigraphic profiles were completed at three locations to link the sedimentary differences observed at the unit level to the stratigraphy of the site as a whole.

5.4.1 26S Profile

The first profile that will be discussed in this chapter is that from the southernmost extent of the site, which was exposed following the first Wolf Willow field season in 2010 (see Figure 5.2 below). At the western end of the trench (see Figure 5.3 below), there is a well-established A horizon underlying a thick layer of sod, which extends from 12cm below the surface to a depth of approximately 25cm below the surface. Artifacts from cultural levels 1 and 2 are compressed into this A horizon, particularly between the two units pictured in Figure 5.3 (below). Beneath this A horizon lies a 20cm-thick gravelly C horizon that goes down to a depth of approximately 45cm below the surface, and a dark, clay-rich horizon that extends another 10cm deeper, in which artifacts from Cultural Level 3 and 4 can be found. In unit 26S 12E, another gravel lens lies beneath the "dark clay" unit, indicating that deposition of gravel at the Wolf Willow site may have been a regular occurrence. The "clay" unit at the bottom of the profile is light in colour, and was found to contain a significant amount of gravel at certain depths.

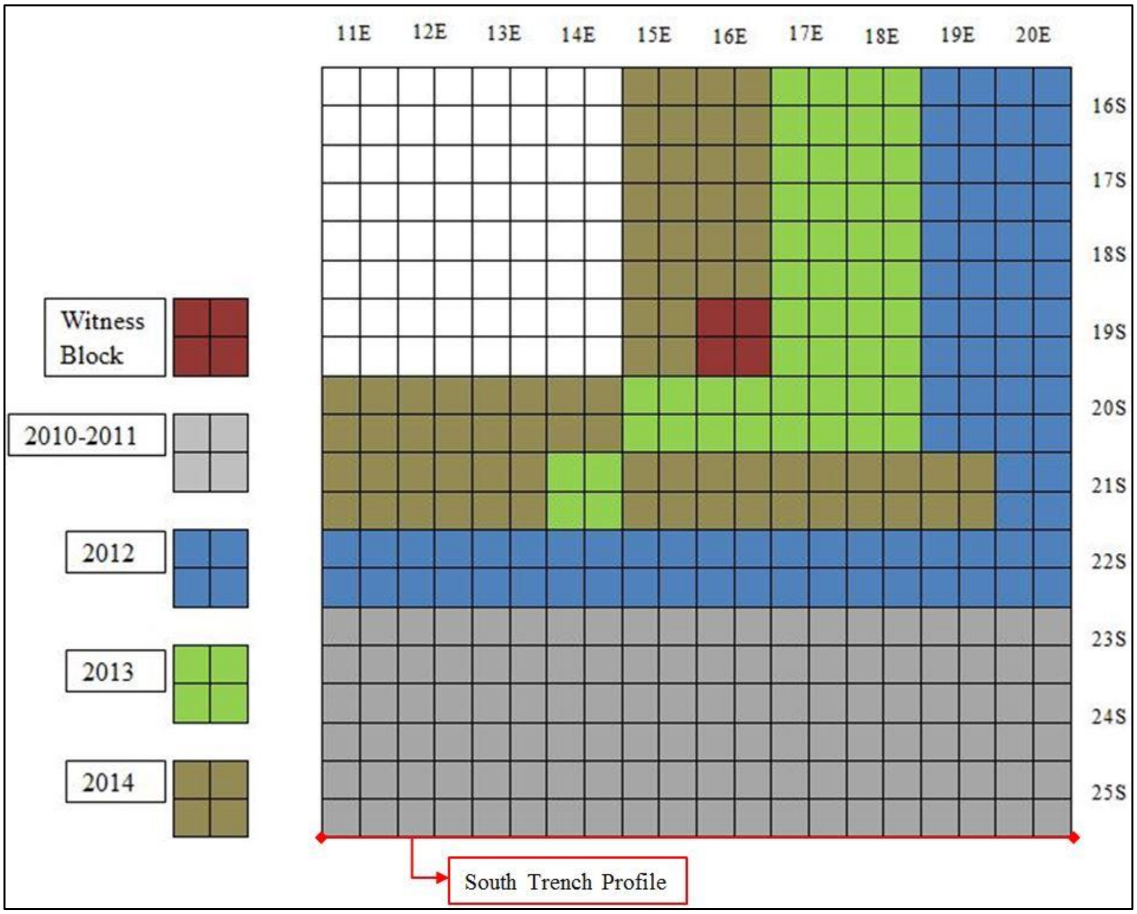

Figure 5.2: Position of southern trench within the site.

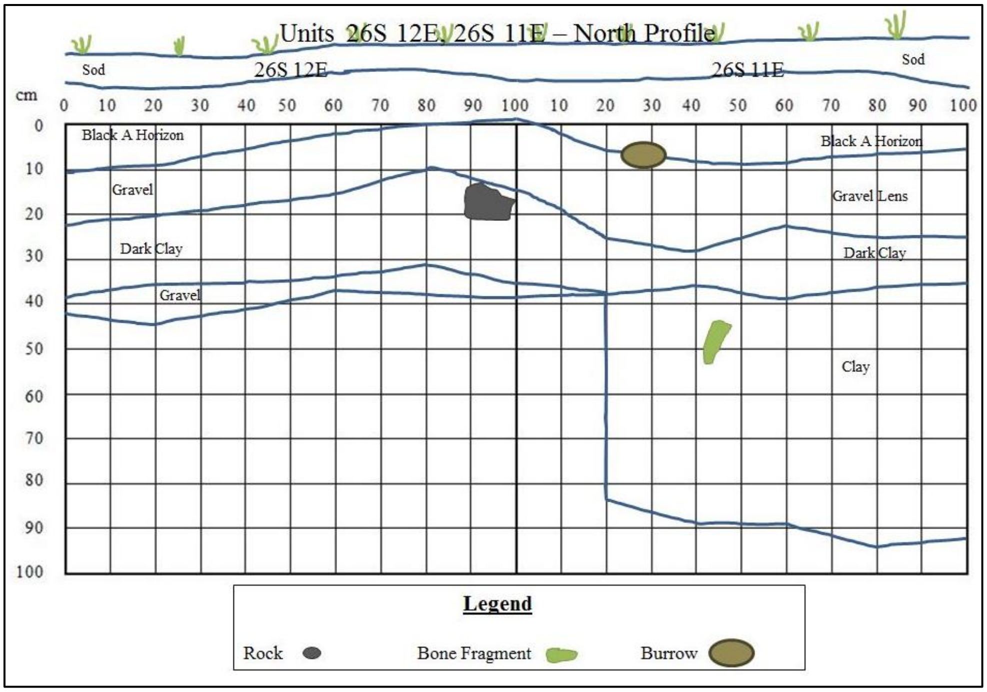

Figure 5.3: Western end of 25S trench profile. Exposed surfaces are north faces of units along unmapped 26S transect. “Step” from 12E to 11E due to difference in excavated depth.

Figure 5.4 (below) exemplifies the sporadic nature of the gravel lens that stretches between cultural levels 2 and 3. At the western end of unit 26S 13E, the gravel lens is approximately 12cm thick, but it pinches out completely at approximately 82cm to the east of the unit datum. While the occurrence of gravel lenses is inconsistent across the site, the presence of a hiatus in cultural activity which is coeval with the gravel lenses is consistent. As of 2013, no diagnostic artifacts had been found at the site that would suggest that it was occupied during the period between 3000 and 1200 years B.P.

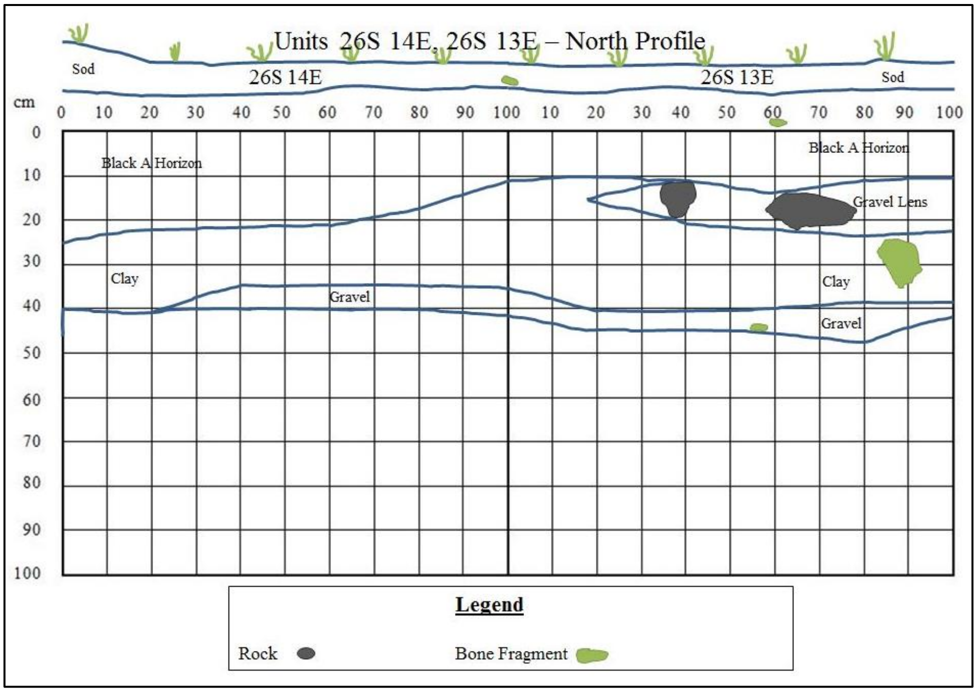

Figure 5.4: North face of units 26S 14E and 26S 13E.

Sediment samples were gathered from four locations within unit 25S 16E. Figure 5.5 shows a stratigraphic profile of the neighbouring units to the one that was sampled, indicating the depths that samples were taken from. It should be noted that the gravel lens that corresponds to the cultural hiatus between C2 and C3 is not present in this profile, and therefore was not sampled. Also, the lack of a sandy layer between the black "A" horizon and the underlying clay-rich "A" horizon in Figure 5.5 is notable, as such a layer is present in the units in the northern half of the site.

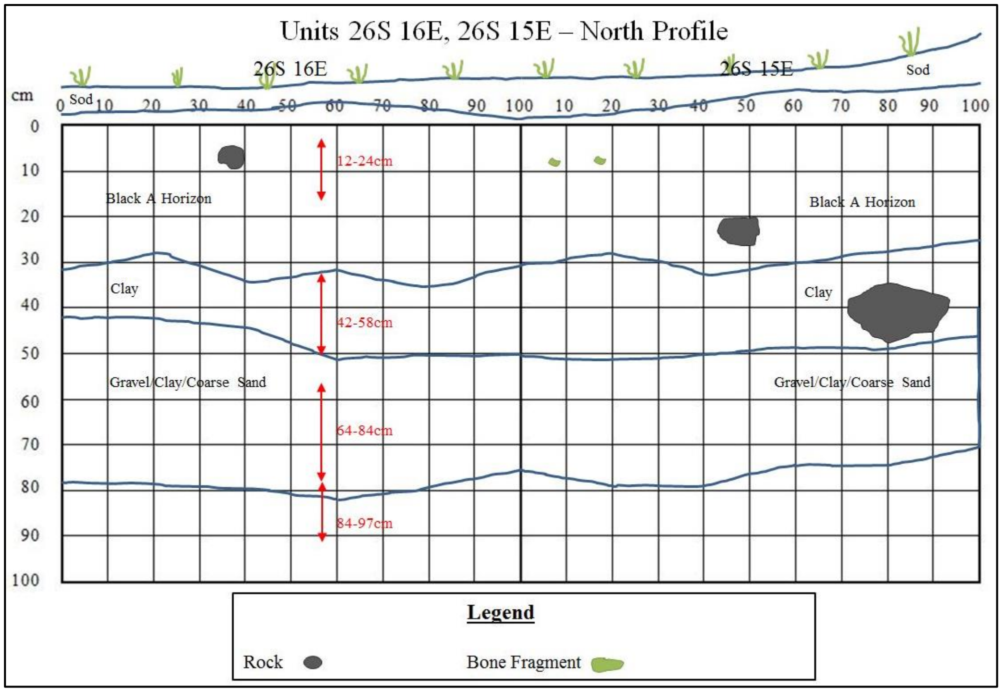

Figure 5.5: North face of units 26S 16E and 26S 15E. Sediment sample depths from unit 25S 16E are indicated in red.

Prior to the opening of the site in May of 2010, much of the Wolf Willow site was covered by dense brush. After they die, roots from trees and shrubs, such as willow and Saskatoon berry that can still be found near the site, can leave distinctive casts behind in a soil profile. Figure 5.6 shows probable evidence of one of these casts in the form of an abrupt intrusion of black “A” horizon sediment into the clay stratum at approximately 80cm east of the datum in unit 26S 17E, although it could also be evidence of bioturbation by a species of burrowing rodent. The “comminuted bone layer” contained within the “A” horizon is evidence of a faunal processing area at the site.

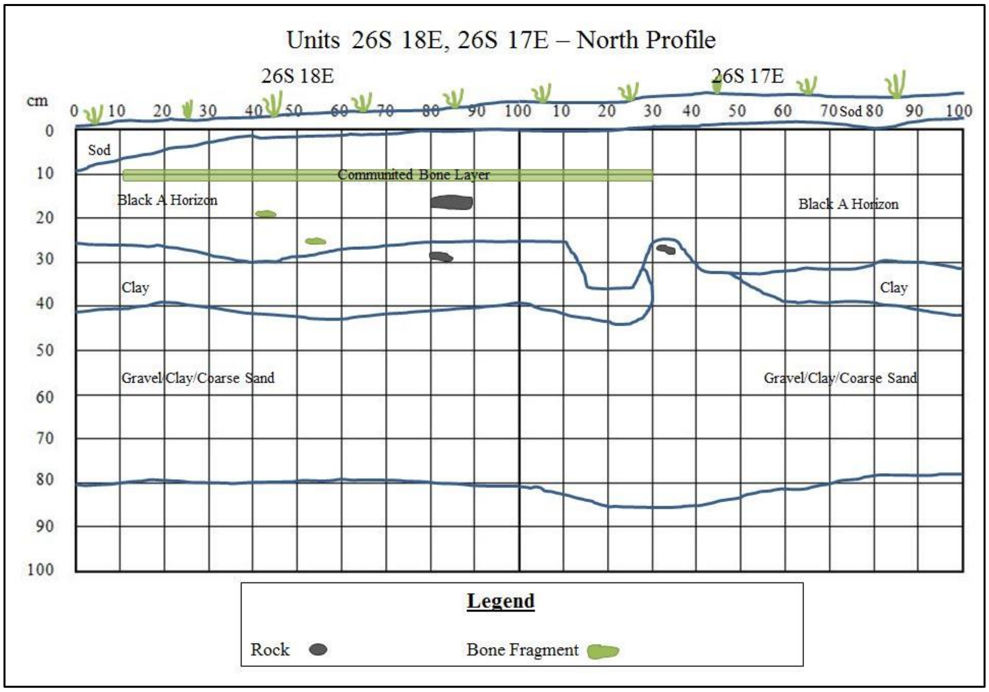

Figure 5.6: North face of units 26S 18E, 26S 17E.

A gravel lens is visible in the two easternmost units of the southern trench from approximately 42cm to 64cm below the surface (see Figure 5.7 below). This gravel lens is similar in stratigraphic position to the one pictured in Figure 5.3 at approximately 50cm to 60cm below the surface at the western end of the trench, and is likely approximately coeval with it as well. Bioturbation appears to have affected this profile as well, as evidenced by the burrow in unit 26S 20E. The “gravel/clay/coarse sand” unit at the bottom of the profile is consistent along the length of the southern trench.

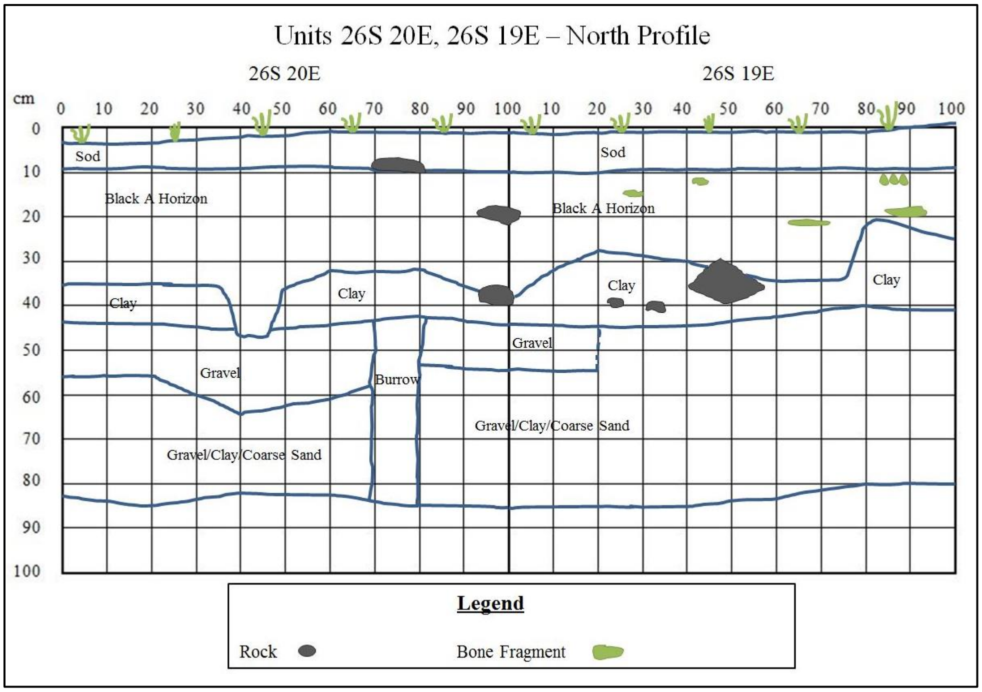

Figure 5.7: North face of units 26S 20E, 26S 19E.

5.4.2 20S 18E, 19S 18E Profile

The eastern walls of units 20S 18E and 19S 18E were also profiled (see Figure 5.8), and provide a good, albeit limited, glimpse at the hiatus between C2 and C3, which is manifested in these particular units by a layer of “brown sand” (see Figure 5.9). Samples from this sandy layer were taken from the eastern profile of the Witness Block of the Wolf Willow site (see Figure 5.10), and their composition will be discussed further in Chapter 7. Other strata seen in this profile include the “A” horizon that is seen across the site in which material from C1 and C2 can be found , as well as the organic-enriched “brown/black sand” stratum that contains cultural material from C3 and C4. There appears to be a mixing of the upper “A” horizon and the buried “A” horizon near where units 19S 18E and 20S 18E meet. This is likely due to some kind of bioturbation, either by burrowing mammals or riparian vegetation.

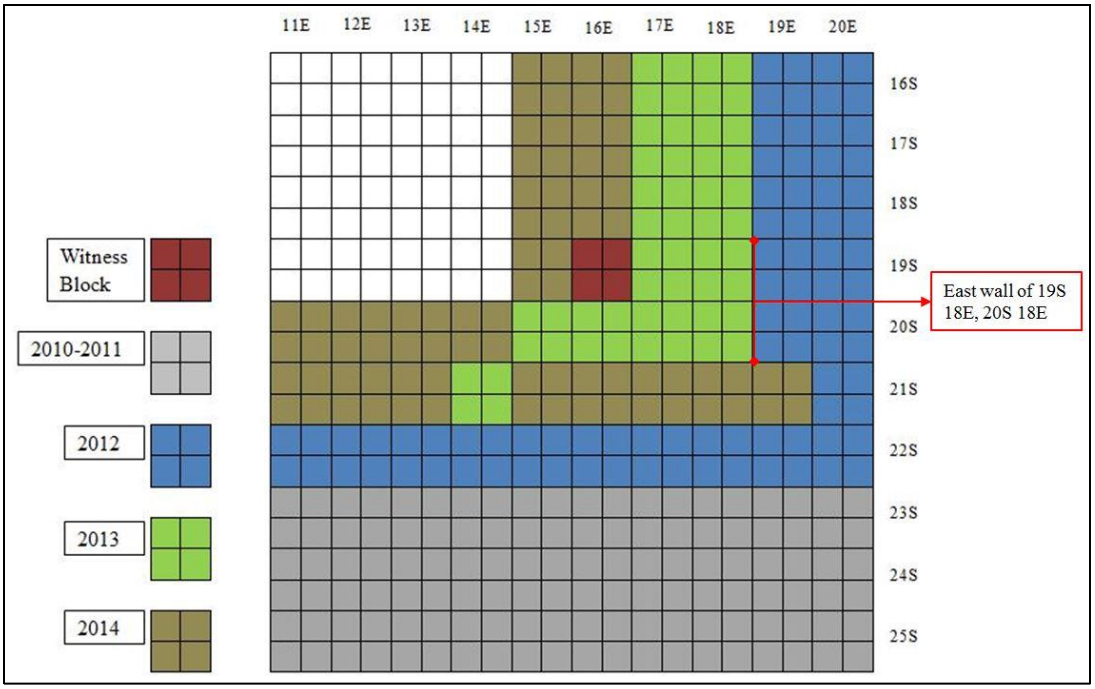

Figure 5.8: Position of the east wall profile of units 19S 18E and 20S 18E within the site.

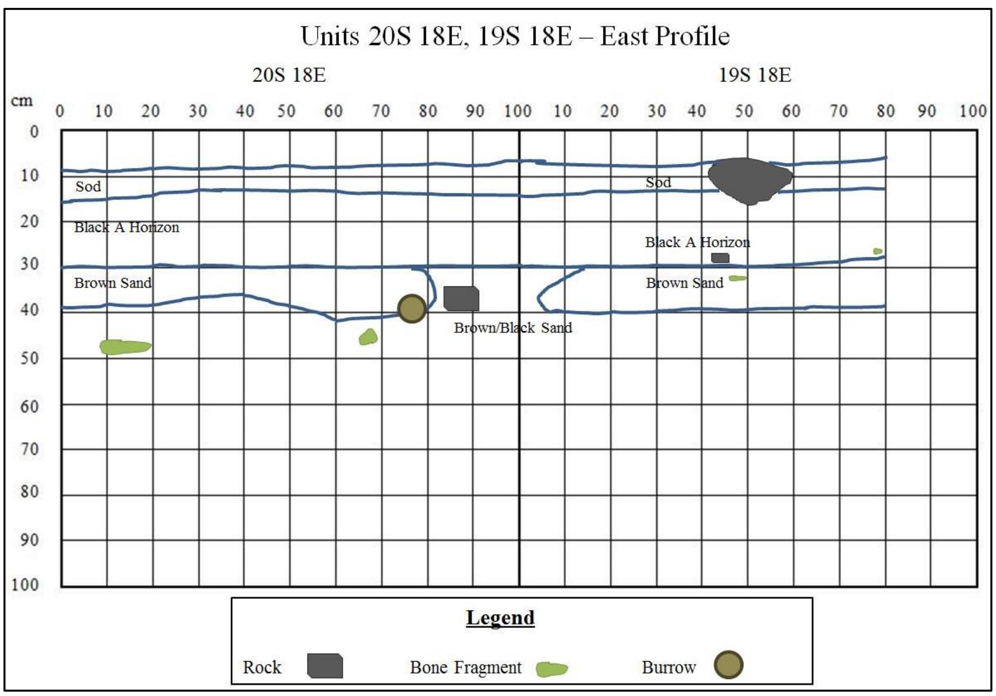

Figure 5.9: East wall profile of units 20S 18E and 19S 18E.

Figure 5.10: East wall profile of Witness Block (unit 19S 16E) with brown sandy layer indicated by red bracket. Orange tags indicate cultural levels. Sampled sections are visible at right in the photo.

5.4.3 21S Profile

The third and final profile that will be discussed in this section is that from units 21S 11E to 21S 19E (see Figure 5.11). Unit 21S 11E, which lies at the westernmost end of this profile (see Figure 5.12), has an interesting sequence of sediments. Immediately below the sod and going down as far as 24cm below the surface is the black “A” horizon, which can be seen across the entire site. Underlying this ubiquitous stratum is a 15cm thick layer of “brown/black sandy clay”, which does not appear to be overlain by either a gravelly or sandy stratum like those seen in other areas of the site. Nonetheless, no diagnostic cultural materials recovered from unit 22S 11E are from the period of time between 3000 and 1800 years B.P. Therefore, the cultural hiatus at the Wolf Willow site appears to remain intact in this unit, regardless of a sedimentary manifestation of that hiatus by either sand or gravel. A “tawny clay/sand” stratum lies between 40cm and 55cm below the surface, and is itself underlain by a stratum of “grey clay” which appears to extend below the fully excavated depth of the profiled units. Unit 21S 12E, however, does have a gravel lens separating cultural levels 2 and 3. Upon review of level records and planview forms of the neighbouring units to the south, it appears that the gravel lens that begins at approximately 32cm to the east of the datum in unit 21S 12E is the same one that can be seen in units 26S 11E, 26S 12E, and 26S 13E (refer back to figures 5.3, 5.4).

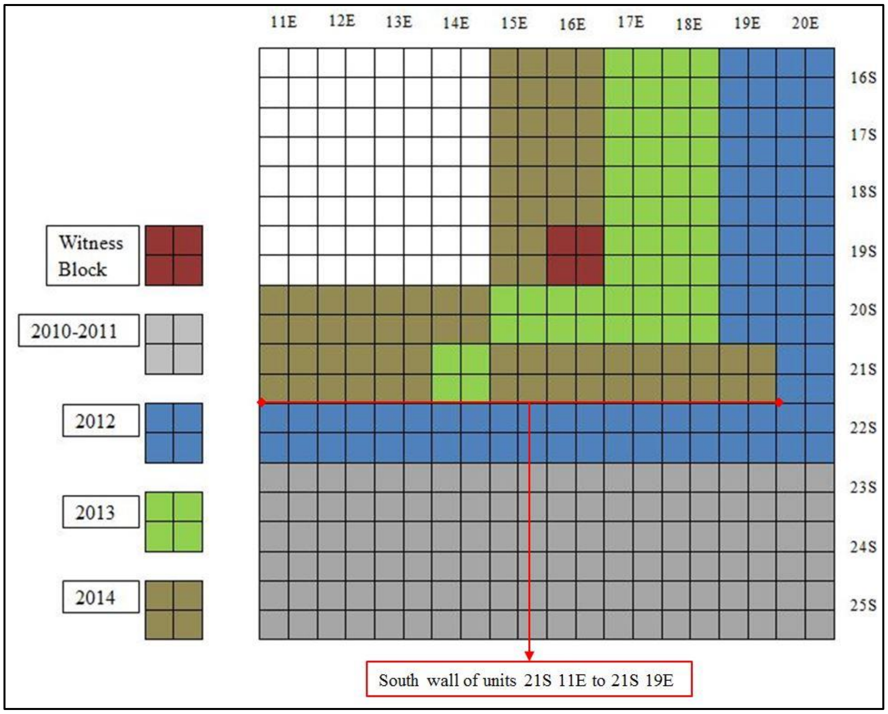

Figure 5.11: Position of south wall profile of units 21S 11E to 21S 19E within the site.

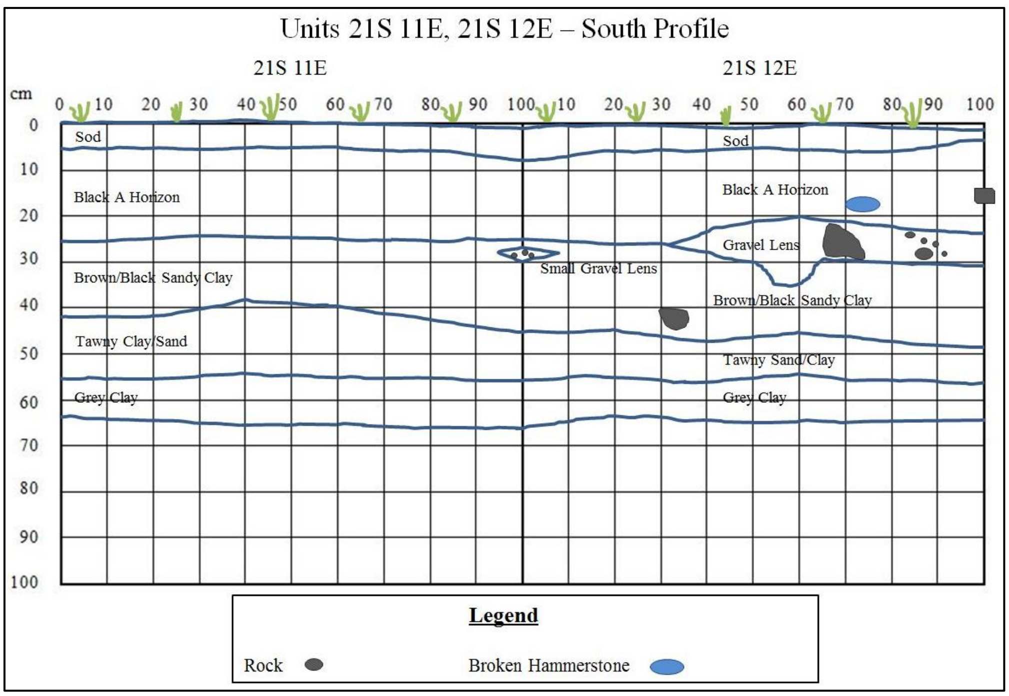

Figure 5.12: South wall profile of units 21S 11E and 21S 12E.

It is clear to see in Figure 5.13 and 5.14 (below) that the same gravel lens that began in unit 21S 12E extends through unit 21S 13E and into unit 21S 14E. The buried "A" horizon that contains material from C3 and C4, which was seen in Figure 5.12, can still be seen to underlie the gravel separating C2 and C3in this unit as well. Two lenses containing gravel and sand can be seen in Figure 5.13 as well, which is interesting due to the fact that they are both situated atop a stratum defined by "tawny sand". The presence of multiple small gravel lenses within or above finer-grained point bar deposits like sand suggests that chute cutoffs may have occurred at the present-day Wolf Willow site on a geologically regular basis.

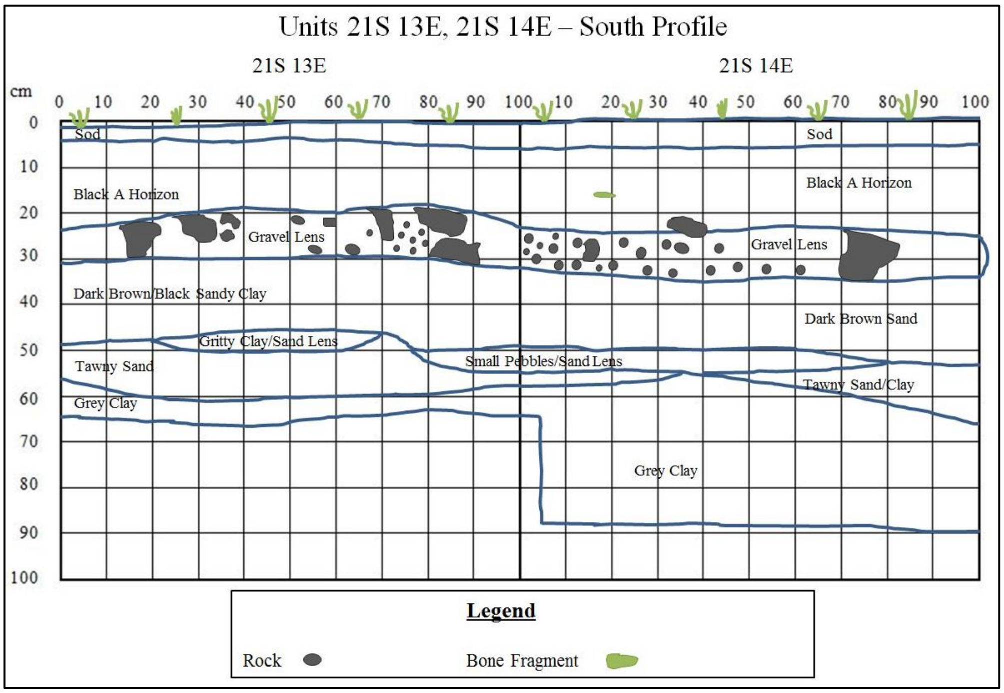

Figure 5.13: South wall profile of units 21S 13E and 21S 14E.

Figure 5.14: South wall profile of unit 21S 13E. Orange tags indicate cultural levels.

In unit 21S 15E (see Figure 5.15 below), the gravel lens separating C2 from C3 in unit 21S 14E experiences a decrease in clast size, and is defined as "brown gritty sand". This stratum pinches out approximately 48cm east of the datum in unit 21S 16E, and another stratum of "brown sand" appears at the same depth (around 30cm) approximately 89cm east of the datum in the same unit. Further down in the profile, the "dark brown/black sand" stratum that contains C3 and C4 appears to have a somewhat erratic morphology along its lower contact with the "tawny sand" stratum. This is likely due to burrowing activity, as the presence of a burrow in unit 21S 16E approximately 60cm below the surface and 70cm east of the datum suggests. The "tawny sand" stratum seen in Figure 5.15, which is a continuation of the same stratum seen in Figure 5.13, is most likely evidence of point bar deposition.

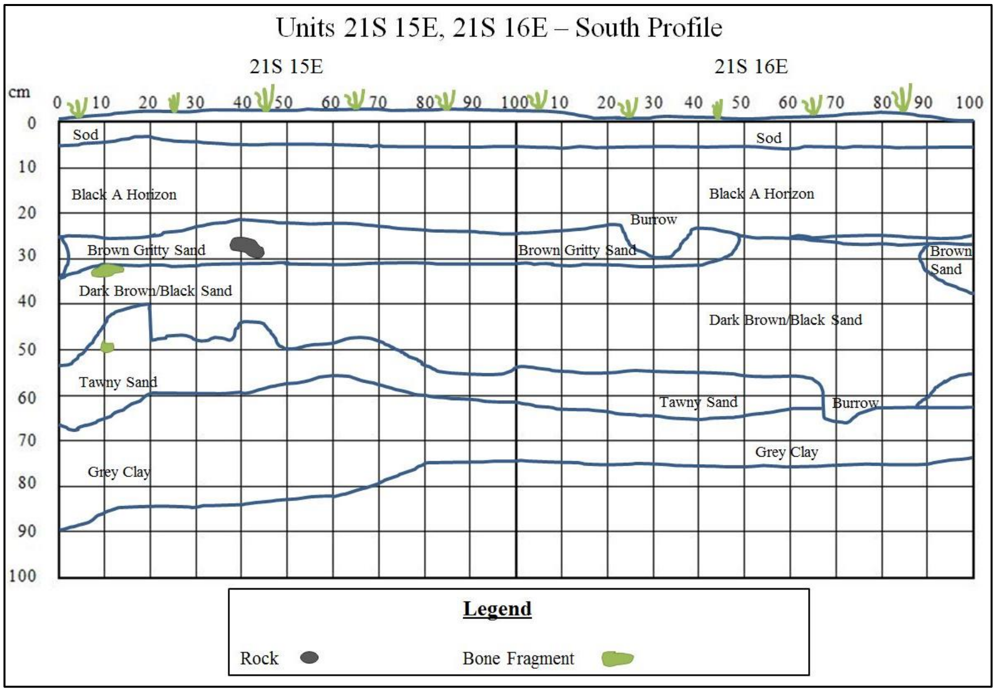

Figure 5.15: South wall profile of units 21S 15E and 21S 16E.

While little is seen of gravel lenses in the remaining three units in the 21S profile, the "brown sand" and "tawny sand" strata are evidence of the same landform instability that allowed for the deposition of gravel lenses in other areas of the Wolf Willow site. Sediments within the stratum dubbed "texture change", which connects and thinly overlays the "brown sand" strata found at 30cm below the surface in the two units depicted in Figure 5.16, was observed at the field level to be finer-grained than those of the "brown sand" strata. At 5cm, the finer "texture change" stratum is also thinner in cross section than the 10cm-thick "brown sand" strata. Bioturbation appears to have affected stratigraphy in this part of the profile as well, as indicated by the root cast intruding from the "brown/black sand" stratum into the lower two strata in unit 21S 17E.

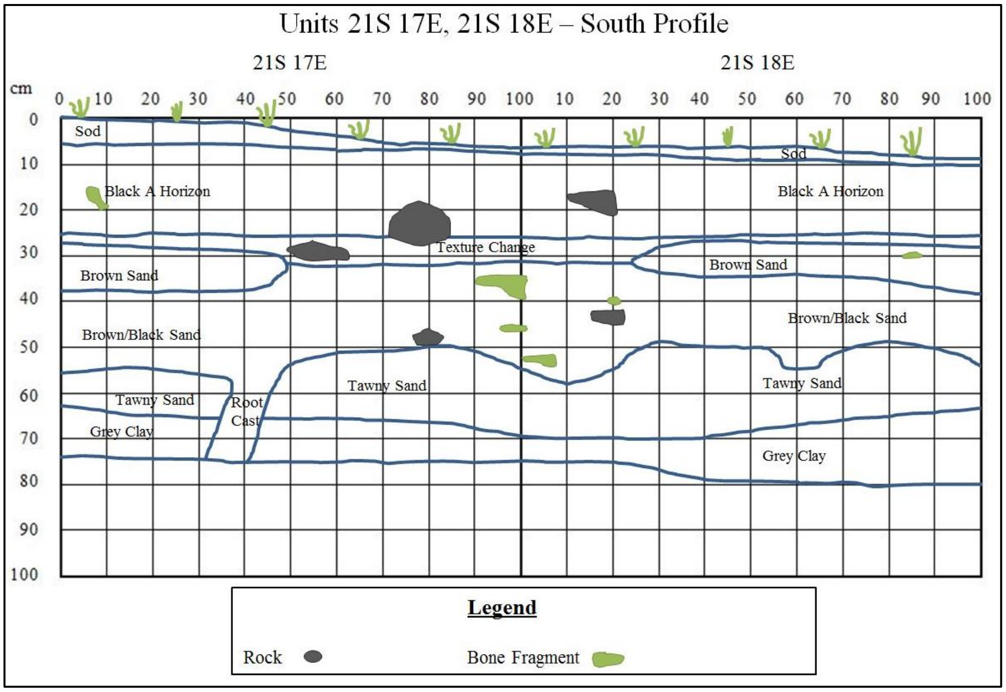

Figure 5.16: South wall profile of units 21S 17E and 21S 18E.

The final unit in the 21S profile is unit 21S 19E (see Figure 5.17). Strata in this unit are much more level than they are in the units that lie immediately to the west (refer back to Figure 5.16 above). The sod layer in this unit is very thin, as grass growth had been severely impeded due to activities associated with excavation, such as being covered by plywood and tarpaulin. The black “A” horizon maintains its thickness from the previous units. It is important to note that while the “brown sand” and “texture change” strata also continue into this unit, the “texture change” stratum thickens toward the eastern extent of the profile. The “brown/black sand”, “tawny sand”, and “grey clay” strata all appear to have been deposited in a level, parallel manner as well.

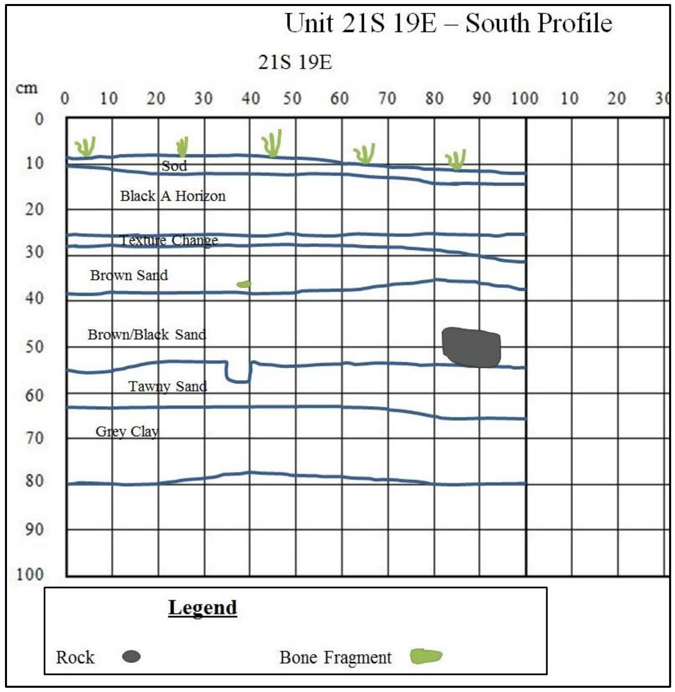

Figure 5.17: South wall profile of unit 21S 19E.

5.5 Discussion

While stratigraphy of the Wolf Willow site is complex, it nevertheless reflects the alternating periods of stability and instability seen in other areas of Opimihaw valley. It is known from previous work that a “geomorphic threshold” was crossed prior to ca. 4600 years B.P. which caused Opimihaw Creek to shift from an incision phase to one of aggradation. This was possibly due to an increase in slopewash made possible by an arid climate and a corresponding paucity of hillslope vegetation (Burt 1997: 184). A lack of or marked deficiency in hillslope vegetation would have allowed unconsolidated sediments to be swept downslope by precipitation events. Eventually, hillslope vegetation recovered as the climate stabilized, as the presence of a buried soil which holds the McKean level at the Wolf Willow site, and paleosols at the Amisk site, corroborate. According to Burt (1997), another period of increased slopewash occurred between 3500 and 3000 years B.P. This period of increased creekbed sedimentation again led the creek to migrate laterally. However, Burt notes that during this period of increased slopewash and sedimentation, “[t]he nature of sedimentation was not uniform across the floodplain (Burt 1997: 185).”

Chapter 6: Artifact Analysis

6.1: Cultural Level 1 (C1)

During excavation, Cultural Level 1 was found immediately below the sod that covered the site. Sod thickness decreased as excavation continued and can be attributed to both an increase in foot traffic and a decrease in sunlight, which can be attributed to the covering of the site with plywood sheeting and tarps. Projectile points recovered from this level associate it with the Plains Side-Notched assemblage, but the recovery of a small number of metallic artifacts indicates a temporal association with the Contact period as well.

6.1.1: Cultural Level 1 Lithic Assemblage

2012-2013 excavations of 32 units gleaned 3 bifaces, 13 bifaces or biface fragments, 24 cores or core fragments, 41 decortication spalls, 1 drill, 11 scrapers or fragments thereof, 1448 pieces of fire-cracked rock (FCR), 1374 flakes, 212 primary flakes, 11 retouched flakes, 1 grinding slab, 2 hammerstones, 13 projectile points or fragments thereof, 5 preforms, 2067 pieces of shatter, 24 spalls, 1 split cobble, 1 uniface, 1 large manuport, and 7 fragments of red ochre. Percentages of each debitage type as well as the material types they are composed of are presented below in Table 6.1.1.

Cultural Level 1 Debitage Counts							
Material	**Shatter**	**Spall**	**Decort. Spall**	**Primary Flake**	**Secondary Flake**	**Total**	**Percent (%)**
Agate	10	1	0	2	31	44	1.2
Agatized Wood	25	1	0	8	44	78	2.1
Basalt	70	1	0	6	17	94	2.5
Brown Chalcedony	11	0	2	11	22	46	1.2
Cathead Chert	30	1	1	15	19	66	1.8
CPL	34	2	8	5	16	65	1.7
Gronlid Siltstone	45	0	3	37	23	108	2.9
Jasper	8	0	0	3	14	25	0.7
Knife River Flint	9	1	1	17	32	60	1.6
Quartz	92	0	0	0	9	101	2.7
Quartzite	143	0	6	17	61	227	6.1
Silicified Peat	115	0	1	22	52	190	5.1
Silicified Siltstone	31	1	0	3	40	75	2.0
Silicified Wood	53	2	3	11	41	110	3.0
Swan River Chert (H.T.)	903	8	10	29	680	1630	43.8
Swan River Chert (raw)	461	5	6	20	252	744	20.0
Other	27	1	0	6	21	55	1.5
Total	2067	24	41	212	1374	3718	100.0
Percent (%)	55.6	0.6	1.1	5.7	37.0	100.0	

Table 6.1.1: C1 Lithic Debitage Counts.

Tools found in Cultural Level 1 (see figures 6.1.1, 6.1.2, and 6.1.3 below) include 1 drill, 5 complete points, 1 broken point, 5 point bases, 1 point tip, 1 “practice point”, 5 preforms, 5 endscrapers, 1 sidescraper, 5 scraper fragments, 1 uniface, 2 hammerstones, 11 retouched flakes, and 24 core fragments. Percentages, counts, and material types for the C1 flaked tool assemblage can be viewed in Table 6.1.2 below. Ground and pecked stone tools found in C1 included 2 quartzite hammerstones, one of which is pictured in Figure 6.1.4. A fragment of a grinding slab made from basalt was also recovered.

Cultural Level 1 Lithic Flaked Tool Counts

Material	**Scraper/ Scraper Fragment**	**Drill**	**Uniface**	**Biface/Biface Fragment**	**Preform**	**Point/Point Fragment**	**Retouched Flake**	**Total**	**Percent (%)**
Agate	1	0	0	0	0	1	0	2	3.6
Agatized Wood	0	0	1	0	0	0	0	1	1.8
Basalt	0	0	0	0	0	0	0	0	0.0
Brown Chalcedony	0	0	0	0	0	0	1	1	1.8
Cathead Chert	0	0	0	2	0	0	0	2	3.6
CPL	1	0	0	0	0	0	1	2	3.6
Fused Shale	0	0	0	0	0	0	1	1	1.8
Gronlid Siltstone	0	0	0	0	0	0	0	0	0.0
Jasper	0	0	0	0	0	1	0	1	1.8
Knife River Flint	0	1	0	0	0	2	0	3	5.5
Quartz	0	0	0	0	0	0	0	0	0.0
Quartzite	1	0	0	0	0	0	1	2	3.6
Silicified Peat	0	0	0	2	1	1	1	5	9.1
Silicified Siltstone	2	0	0	1	0	0	1	4	7.3
Silicified Wood	0	0	0	2	0	0	0	2	3.6
Swan River Chert (H.T.)	3	0	0	4	3	5	1	16	29.1
Swan River Chert (raw)	2	0	0	2	0	2	2	8	14.5
Other	1	0	0	0	1	1	2	5	9.1
Total	11	1	1	13	5	13	11	55	100.0
Percent (%)	20.0	1.8	1.8	23.6	9.1	23.6	20.0	100.0	

Table 6.1.2: C1 Flaked Tool Counts.

Plains Side-Notched points pictured in Figure 6.1.1 (below) exhibit some variation in material type, and many were found in a fragmentary state. The complete Knife River Flint point, Cat.# 7363 at top left in the photo, is the most complete point recovered from this level, and with its square base and well-defined notches is a perfect example of this point type. Cat.# 250, the heat-treated Swan River Chert point at center in the top row, may be a Plains Triangular point, but the presence of notches on each side of its blade suggest that it may be an incomplete Plains Side-Notched preform. Cat.# 6948 at top right in Figure 6.1.1 is composed of silicified peat, and seems to have been less well-made than some of the other points in this assemblage judging by its asymmetrical appearance. With the exception of the point at bottom left, the point bases pictured in the bottom row of Figure 6.1.1 exhibit exceptional symmetry and the distinctive square bases that characterize Plains Side-Notched points. It is also important to note that many of the bases recovered from C1 exhibit transverse or oblique fracture patterns, which are likely the result of impact with hard objects.

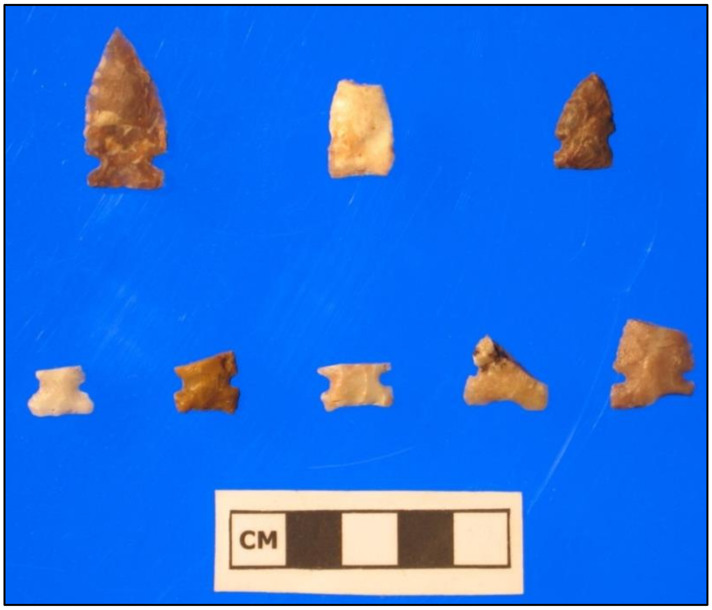

Figure 6.1.1: Plains Side-Notched Points from C1. Top row, from left to right: Cat.# 7363 (KRF), 250 (H.T. SRC), 6948 (Silicified Peat). Bottom row, from left to right: Cat.# 535 (SRC), 136 (Jasper), 219 (H.T. SRC), 205 (H.T. SRC), 4123 (H.T. SRC).

One of the 13 points or point fragments found in Cultural Level 1, a Hanna point, actually belongs in another level, having been moved into its discovered position by natural processes. Specifically, these natural processes are either cryoturbation or bioturbation. Cryoturbation is a physical process wherein the freezing and thawing of the ground can displace archaeological material (Waters 1992: 104). Bioturbation, however, is a biological process that can result in the displacement of archaeological materials via the movement of animals or plants within the sediment matrix (Waters 1992: 104).

Bifaces recovered from C1 can be viewed below in Figure 6.1.2. While Cat.# 3285 at top left in the photo is not the symmetrical triangular or lanceolate shape one would expect from a Late Precontact biface or preform, it does appear to have been bifacially retouched. Two Cathead Chert biface fragments at center in the top row, Cat.# 6995 (left) and 4870 (right), appear to have been fractured, likely during manufacture. However, judging by the step fracture on the right lateral edge of Cat.# 6995, it would likely have been discarded anyway. Cat.# 6663 (top right) and Cat.# 2186 (bottom left) are composed of quite low quality materials, and were likely discarded due to flaws in their respective materials. Cat.# 4646 (left) and 5483 (right) at bottom center in the photo are relatively small compared to other bifaces in Figure 6.1.2, and may be point preforms. Cat.# 4646 has a noticeable step fracture near its distal end that may have resulted in its being discarded. Cat.# 3337 at bottom right is also a possible preform that was discarded due to flaking difficulties associated with its inconsistent material type, Swan River Chert.

Figure 6.1.2: Bifaces (top) and Preforms (bottom) from C1. Top row, from left to right: Cat.# 3285 (Silicified Wood), 6995 (Cathead Chert), 4870 (Cathead Chert), 6663 (Silicified Siltstone). Bottom row, from left to right: Cat.# 2186 (Mottled Chert), 4646 (H.T. SRC), 5483 (H.T. SRC), 3337 (H.T. SRC).

Scrapers recovered from C1 appear to have been used until they were either too small (ie: “thumbnail scrapers”) or were fractured during use. Cat.# 7674 (top left) and 5890 (top right) appear to be unsuccessful attempts at uniface manufacture, due either to the shallowness of their prospective working edges and/or flaws in their respective materials. Cat.# 6662 (top center) and Cat.# 3819 (bottom right) were clearly transversely fractured, while Cat.# 2167 (bottom left) was likely too small to be of further use, and retouchable material appears to have been exhausted on Cat.# 5937 (bottom center).

Figure 6.1.3: Scrapers from C1. Top row, from left to right: Cat.# 7674 (H.T. SRC), 6662 (Agate), 5890 (Quartzite). Bottom row, from left to right: Cat.# 2167 (SRC), 5937 (H.T. SRC), 3819 (Grey Chalcedony).

Judging by the extensive pecking visible at its distal working edge (see photo at right), Cat.# 8372 (see Figure 6.1.4 below) was a well-used hammerstone. The quartzite it is composed of is very high in silica content and therefore relatively easy to fracture or manufacture flaked tools from. It is possible that the siliceous and easily-flaked quartzite that composes this artifact may have aided in its fracture and subsequent discard.

Figure 6.1.4: Broken Quartzite Hammerstone from C1 (Cat.# 8372). Note the pecked working end of the tool in the picture at right.

Of the 24 core fragments recovered from this level, 4.2% are agate, 8.3% basalt, 4.2% Cathead chert, 4.2% CPL, 16.7% quartz, 12.5% silicified siltstone, 4.2% silicified wood, and 8.3% raw and 25.0% heat treated Swan River Chert (see Table 6.1.3 below).

Cultural Level 1 Core Counts				
Material	**Core**	**Bipolar Core**	**Total**	**Percent (%)**
Agate	0	1	1	4.2
Agatized Wood	0	0	0	0.0
Basalt	1	1	2	8.3
Brown Chalcedony	0	0	0	0.0
Cathead Chert	1	0	1	4.2
CPL	1	0	1	4.2
Gronlid Siltstone	0	0	0	0.0
Jasper	0	0	0	0.0
Knife River Flint	0	0	0	0.0
Quartz	4	0	4	16.7
Quartzite	2	1	3	12.5
Silicified Peat	0	0	0	0.0
Silicified Siltstone	0	3	3	12.5
Silicified Wood	1	0	1	4.2
Swan River Chert (H.T.)	6	0	6	25.0
Swan River Chert (raw)	2	0	2	8.3
Other	0	0	0	0.0
Total	18	6	24	100.0
Percent (%)	75.0	25.0	100.0	

Table 6.1.3: C1 Lithic Core Counts.

Several of the cores mentioned in Table 6.1.3 can be seen in Figures 6.1.5, 6.1.6, and 6.1.7 below. Some cores such as Cat.# 3770 (see Figure 6.1.5 below, at center) and Cat.# 5133 (Figure 6.1.5, at right) may be representative of materials testing by flintknappers, as very little of the available material appears to have been utilized, and much cortex remains on their surfaces. Conversely, Cat.# 2225 (below, at left) appears to be an exhausted core.

Figure 6.1.5: Cores from C1. From left to right: Cat.# 2225 (Quartz), 3770 (Cathead Chert), 5133 (Silicified Wood).

Precisely one third (33.3%) of cores from C1 are composed of raw or heat-treated Swan River Chert. Several of these cores are pictured in Figure 6.1.6 below, and are excellent examples of how variable the grain size of Swan River Chert can be, as well as how well the material can respond to heat treatment.

Figure 6.1.6: SRC Cores from C1. Top row, from left to right: Cat.# 7678 (H.T.), 6669 (H.T.). Bottom row, from left to right: Cat.# 6668 (H.T.), 543 (Raw), 7319 (H.T.).

Bipolar core reduction is an effective flaking strategy when a knappable material is present in pebble form, as is the case for materials in Saskatchewan such as quartzite and silicified siltstone. Three such bipolar cores from Cultural Level 1 can be seen in Figure 6.1.7 below.

Figure 6.1.7: Three Bipolar Cores from C1. From left to right: Cat.# 7398 (Quartzite), 128 (Agate), 210 (Silicified Siltstone).

Distribution of lithic artifacts from the 2012-2013 excavations of this level appears to be concentrated in four main areas: one area in the northern extent of the site and three along its southern border (see Figures 6.1.8, 6.1.9). These distribution maps suggest that stone tools were being manufactured or modified at specific locations within the Wolf Willow site, and could be considered "activity areas" within the site.

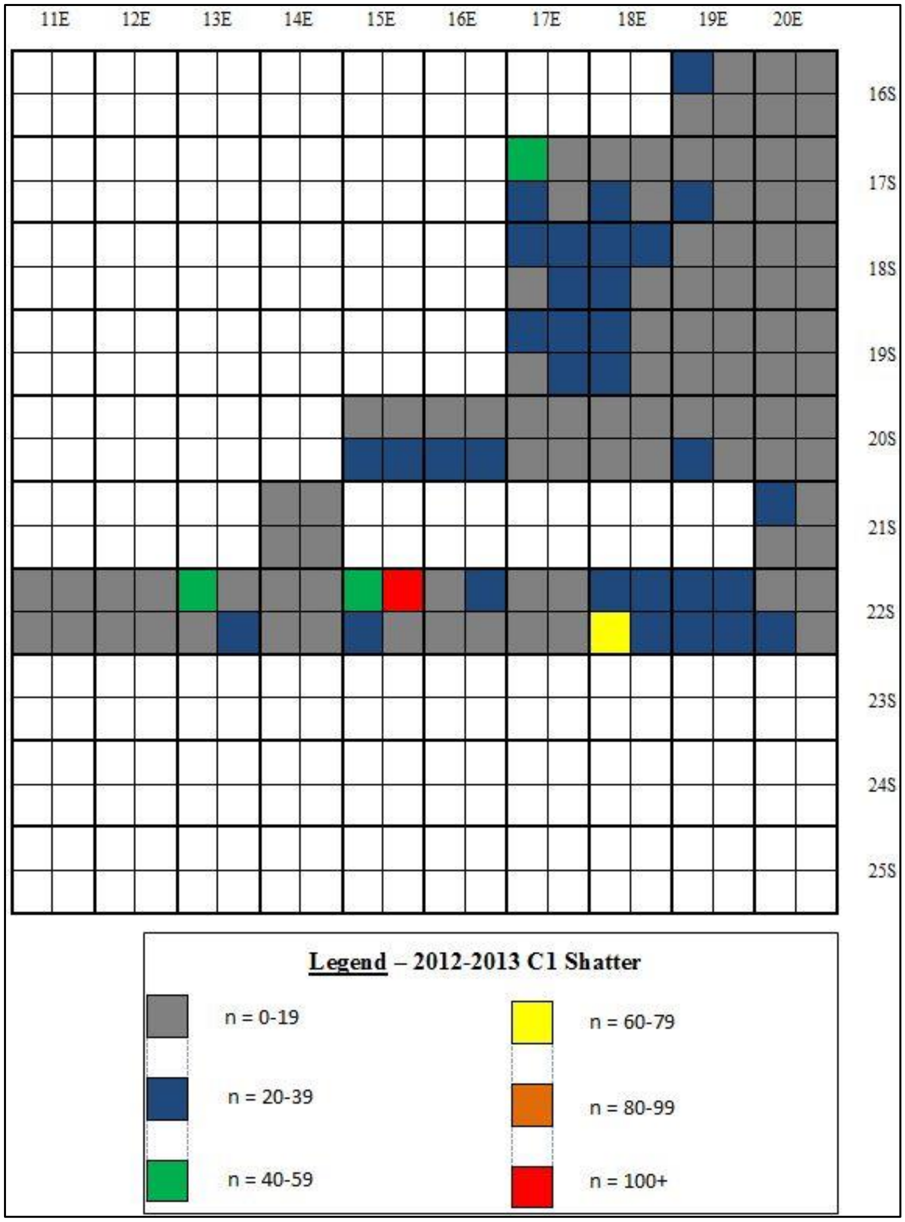

Figure 6.1.8: Distribution of C1 Lithic Shatter.

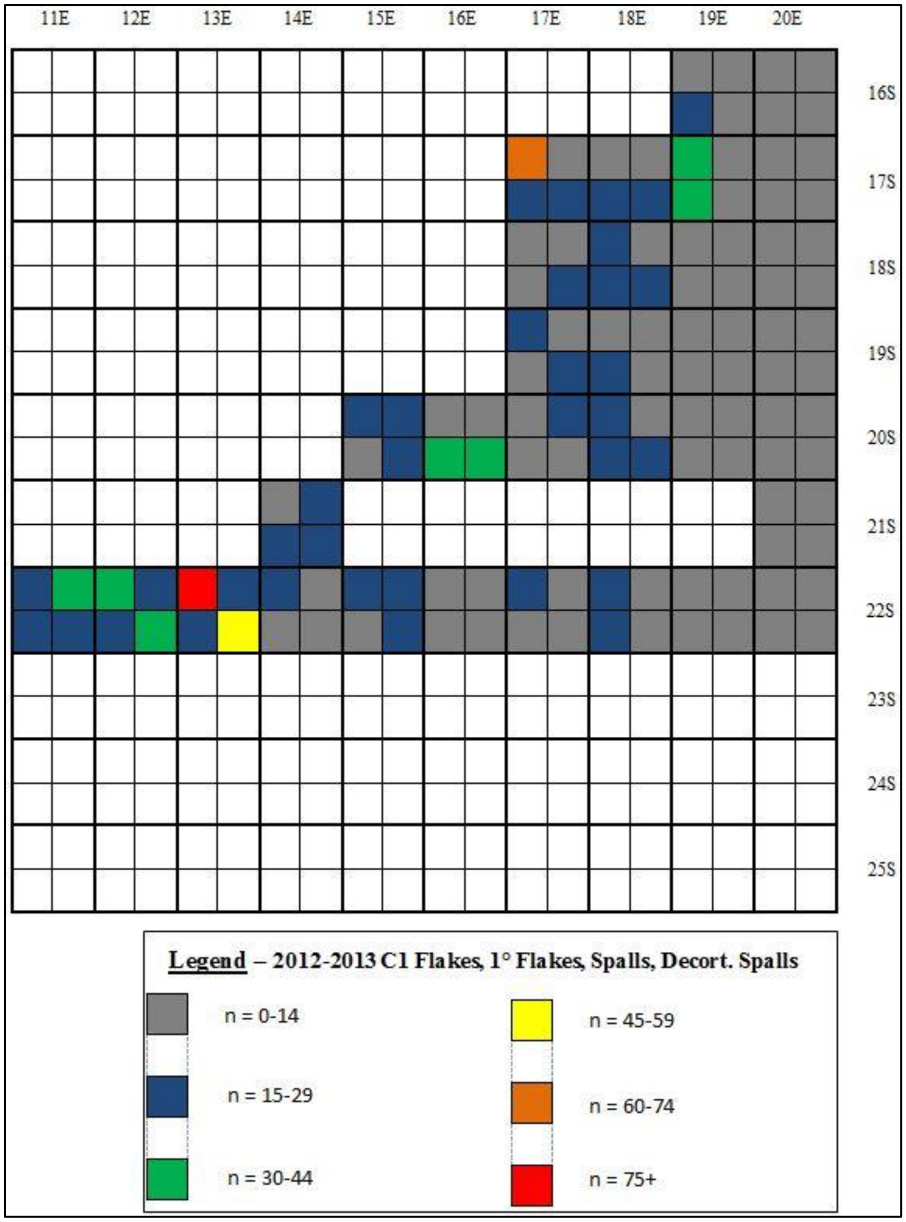

Figure 6.1.9: Distribution of other C1 Lithic Debitage.

6.1.2: Cultural Level 1 Metal Assemblage

Three metallic artifacts were found in Cultural Level 1. Two were iron nails which appear to be from the first half of the 20th Century. The third artifact is a lead musketball that does not appear to have been fired (see Figure 6.1.10), as it has not been deformed in any way. One notable attribute of the musketball is that it has a calibre of .52, which may provide an avenue for future study.

Figure 6.1.10: .52 cal. Musketball from C1 (Cat.# 380).

6.1.3: Cultural Level 1 Faunal Assemblage

Excavations in 2012 and 2013 gleaned a total of 17,972 faunal specimens weighing 13,377.3g from Cultural Level 1 (see Table 6.1.4 below). MNI (minimum number of individuals) analysis revealed that a minimum of 3 bison are represented in this assemblage (see Table 6.1.4, Figure 6.1.11 below). Other species represented in this level by one individual include: large canid - *Canis sp*. (see figure 6.12), *Lepus americanus* (see Figure 6.1.13), *Sus scrofa*, *Bos sp*., *Vulpes velox*, *Cervus canadensis*, *Castor canadensis*, and Sciurid rodent. Species of the Phylum Mollusca are also represented in this level, although due to a lack of identifiable hinge fragments, MNI analysis is, at best, difficult.

Cultural Level 1 Faunal Counts		
Species	**NISP**	**MNI**
Bison bison	1741	3
*Bos sp.**	1	1
Canis sp.	24	1
Castor canadensis	3	1
Cervus canadensis	1	1
Lepus americanus	53	1
*Sus scrofa**	2	1
Vulpes velox	3	1
Large Mammal	16,095	n/a
Small Mammal	8	1
Small Carnivore	1	1
Sciurid Rodent	5	1
Small Rodent	1	1
Mollusk	34	n/a
Total	17,972	14

Table 6.1.4: C1 Faunal Counts.

Figure 6.1.11: *Bison bison* Mandible from C1 (Cat.# 8393).

Figure 6.1.12: *Canis sp*. Right 3rd Metacarpal from C1 (Cat.# 235).

Figure 6.1.13: *Lepus americanus* Right Hindlimb Elements. Top: Femur (Cat.# 3081). Bottom, at Left: Calcaneus (Cat.# 3086). Bottom, at Right: Astragalus (Cat.# 3087).

Figure 6.1.14: *Lepus americanus* Sacrum (Cat.# 3084).

By weight, approximately 86.2% of the C1 faunal assemblage is comprised of unburned, un-utilized bone. Burned and calcined faunal remains constitute a further 4.5% of the assemblage. The remaining 9.3% includes teeth, fragments of maxillae and mandibles, carved faunal remains, polished faunal remains (including fragments of bone tools), and shell fragments. By number, 9.4% of C1 faunal remains were identified as originating from bison (n=1698), with the remaining 90.6% being comprised of large Canids (n=24), Elk (n=1) Snowshoe hare (n=53), pig (historical, n=2), rodents (n=6), Swift fox (n=3), mollusks (n=34), small mammals (n=7), and an overwhelming majority of unidentifiable large mammals (89.6%).

Several faunal artifacts were clearly modified and used by Plains peoples for a number of purposes. One fragment of a bone flesher was recovered, as was a fragment of a bone awl and several beads made from long bone shafts of small mammals (see Figure 6.1.15 below). Perhaps the most notable of all utilized faunal remains from this level is a carved elk canine pendant (see Figure 6.1.16), which is the first of its kind to be unearthed at Wanuskewin Heritage Park.

Figure 6.1.15: Polished Bone Fragments from C1. Top, at Left: Bone Flesher Fragment (Cat.# 1731). Bottom, at Left: Bone Awl Fragment (Cat.# 1805). At Right: Bone Beads. Cat.# 7012 (left), 4039 (right).

Figure 6.1.16: Elk (*Cervus canadensis*) Canine Tooth Pendant from C1 (Cat.# 3806).

As seen in Figures 6.1.17 and 6.1.18 below, concentrations of burned faunal remains seem to spatially co-occur with fire-cracked rock (FCR) and hearth features (see Figure 6.1.19). This is also true of un-burned, un-utilized faunal remains (see Figure 6.1.20), although some lesser concentrations do occur away from the peripheries of thermal features as well.

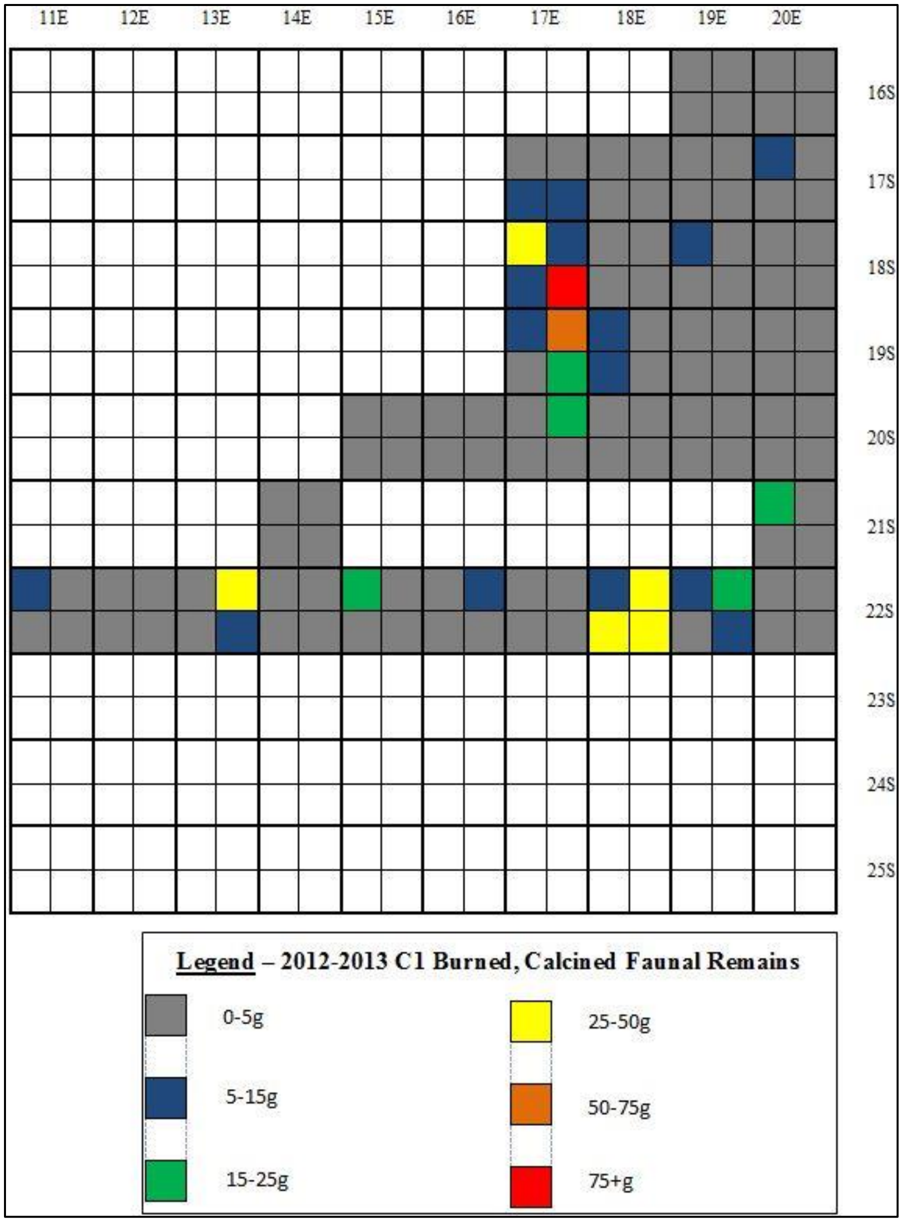

Figure 6.1.17: Distribution of C1 burned faunal remains.

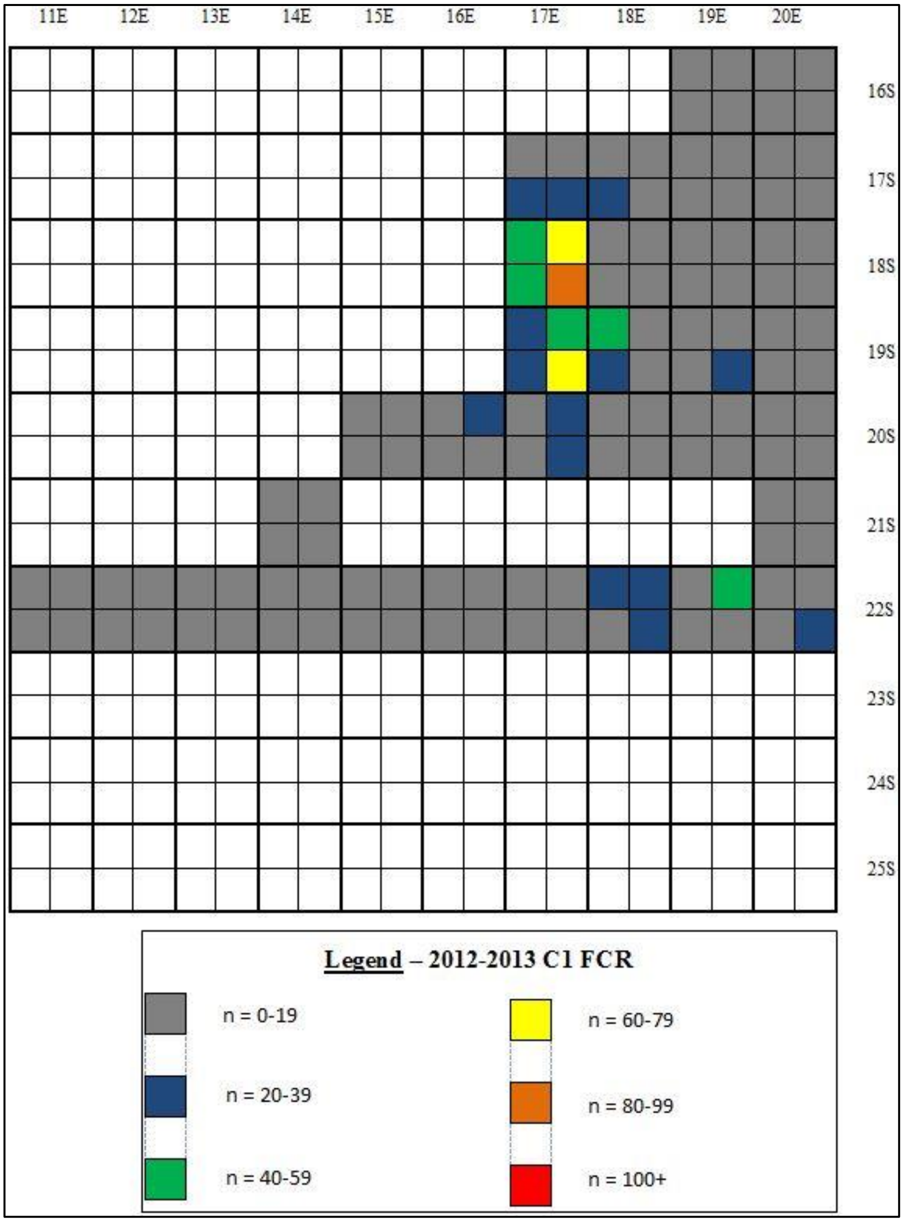

Figure 6.1.18: Distribution of C1 fire-cracked rock.

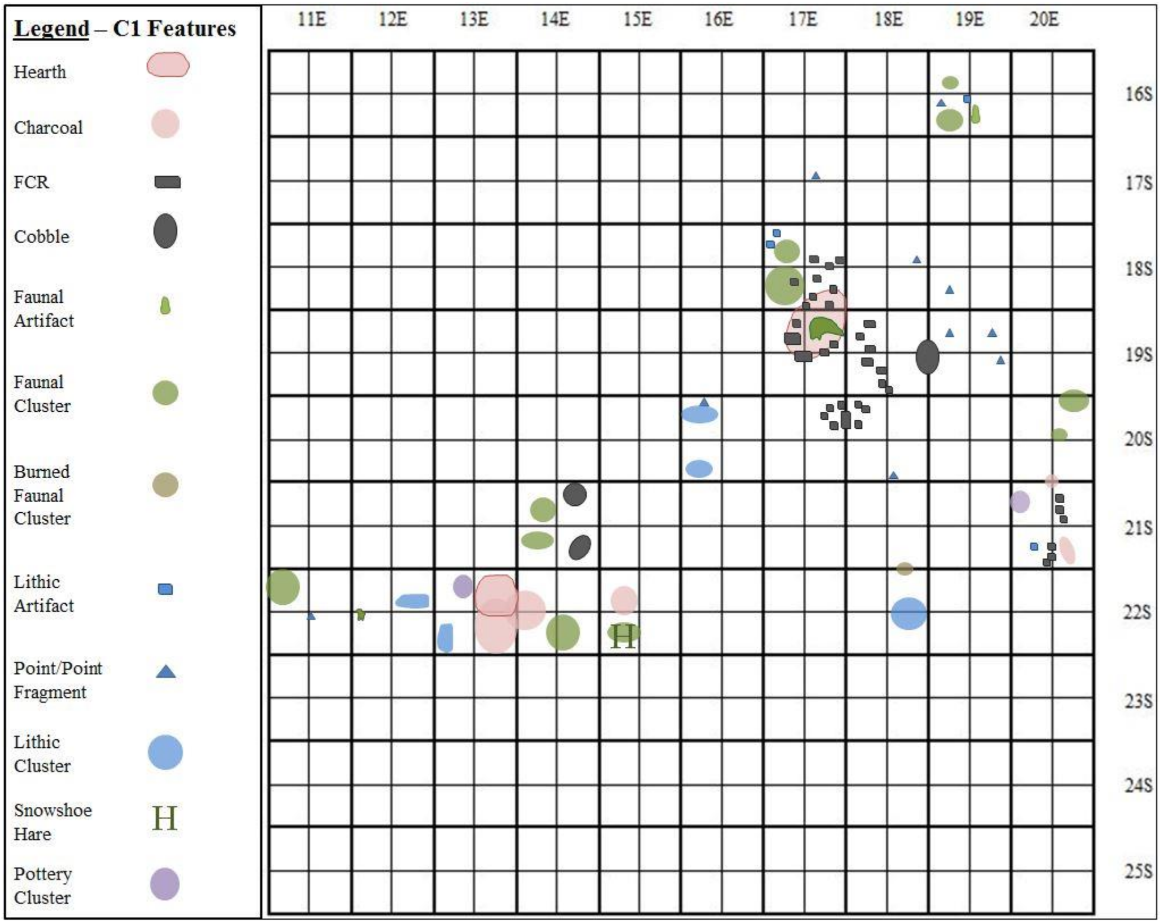

Figure 6.1.19: Distribution of 2012-2013 C1 Features.

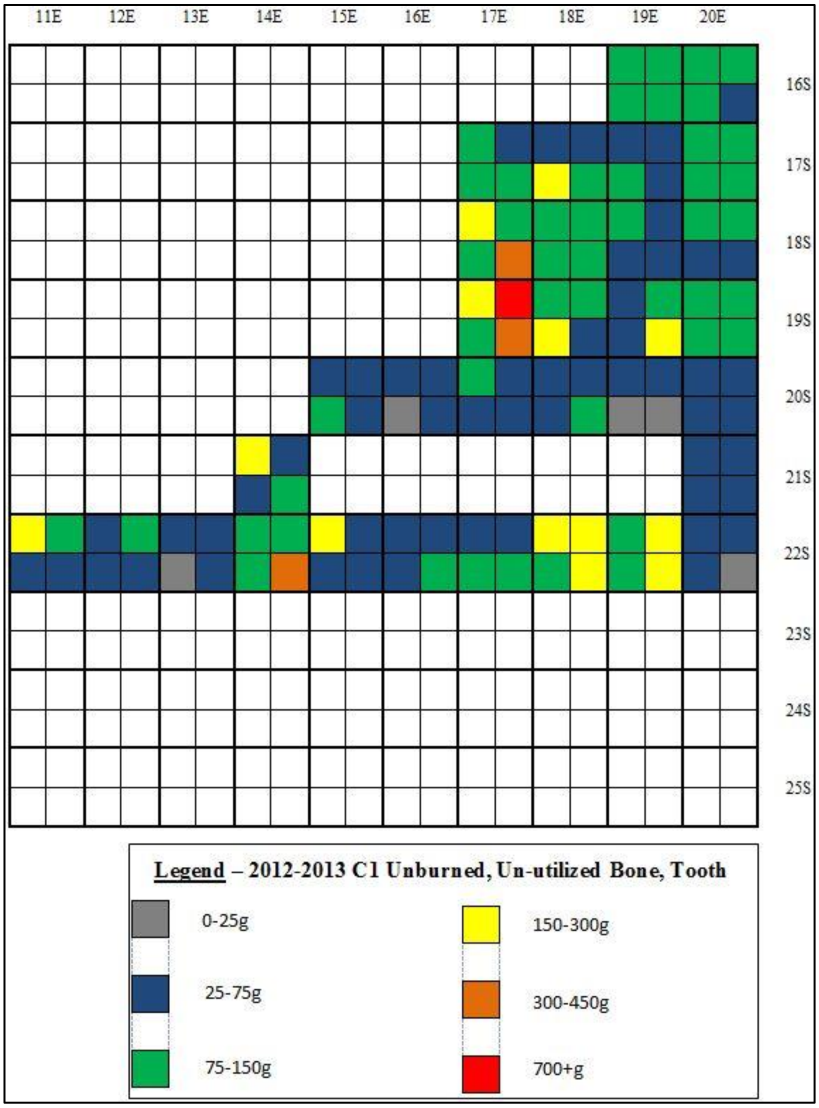

Figure 6.1.20: Distribution of C1 unburned, un-utilized bone and tooth fragments.

6.1.4: Cultural Level 1 Pottery Assemblage

A total of 206 pot sherds were recovered from this level during the 2012 and 2013 field seasons. While none of these sherds had any discernible diagnostic decorations or morphological characteristics (see Figure 6.1.21 below), their presence in the same level as Plains Side-notched points implies an association with the Mortlach Phase (Walde et al. 1995). The spatial distribution of pottery appears to show a concentration of sherds near the southeast corner of the site (see Figure 6.1.22 below).

Figure 6.1.21: Pot Sherd from C1 (Cat.# 7337).

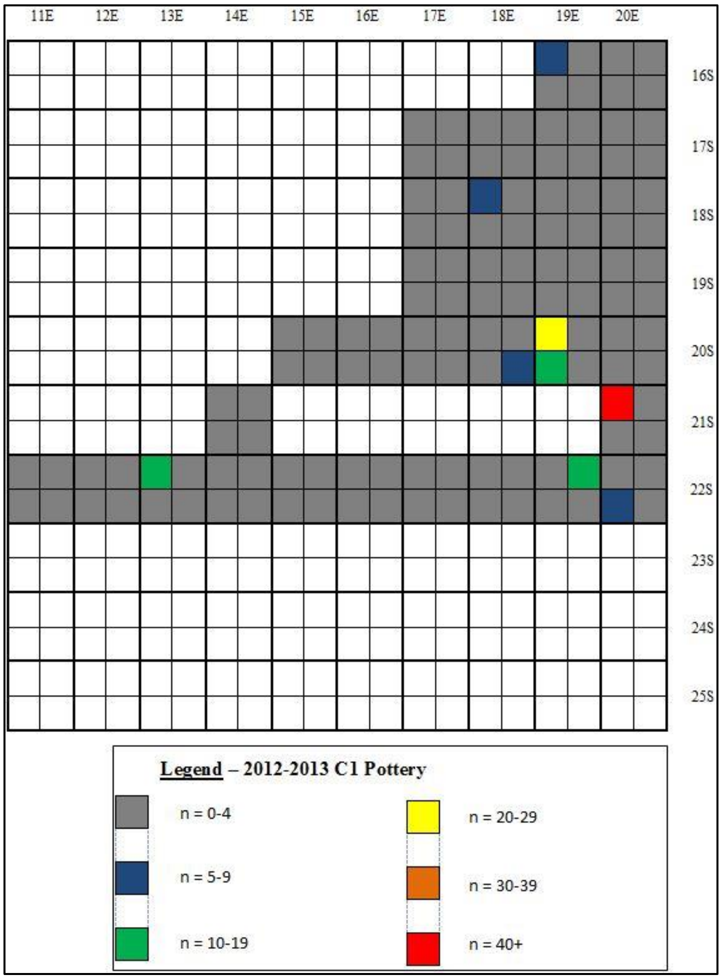

Figure 6.1.22: Distribution of C1 Pottery.

6.1.5: C1 Summary

Artifacts recovered from Cultural Level 1 indicate a clear connection to the Late Precontact period, which due to the presence of a musketball appears to have extended into the Contact period as well. The association with the Late Precontact is based on the presence of both Plains Side-notched projectile points and Mortlach pottery. Occupants of this Late Precontact campsite seem to have favoured local lithic material types like Swan River Chert and silicified or agatized wood for the manufacture of stone tools, although exotics like Knife River Flint were also observed. Faunal remains recovered from this level indicate that the occupants of the Wolf Willow site had a taste, or use, for a wide range of vertebrate species including bison, elk, snowshoe hare, and Swift fox, as well as invertebrates such as mollusks. While many faunal specimens were unidentifiable due to their fragmented nature, it is highly likely that they originate from *B. bison*. A radiocarbon age of 220 +/- 30 years B.P. from Maria Mampé's work at the Wolf Willow site affirms the affiliation of this cultural level with the end of the Late Precontact period. A lack of fetal *B. bison* remains unfortunately renders the determination of seasonality for this occupation impossible.

6.2: Cultural Level 2

Cultural Level 2 was found to be immediately below Cultural Level 1 at a depth of approximately 15 to 18cm. Delineation of this cultural level is predicated on the presence of projectile points belonging to the Prairie Side-notched point type. Because the colour and texture of sediments from C1 and C2 are virtually indistinguishable, and due to the fact that field school participants excavated in arbitrary increments of 5cm, it is possible that artifacts from either level were intermixed, and remain as such in the catalogue. However, despite this possibility, the assemblage from this cultural level is nonetheless unique from all the others.

Artifacts recovered from a depth of 25cm or deeper typically have noticeable carbonate deposits coating them, which can only occur when the surrounding sediments are alkaline. Due to the fact that solubility of silica increases as alkalinity also increases beyond a pH of 8 (VanNest 1985: 335), it can be postulated that some lithic artifacts from near the bottom of this level are found to be patinated as a result of increased or basic pH.

6.2.1: Cultural Level 2 Lithic Assemblage

2012-2013 excavations of the Wolf Willow site recovered 853 flakes, 119 primary flakes, 74 tools or tool fragments, 1607 pieces of shatter, 16 spalls, 37 decortication spalls, and 797 pieces of fire-cracked rock. Material types represented by flakes, spalls, and shatter recovered from C2 can be viewed in Table 6.2.1 below, as can the percentages for each category and material type.

Cultural Level 2 Debitage Counts							
Material	**Shatter**	**Spall**	**Decort. Spall**	**Primary Flake**	**Secondary Flake**	**Total**	**Percent (%)**
Agate	13	1	1	1	10	26	1.0
Agatized Wood	14	0	0	3	19	36	1.4
Basalt	9	2	0	2	7	20	0.8
Brown Chalcedony	1	0	0	2	11	14	0.5
Cathead Chert	37	0	3	11	13	64	2.4
CPL	26	0	6	6	14	52	2.0
Gronlid Siltstone	12	1	1	15	11	40	1.5
Jasper	12	0	0	1	3	16	0.6
Knife River Flint	5	0	0	2	20	27	1.0
Quartz	185	0	1	1	39	226	8.6
Quartzite	248	3	10	24	102	387	14.7
Red Chert	105	0	2	7	25	139	5.3
Silicified Peat	31	0	2	11	30	74	2.8
Silicified Siltstone	25	1	0	1	18	45	1.7
Silicified Wood	48	0	0	4	22	74	2.8
Swan River Chert (H.T.)	449	6	8	13	334	810	30.8
Swan River Chert (raw)	359	2	2	15	150	528	20.1
Other	28	0	1	0	25	54	2.1
Total	1607	16	37	119	853	2632	100.0
Percent (%)	61.1	0.6	1.4	4.5	32.4	100.0	

Table 6.2.1: C2 Lithic Debitage Counts.

The Cultural Level 2 tool assemblage includes 1 grinding slab (see Figure 6.2.1 below), a backed knife, 8 bifaces or biface fragments (see Figures 6.2.2, 6.2.3 below), 1 broken preform, 1 preform, 35 cores or core fragments, 1 drill, 9 scrapers or fragments thereof, 1 hammerstone, 2 possible hammerstones, 1 hearth stone, 8 points or point fragments, 4 retouched flakes, and 1 spokeshave (see Figure 6.2.4 below).

Figure 6.2.1: Basalt Grinding Slab (Cat.# 3163). Note the extensive tan-coloured carbonate deposits covering the artifact.

The large quartzite biface pictured in Figure 6.2.2 below appears to be largely symmetrical except for the significant protrusion on its right lateral edge. Due to the coarseness of the material use-wear is difficult to discern. However, the biface could have been used as a handheld tool for a variety of purposes.

Figure 6.2.2: Large Quartzite Biface (Cat.# 2334).

Several smaller biface fragments were also recovered from this level, such as those pictured in Figure 6.2.3 below. Cat.# 6808 and 6777 were recovered from different units, but fit together perfectly to form what would have been a gorgeous jasper biface. Bifaces pictured in the bottom row of Figure 6.2.3 all appear to have been transversely or obliquely fractured. However, it is unclear at this time whether they were broken during manufacture or while being utilized.

Figure 6.2.3: Biface Fragments from C2. Top, at top: Cat.# 6808 (Jasper). Top, at bottom: 6777 (Jasper – fits with Cat.# 6808). Bottom, from left to right: 78 (Quartzite), 193 (Prairie Side-Notched Point Tip – Silicified Peat), 1577 (Backed Knife Fragment - Agatized Wood).

Several tools and utilized flakes were recovered from Cultural Level 2, and can be seen in Figure 6.2.4 below. Cat.# 5230 (top right) is a spokeshave made from Cathead Chert, and its concave working edge can be clearly seen st its upper extent in the photo. Cat.# 5258 (top right) is an agate drill that appears to have been discarded due to its diminished size. Retouched flakes pictured in the bottom row are comprised of raw and heat-treated Swan River Chert, Cathead Chert, and quartz, and could have served a number of purposes.

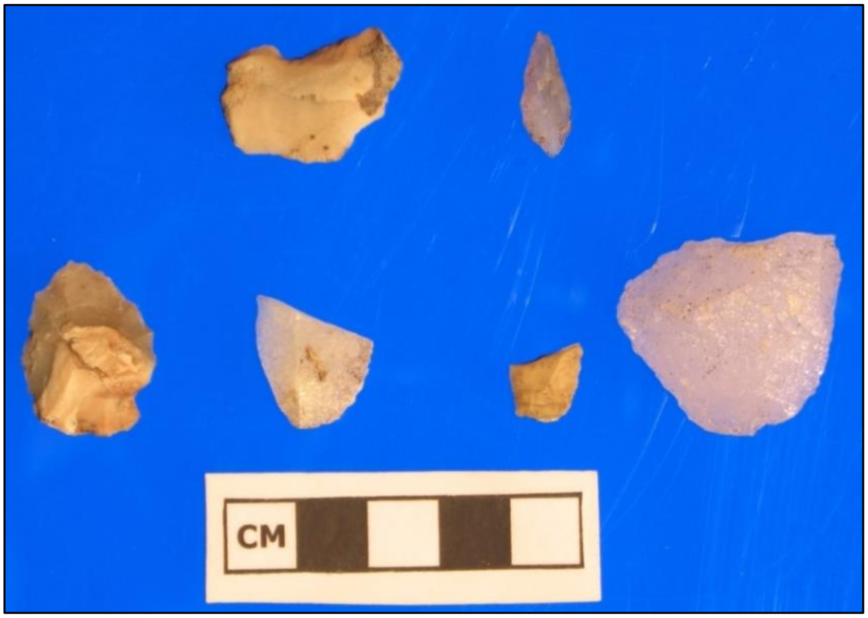

Figure 6.2.4: Tools (top row) and Retouched Flakes (bottom row) from C2. Top row, from left to right: Spokeshave, Cat.# 5230 (Cathead Chert); Drill, Cat.# 5258 (Agatized Wood). Bottom row, from left to right: Cat.# 7107 (H.T. SRC), 2318 (SRC), 1893 (Cathead Chert), 2611 (Quartz).

Of the 6 point fragments recovered from this level, 2 are composed of agate, 1 of silicified peat, 1 of silicified siltstone, and 2 are made of heat treated Swan River Chert (see Figure 6.2.5 below). The agate point at left in Figure 6.2.5 lost the distalmost portion of its tip, possibly due to an impact or during manufacture or retouch. The silicified siltstone point at right in Figure 6.2.5 is transversely fractured across the distal 1/5 of its length, also possibly during manufacture. The 2 intact points were made of raw and heat treated Swan River Chert respectively.

Figure 6.2.5: Two Prairie Side-Notched Points from C2. Left: Cat.# 6018 (Agate). Right: Cat.# 3336 (Silicified Siltstone).

One third of the scrapers recovered from Cultural Level 2 are made from Knife River Flint, and two of them can be seen in Figure 6.2.6 below. Many of the scrapers were found intact but exhausted, and Cat.# 3372 at top center in Figure 6.2.6 below has been unifacially retouched around all of its edges. It should also be noted that 2 possible hammerstones were recovered from this level and were both composed of quartz, while the identifiable hammerstone was made of granite.

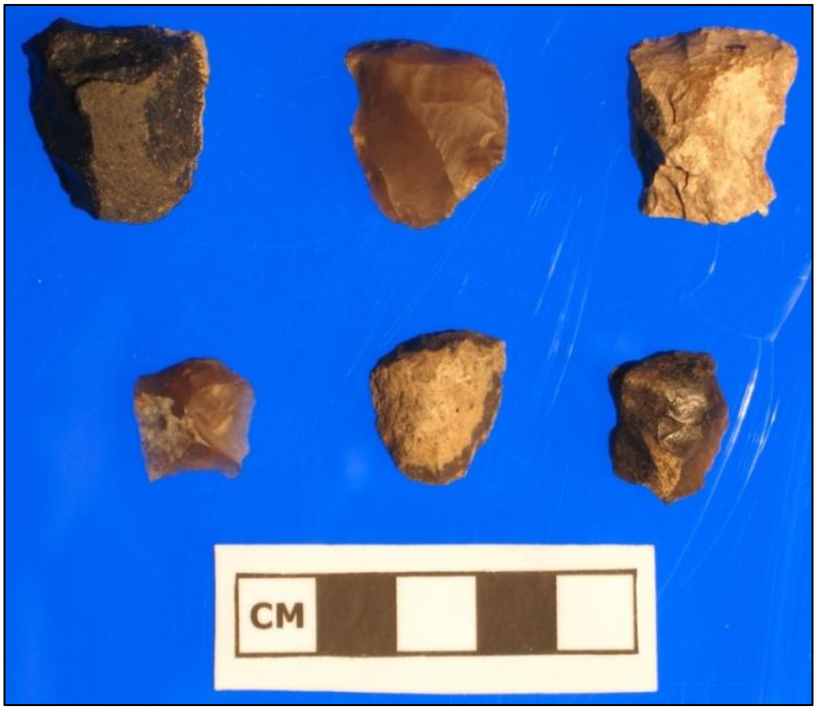

Figure 6.2.6: Scrapers from C2. Top row, from left to right: Cat.# 178 (Silicified Siltstone), 3372 (KRF), 1926 (Silicified Peat). Bottom row, from left to right: 6795 (KRF), 4964 (CPL), 6760 (Silicified Wood).

Cultural Level 2 Lithic Flaked Tool Counts

Material	Scraper/ Scraper Fragment	Drill	Backed Knife	Biface/Biface Fragment	Preform/ Preform Fragment	Point/Point Fragment	Retouched Flake	Spokeshave	Total	Percent (%)
Agate	0	0	0	0	0	2	0	0	2	5.9
Agatized Wood	0	1	1	0	0	0	0	0	2	5.9
Basalt	0	0	0	0	0	0	0	0	0	0.0
Brown Chalcedony	0	0	0	0	0	0	0	0	0	0.0
Cathead Chert	1	0	0	1	0	0	1	1	4	11.8
CPL	1	0	0	0	0	0	0	0	1	2.9
Fused Shale	0	0	0	0	0	0	0	0	0	0.0
Gronlid Siltstone	0	0	0	0	0	0	0	0	0	0.0
Jasper	0	0	0	3	0	0	0	0	3	8.8
Knife River Flint	3	0	0	0	0	0	0	0	3	8.8
Quartz	0	0	0	1	0	0	1	0	2	5.9
Quartzite	0	0	0	2	0	0	0	0	2	5.9
Silicified Peat	1	0	0	0	0	1	0	0	2	5.9
Silicified Siltstone	2	0	0	0	0	1	0	0	3	8.8
Silicified Wood	1	0	0	0	1	0	0	0	2	5.9
Swan River Chert (H.T.)	0	0	0	1	0	3	1	0	5	14.7
Swan River Chert (raw)	0	0	0	0	1	1	1	0	3	8.8
Other	0	0	0	0	0	0	0	0	0	0.0
Total	9	1	1	8	2	8	4	1	34	100.0
Percent (%)	26.5	2.9	2.9	23.5	5.9	23.5	11.8	2.9	100.0	

Table 6.2.2: C2 Flaked Tool Counts.

Cores and core fragments were plentiful in this cultural level. Figure 6.2.7 below shows one such core composed of quartzite. Figure 6.2.8 (below) is of particular interest with regard to Cultural Level 2; both of the cores pictured in Figure 6.2.8 are composed of the enigmatic red orthoquartzite mentioned earlier. Note the mottled colouration and relatively fine grain size compared to the core pictured in Figure 6.2.7. Were it not for the red colour, this red orthoquartzite may have been identified as Beaver River Sandstone.

Figure 6.2.7: Quartzite Core from C2 (Cat.# 3894).

Figure 6.2.8: Red Orthoquartzite Cores from C2. Top: Cat.# 7848. Bottom: Cat.# 7468.

Other cores recovered from C2 are composed of many material types, and as Figure 6.2.9 (below) shows they also exhibit diversity in their respective morphologies. As was the case with the overlying cultural level, Swan River Chert cores from Cultural Level 2 have a wide range of grain sizes. This is partially due to differing degrees of heat treatment, as well as inherent inconsistencies such as vugs within the parent nodules themselves. Counts for cores recovered from C2 are given in Table 6.2.3 below, as are numbers and percentages of the material types which comprise them.

Figure 6.2.9: Cores from C2. Top row, from left to right: Cat.# 6773 (Cathead Chert), 5559 (Cathead Chert), 4214 (Cathead Chert). Bottom row, from left to right: 7803 (Black Chert), 4954 (Quartzite), 2892 (H.T. SRC), 3893 (SRC).

Cultural Level 2 Core Counts				
Material	**Core**	**Bipolar Core**	**Total**	**Percent (%)**
Agate	0	0	0	0.0
Agatized Wood	0	0	0	0.0
Basalt	2	0	2	5.7
Black Chert	1	0	1	2.9
Brown Chalcedony	0	0	0	0.0
Cathead Chert	5	0	5	14.3
CPL	4	0	4	11.4
Gronlid Siltstone	0	0	0	0.0
Jasper	0	0	0	0.0
Knife River Flint	0	0	0	0.0
Quartz	5	0	5	14.3
Quartzite	5	0	5	14.3
Red Chert	2	0	2	5.7
Silicified Peat	0	0	0	0.0
Silicified Siltstone	0	1	1	2.9
Silicified Wood	0	0	0	0.0
Swan River Chert (H.T.)	6	0	6	17.1
Swan River Chert (raw)	4	0	4	11.4
Other	0	0	0	0.0
Total	34	1	35	100.0
Percent (%)			100.0	

Table 6.2.3: C2 Lithic Core Counts.

One item not listed with all other lithics from this level is a bead made from some kind of amber-like fossilized material. While the material type is something of a mystery, the fact that it has been modified by human hands is not, as cut marks are clearly visible near the un-tapered end (see Figure 6.2.10 below).

Figure 6.2.10: Fossil Bead (Cat.# 4780). Note the score marks near the base of the artifact.

Distribution of lithic artifacts from Cultural Level 2 appears to be concentrated in four main areas across the site (see Figures 6.2.11, 6.2.12, 6.2.13 below), one of which is located near a hearth feature in unit number 19S 18E (see Figure 6.2.14 below).

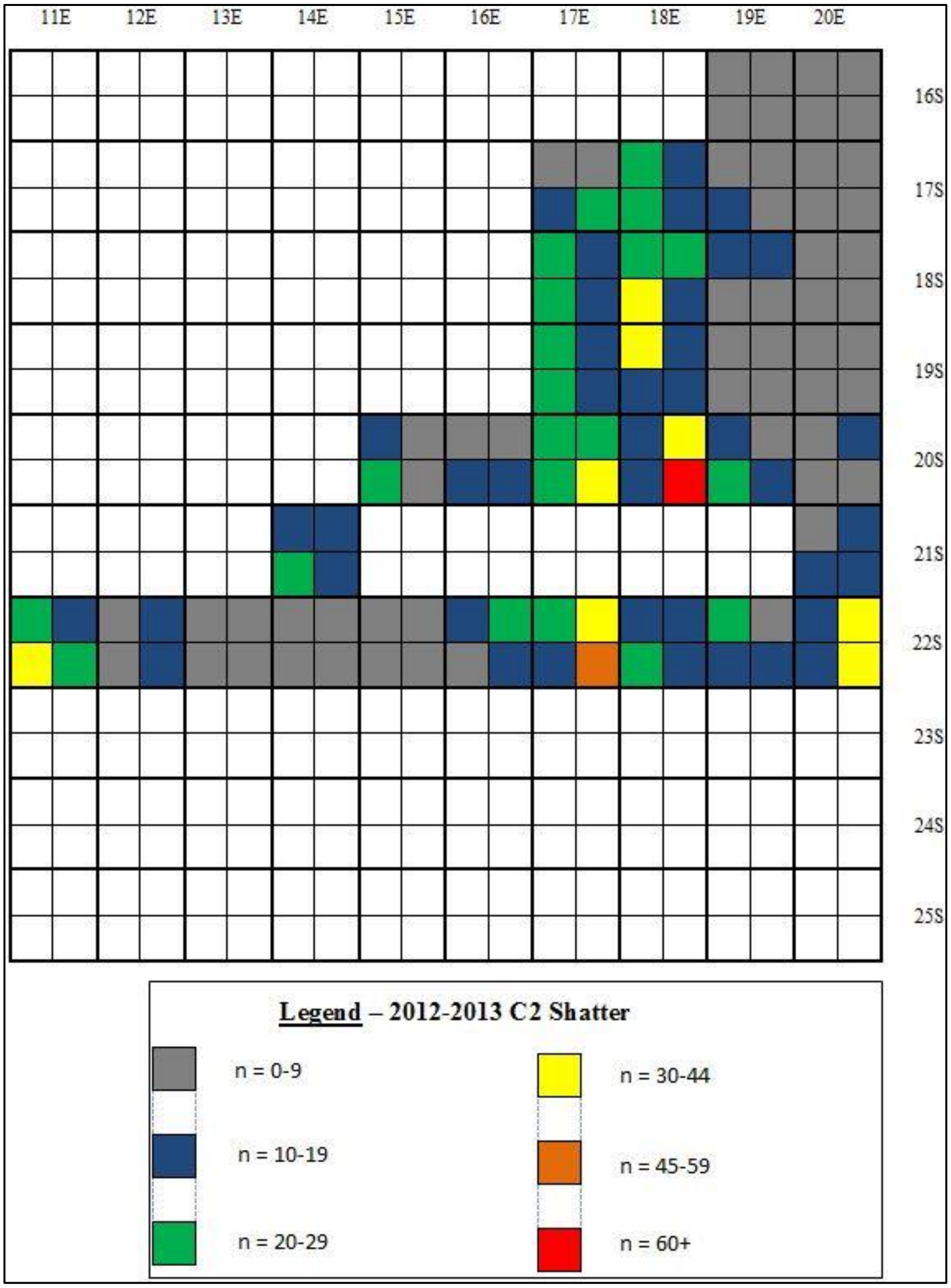

Figure 6.2.11: Distribution of C2 lithic shatter.

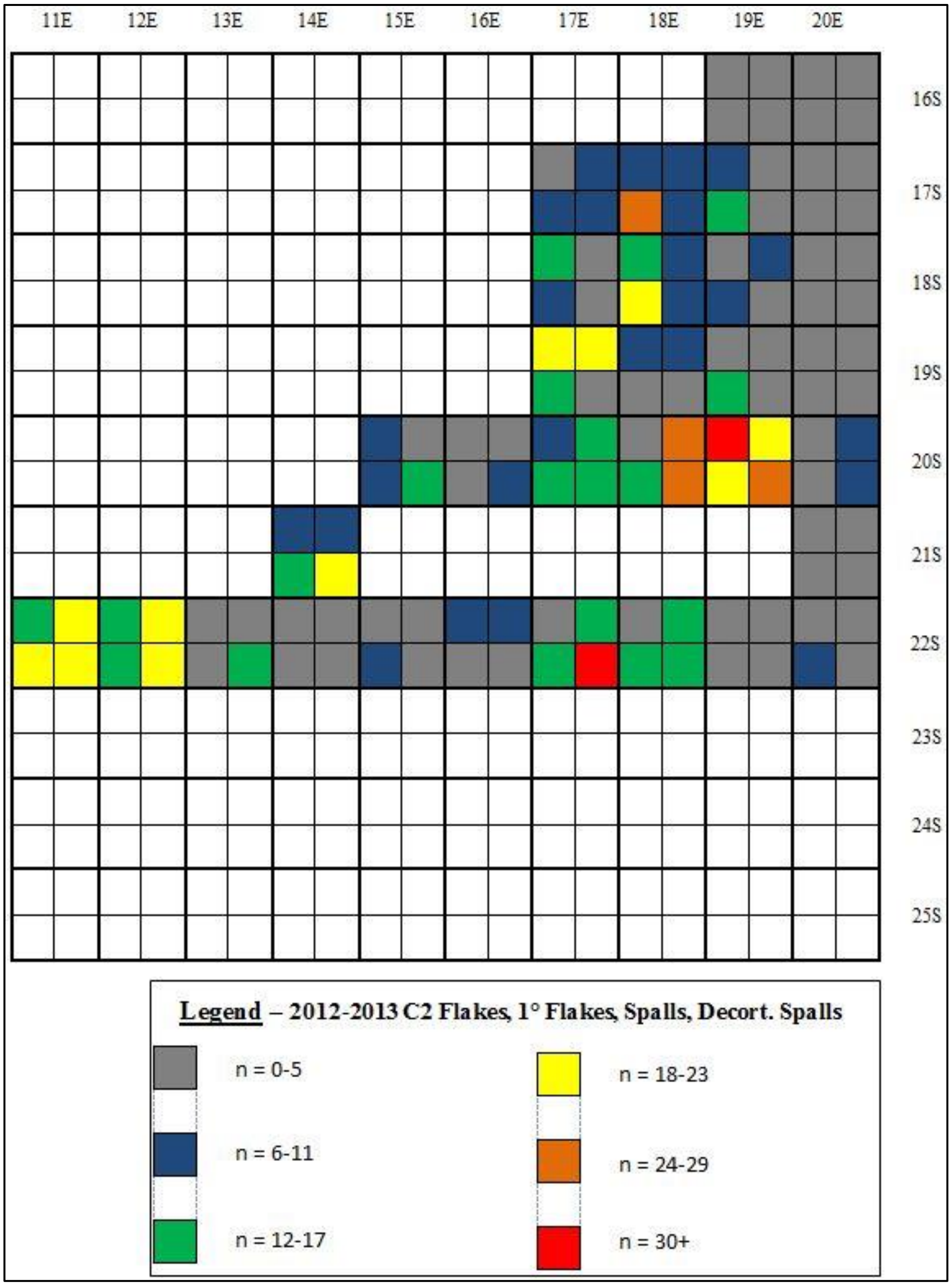

Figure 6.2.12: Distribution of other C2 lithic debitage.

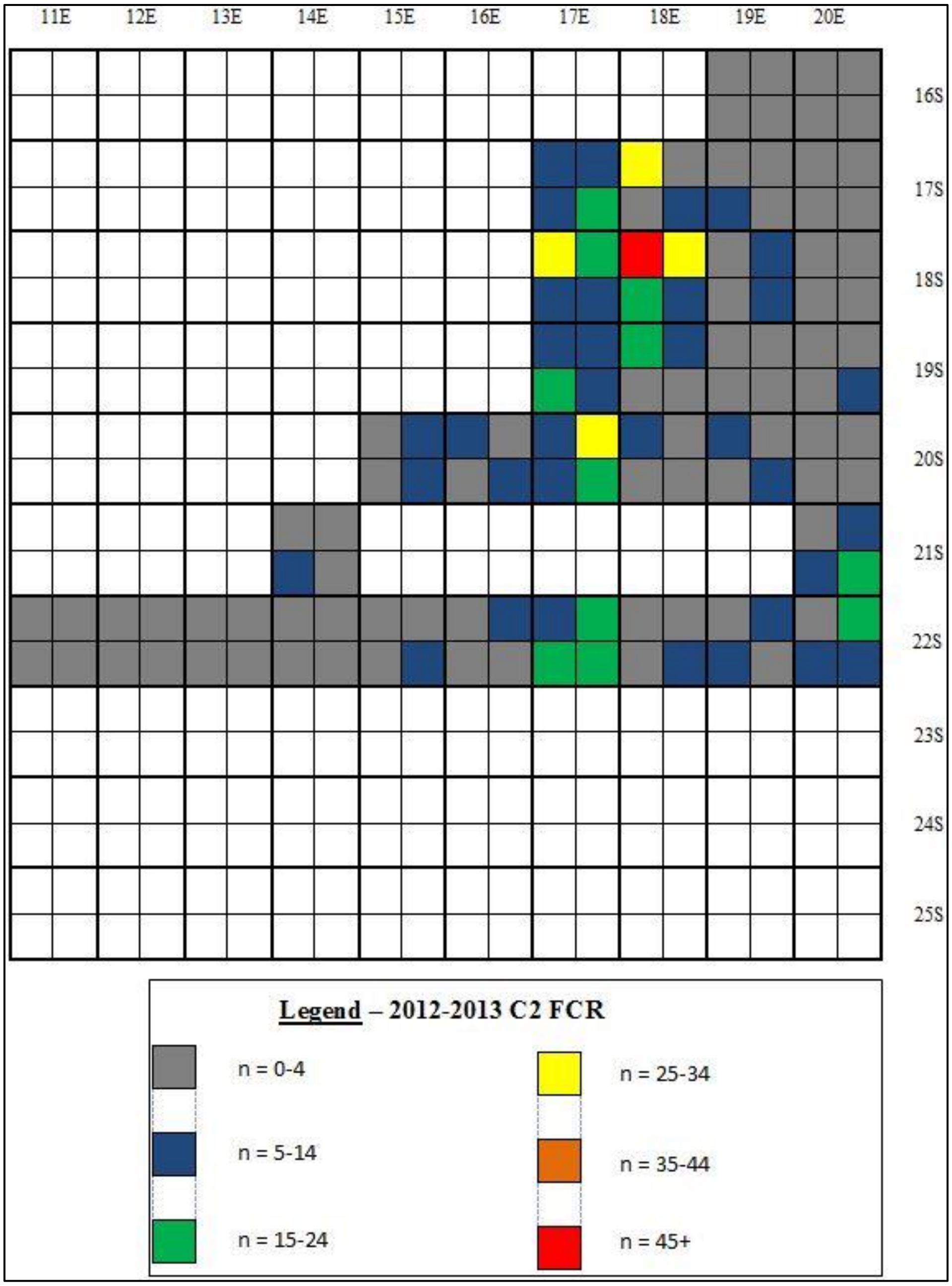

Figure 6.2.13: Distribution of C2 fire-cracked rock.

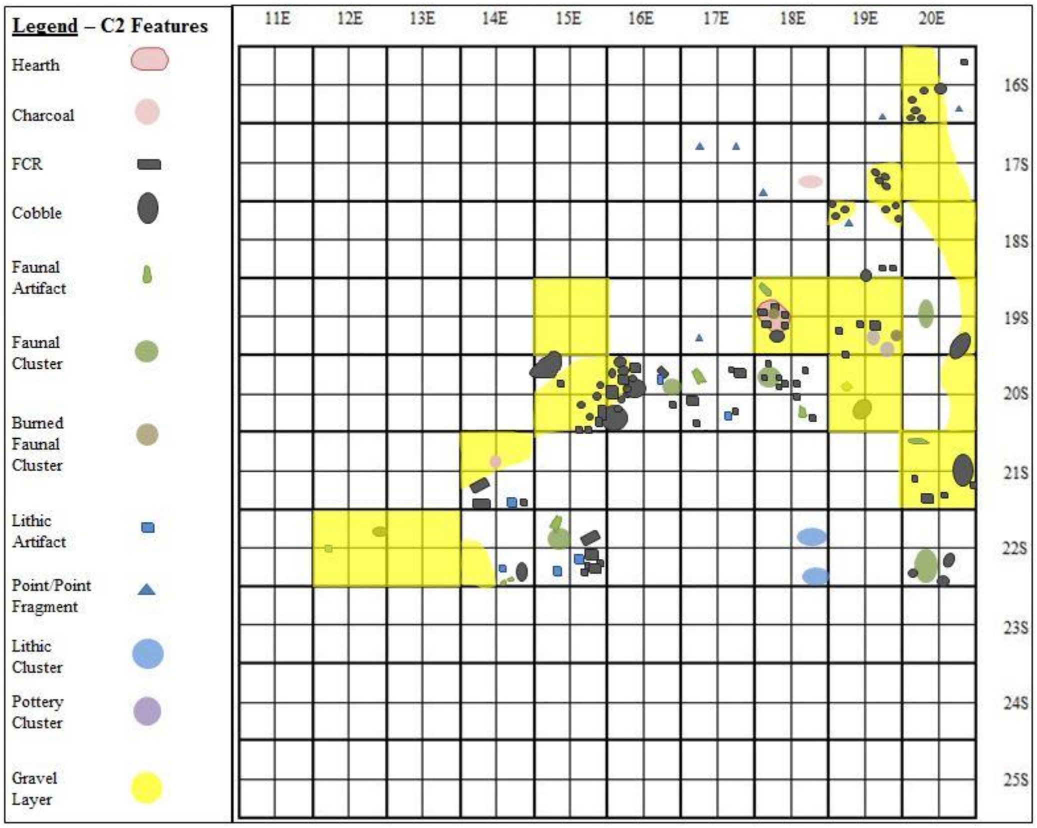

Figure 6.2.14: Distribution of 2012-2013 C2 Features.

6.2.2: Cultural Level 2 Faunal Assemblage

A total of 11,941 faunal specimens weighing 12,225.1g were recovered from Cultural Level 2 during the 2012 and 2013 field seasons. MNI analysis determined that a minimum of 3 bison are represented in this level. Other species identified in this level include *Canis lupus* (n=1) (see Figure 6.2.15 below), *Canis sp*. (n=1) (see Figure 6.2.16 below), *Castor canadensis* (n=1), *Lepus americanus* (n=1), *Lepus sp.* (n=1), members of the Mustelidae (n=1) and Sciuridae (n=1) families, as well as a small mammal and a medium-sized carnivore. Fragments of Mollusk shells were also recovered from Cultural Level 2, but as was the case with the shell fragments from the previous level, no diagnostic fragments were recovered, and MNI was therefore incalculable.

Figure 6.2.15: *Canis lupus* Right Humerus Head (Cat.# 1906).

Figure 6.2.16: *Canis sp*. 2nd Phalanx (Cat.# 3602).

By weight, approximately 94.4% of the faunal assemblage from Cultural Level 2 consists of unburned, un-utilized bone. A further 0.4% is comprised of maxillary or mandibular fragments which include both bone and tooth, while 2.8% is made up of just teeth or tooth fragments. Burned and calcined faunal remains account for the remaining approximately 3.0% of the weight of this assemblage, while a bone bead and 8 shell fragments account for a very small fraction of a percentage. By number, 10.9% of C2 faunal specimens were identified as bison, while 88.6% belonged to unidentifiable large mammals. The remaining 0.4% of faunal specimens is comprised of the species mentioned in the above paragraph.

C2 faunal remains exhibit something of a spatial dichotomy between burned and unburned remains. Burned and calcined remains appear to be concentrated in one main area in unit number 19S 17E, while unburned specimens seem to be especially concentrated in the eastern half of the site (see Figures 6.2.17 and 6.2.18 below).

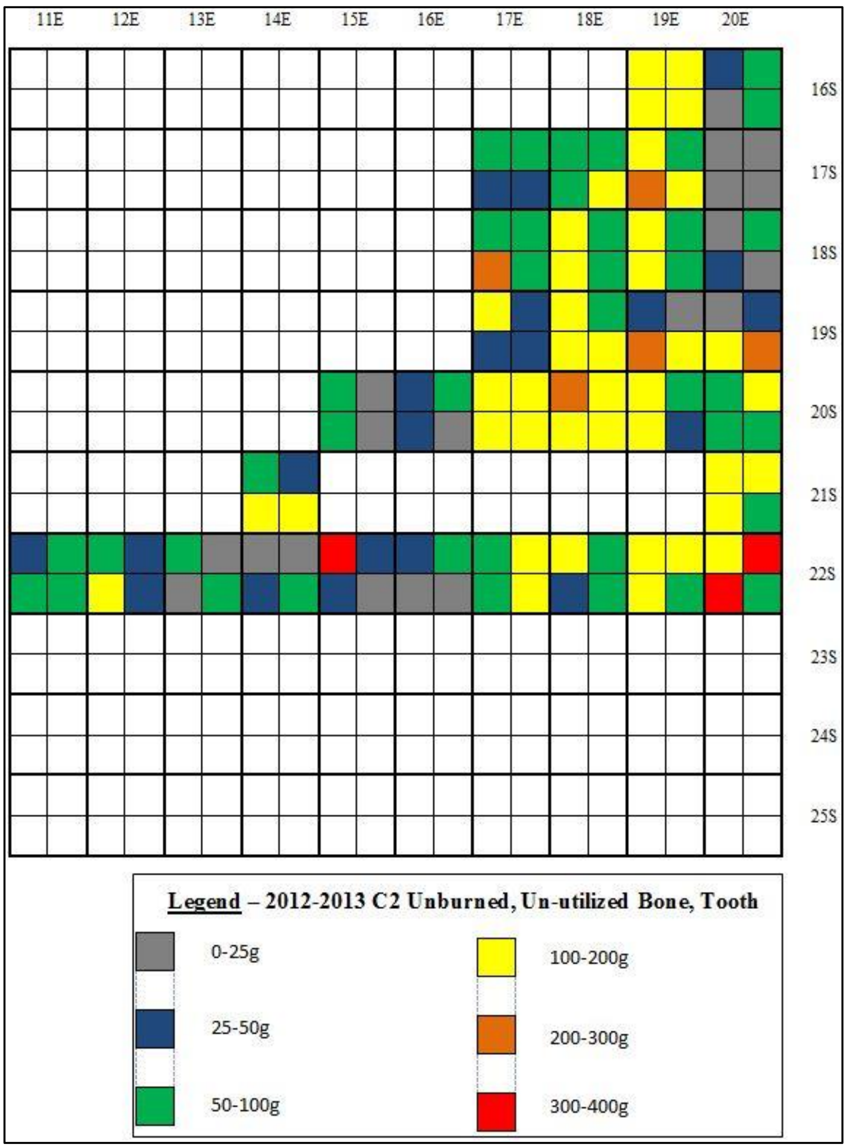

Figure 6.2.17: Distribution of C2 unburned, un-utilized bone and tooth fragments.

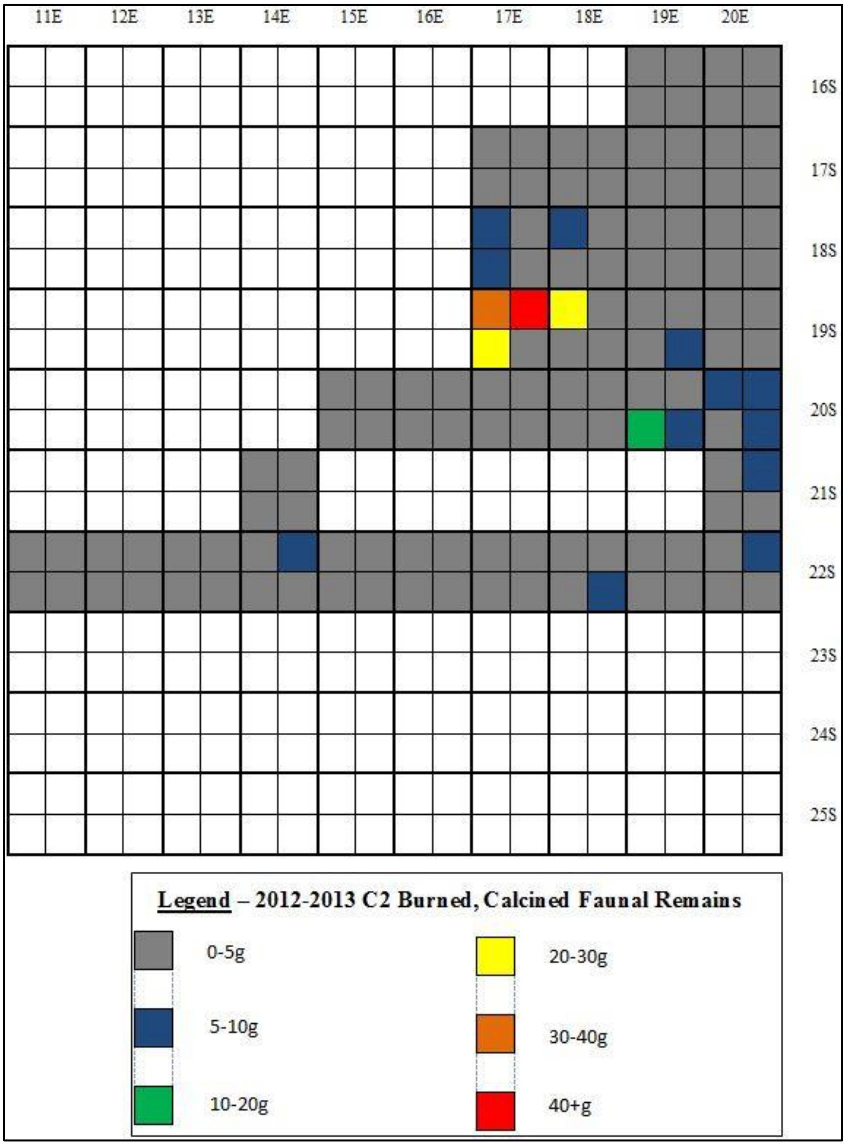

Figure 6.2.18: Distribution of C2 burned faunal remains.

6.2.3: Cultural Level 2 Pottery Assemblage

198 pot sherds were recovered from C2 during the 2012 and 2013 field seasons. Although they bear no visible diagnostic attributes, their occurrence at the same level as Prairie Side-notched projectile points suggests that they are fragments of Old Women's pottery. Distribution of these sherds is intensely concentrated in unit number 19S 19E (see Figure 6.2.19 below).

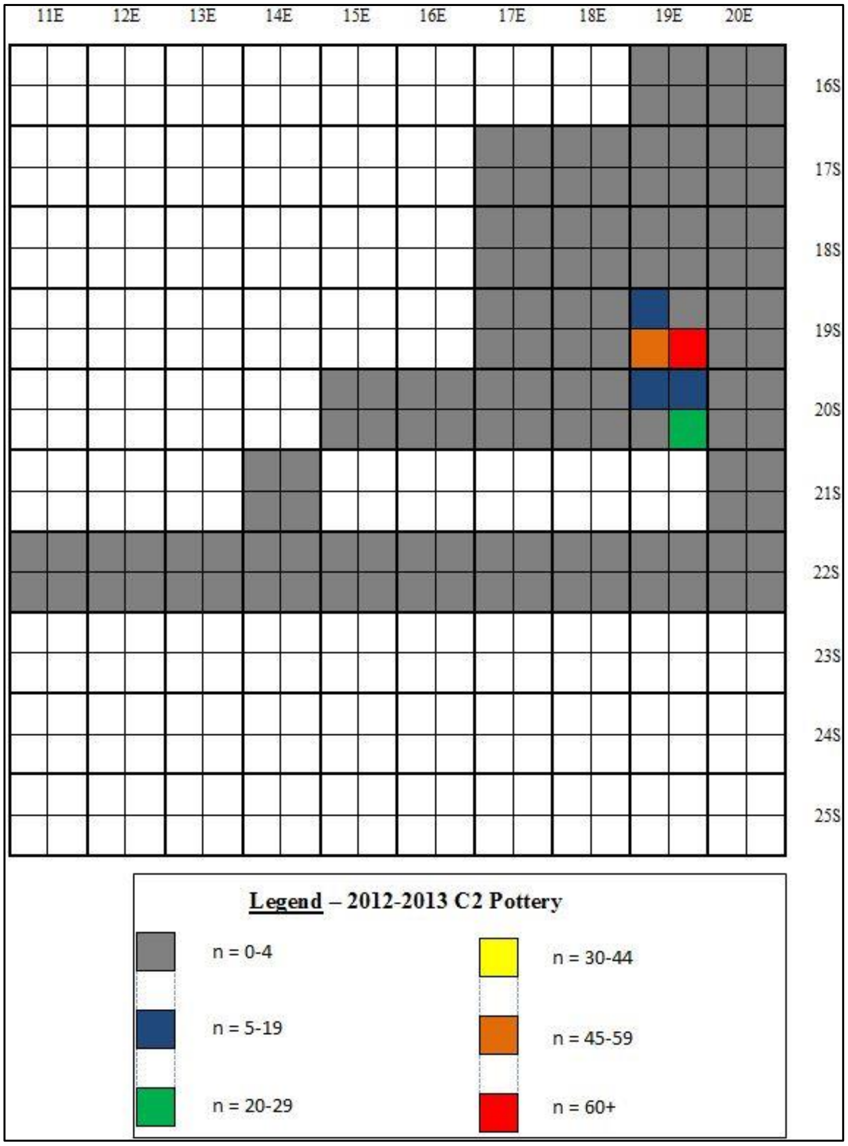

Figure 6.2.19: Distribution of C2 pottery.

6.2.4: C2 Summary

Similar types of artifacts were recovered from Cultural Level 2 as from Cultural Level 1. However, C2 has a much lower number of flaked tools than C1, with the total for C2 being 34, versus 55 from C1. Looking at lithic core use, C2 exhibits a decrease compared to C1 in the use of both bipolar percussion methodology and the use of Silicified Siltstone pebbles, but an increase in the use of Cathead Chert and chert precipitated in limestone (CPL). The use of Swan River Chert also differs between C1 and C2. In C2, heat-treated Swan River Chert accounted for 30.8% of all debitage recovered from that level, while in C1 it accounted for 43.8%. Pot sherds recovered from C2 are consistent with occupation by Old Women's Phase peoples. Prairie Side-Notched points affirm this statement.

6.3: Cultural Level 3

Cultural Level 3 was found to be under Cultural Level 2 at a depth of approximately 30cm. In many parts of the site, there is a distinct sedimentary unit consisting of gravel or tan-coloured coarse sand which separates C2 and C3. This sedimentary unit is between 5cm and 10cm thick, and can be centered at depths between approximately 25 and 30cm below the ground surface. Projectile points recovered from this level associate it with the McKean series, which includes McKean lanceolate, Duncan, and Hanna points. As is the case for artifacts recovered from the lower portion of Cultural Level 2, artifacts from this level tend to have carbonate deposits on them. For lithic artifacts, but chalcedonies in particular, the presence of these deposits can often be accompanied by patination. Faunal artifacts from C3 tend to be heavier than those from previous levels, and are therefore labelled in the catalogue as "partially mineralized."

6.3.1: Cultural Level 3 Lithic Assemblage

Excavations at the Wolf Willow site in 2012 and 2013 recovered 42 primary flakes, 481 flakes, 18 decortication spalls, 12 spalls, 2 bifaces, 8 biface fragments, 22 core fragments, 5 scrapers, 2 points, 3 point fragments, 3 retouched flakes, 2 hammerstones, 1 mano, 1 grooved maul, and 592 pieces of shatter. Debitage counts are given in Table 6.3.1 below.

Cultural Level 3 Debitage Counts							
Material	**Shatter**	**Spall**	**Decort. Spall**	**Primary Flake**	**Secondary Flake**	**Total**	**Percent (%)**
Agate	6	0	0	0	7	13	1.1
Agatized Wood	2	0	0	0	0	2	0.2
Basalt	2	2	0	0	6	10	0.9
Brown Chalcedony	4	0	2	2	2	10	0.9
Cathead Chert	8	1	2	1	4	16	1.4
CPL	13	0	1	1	8	23	2.0
Gronlid Siltstone	1	0	0	3	4	8	0.7
Jasper	2	0	0	0	0	2	0.2
Knife River Flint	0	0	0	1	4	5	0.4
Quartz	79	1	2	3	15	100	8.7
Quartzite	64	0	9	23	66	162	14.1
Red Chert	20	0	0	0	3	23	2.0
Silicified Peat	9	0	0	0	3	12	1.0
Silicified Siltstone	3	0	0	0	2	5	0.4
Silicified Wood	4	0	0	0	4	8	0.7
Swan River Chert (H.T.)	228	5	1	3	212	449	39.2
Swan River Chert (raw)	141	1	1	2	125	270	23.6
Other	6	2	0	3	16	27	2.4
Total	592	12	18	42	481	1145	100.0
Percent (%)	51.7	1.0	1.6	3.7	42.0	100.0	

Table 6.3.1: C3 Lithic Debitage Counts.

Material types comprising the C3 biface assemblage (n=10) include Knife River flint (10%), quartz (20%), silicified peat (20%), and raw (20%) and heat treated (30%) Swan River Chert (see Figure 6.3.1 below). Note the extensive tan-coloured carbonate deposits covering the artifacts. While many of te bifaces in Figure 6.3.1 appear to be transversely fractured Cat.# 5422, 3952, 8147, and 6131), one biface (Cat.# 6130, at bottom right) appears to have been retouched along all its trapezoidally-shaped edges, and may have been hafted at its narrowest margin (at top) where the striking platform for the original flake is.

Figure 6.3.1: Bifaces from C3. At top, from left to right: Cat.# 5048 (KRF), 5422 (Quartz). At bottom, from left to right: Cat.# 3952 (H.T. SRC), 8147 (H.T. SRC), 6131 (SRC), 6130 (H.T. SRC).

Scrapers (n=5) were composed of Cathead chert (60%), CPL (20%) and Gronlid siltstone (20%) (see Figure 6.3.2 below), while a large nondescript uniface was composed of quartzite (see Figure 6.3.3 below).

Figure 6.3.2: Scrapers from C3. From left to right: Cat.# 8072 (CPL), 4604 (Cathead Chert), 5062 (Cathead Chert), 4264 (Gronlid Siltstone).

Figure 6.3.3: Quartzite Uniface from C3. Cat.# 3218.

All 5 points or point fragments from this level were made of Swan River Chert, with the majority (60%) being heat treated. While one point tip was unidentifiable, 2 McKean lanceolate and 2 Duncan points remained sufficiently intact and were therefore able to be identified (see Figure 6.3.4 below). The top two artifacts pictured in Figure 6.3.4 are clearly McKean Lanceolate points, with Cat.# 2331 (top left) being transversely fractured across the approximate middle of its blade. Cat.# 2368 (top right) is covered extensively in tan-coloured carbonate deposits. Cat.# 6869 (bottom left) with its shallow side notches and slightly concave base is clearly a Duncan point, and it has an oblique fracture at its tip, likely caused by an impact. Cat.# 1997 (bottom left) is quite a large possible point tip made from very fine-grained heat-treated Swan River Chert that appears to have been detached from its base during manufacture, judging by the abrupt transverse fracture at its proximal end.

Figure 6.3.4: 3 Identifiable Points & 1 Point Tip from C3. At top, from left to right: Cat.# 2331 (McKean Lanceolate – H.T. SRC), 2368 (McKean Lanceolate – SRC). At bottom, from left to right: Cat.# 6869 (Duncan – SRC), 1997 (Unknown cultural affiliation – H.T. SRC).

Retouched flakes (n=3) were composed of banded chert, CPL, and heat treated Swan River Chert (see Figure 6.3.5 below). The large Knife River Flint flake (Cat.# 8034, top center) appears to have broken during use or manufacture, as denoted by the abrupt fracture along its bottom extent in the photo. Cat.# 8034 is also extensively patinated, which suggest that it has spent a great number of years detached from its parent nodule. Cat.# 6120 (bottom left) and 3688 (bottom right) are unifacially retouched flakes that have clear concave working edges, although the purpose of these edges is as yet undetermined.

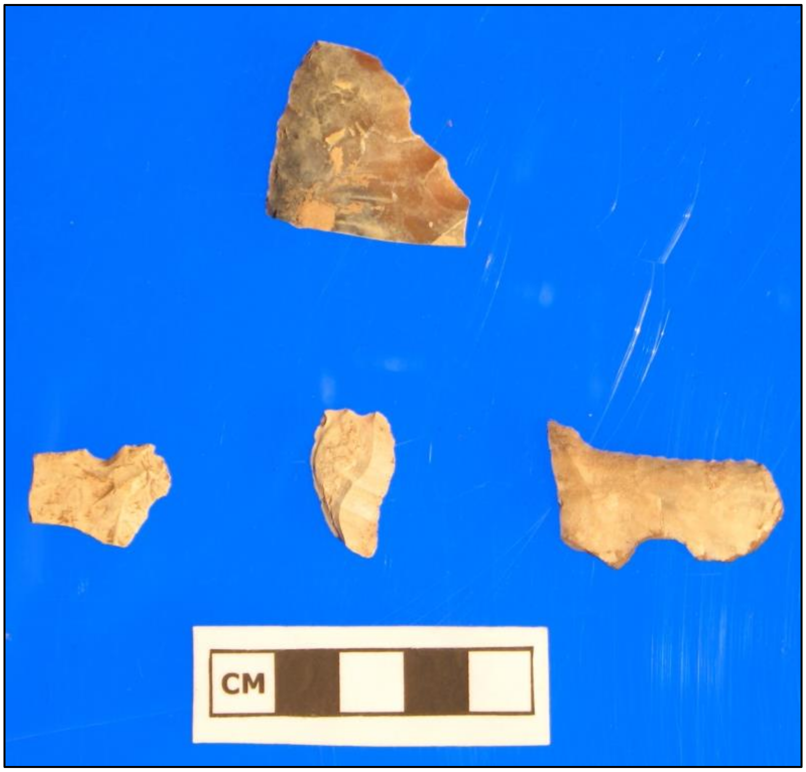

Figure 6.3.5: Patinated KRF Flake and Retouched Flakes from C3. Top: Cat.# 8034 (KRF - Patinated). Bottom, from left to right: Cat.# 6120 (CPL), 2005 (Banded Chert), 3688 (H.T. SRC).

Cores and core fragments (n=22) from C3 are notable. In Figure 6.3.6 below, there are cases of material testing exemplified by Cat.# 1708 (top right) and 3955 (bottom left). Also, the only feldspathic siltstone core recovered from the 2012 and 2013 field seasons (Cat.# 3416) was found in C3, and is pictured at bottom center in Figure 6.3.6.

Figure 6.3.6: Cores from C3. At top, from left to right: Cat.# 7201 (H.T. SRC), 2961 (SRC), 1708 (Cathead Chert). At bottom, from left to right: Cat.# 3955 (Silicified Wood), 3416 (Feldspathic Siltstone), 7282 (KRF - Patinated).

Cores pictured in Figure 6.3.7 (below) are some of the clearest examples of bifacial core reduction from the 2012 and 2013 Wolf Willow site assemblage. Ground stone tools from this level included 2 hammerstones made of dolomite and limestone, as well as a dolomite grooved maul and a mano composed of some type of coarse-grained igneous rock. Counts for both the flaked tool assemblage and core assemblage are given in Tables 6.3.2 and 6.3.3 below.

Figure 6.3.7: Cores from C3. At top, from left to right: Cat.# 3424 (Quartz), 5372 (Quartz). At bottom, from left to right: Cat.# 1228 (Quartzite), 3414 (Quartzite).

Cultural Level 3 Lithic Flaked Tool Counts

Material	Scraper/ Scraper Fragment	Biface/Biface Fragment	Point/Point Fragment	Retouched Flake	Total	Percent (%)
Agate	0	0	0	0	0	0.0
Agatized Wood	0	0	0	0	0	0.0
Basalt	0	0	0	0	0	0.0
Brown Chalcedony	0	0	0	0	0	0.0
Cathead Chert	3	0	0	0	3	13.0
CPL	1	0	0	1	2	8.7
Fused Shale	0	0	0	0	0	0.0
Gronlid Siltstone	1	0	0	0	1	4.3
Jasper	0	0	0	0	0	0.0
Knife River Flint	0	1	0	0	1	4.3
Quartz	0	2	0	0	2	8.7
Quartzite	0	0	0	0	0	0.0
Silicified Peat	0	2	0	0	2	8.7
Silicified Siltstone	0	0	0	0	0	0.0
Silicified Wood	0	0	0	0	0	0.0
Swan River Chert (H.T.)	0	3	3	1	7	30.4
Swan River Chert (raw)	0	2	2	0	4	17.4
Other	0	0	0	1	1	4.3
Total	5	10	5	3	23	100.0
Percent (%)	21.7	43.5	21.7	13.0	100.0	

Table 6.3.2: C3 Flaked Tool Counts.

Cultural Level 3 Core Counts				
Material	**Core**	**Bipolar Core**	**Total**	**Percent (%)**
Agate	0	0	0	0.0
Agatized Wood	0	0	0	0.0
Basalt	0	0	0	0.0
Black Chert	0	0	0	0.0
Brown Chalcedony	0	0	0	0.0
Cathead Chert	1	1	2	9.1
CPL	2	0	2	9.1
Feldspathic Siltstone	1	0	1	4.5
Gronlid Siltstone	0	0	0	0.0
Jasper	0	0	0	0.0
Knife River Flint	1	0	1	4.5
Quartz	3	0	3	13.6
Quartzite	6	0	6	27.3
Red Chert	0	0	0	0.0
Silicified Peat	0	0	0	0.0
Silicified Siltstone	0	0	0	0.0
Silicified Wood	1	0	1	4.5
Swan River Chert (H.T.)	2	0	2	9.1
Swan River Chert (raw)	4	0	4	18.2
Other	0	0	0	0.0
Total	21	1	22	100.0
Percent (%)	95.5	4.5	100.0	

Table 6.3.3: C3 Lithic Core Counts.

Lithic artifacts from Cultural Level 3 appear to be concentrated in 4 main areas; 3 in a line from southwest to northeast along the northwestern edge of the area excavated in 2012 and 2013, and one in the southeast corner (see Figures 6.3.8 and 6.3.9 below).

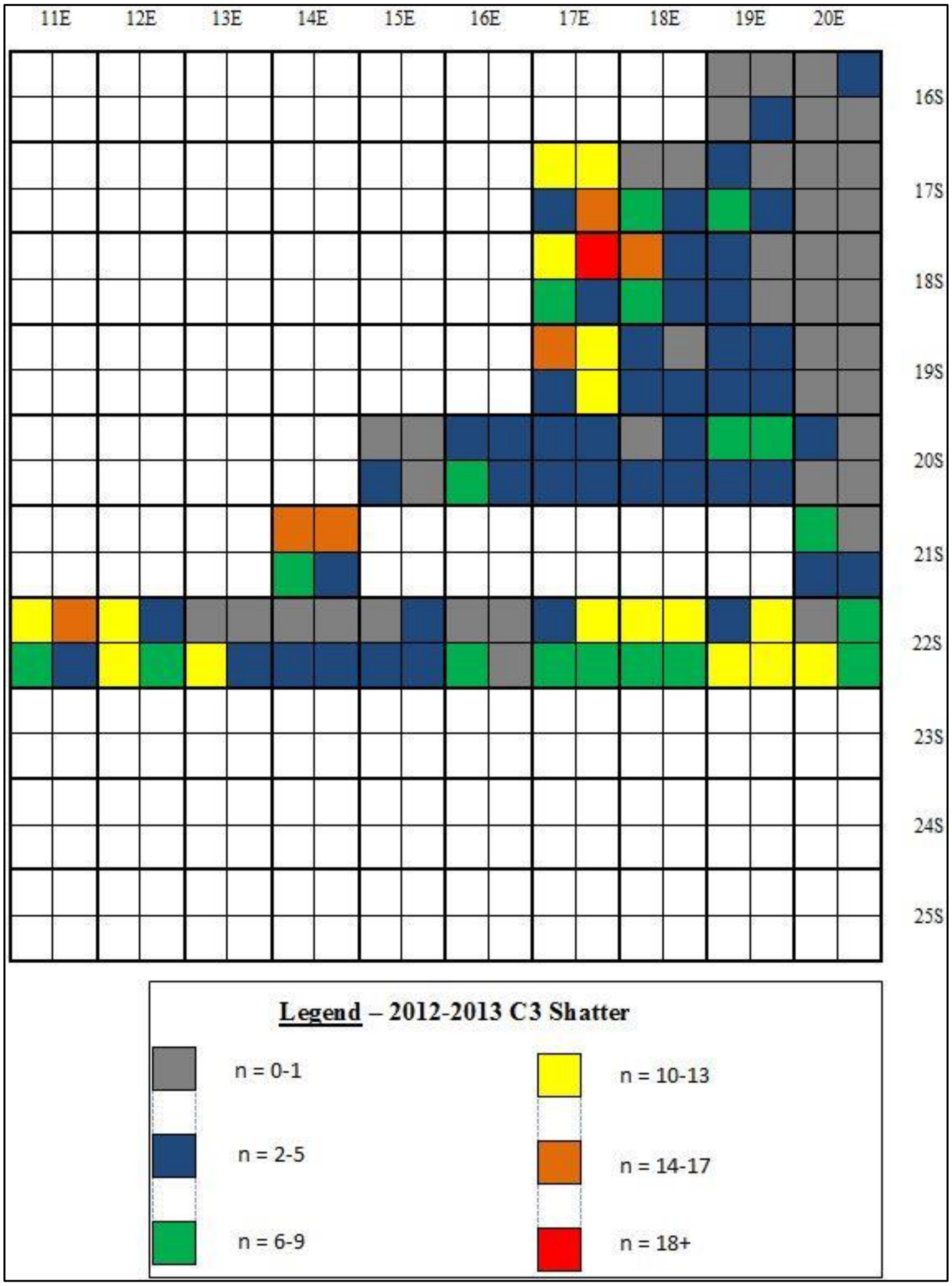

Figure 6.3.8: Distribution of C3 lithic shatter.

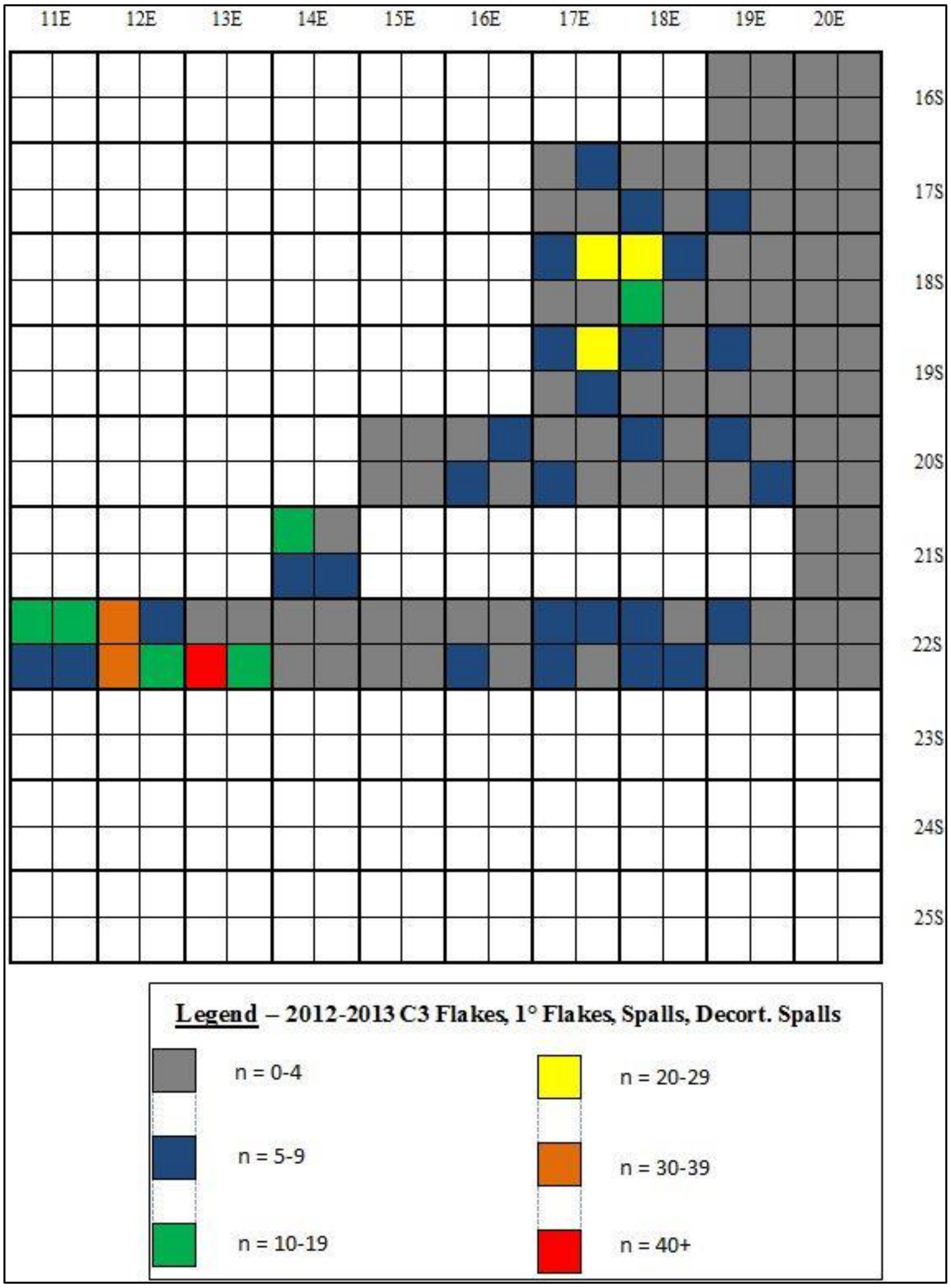

Figure 6.3.9: Distribution of other C3 lithic debitage.

6.3.2: Cultural Level 3 Faunal Assemblage

In all, 9,063 specimens weighing 17,315.3g were recovered from this level during the 2012 and 2013 field seasons. By number, 15.3% of faunal remains were identified as bison, while 84.5% were unidentifiable. The remaining 0.2% includes pronghorn (see Figure 6.3.10 below), wolf, *Canis sp*. (see Figures 6.3.11, 6.3.12, and 6.3.13 below), Northern pocket gopher, and Swift fox (see Figure 6.3.14), all of which each have an MNI of 1. Analysis of bison specimens produced an MNI of 3. One mollusk shell fragment was recovered, as was one intact gastropod shell. Unburned, un-utilized bone comprises approximately 92.6% of the faunal assemblage by weight, while the remaining 7.4% is made up of mandible or maxilla fragments (~3.5%), unburned, un-utilized teeth or tooth fragments (~2.3%), and burned or calcined remains (~1.5%), as well as a miniscule percentage of shell fragments.

Figure 6.3.10: *Antilocapra americana* 2nd Phalanx from C3. Cat.# 3926.

Figure 6.3.11: Canis sp. Teeth from C3. Top: Cat.# 3634 (Left 3rd Maxillary Molar). Bottom, from left to right: Cat.# 3632 (Left Lateral Mandibular Incisor), 3633 (Left 2nd Mandibular Premolar), 3635 (Left 3rd Mandibular Premolar).

Figure 6.3.12: *Canis sp.*, *Canis lupus* Metapodial Fragments from C3. Top: Cat.# 5391 (*Canis sp*. Metapodial, Proximal Portion – Chewed). Bottom, from left to right: Cat.# 1704 (*Canis sp*. 5th Metacarpal, Proximal Portion), 1975 (*Canis lupus*. 4th Metacarpal, Proximal Portion).

Figure 6.3.13: *Canis sp*. Left Ischium from C3. Cat.# 4845.

Figure 6.3.14: *Vulpes velox* Metatarsal Fragments from C3. From left to right: Cat.# 6164, 6165.

Faunal remains from this level appear to be concentrated in several areas across the site, and in some instances co-occur with hearth features (see Figure 6.3.15 below). Figures 6.3.16 and 6.3.17 below illustrate the spatial distribution of faunal remains from this level. It should be noted here that fire-cracked rock and other stones from the hearth in unit 19S 19E were not weighed in the lab, but were instead mapped in and kept at Wanuskewin Heritage Park with the intention of one day reconstructing it and putting it on display.

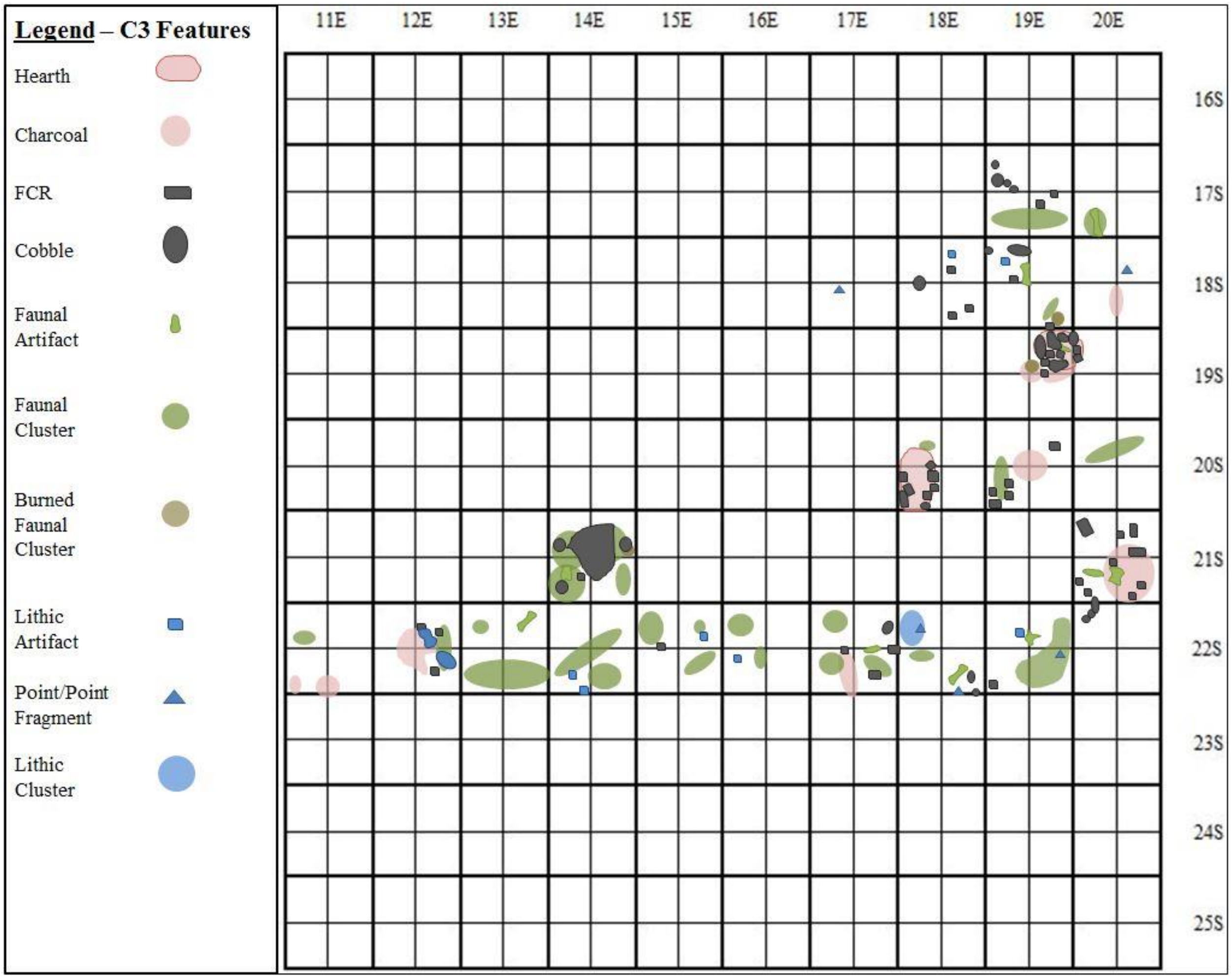

Figure 6.3.15: Distribution of 2012-2013 C3 Features.

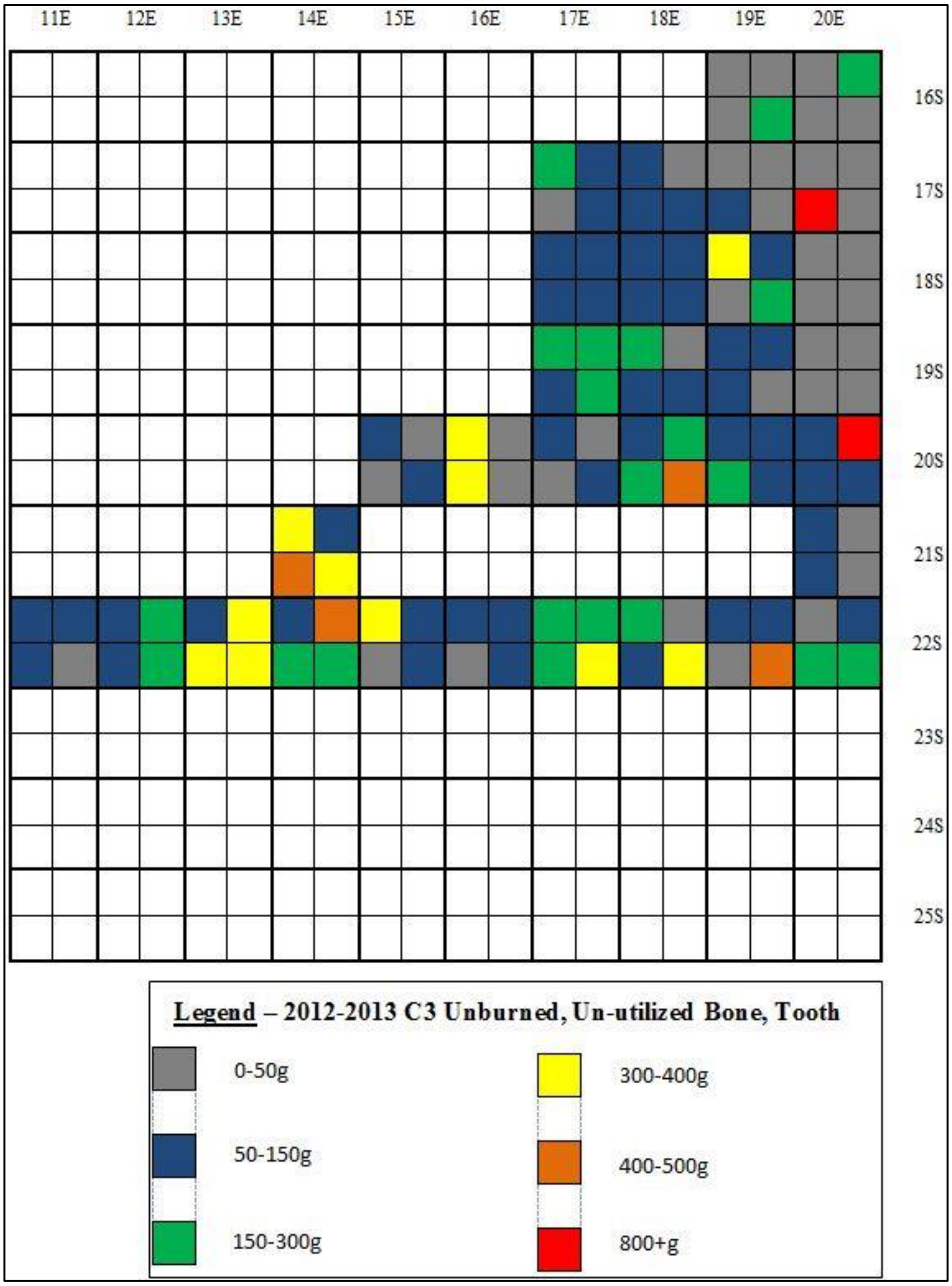

Figure 6.3.16: Distribution of C3 unburned, un-utilized bone and tooth fragments.

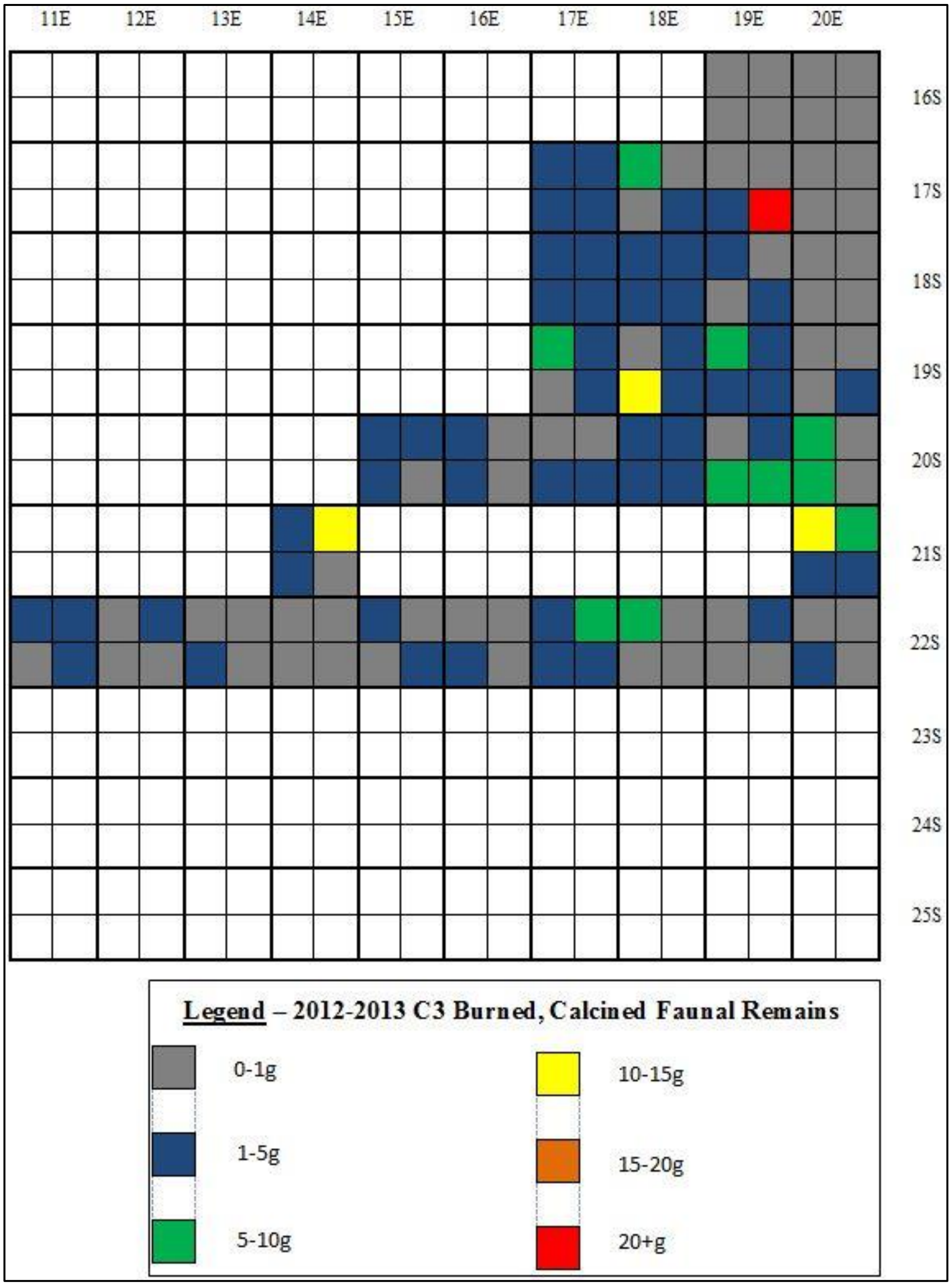

Figure 6.3.17: Distribution of C3 burned faunal remains.

6.3.3: C3 Summary

Cultural level 3 exhibits more variety pertaining to faunal choice than C2 does, as the presence of pronghorn remains attests. Conversely, lithic material choice in this McKean Series level seems to be more reliant on local types than later (C1, C2) cultural levels. As with the upper two levels, C3 appears to be representative of one or several low-intensity occupations. Relatively low amounts of different types of artifacts; from lithic debris for making stone tools to the charred and unburned bones of species of prey animals, indicate that the Wolf Willow site was used for short-term habitation.

6.4: Cultural Level 4

Cultural Level 4 is located beneath Cultural Level 3 at a depth of approximately 45cm. One intact projectile point belonging to the Oxbow complex was recovered from this level during the 2012-2013 excavation at a depth of 44cm.

6.4.1: Cultural Level 4 Lithic Assemblage

Excavations in 2012 and 2013 recovered 6 core fragments, 1 scraper, 1 point, 1 retouched flake, and 1 hammerstone, as well as 36 pieces of shatter and 47 flakes. Shatter from this level is comprised of Cathead chert (2.8%), CPL (2.8%), dolomite (5.6%), feldspathic siltstone (2.8%), Gronlid siltstone (2.8%), jasper (2.8%), quartz (22.2%), quartzite (11.1%), and raw (16.7%) and heat treated (30.6%) Swan River Chert. Material types comprising the flake assemblage include basalt (6.4%), Knife River flint (2.1%), quartz (2.1%), quartzite (10.6%), and raw (27.7%) and heat treated (51.1%) Swan River Chert. Debitage counts are given in Table 6.4.1 below.

Cultural Level 4 Debitage Counts				
Material	**Shatter**	**Secondary Flake**	**Total**	**Percent (%)**
Agate	0	0	0	0.0
Agatized Wood	0	0	0	0.0
Basalt	0	3	3	3.6
Brown Chalcedony	0	0	0	0.0
Cathead Chert	1	0	1	1.2
CPL	1	0	1	1.2
Dolomite	2	0	2	2.4
Feldspathic Siltstone	1	0	1	1.2
Gronlid Siltstone	1	0	1	1.2
Jasper	1	0	1	1.2
Knife River Flint	0	1	1	1.2
Quartz	8	1	9	10.8
Quartzite	4	5	9	10.8
Silicified Peat	0	0	0	0.0
Silicified Siltstone	0	0	0	0.0
Silicified Wood	0	0	0	0.0
Swan River Chert (H.T.)	11	24	35	42.2
Swan River Chert (raw)	6	13	19	22.9
Other	0	0	0	0.0
Total	36	47	83	100.0
Percent (%)	43.4	56.6	100.0	

Table 6.4.1: C4 Lithic Debitage Counts.

Core fragments recovered from this level are composed of grey orthoquartzite (16.7%), quartzite (16.7%), tan-coloured chert (16.7%), and heat treated Swan River Chert (50.0%) (see Figure 6.4.1 below). The use of these material types at the Wolf Willow site indicates that Oxbow people were making use of locally-occurring materials, not exotics.

Figure 6.4.1: Cores from C4. From left to right: Cat.# 7286 (Tan Chert), 4016 (H.T. SRC), 8100 (Quartzite).

The one point (see Figure 6.4.2 below), as well as the one retouched flake recovered from this level are both manufactured from heat treated Swan River Chert. The endscraper (see Figure 6.4.2 below) is composed of silicified wood, and the hammerstone from dolomite.

Figure 6.4.2: Flaked Tools recovered from C4. At left, Cat.# 2786 (Oxbow Point, H.T. SRC). At right, Cat.# 8259 (Scraper, Silicified Wood).

The majority of lithic artifacts recovered from Cultural Level 4 during the 2012 and 2013 field seasons are located along the southern periphery of the excavated area (see Figures 6.4.3 and 6.4.4 below).

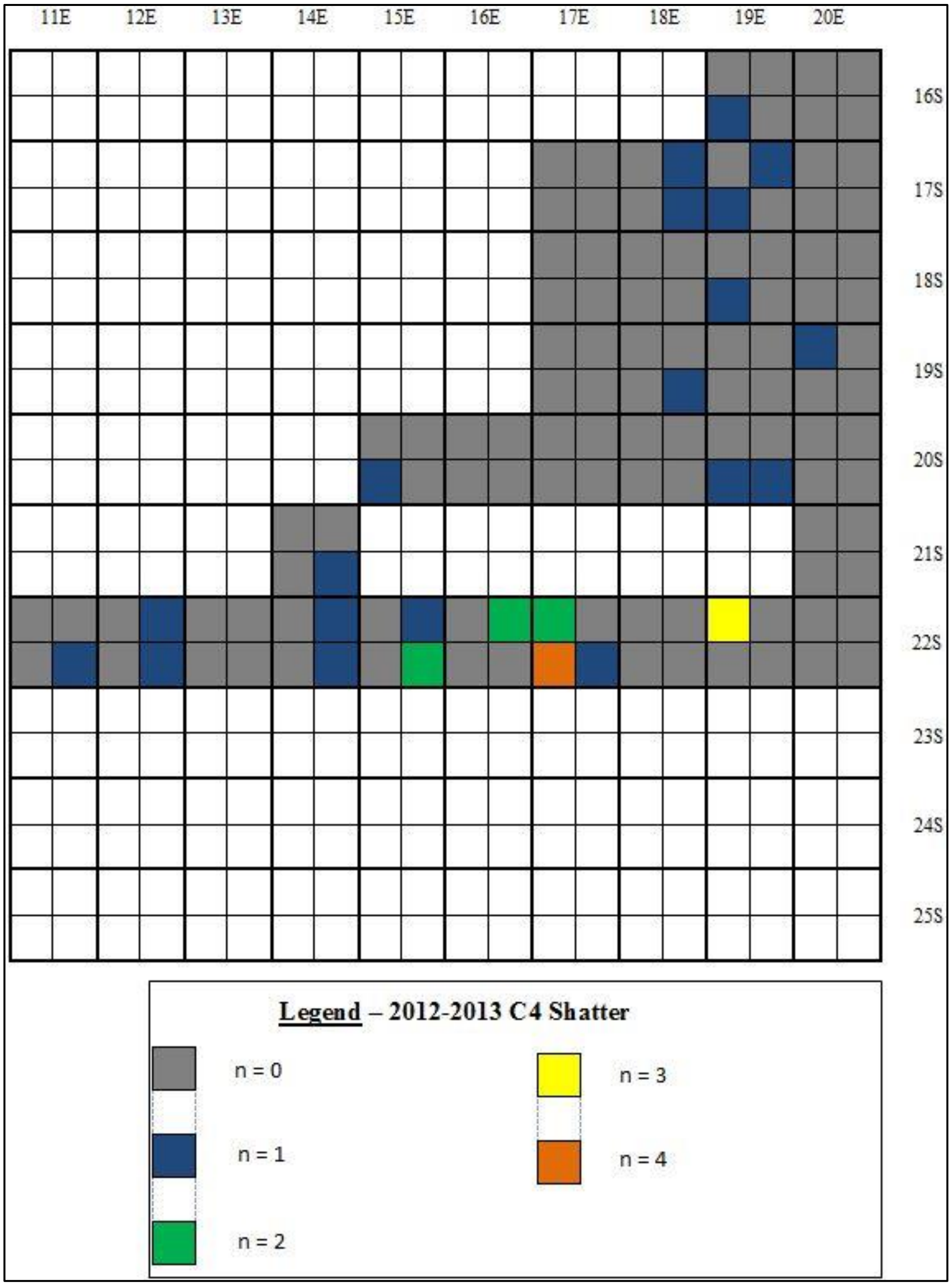

Figure 6.4.3: Distribution of C4 lithic shatter.

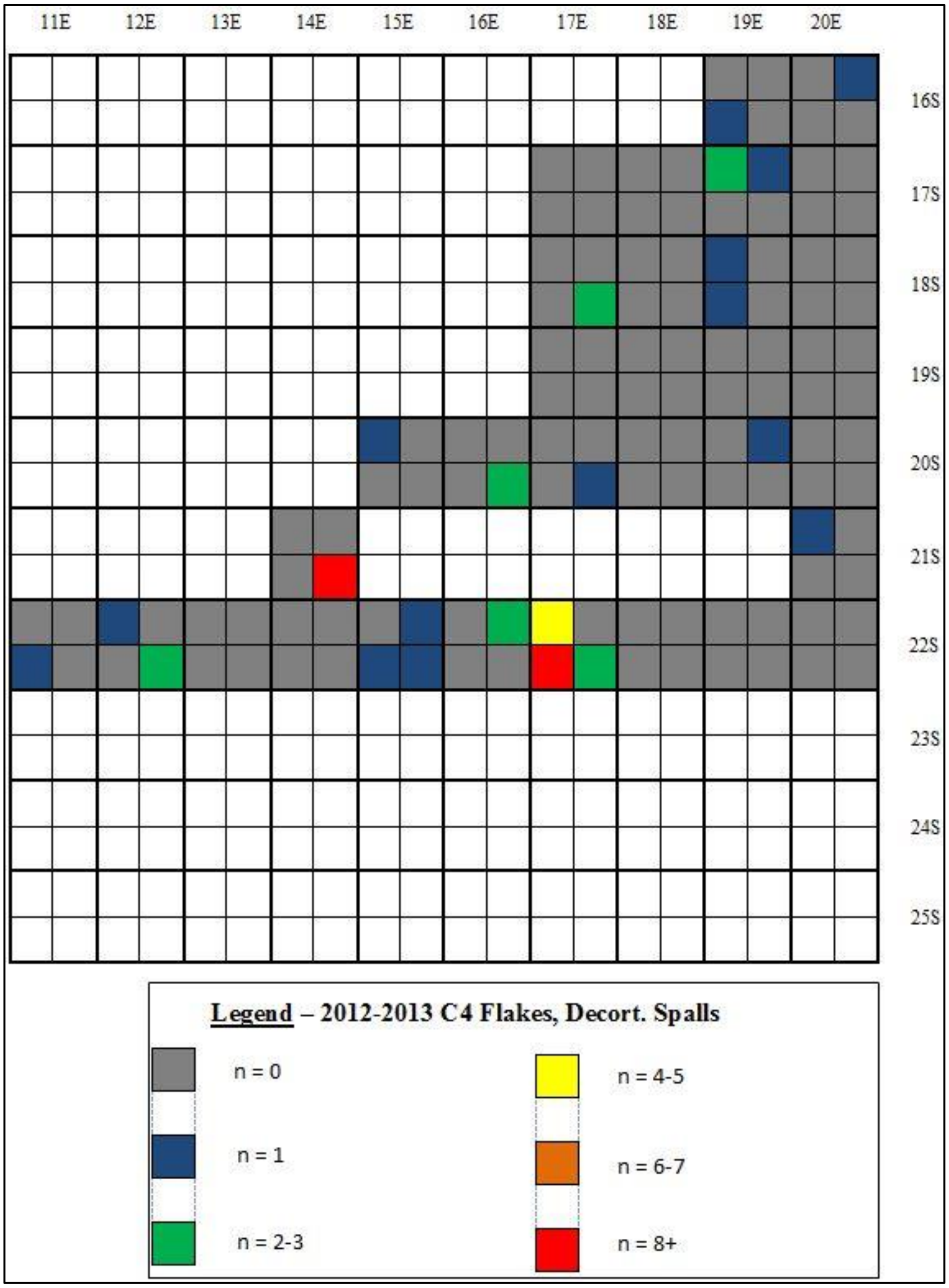

Figure 6.4.4: Distribution of other C4 Lithic Debitage.

6.4.2: Cultural Level 4 Faunal Assemblage

A total of 1,636 specimens weighing 8710.9g were recovered from this level during the 2012 and 2013 field seasons. Unburned, un-utilized bone accounts for approximately 92.5% of the C4 assemblage by weight, while the remaining 7.5% is made up of unburned, un-utilized teeth or tooth fragments (1.7%), mandibular or maxillary fragments (5.1%), and burned or calcined bone fragments (0.5%). By number, bison account for approximately 23.1% of recovered specimens, while unidentifiable faunal specimens make up a further 75.3%. The remaining 1.6% is comprised of *Canis sp.* (see Figure 6.4.5 below), gastropod, unidentifiable mollusk, and red fox. MNI analysis of C4 faunal remains determined that a minimum of 5 bison, 1 Canis sp., 1 red fox, 6 gastropods, and 1 mollusk are represented in this assemblage.

Figure 6.4.5: *Canis sp.* Right Mandible Segment. Cat.# 3438.

Spatial distribution of burned and calcined bone fragments appears to relate to that of fire-cracked rock in this level, being found in the vicinity of units 22S 15E, 22S 17E, and 18S 17E (see Figures 6.4.6 and 6.4.7 below).

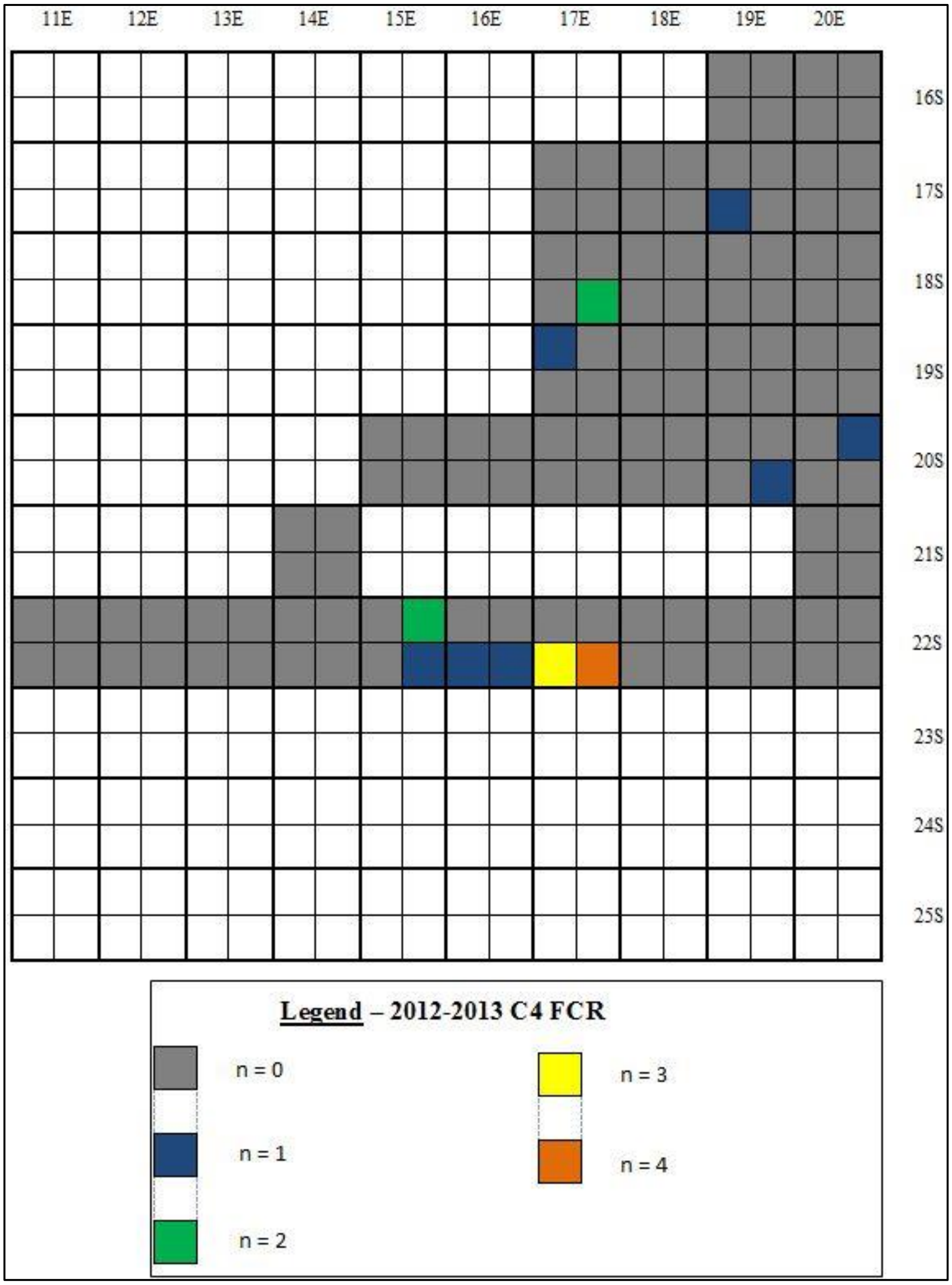

Figure 6.4.6: Distribution of C4 fire-cracked rock.

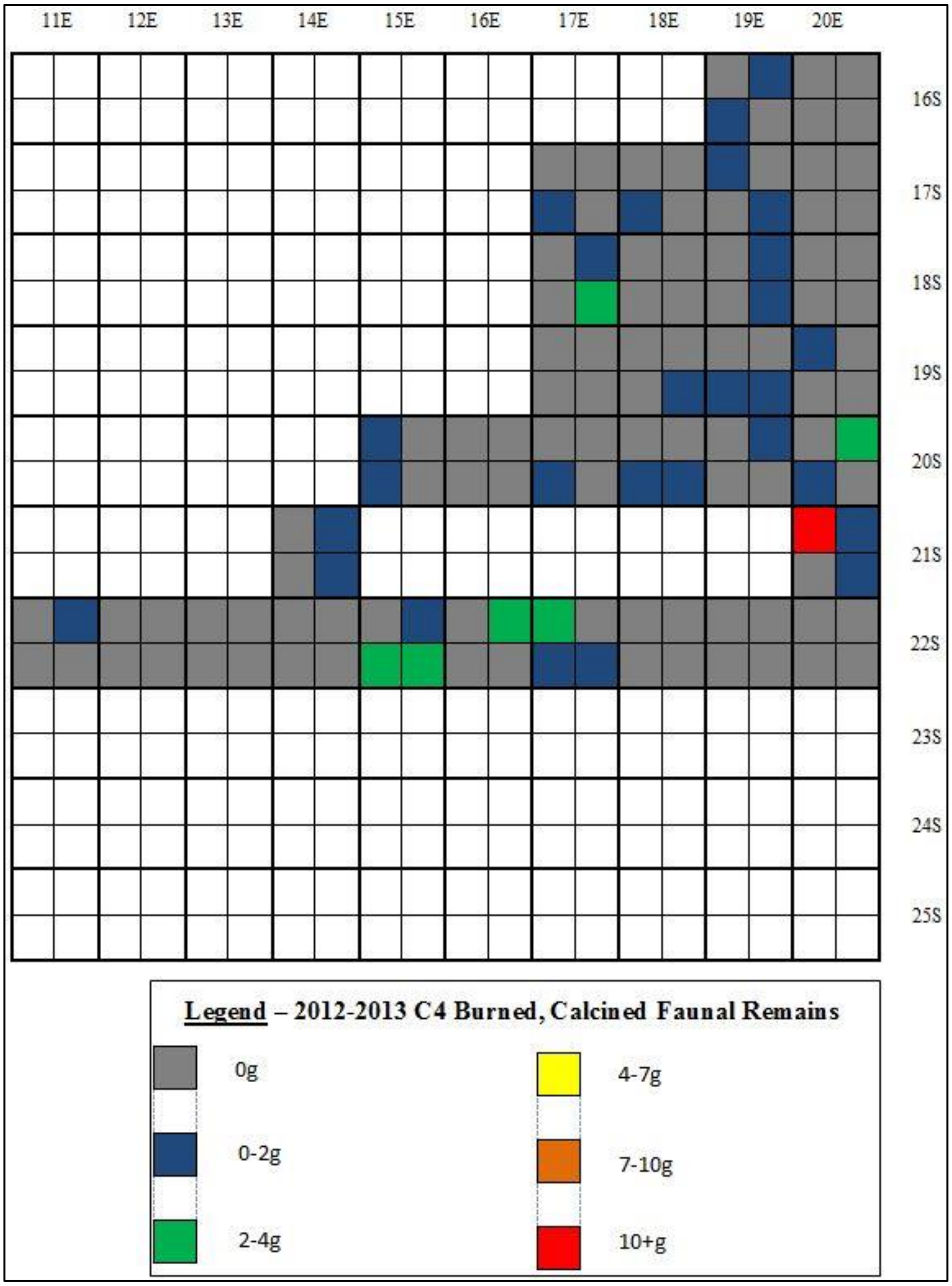

Figure 6.4.7: Distribution of C4 burned faunal remains.

Unburned, un-utilized bone fragments, however, seem to be less spatially restricted, and occur across the site in some quantity (see Figure 6.4.8 below). Concentrations of these faunal artifacts also seem to spatially co-occur with those of fire-cracked rock, but not in a mutually exclusive fashion (see Figure 6.4.9 below).

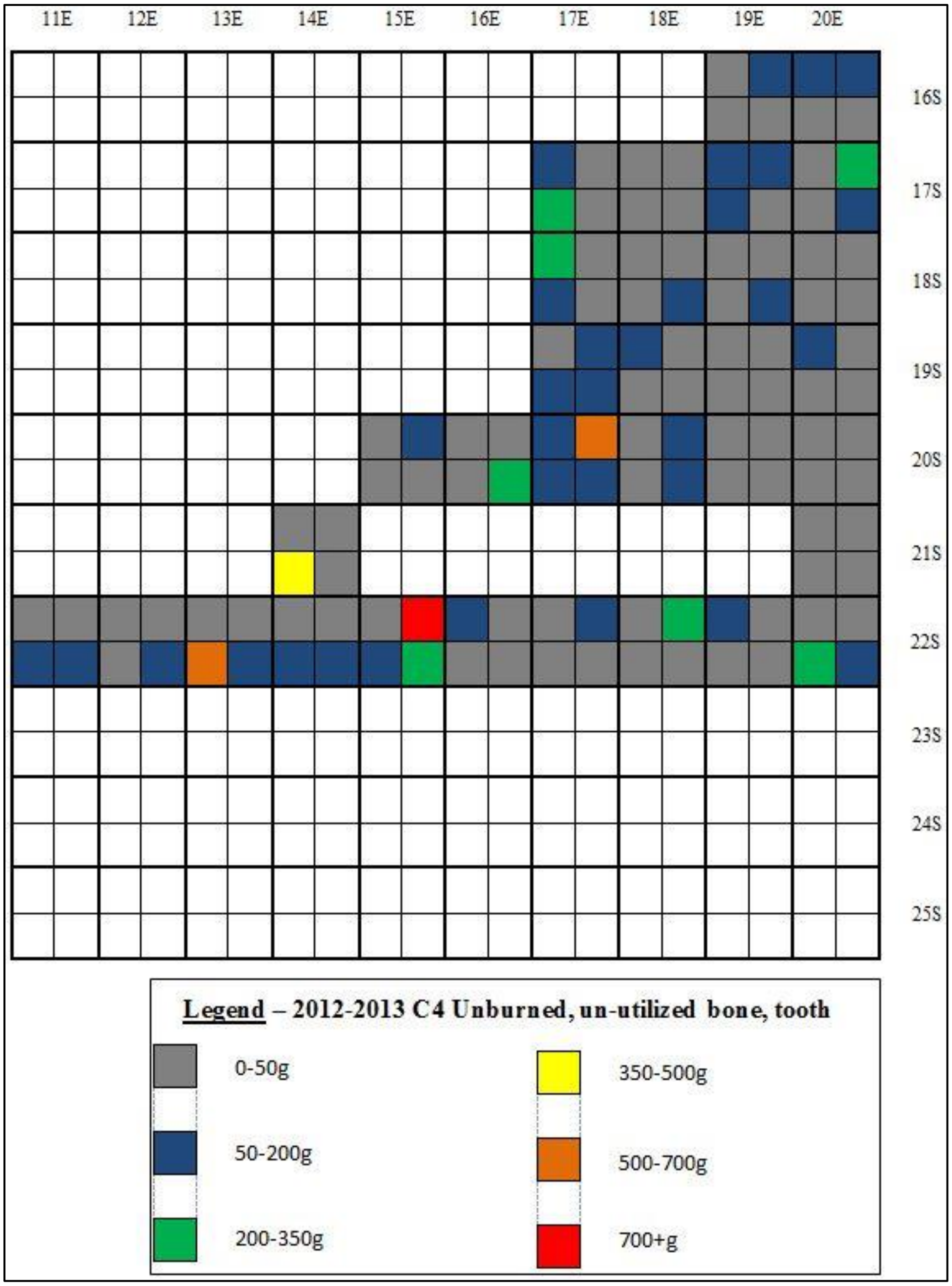

Figure 6.4.8: Distribution of C4 unburned, un-utilized bone and tooth fragments.

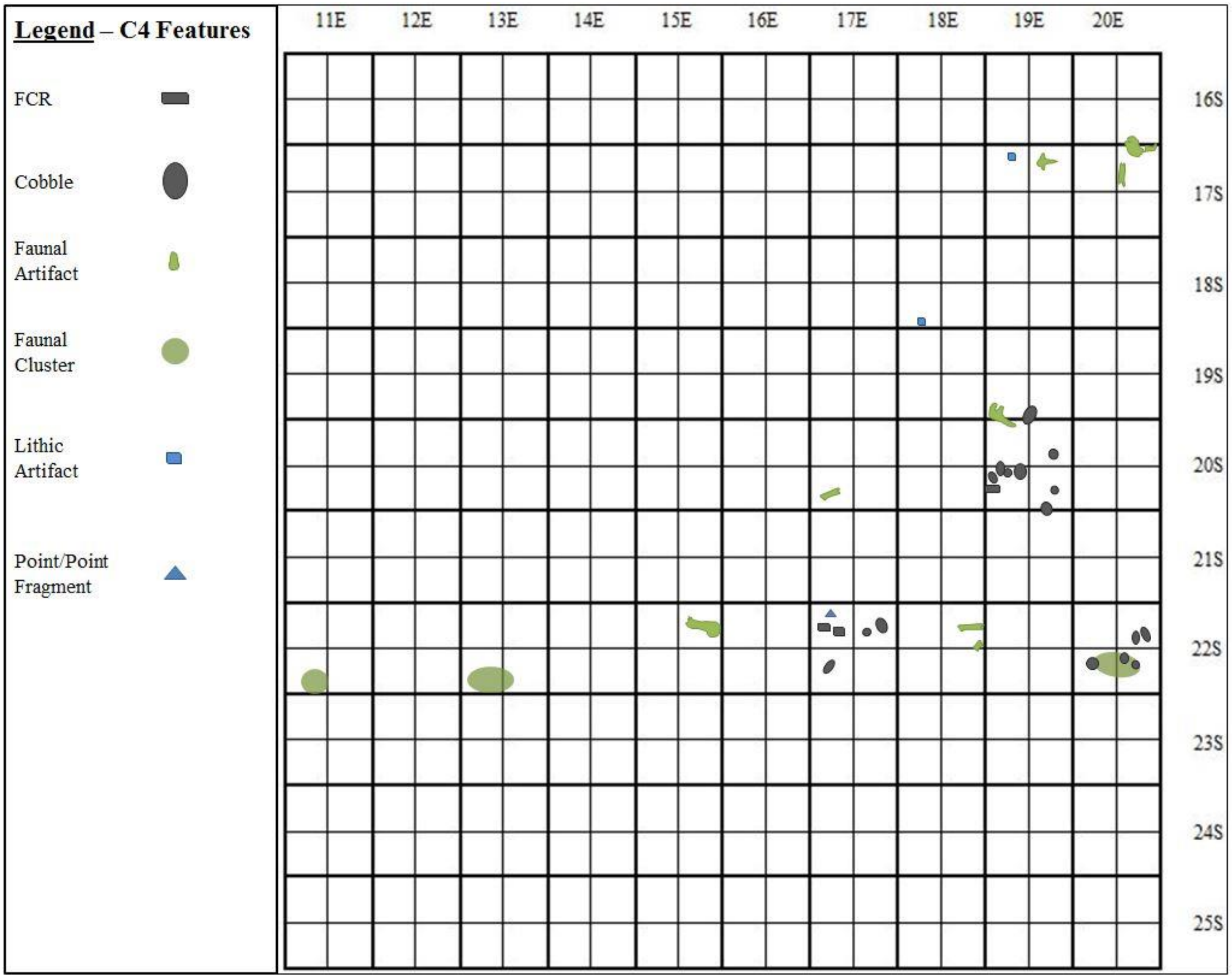

Figure 6.4.9: Distribution of 2012-2013 C4 Features.

6.4.3: C4 Summary

Materials recovered from the Oxbow occupation of the Wolf Willow site are consistent with the use of the site for short-term habitations. A small amount of fire-cracked rock in three concentrated areas with few other associated artifacts indicates that the site was likely inhabited by few people.

6.5: Level 5

6.5.1: Level 5 Faunal Assemblage

Due to a lack of lithic artifacts in this level, it is not considered to be cultural at this time. However, the presence of several large faunal specimens in this level is at the very least notable. In all, 265 faunal specimens weighing 4828.7g were recovered from Level 5. Unburned, un-utilized bone comprises 97.0% of this assemblage by weight, while the remaining 3.0% is made up of unburned, un-utilized tooth or mandible fragments (2.9%) and one burned bone fragment (0.1%). By number, 37.0% of faunal specimens originate from bison, while 63.0% are unidentifiable. However, by weight, bison account for 92.5% of the Level 5 faunal assemblage (see Figures 6.5.1 and 6.5.2 below), with the remaining 7.5% being unidentifiable. Figures 6.5.3 and 6.5.4 illustrate the spatial distribution of faunal remains from Level 5 across the site.

Figure 6.5.1: *Bison bison* Hyoid. Cat.# 7621.

Figure 6.5.2: *Bison bison* Right Scapula. Cat.# 8394.

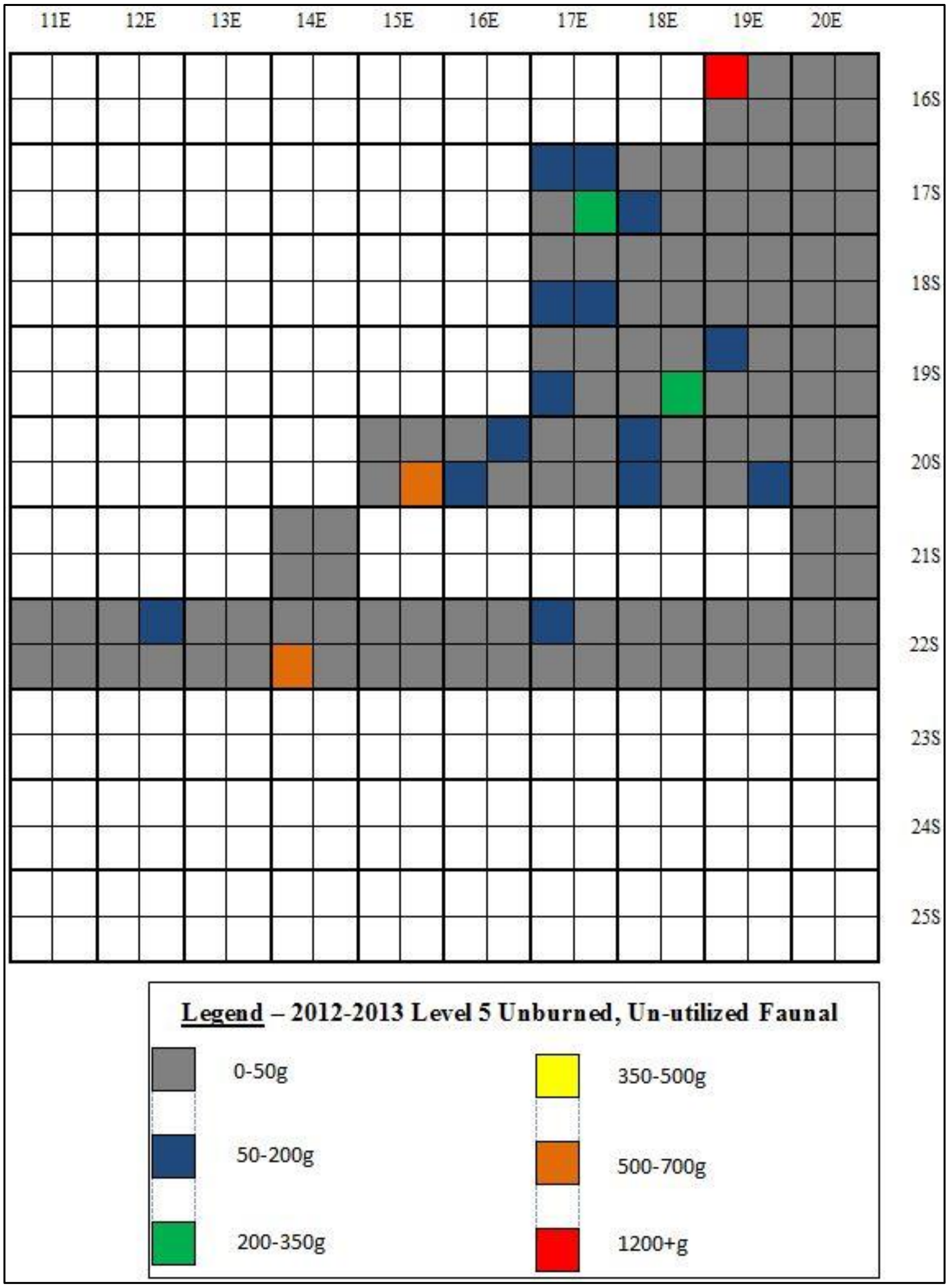

Figure 6.5.3: Distribution of 2012-2013 Level 5 unburned, un-utilized bone and tooth fragments.

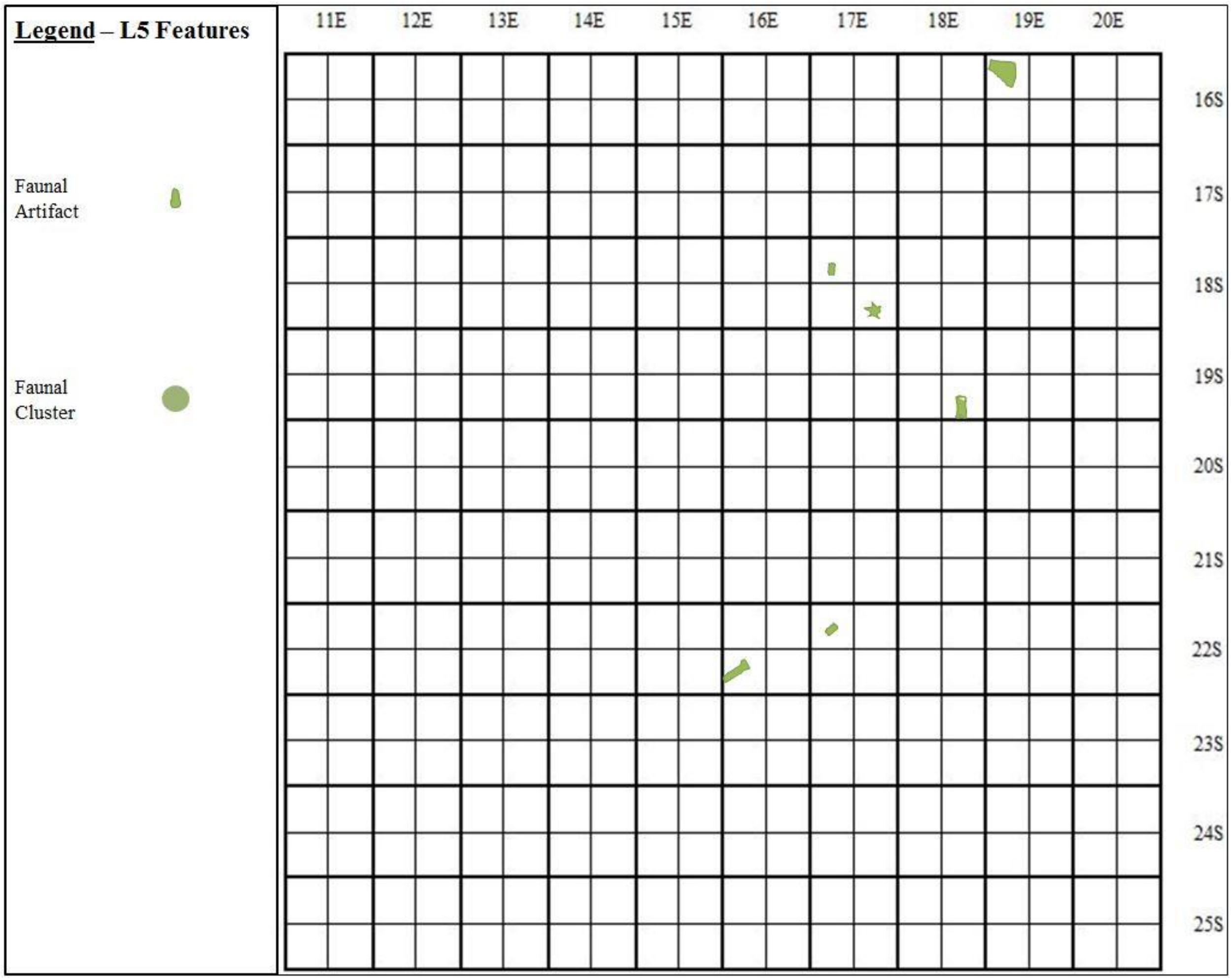

Figure 6.5.4: Distribution of significant 2012-2013 Level 5 faunal artifacts.

6.5.2: Level 5 Lithic Assemblage

One lithic artifact was recovered from this level – a quartzite flake. Due to the intact nature of much of the faunal assemblage, the Level 5 assemblage is at present believed to be comprised of re-deposited artifacts or ecofacts, and therefore is not considered to have cultural significance.

6.5.3: Level 5 Summary

The spatial distribution of faunal remains from Level 5 supports the argument that they were secondarily transported by Opimihaw Creek. Not only are two clear arcs of units that have significant amounts of faunal material in them are visible in Figure 6.5.3, but the sedimentary matrix of this level in many units along the trajectory of those arcs is quite gravelly. Correlation of elevated gravel content with the spatial distribution of large, often intact, faunal elements strongly indicates that faunal remains and sediments were transported and deposited by the same fluvial processes.

Chapter 7: Sediment Analysis

Analyses discussed in this chapter will include the loss-on-ignition and particle size analyses that were briefly mentioned in Chapter 4, for each of the seven lithostratigraphic units sampled. Detailed procedures and calculations for these analyses can be found in Appendix A.

7.1: Wolf Willow Sediment Profile

7.1.1: L1 (68 to 90cm)

Sediments were visually evaluated using a Munsell colour chart prior to being placed in a crucible and weighed to 0.0001g. As mentioned in Chapter 4, a Munsell colour of 10YR 7/1 indicates that this level is leached and is also high in carbonate content. However, the inorganic carbon content of these samples was unfortunately not able to be evaluated due to an equipment malfunction. Organic carbon content of this sample is expectedly low, but not negligible at 0.85%. While skeletal elements of bison are one obvious source of organic matter, it is possible that organic matter was leached out of overlying strata and deposited in this level.

Once a crucible had been weighed to 0.0001g and had its weight recorded, approximately 10g of oven-dried sediment was added to it. This combined weight was then assessed and also recorded. A muffle furnace was then preheated to 550°C, whereupon crucibles containing sediment were placed inside and removed one hour later. After cooling in a desiccator for at least one hour, the weights of the crucibles plus the ashed sediment were recorded. Due to the fact that oven-drying the samples removed all moisture, any resulting loss in mass following a one-hour period in the furnace indicated how much organic carbon had been burned out of the sample.

Once a sample had been ground with a mortar and pestle to break apart any consolidated sediment, it was put through a riffler, which is an apparatus that homogenizes the sample to ensure that the approximately 30g portion put through the screens was representative of the sample as a whole. After clasts of each grain size had been weighed, the amount of material lost to the sieves during the shaking process was determined. A resulting sieve loss of less than 5% was deemed acceptable. As shown in Table B.4 in Appendix B, the sample from L1 is decidedly sandy. More specifically, the clast size that makes up the highest proportion of its sediment matrix is “medium sand” (355µm and 250 µm). L1 also, surprisingly, has the highest proportion of gravel of any of the levels sampled at Wolf Willow, with a very low percentage of silt and clay. Therefore, according to the Folk system for classifying clastic sediments, this sample is considered to be “gravelly sand” (see Figure B.1 in Appendix B).

Several statistical analyses were carried out in order to glean meaningful information from the particle size data. First, the percentage of the sample that was trapped by each sieve was determined by dividing the total weight of sediment trapped by a sieve by the total initial weight of the sample, and multiplying by 100. These percentages are presented in Table B.4. Particle sizes for statistically relevant values such as mean, median, and mode are also given in Appendix B, Table B.1 in ϕ units for each sample and were calculated using *Gradistat*© software (see Figure B.3 in Appendix B). Mean particle size for L1 sediments is in the “medium sand” range on the Wentworth scale (see Figure B.2 in Appendix B) as is their median (Q2) particle size. Due to the fact that the computed sorting coefficient (S_o) of this lithostratigraphic unit is between 1.0 and 2.0, it is considered to be poorly sorted. At a value of 1.463, it is also the most poorly-sorted lithostratigraphic unit in the Witness Block profile.

7.1.2: L2 (52 to 68cm)

A Munsell colour of 10YR 8/2 indicates that this level is the same 10YR hue as the sample from L1, with a higher, lighter “value” of 8 and a low chroma number. Such a light colour with a YR hue indicates that this level is quite leached and also contains a significant amount of carbonates. Loss-on-ignition analysis indicates an average organic carbon content of 0.89% between the two samples. Due to the fact that L2 is within the bounds of cultural level 4, with faunal artifacts occurring near its topmost extent, a higher organic carbon content than that of L1 was expected.

L2 is slightly less gravelly than L1 with a gravel percentage of 5.42%, but has a much coarser sand component (see Table B.4 in Appendix B). Like L1, the sample from L2 is also considered to be “gravelly sand” by the Folk (1954, 1974) system (see Figure B.1 in Appendix B). Silt and clay content for L2 is negligible and at 0.28% is the lowest of all seven sampled levels.

Statistical analysis of L2 sediments determined that they are the second most poorly-sorted of the 7 sampled levels at the Wolf Willow site as indicated in Table B.1 in Appendix B. This level has a mean and median particle size that fall within the “medium sand” range on the

Wentworth scale. Due to the presence of gravel lenses at depths of approximately 25cm in units adjacent to the one that was sampled for this thesis, it was thought that the coarsest sampled level would be at a much shallower depth than L2 is. However, as the data clearly shows, this is not the case.

7.1.3: L3 (44 to 52cm)

As in the previous two levels, sediments in L3 have a 10YR Munsell hue. However, darker values of 6 and 7 reflect a slight increase in average organic carbon content for the level, at 1.19%, from the previous two levels. Due to the fact that the top of L3 straddles the contact of the 3rd and 4th cultural levels, and cultural level 3 contains more faunal remains than cultural level 4, an increase in organic matter content is to be expected. Organic carbon content for L3 can be viewed in Table B.1 in Appendix B.

As seen in Table B.4 in Appendix B, L3 has a much lower gravel and coarse sand fraction than L2, but higher gravel and coarse sand fractions than those of L4. A gravel content of 2.64% gives the sample a Folk (1954, 1974) system classification of “slightly gravelly sand” (see Figure B.1 in Appendix B). Silt and clay content, while higher than the preceding or overlying levels, is still negligible at a mere 1.02%.

Upon applying statistical analyses, it was determined that L3 sediments better-sorted than those from both L1 and L2. As indicated in Table B.1 in Appendix B, L3 has a mean particle size that falls into the finer extent of the “medium sand” range and median (Q2) particle size in the coarser extent of the “fine sand” range. A sorting coefficient of 1.24 indicates that sediments from L3 are poorly sorted.

7.1.4: L4 (35 to 44cm)

Munsell colour values for L4 are indistinguishable from those of L3, with a classification of 10YR 6/2 and 10YR 7/2 for its two samples. An average organic carbon content of 1.16% is also nearly identical to that of the previous level (Table B.1 in Appendix B). L4, like L1, L2, and L3, is therefore also quite leached and has an accumulation of inorganic carbonates.

While the colour and organic carbon content of L3 and L4 are nearly identical to each other, there are some notable textural differences between the two levels (see Table B.4 in Appendix B). First, there is very little gravel (0.82%) in L4, which indicates a nearly 2%

decrease from L3. Second, L4 is over 3% lower in coarse sand than L3, but its fine sand portion is nearly 6% higher than that of L3. A gravel content of 0.82% defines the texture of L4 as "slightly gravelly sand."

Sediments from L4 have mean and median grain sizes in the "fine sand" range. When entered into the sorting formula, these statistical values give a sorting coefficient of 1.06 making L4 the best-sorted lithostratigraphic unit in the Witness Block profile.

7.1.5: L5 (24 to 35cm)

A Munsell colour of 10YR 6/2 reflects a slight increase in organic carbon content from L4, as seen in Table B.1 in Appendix B. A darker Munsell colour and increased organic carbon content indicate that L5 is less leached than the lithostratigraphic levels which underlie it.

L5 has a gravel percentage approximately twice that of L4 at 1.6% and a sand content that is 3.9% lower than that of L4 at 94.6% (see Table B.1 in Appendix B). Silt and clay content of L5, however, is noticeably higher than that of L4 at 3.74%. The texture of L5 is therefore classified as "slightly gravelly sand". Particle sizes for L5 can be viewed in Table B.4 in Appendix B.

L5 sediments have mean and median particle sizes in the "fine sand" range. A sorting coefficient of 1.19 indicated that, while sediments from this level are "poorly sorted", they are the third most well-sorted in the Witness Block profile (Table B.1 in Appendix B).

7.1.6: L6 (14 to 24cm)

The colour of L6 sediments, while still in the 10YR hue, is significantly darker than any previous level in the sample column with a value of 2. Actual organic content of this level is 1.55%, which is only 0.17% higher than the organic content of the previous level (Table B.1 in Appendix B). L6 straddles the top of the culturally sterile hiatus that separates C2 and C3, and the bottom portion of a cumulic "A" horizon that was established once the position of Opimihaw Creek moved further away from the Wolf Willow site.

In addition to a change in colour and organic carbon content, there are several textural characteristics that set L6 apart from the previous level. An increase in the percentages of gravel, coarse sand, very coarse sand, and mud (see Table B.4 in Appendix B) further set L6 apart from L5. L6 is classified as “slightly gravelly sand” using the Folk (1954, 1974) classification system.

As seen in Table B.1 in Appendix B, the mean particle size for sediments from L6 is in the “medium sand” range, while the median particle size is in the “fine sand” range. A sorting coefficient of 1.32 is numerically higher than those of the adjacent (L5 and L7) lithostratigraphic units, but like the others still remains “poorly sorted”.

7.1.7: L7 (0 to 14cm)

Due to the fact that this level includes an active pedological unit, L7 was expected to have the highest organic carbon content of all seven sampled levels. This expectation was confirmed by a measured organic carbon content of 4.02% (see Table B.1 in Appendix B). A Munsell colour of 10YR 3/1 is further indicative of a dark, organic-rich horizon.

As displayed in Table B.4 in Appendix B, the sieve loss for this sample had to be corrected. This was due to the presence of several small bone fragments that were found to be in the sample after it had been shaken. One notable difference between the sedimentary textures of L7 and L6 is the increase in medium, fine, and very fine sand fractions in L7, which is attributable to the fact that L6 is partially comprised of sediment from the sterile “hiatus” level between C2 and C3. Also, there is little enough gravel for this level to be defined as “slightly gravelly sand”.

Mean and median particle sizes for L7 are both in the “fine sand” range and are therefore slightly finer than those of L6. A sorting coefficient of 1.18 indicates that while L7 sediments are statistically considered to be “poorly sorted”. L7 is nonetheless the second best-sorted lithostratigraphic unit in the Witness Block profile (see Table B.1 in Appendix B).

7.2: Sediment Data from Other Sources

The Witness Block profile was one of two areas of the Wolf Willow site that were sampled. David Hilger’s (2013) undergraduate Honours thesis was partially based on four sediment samples which were gleaned from unit 25S 16E at the southern extent of the excavated area of the site. It should be noted here that Hilger’s (2013) data leaves out two sieve sizes; 180μm (2.5ϕ), which falls into the “fine sand” range, and 90μm (3.5ϕ), which falls into the “very fine sand” range. Due to this difference in methodology, intra-site comparisons between sediment samples from the Witness Block and unit 25S 16E will be presented and discussed in general terms.

7.2.1: 25S 16E 12-24cm

Due to the fact that this sample is the only one in the sampled profile that came from an area of active pedogenesis, it has the highest percentage of organic carbon at 5.44% (see Table B.1 in Appendix B). This is a significantly higher percentage than that from a comparable depth (14 to 24cm) in the Witness Block profile. Although the reason for this discrepancy is ultimately unknown, the intra-site variability in organic content could be explained by spatial concentrations of organic-rich deposits such as charcoal or faunal remains. A Munsell colour of 5 Y 2.5/1 indicates that this sample has a yellowish hue, a fairly dark value, and a low degree of colour purity.

As Table B.1 shows, sediments from this sample depth contain very little gravel at only 1.76% of the final mass of the sample. The proportion of this sample that is comprised of silt and clay is perhaps its most interesting attribute. At 11.33%, the silt and clay content of this sample is nearly 8% higher than that from a comparable depth (14 to 24cm) in the Witness Block profile. As mentioned in section 7.8 above, two sieve sizes that were used in the analysis of sediments from the Witness Block profile, 180µm and 90µm, were not used in the analysis of sediments from unit 25S 16E, and so intra-site comparison of the “fine” and “very fine” sand fractions from the two sampled profiles is impossible.

Texturally, this sample is classified as “slightly gravelly muddy sand” by the Folk (1954, 1974) system, which indicates that it is the only sample presented in this thesis that has a significant mud fraction. Statistical analysis of the “12 to 24cm” sample reveals that it has a mean particle size in the “fine sand” range, a median in the “medium sand” range and three modes (see Table B.1 in Appendix B). A sorting coefficient of 1.77 indicates that this sample is not only poorly sorted, but is the most poorly sorted level presented in this thesis.

7.2.2: 25S 16E 42 to 58cm

Organic content of this sample is 1.80%, which is comparable to that from L3, a similar sample depth from the Witness Block profile (see Table B.1 in Appendix B). A Munsell colour of 10YR 7/2 indicates that sediments from this level are quite leached, and are therefore also comparable to sediments from L3 in the Witness Block profile in this way.

Sediments from between 42 and 58cm in the 25S 16E profile have a significant percentage of silt and clay, and at 8.3%, have the second-highest mud fraction of all samples presented herein. Texturally, this sample is considered to be “slightly gravelly sand” by the Folk (1954, 1974) system. Statistical analysis of this sample gives a mean in the “fine sand” range, a median in the “medium sand” range, and three modes (see Table B.1 in Appendix B). A sorting coefficient of 1.62 indicates that sediments from this sample are the second-most poorly sorted in the 25S 16E profile and also among all the samples presented in this thesis.

7.2.3: 25S 16E 64 to 84cm

A Munsell colour of 2.5Y 7/2 indicates that this sample is fairly leached, and at 0.47%, it also has the lowest amount of organic matter of all the samples presented in this thesis (see Table B.1 in Appendix B). The likely reason for this low percentage of organic matter will become clear in the sections that follow.

Sediments from between 64 and 84cm depth in the 25S 16E profile are decidedly gravelly, being comprised of 60.1% gravel by mass (see Table B.1 in Appendix B). The remaining 39.9% of the sample is made up of a very coarse sand fraction and a negligible (0.89%) amount of silt and clay. Due to the overwhelming amount of gravel in the sample, it is texturally classified as “sandy gravel”.

Statistical analysis of this sample revealed that it has a mean particle size in the “very coarse sand” range, a median particle size in the “granule” range, and a mode also in the “granule” range. A sorting coefficient of 0.94, or “moderately sorted”, means that this sample is the best-sorted of all samples presented in this thesis (see Table B.1 in Appendix B).

7.2.4: 25S 16E 84 to 97cm

Sediments from this sample appear to be quite leached and full of carbonate deposits, as a Munsell colour of 5Y 8/2 attests. However, there also appears to be a fair (1.68%) amount of organic matter in the sample which could be accounted for by the presence of secondarily-deposited faunal remains (see Table B.1 in Appendix B).

Sediments from this depth have a gravel fraction that is comparable to those from “L1” and “L2” of the Witness Block. It is also texturally classified as “gravely sand”. Mean and median particle sizes are both in the “medium sand” range, but the sample has three modes. A sorting coefficient of 1.48 defines this sample as “poorly sorted” (see Table B.1 in Appendix B). It should also be noted that the percentage of this sample that is comprised of silt and clay (5.0%) is far from insignificant, and is much higher than that of “L1” from the Witness Block.

7.2.5: The Thundercloud Site

Abigail K. Burt’s (1997) thesis examined sediment data from several sites within the Opimihaw Valley, but of particular interest with regard to this thesis is her work from the Thundercloud site. Thundercloud lies to the north of the Wolf Willow site and shares several key attributes with its neighbour. Like Wolf Willow, it is located on a point bar deposit near the bottom of the valley which is also located below a colluvial slope (see Figure 7.1 below). As will be discussed shortly, Thundercloud’s sedimentary layers also record periods of landscape instability that not only echo those seen at Wolf Willow, but may also have influenced them in some way.

Figure 7.1: A view of the colluvial slope (sloping from right to left or east to west) at the Thundercloud site from the Wolf Willow site. Camera is pointing North-Northeast.

A “facies” is defined by Waters (1992) as “a spatially restricted sedimentary deposit that exhibits characteristics (e.g., lithology, texture, structure, and fossil content) that are significantly different from the characteristics of other deposits that are the same age (Waters 1992: 39).” As previously mentioned, two such sedimentary facies identified at the Thundercloud site are pertinent to the discussion of site formation processes at the Wolf Willow site; “Facies 3” and “Facies 5”.

The texture of Facies 3 at all three of its depths is classified as “gravelly muddy sand” by the Folk (1954, 1974) system, and due to the low mean grain size caused by high silt and clay content, it is defined as “very poorly sorted” (see Table B.2 in Appendix B). Due to this poor degree of sorting, “Facies 3” at the Thundercloud site is described as being indicative of “deposition of coarser material, possibly reflecting the introduction of more sediment form (*sic*) the slopes (Burt 1997: 131-132).” Interestingly, this facies is seen at three different depths within the site; from 19 to 27cm, from 78 to 86cm, and again from 91 to 94cm (see Table B.2 in Appendix B).

Perhaps the most compelling attribute of Facies 3 with regard to its relationship to the Wolf Willow site, however, is its age. The manifestation of Facies 3 that occurs between 19 and 27cm in the Thundercloud site is in a relative chronology between C3, which is affiliated with artifacts from the Besant and Pelican Lake cultures, and C4, which contains no diagnostic artifacts, but follows a Duncan occupation (Burt 1997: 129-130). This relative chronology places the upper Thundercloud site occurrence of Facies 3 between approximately 3000 and 2500 years B.P., which coincides with the hiatus that separates cultural levels 2 and 3 at the Wolf Willow site.

Two pits were dug near the Thundercloud site at the base of the colluvial slope in an effort to correlate the stratigraphy seen at the site to that of the hillslope. In both of these pits, Facies 3 occurred as a nearly 50cm thick bed of sediment (Burt 1997: 133), which is even more poorly sorted than the Facies 3 deposits from the Thundercloud site itself (see Table B.3 on page 185). Furthermore, Burt (1997) states that “[t]he lack of vertical accretion sediments supports deposition by slope processes above the main floodplain surface (Burt 1997: 132).” However, because no radiocarbon dates were obtained for either of the pits above the Thundercloud site, the temporal extent of Facies 3 deposits at the base of the colluvial slope unfortunately remains unknown.

According to Burt (1997), "Facies 5", which lies beneath a McKean Lanceolate occupation at the Thundercloud site, "…is likely a channel lag deposited prior to ca. 4 ka B.P. (4040 +/- 90 S-3645), the radiocarbon date on cultural layer 6 (Burt 1997: 131)." However, it should be noted that Facies 5 is overlain by another cultural level (cultural level 7) in addition to cultural level 6, albeit unaccompanied by a radiocarbon date or diagnostic artifacts (Burt 1997: 129). Texturally, Facies 5 is classified as "muddy, sandy gravel" by the Folk (1954, 1974) system (see Table B.2 in Appendix B). Following deposition of the Facies 5 channel lag deposits, Burt (1997) states that "[t]he channel then migrated away from the site burying the channel lag with point bar then floodplain sediments (Burt 1997: 131)[,]" as sediments from both "Facies 2b" and "Facies 2a" corroborate (see Table B.2 in Appendix B). Given that a cultural level which predates a McKean occupation lies above Facies 5 at the Thundercloud site, it is asserted by the author that Facies 5 can be temporally and texturally correlated to similar channel lag deposits (ie: WNS 25S 16E 64 to 84) at the Wolf Willow site (see Table B.1 in Appendix B).

Chapter 8: Discussion and Conclusion

8.1: Channel Migration Before and During Oxbow Occupation

8.1.1: Climate

While there is by no means a wealth of climatic data for the last 6000 years on the Northern Plains, proxy data from stable hydrogen isotopes of bison bone collagen gleaned from sites in and near Wanuskewin Heritage Park provide some excellent insight into paleoclimatic conditions for the region. Additionally, plant macrofossils analyzed by Yansa and Basinger (1999) from a kettle lake near Moose Jaw, Saskatchewan suggest that there was a period of "increasing aridity between 8800 and 5500 years B.P. (Leyden et al. 2006: 91)." However, as stable hydrogen isotope data from bison bone collagen shows, this period of increasing aridity came to a halt at approximately 5000 years B.P. Between approximately 5000 years B.P. and 4800 years B.P., the relative temperature of the Saskatoon area appears to have decreased to below present-day values (Leyden et al. 2006: 94), and would have presumably been accompanied by a wetter precipitation regime. However, the work of Schiele (2011) shows a different trend in climatic proxy data for the time period between 6500 years B.P. and 4800 years B.P. based on isotope data from bison tooth enamel. This study indicates that the climate cooled during the first 400 years and became gradually warmer and drier over the course of the next 1300 years (Schiele & Walker 2013: 120). A stable hydrogen isotope ratio is the ratio of deuterium (^{2}H) to protium (^{1}H), measured as δD, that is present in a given sample (Leyden et al. 2006). In the case of bison bone collagen, this ratio indicates average ratios of local precipitation, thereby indicating either how hot and dry or cool and wet a given area was in the past (Leyden et al. 2006).

8.1.2: Data from the Wolf Willow Site

A bone sample from level 5 at 74cm below the modern ground surface in unit 16S 19E has a calibrated age of 5660 years B.P. (4960 RC years B.P.). In the neighbouring unit to the south, unit 17S 19E, a bone sample from 56cm below the modern ground surface was found to have a calibrated radiocarbon age of 5317 years B.P. (4620 RC years B.P.) (see Figure 8.1 below). As mentioned in Chapter 5 of this thesis, it has been noted that "[p]rior to ca. 4.6 ka B.P., the crossing of a geomorphic threshold caused the stream to shift from an incising to an aggrading system (Burt 1997: 184).” These two dates, which are separated by more than 300 years, are also separated by approximately 18cm of sediment. During excavation of the Wolf Willow site in the spring of 2014, an Oxbow point was recovered from a depth of 47cm, indicating that sedimentation was taking place at an increased rate before and during the Oxbow occupation, a trend seen at several other sites in Wanuskewin Heritage Park (Burt 1997: 175-176). However, whereas “dietary isotopic inputs obtained from collagen will be time averaged (Schiele & Walker 2013: 121),” over the course of an animal’s life, tooth enamel is more capable of measuring “small-scale climate change” due to the fact that it produces “a time-series of isotope ratios representative of dietary and environmental changes over an approximate 15 to 18 month period (Schiele & Walker 2013: 122).”

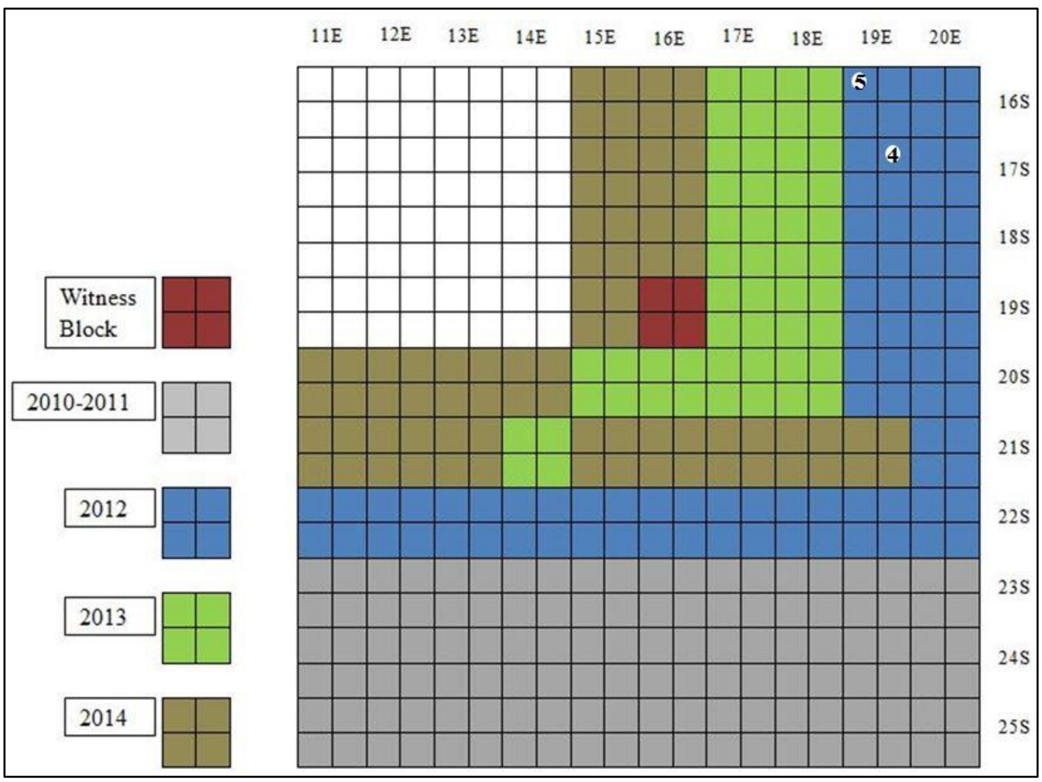

Figure 8.1: Locations of Level 5 and C4 radiocarbon samples in the Wolf Willow site.

As noted in Chapter 5, channel lag deposits were observed in several units along a trench at the southern end of the site. Following the recording of the sedimentary profile of the trench, one such channel lag which lay between 64 and 84cm below the surface in unit 25S 16E, was sampled and analyzed by Hilger (2013) (see Table B.1 in Appendix B). Interestingly, the two samples recovered from directly above this channel lag deposit were found to contain significant portions of silt and clay, whereas samples from the Witness Block profile, which does not possess an obvious channel lag in any of its strata, were found not to contain significant amounts of silt and clay (see Table B.1 in Appendix B). Therefore, it is likely that the topographical constraints that led the creek to deposit channel gravels between 64 and 84cm deep in unit 25S 16E also allowed water to pool and subsequently deposit silt and clay-sized particles out of suspension.

8.1.3: Data from the Thundercloud Site

"Facies 5" is argued by Burt (1997) to be evidence of deposition by fluvial processes. Given its location approximately 40cm below the base of a McKean occupation level, "Facies 5" is undoubtedly evidence of the period of increased creekbed sedimentation that began prior to 4600 years B.P. Because it is overlain by a 15cm thick "Facies 3" (coarse colluvial) unit, which is itself overlain by a 30cm thick "Facies 2B" (fine slopewash) unit, it is apparent that this period of increased creekbed sedimentation diminished in intensity over time culminating in a period of stability that will be discussed in the subsequent section.

8.2: Site Stability During the McKean Occupation

8.2.1: Climate

According to stable hydrogen isotope data presented by Leyden et al. (2006), climatic conditions during the period when McKean Series cultural materials were deposited at the Wolf Willow site were slightly moister and cooler than they are at present. As mentioned in the previous section, these cooler, moister conditions began at approximately 4800 years B.P., halting a period dominated by warm, dry conditions.

8.2.2: Data from the Wolf Willow Site

Sediment sample L4 from Cultural Level 3, the McKean level at the Wolf Willow site, has an elevated percentage of organic matter compared to lower sampled levels, but a similar percentage of organic matter compared to sample L3 which is at the upper extent of Cultural Level 4. The proportion of gravel in sample L4 is much lower, at 0.8%, than those in lower levels (see Table B.1 in Appendix B). This marked decrease in gravel deposition, taken in conjunction with both an increase in organic content and deposition of cultural artifacts, indicates that the surface of the Wolf Willow site was stable for long enough to allow a thin soil to develop and attract human occupants. A marked decrease in gravel deposition in L3 and especially L4 also indicates that the main channel of Opimihaw Creek migrated away from the Wolf Willow site, but moderate amounts of sand, silt and clay continued to be deposited at the site due to overbank flooding.

While sedimentary data from the Witness Block (unit 19S 16E) profile lack significant amounts of silt and clay at every sample depth, they also lack significant amounts of gravel. However, data provided by David Hilger (2013) tell the rest of the story. A large (>60%) percentage of gravel in a sample taken from between 64 and 84cm depth in unit 25S 16E is indicative of channel lag deposits, while the remaining two sampled levels (42 to 58cm, 12 to 24cm) have much higher percentages of silt and clay. The likely explanation for this increase in silt and clay content in the two upper samples from unit 25S 16E is that the topography, which was lower in areas of the site where channel lag gravels were deposited, subsequently allowed for the pooling of floodwater and thus the deposition of finer sizes of sediment particles in certain areas (see Table B.1 in Appendix B).

8.3: The C2-C3 Hiatus and C2 Dating Issues

8.3.1: Climate

Radiocarbon dates place the age of the C2-C3 cultural hiatus at the Wolf Willow site between 2750 calibrated years B.P. and approximately 1200 years B.P. According to stable hydrogen isotope data from Leyden et al. (2006), the local climate at the Wolf Willow site between 3000 and 1500 years B.P. was increasingly warmer and drier than present, peaking in temperature and aridity at approximately the latter date. It is known from Munroe et al. (2012) that there was a period of glacial advancement in Glacier National Park in northern Montana between approximately 3700 and 1900 years B.P., overlapping with the aforementioned period of increased temperature and aridity observed in Saskatchewan.

8.3.2: Data from the Wolf Willow Site

Two sediment samples from the Witness Block profile are representative of the C2/C3 hiatus: L5 and L6 (see Table B.1 in Appendix B). These samples, as was mentioned in Chapter 7, contain higher amounts of gravel than do samples in adjacent levels (ie: L4 and L7). In other units across the site, gravels were deposited in greater quantities between C2 and C3. These gravels, though unsampled and not presented in this thesis, were occasionally observed during excavation to be supported by a coarse sand matrix. The presence of coarse sand matrix-supported gravels, taken in conjunction with an absence of humic organic matter, has led to the characterization of these gravel lenses as being fluvial in origin. When viewed on a distribution map, these gravels appear to be oriented generally north to south, with some curvature toward the east (see Figure 8.2 below), which is to be expected due to the fact that the point bar on which the site is located slopes to the east.

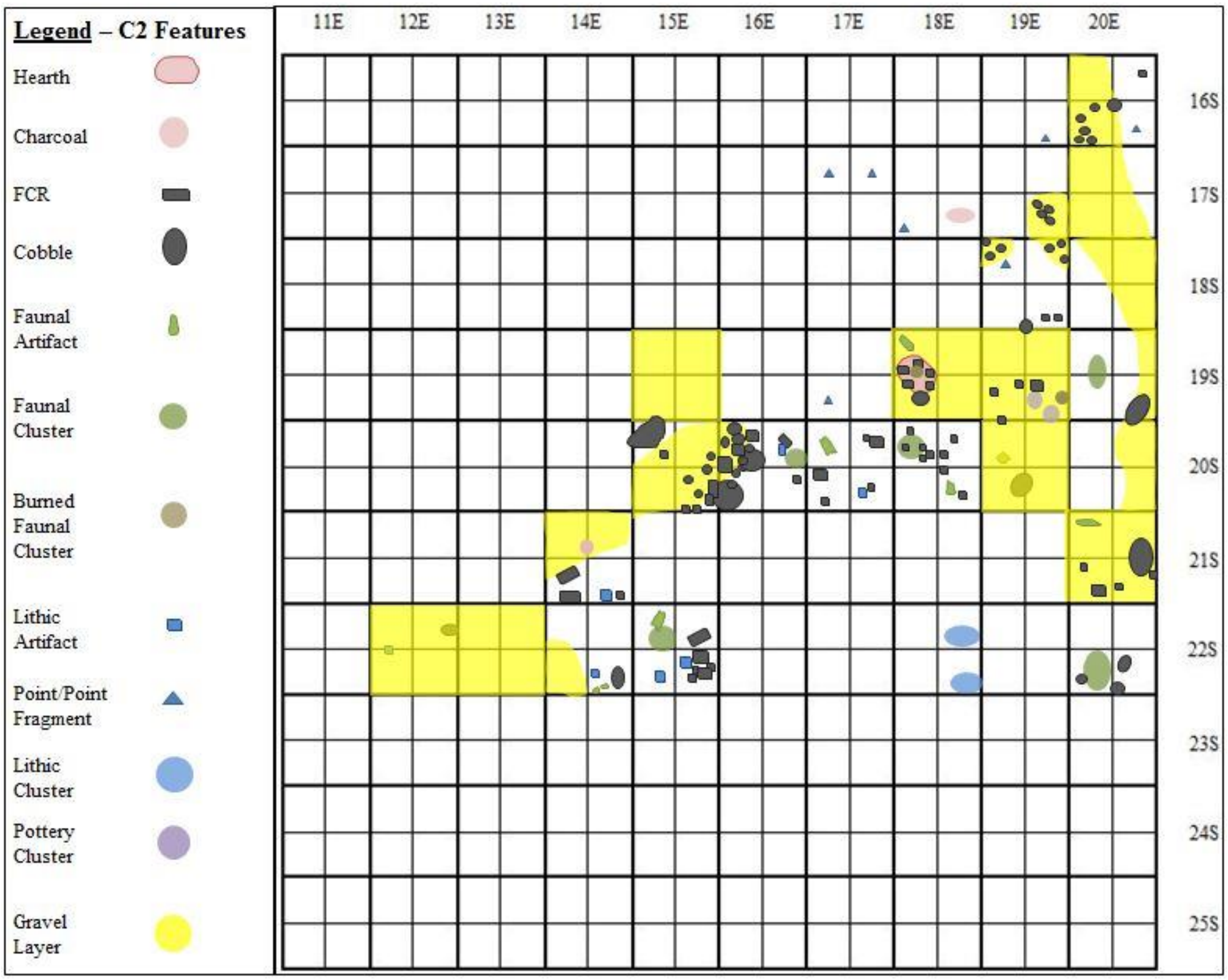

Figure 8.2: Distribution of features from Cultural Level 2. Note the curvature and north-south orientation of the gravel deposits from units 16S 20E to 21S 20E.

It is known from work conducted in floodplains by geomorphologists and sedimentologists that rivers can create new channels through established point bar deposits. These channels are known as "chute cutoffs", because they effectively cut off streamflow to the abandoned meander loop. According to Van Dijk et al. (2014), several factors can cause a river or stream to cut through a point bar, but only three of these will be discussed in regard to the Wolf Willow site. The first factor is a sufficiently high water level which allows for water to flow over a point bar and initiate a chute cutoff. The second and third factors are the elevation of the floodplain and the extent to which a point bar is colonized by riparian vegetation. If a point bar is heavily vegetated, the development of a chute cutoff across its surface is unlikely (Van Dijk et al. 2014: 290).

However, a sufficiently powerful hydrological force could run through even a vegetated point bar. Given the size of the gravel clasts deposited in some areas of the Wolf Willow site, it is clear that an immensely powerful flood event cut through the Wolf Willow point bar, at first transporting and then depositing some fairly coarse gravel as it waned. The exact cause of this flood event is unknown, but the sedimentary evidence it left of itself indicates that it was very powerful indeed.

While it is difficult to determine the exact hydrological, biological, and climatic conditions that were present at the Wolf Willow site thousands of years ago, it is possible to draw certain inferences from the data presented in this thesis. It is known from Leyden et al.'s (2006) paleoclimatic analysis that southern Saskatchewan was generally warmer and drier between approximately 3200 years B.P and 700 years B.P. than it is today. Implications of a warm, dry climate in the Opimihaw valley would have included an overall decrease in vegetation cover, an increased potential for hillslope instability, and a decrease in average discharge of Opimihaw Creek.

However, even in a seemingly stable year, any resident of Saskatchewan will attest to the instability of the province's weather. Rapid snowmelt in the winter or early spring, or a sudden downpour at any other time of year, could easily raise the level of the creek to a sufficient height to run across a sparsely-vegetated point bar like that on which the Wolf Willow site is situated. Or, perhaps the level of the creek was raised by other more localized processes. For example, a slopewash or rotational slump event could block the creek and either change its flow directionality or create a dam, forcing the stream to take the next best route to reach the mouth of the valley. Lastly, and least likely given what is known about climatic conditions, is the possibility that localized flooding across the Wolf Willow site's point bar was caused by a biogenic process, such as the damming of the creek by beavers. This possibility is notable given how much beaver activity the Opimihaw valley has seen in recent years.

Given the relatively high degrees of sorting of all samples from the Witness Block profile (between 1.06 and 1.46), particularly those from depths above and below the C2/C3 hiatus (L5=1.19, L6=1.32), no sediment samples from the Witness Block are considered to be colluvial in origin. Furthermore, given that a gravel lens was observed at a depth between that of C2 and C3 in units located to the east, or downslope, from the Witness Block, it can be concluded that those gravels were transported and deposited by fluvial processes.

Due to the fact that no Pelican Lake points have been recovered from the Wolf Willow site in six years of excavation, the hiatus that separates C2 from C3 was understandably believed to span approximately 2000 years. Fortunately, the unit which the Pelican Lake-aged sample was recovered from, unit 19S 19E, was also found to contain a gravel layer beneath the organic-rich A horizon that can be found across the site. This indicates that the chute cutoff which ran through the site between C2 and C3 was initiated after sample 414919, which dates to 2750 cal. years B.P., was deposited.

Cores obtained from Redberry Lake north of Saskatoon by Van Stempvoort et al. (1993) indicate that the local climate in the Saskatoon area was especially hot and dry between approximately 2500 and 1500 years B.P., which would have undoubtedly contributed to landscape instability in the area. Therefore, it is likely that the gravels and coarse sands that lie between C2 and C3 in fact lie between C2 and a poorly-defined Pelican Lake-aged component. Further, following the accidental discovery of a Pelican Lake-age component, these gravel and sand deposits can be more narrowly dated to between 2750 cal. years B.P. and approximately 1100 years B.P., as an agreeable date for the Prairie Side-Notched (Cultural Level 2) component has yet to be obtained.

8.4: Site Stability from 1200 Years B.P. – Present

8.4.1: Climate

According to Leyden et al. (2006) and confirmed by Schiele (2011), the warm, dry conditions that prevailed in the Saskatoon area after 3.2 k.a. B.P. peaked at approximately 1.5 k.a. B.P. The climate then cooled gradually, as corroborated by glacial advancement data from Glacier National Park in northern Montana presented by Munroe et al. (2012). This gradual cooling trend continued until approximately 700 years B.P., when the it accelerated during the Little Ice Age (Munroe et al. 2012). Figure 9.3 below shows stable hydrogen isotope values from Leyden et al. (2006: 94) with Neoglacial advancements from Munroe et al. (2012) and periods of warm, dry conditions observed from Van Stempvoort et al.'s (1993) Redberry Lake core data.

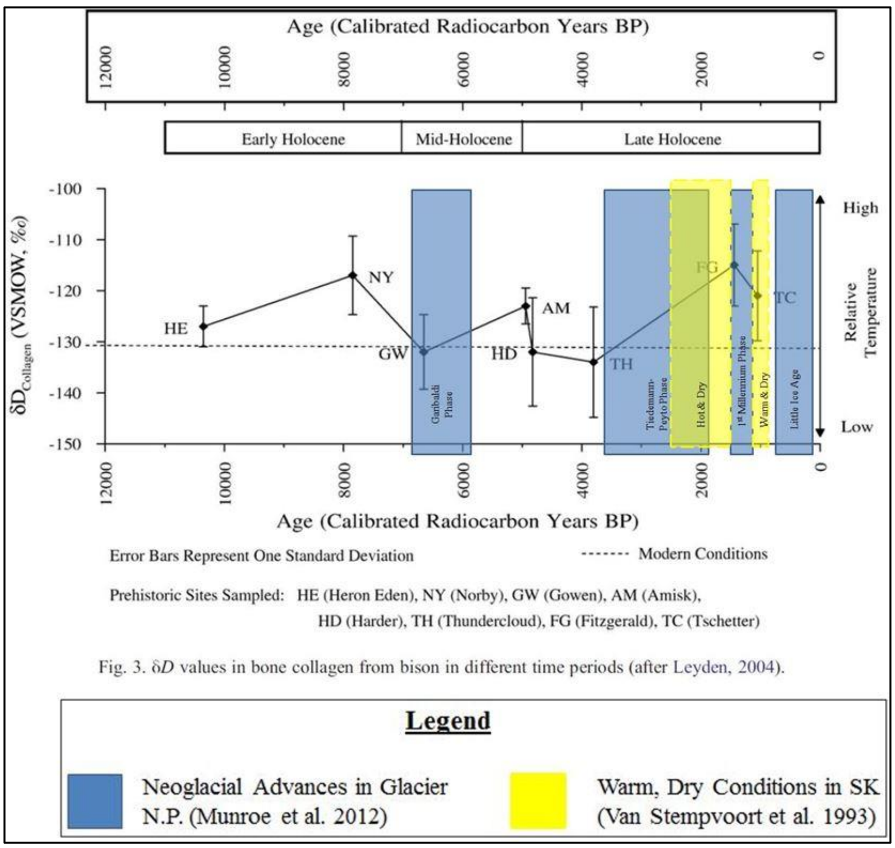

Fig. 3. δ*D* values in bone collagen from bison in different time periods (after Leyden, 2004).

Figure 8.3: Graph Showing Stable H isotope Data (from Leyden et al. 2006: 94) with Glacial (Munroe et al. 2012) and Redberry Lake Core (Van Stempvoort et al. 1993) Data Superimposed.

8.4.2: Data from the Wolf Willow Site

Given that all Prairie Side-Notched points recovered from Wolf Willow during the 2012 and 2013 excavations were gleaned from depths of between 15 and 22cm, and within the dark A horizon, it can be stated with relative certainty that the Wolf Willow site was stable and vegetated preceding, during, and following its occupation by groups of early Old Women's Phase peoples. However, it is possible that the Wolf Willow site was briefly inundated by floodwaters over the past 1200 years, given that the sedimentary matrix of the A horizon in which C1 and C2 lie contains a significant fraction of silt and clay in lower-lying areas like unit 25S 16E (see Table B.1 in Appendix B).

8.5: Conclusion and Directions for Future Research

From the sedimentary data presented in this thesis, it is clear that the gravel and coarse sand-dominated sedimentary unit which lies between C2 and C3 was deposited by Opimihaw Creek as it cut through the site, and is representative of a chute cutoff of the creek through the point bar deposit on which the Wolf Willow site lies. Climatic data from stable hydrogen isotope analysis of bison bone samples (Leyden et al. 2006) and core data from Redberry Lake (Van Stempvoort et al. 1993) support this conclusion. It is suggested that the hot, dry conditions that prevailed between 2500 and 1500 years B.P. could have sufficiently de-vegetated the surface of the Wolf Willow site's point bar, allowing for a chute to initiate and effectively create an alternate channel of the creek.

Radiocarbon dating of a bone sample from a hearth feature believed to be in cultural level 3 resulted in the discovery of a Pelican Lake-aged component of the Wolf Willow site, although no diagnostic artifacts have yet been found corroborating this assessment. Because this bone sample was found beneath the C2/C3 hiatus gravel layer, the window of occurrence for the deposition of that gravel layer has been narrowed from 2000 years, or between McKean and Prairie Side-Notched, to 1000 years, or between Pelican Lake and Prairie Side-Notched.

Therefore, the first recommended avenue for further study from this thesis is the more precise definition of cultural levels at the Wolf Willow site. More specifically, the vertical distribution of artifacts should be recorded with a higher degree of resolution. This could be achieved by expanding the criteria for taking 3-point provenience of artifacts to include smaller artifacts, and by digging in arbitrary increments of 2cm instead of 5 or 10cm. A solid radiocarbon date for Cultural Level 2 should also be obtained so that the culture history of the site can at last be completed.

The second recommended avenue for further study is the analysis of the red orthoquartzite recovered from cultural level 2. If the chemical nature and geological provenance of this material can be determined, more will be understood regarding lithic procurement strategies of Old Women's Phase peoples in the Saskatoon area.

The Wolf Willow site is an excellent example of the value of a multidisciplinary approach to archaeological site interpretation. The integration of geoarchaeological analytical methods in the interpretation of the Wolf Willow site has led to a more detailed understanding of the natural processes which formed it, and how those processes and the sedimentary evidence they left behind impacted the human inhabitants of the Opimihaw Valley and the artifacts they deposited within it. Finally, the importance of the Wolf Willow site and others within Wanuskewin Heritage Park as an interface for interaction between the discipline of archaeology and the public cannot be overstated.

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Appendix A: Modified Loss-on-Ignition Procedure and Calculations, Modified Particle Size Analysis Procedure

Modified Loss on Ignition Method

The following loss on ignition method for the determination of percent organic carbon in a sediment sample is taken and adapted from Burt (1997).

Procedure

Note: Tongs must be used to grip crucibles as skin oil will affect results.

1. A powdered sample weighing approximately 100g is dried in an oven at 90° - 100°C for a minimum of one hour, and then cooled at room temperature in a desiccator.
2. Approximately 10g of this dried sample is placed in a crucible that has been pre-weighed to 0.0001g. The sample and crucible are then weighed to 0.0001g in order to determine the dry weight of the sample to be analyzed.
3. The samples and crucibles are places in a 550°C muffle furnace for one hour then cooled to room temperature in a desiccator and weighed to 0.0001g.

Calculations

The percent of organic carbon in the sample is calculated as follows.

$$\%\text{ organic C} = \frac{\text{mass of oven-dried soil before ignition} - \text{mass of soil after }550^{\circ}\text{C burn}}{\text{mass of oven-dried soil before ignition}} \text{ X } 100$$

Modified Particle Size Analysis Method

The following particle size analysis method is taken from Aitken (2015).

Procedure

Sample Preparation

1. Place approximately 30g of air dry sample in mortar. Gently grind with pestle to ensure clasts are totally unconsolidated, but not so hard as to affect clast sizes.
2. Pour ground sample through riffler to homogenize.
3. Place clean, empty weigh boat on scale and tare.
4. Pour homogenized sample from riffler into weigh boat. Be sure to remove all clasts from riffler grate.
5. Record mass of sample before dry sieving (initial weight).

Dry Sieving

1. Set up sieve column. Half phi (ϕ) intervals should be used (2.0mm, 1.4mm, 1.00mm, 710µm, 500µm, 355µm, 250µm, 180µm, 125µm, 90µm, 63µm), as well as a pan at the bottom to catch silt and clay-sized particles.
2. Place sieve column on shaker.
3. Place sample atop sieve column.
4. Secure lid and tighten restraining device.
5. Shake on medium setting for 20 minutes.
6. Remove sieve from top of column. Pour contents of sieve onto large mobile, flexible surface (eg: plastic Bristol board), leaving sieve overturned on Bristol board. Use brush on underside of sieve to remove entrained particles.
7. Tare a weigh boat.
8. Pour sediment from Bristol board into weigh boat. Use brush to remove as much sediment from Bristol board as possible.
9. Record mass of sample.
10. Discard sample. Wipe Bristol board and weigh boat with a dry cloth to remove any residual sediment.
11. Repeat steps 6 – 10 for each sieve on column, including the pan.

Appendix B: Particle Size, Organic Carbon Content, Colour, and Statistical Parameters

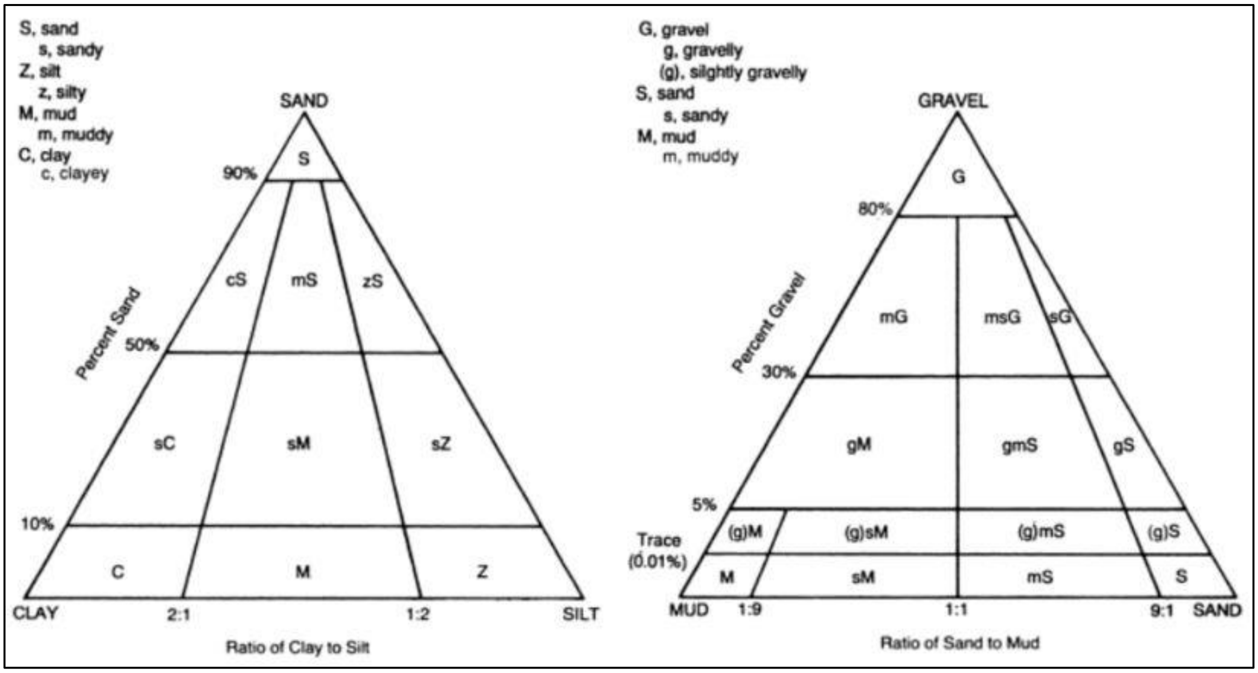

Figure B.1: Triangular diagrams by Folk (1954, 1974) taken from Waters (1992: 22) used to determine the textural class of a sediment sample. The triangle on the left is used for samples that do not contain gravel. The triangle on the right is used for samples that do contain gravel.

	U.S. Standard Sieve Mesh	Millimeters		Phi (φ) Units	Wentworth Size Class
		4096		−12	Boulder
		1024		−10	
		256	256	−8	
					Cobble
Gravel		64	64	−6	
		16		−4	Pebble
	5	4	4	−2	
	6	3.36		−1.75	
	7	2.83		−1.5	Granule
	8	2.38		−1.25	
	10	2.00	2	−1.0	
	12	1.68		−0.75	Very coarse sand
	14	1.41		−0.5	
	16	1.19		−0.25	
	18	1.00	1	0.0	
	20	0.84		0.25	
	25	0.71		0.5	Coarse sand
	30	0.59		0.75	
	35	0.50	½	1.0	
	40	0.42		1.25	
Sand	45	0.35		1.5	Medium sand
	50	0.30		1.75	
	60	0.25	¼	2.0	
	70	0.210		2.25	
	80	0.177		2.5	Fine sand
	100	0.149		2.75	
	120	0.125	⅛	3.0	
	140	0.105		3.25	
	170	0.088		3.5	Very fine sand
	200	0.074		3.75	

	U.S. Standard Sieve Mesh	Millimeters		Phi (φ) Units	Wentworth Size Class
	230	0.0625	1/16	4.0	
	270	0.053		4.25	
	325	0.044		4.5	Coarse silt
		0.037		4.75	
Silt		0.0312	1/32	5.0	
					Medium silt
		0.0156	1/64	6.0	
					Fine silt
		0.0078	1/128	7.0	
					Very fine silt
		0.0039	1/256	8.0	
		0.0020		9.0	
		0.00098		10.0	
Clay		0.00049		11.0	Clay
		0.00024		12.0	
		0.00012		13.0	
		0.00006		14.0	

Figure B.2: Wentworth Grain Size Classification for Sediments from Waters (1992: 20-21).

Sample Number	Depth (cm)	Munsell Colour	Composition (%) Organic Carbon	Gravel	Sand	Silt & Clay	Class	Mean (Φ)	Median (Φ)	Mode (Φ)	Sorting Coefficient (S_o)
Wolf Willow Site - 19S 16E											
WW 19S 16E 0 to 14 **(L7)**	0 to 14	10 YR 3/1	4.02	1.0	95.8	3.2	(g)S	2.03	2.08	2.24	1.18
WW 19S 16E 14 to 24 **(L6)**	14 to 24	10 YR 2/2	1.55	3.0	93.2	3.8	(g)S	1.92	2.02	2.24	1.32
WW 19S 16E 24 to 35 **(L5)**	24 to 35	10 YR 6/2	1.38	1.6	94.6	3.7	(g)S	2.16	2.16	2.24	1.19
WW 19S 16E 35 to 44 **(L4)**	35 to 44	10 YR 6.5/2	1.16	0.8	98.5	0.7	(g)S	2.12	2.16	2.24	1.06
WW 19S 16E 44 to 52 **(L3)**	44 to 52	10 YR 6.5/2	1.19	2.6	96.3	1.0	(g)S	1.99	2.07	2.24	1.24
WW 19S 16E 52 to 68 **(L2)**	52 to 68	10 YR 8/2	0.89	5.4	94.3	0.3	gS	1.35	1.40	1.247, -1.243	1.33
WW 19S 16E 68 to 90 **(L1)**	68 to 90	10 YR 7/1	0.85	6.7	92.5	0.8	gS	1.54	1.71	2.237, -1.243	1.46
Wolf Willow Site - 25S 16E											
WNS 25S 16E 12 to 24	12 to 24	5 Y 2.5/1	5.44	1.8	86.9	11.3	(g)mS	2.17	1.94	1.747, 2.737, 3.731	1.77
WNS 25S 16E 42 to 58	42 to 58	10 YR 7/2	1.80	1.1	90.6	8.3	(g)S	2.06	1.79	1.747, 2.737, 3.731	1.62
WNS 25S 16E 64 to 84	64 to 84	2.5 Y 7/2	0.47	60.1	39.0	0.9	sG	-0.66	-1.08	-1.24	0.94
WNS 25S 16E 84 to 97	84 to 97	5 Y 8/2	1.68	6.0	89.0	5.0	gS	1.43	1.57	1.747, 2.737, -1.243	1.48

Table B.1: Sedimentary data from the Wolf Willow site. Samples from Unit 19S 16E were analyzed by the author, while samples from unit 25S 16E were analyzed by Hilger (2013).

			Composition (%)									
Sample Number	Depth (cm)	Colour	Organic Carbon	Inorganic Carbon	Gravel	Sand	Silt	Clay	Class	Facies	Mean (φ)	Std. Dev. (φ)
Thundercloud Site												
TC-0815-GS-103	0 to 10	10YR2/1.5	8.91	1.75	0.68	55.61	27.74	15.98	(g)mS	2a	4.677	3.996
TC-0815-GS-105	11 to 19	10YR2/1	5.18	1.69	1.87	61.05	21.96	15.12	(g)mS	2a	4.290	4.230
TC-0815-GS-106	19 to 27	10YR2.5/2			6.28	62.44	23.06	8.22	gmS	3	2.887	3.193
TC-0815-GS-107	27 to 30	10YR2/1	5.18	1.57								
TC-0815-GS-108	30 to 37	10YR2.5/1.5	4.26	1.97	0.00	52.34	28.67	18.98	mS	1b	5.397	3.844
TC-0815-GS-109	37 to 38.5	10YR2/1	12.88	8.70								
TC-0815-GS-110	38.5 to 48	10YR4/2	4.55	14.03	0.48	43.76	33.51	22.25	(g)sM	2a	5.693	3.894
TC-0815-GS-112	53 to 60	10YR5/3	2.76	13.89	0.10	59.51	24.14	16.25	(g)mS	2b	4.623	3.540
TC-0815-GS-114	72 to 78	2.5Y4/4	1.36	10.54	4.35	75.62	12.64	7.38	(g)mS	2b	2.623	2.735
TC-0815-GS-115	78 to 86	2.5Y4/4	1.97	9.69	11.51	61.18	16.68	10.64	gmS	3	3.180	3.778
TC-0815-GS-116	97 to 103	2.5Y4/4	1.60	12.28	2.32	69.17	15.80	12.70	(g)mS	2b	3.457	3.576
TC-0815-GS-117	76 to 84	2.5Y4/4	2.44	13.95	0.03	57.72	22.56	19.69	(g)mS	2b	5.040	4.010
TC-0815-GS-118	84 to 91	2.5Y4/4			2.89	55.32	21.61	20.19	(g)mS	2b	5.027	4.164
TC-0815-GS-119	91 to 94	2.5Y4/4	0.84	20.83	21.26	68.99	6.45	3.30	gmS	3	0.430	2.270
TC-0815-GS-120	94 to 103	2.5Y4/4	0.92	20.92	41.28	47.15	7.08	4.49	msG	5	-0.017	3.211

Table B.2: Sedimentary data from the Thundercloud site adapted from Burt (1997: 241-242).

Sample Number	Depth (cm)	Colour	Composition (%)							Class	Facies	Mean (φ)	Std. Dev. (φ)
			Organic Carbon	Inorganic Carbon	Gravel	Sand	Silt	Clay				
Thundercloud Pit 1												
TC-1008-GS-201	7 to 26	10YR3/2D			3.28	61.60	20.41	14.71	(g)mS	2b	3.970	4.920
TC-1008-GS-202	26 to 41	2.5Y4/3D grades to 10YR2.5/2	2.85	3.25	8.24	64.08	15.81	11.88	gmS	3	3.160	4.256
TC-1008-GS-203	50 to 63	2.5Y6/6	1.86	5.89	6.59	65.26	15.32	12.84	gmS	3	3.307	3.770
TC-1008-GS-204	71 to 78	2.5Y5/4M	3.62	26.76	3.24	43.07	24.06	29.63	(g)sM	2a	3.093	5.165
TC-1008-GS-205	78 to 91	2.5Y6.5/4	2.54	33.49	2.53	37.96	27.61	31.90	(g)sM	2b	6.520	5.036
TC-1008-GS-206	91 to 101	2.5Y5/4	2.02	20.25	2.91	46.17	29.12	21.80	(g)sM	2b	5.673	4.386
TC-1008-GS-207	101 to 116	2.5Y5/4	1.46	19.83	0.63	49.26	31.50	18.60	(g)sM	2b	5.553	3.949
TC-1008-GS-208	116 to 132	2.5Y5/4	1.36	16.60	0.88	48.36	33.89	16.87	(g)sM	2b	5.330	3.360
TC-1008-GS-209	132 to 149	2.5Y5/4	1.20	13.64	2.66	47.86	33.61	15.87	(g)sM	2b	5.193	3.512
Thundercloud Pit 2												
TC-1008-GS-213	5 to 31	10YR2/2D	4.33	1.19	4.23	60.04	21.44	14.30	(g)mS	2a	4.030	4.257
TC-1008-GS-214	31 to 53	10YR4/2.5	2.47	13.68	15.13	59.27	15.12	10.48	gmS	3	2.310	4.232
TC-1008-GS-210	53 to 63	2.5Y5/4	2.90	24.73	8.70	35.42	27.68	28.21	gM	3	5.883	5.134
TC-1008-GS-211	81 to 92	2.5Y5/4	2.16	14.18	3.76	40.54	31.55	24.15	(g)sM	2b	5.913	5.082
TC-1008-GS-212	92 to 104	2.5Y5/4	2.06	19.10	3.23	38.20	31.98	26.59	(g)sM	2b	5.997	4.822

Table B.3: Sedimentary data from pits dug near the Thundercloud site, adapted from Burt (1997: 241-242).

Depth	Sieve Size (% final weight)												Final	Original	Seive	Corrected Sieve
(cm)	2.0mm	1.4mm	1.00mm	710µm	500µm	355µm	250µm	180µm	125µm	90µm	63µm	pan	Weight (g)	Weight (g)	Loss/Gain (%)	Loss/Gain (%)
0 to 14	0.99	1.84	3.21	4.46	7.80	11.35	16.83	20.80	13.48	9.31	6.41	3.21	35.24	35.00	-0.69	-0.37
14 to 24	2.97	2.92	3.81	4.55	7.63	10.87	16.19	19.40	12.45	8.75	6.08	3.81	36.70	36.96	0.70	1.27
24 to 35	1.62	1.35	2.36	3.68	7.11	11.16	16.24	19.34	13.58	10.94	8.89	3.74	32.63	32.70	0.21	
35 to 44	0.82	1.54	2.26	3.42	6.60	10.43	17.18	22.80	15.99	11.24	7.00	0.72	31.84	32.07	0.72	
44 to 52	2.64	2.11	2.67	4.57	8.57	11.49	15.35	18.90	13.95	11.14	7.59	1.02	28.46	28.60	0.49	
52 to 68	5.42	3.61	6.80	8.97	13.02	14.95	14.98	13.81	7.96	6.31	3.89	0.28	32.65	32.79	0.43	
68 to 90	6.65	4.13	5.67	6.34	8.98	11.63	15.70	15.67	10.28	8.45	5.67	0.82	31.72	31.93	0.66	

Table B.4: Particle size data from the Witness Block (unit 19S 16E) of the Wolf Willow site.

SAMPLE STATISTICS

SAMPLE IDENTITY: **WW 19 S16E 0-14cm** ANALYST & DATE: D. Stumborg,

SAMPLE TYPE: Unimodal, Poorly Sorted TEXTURAL GROUP: Slightly Gravelly Sand

SEDIMENT NAME: Slightly Very Fine Gravelly Fine Sand

	μm	φ
MODE 1:	215.0	2.237
MODE 2:		
MODE 3:		
D_{10}:	91.12	0.435
MEDIAN or D_{50}:	237.1	2.077
D_{90}:	739.5	3.456
(D_{90} / D_{10}):	8.117	7.940
$(D_{90} - D_{10})$:	648.4	3.021
(D_{75} / D_{25}):	2.785	2.147
$(D_{75} - D_{25})$:	262.4	1.478

GRAIN SIZE DISTRIBUTION			
GRAVEL:	1.0%	COARSE SAND:	12.3%
SAND:	95.8%	MEDIUM SAND:	28.3%
MUD:	3.2%	FINE SAND:	34.4%
		V FINE SAND:	15.8%
V COARSE GRAVEL:	0.0%	V COARSE SILT:	0.5%
COARSE GRAVEL:	0.0%	COARSE SILT:	0.5%
MEDIUM GRAVEL:	0.0%	MEDIUM SILT:	0.5%
FINE GRAVEL:	0.0%	FINE SILT:	0.5%
V FINE GRAVEL:	1.0%	V FINE SILT:	0.5%
V COARSE SAND:	5.1%	CLAY:	0.5%

	METHOD OF MOMENTS			FOLK & WARD METHOD		
	Arithmetic μm	Geometric μm	Logarithmic φ	Geometric μm	Logarithmic φ	Description
MEAN ($\bar{x}$):	360.6	237.0	2.077	245.7	2.025	Fine Sand
SORTING (σ):	372.5	2.638	1.400	2.270	1.183	Poorly Sorted
SKEWNESS (Sk):	2.868	-0.947	0.947	0.092	-0.092	Symmetrical
KURTOSIS (K):	13.08	6.153	6.153	1.111	1.111	Leptokurtic

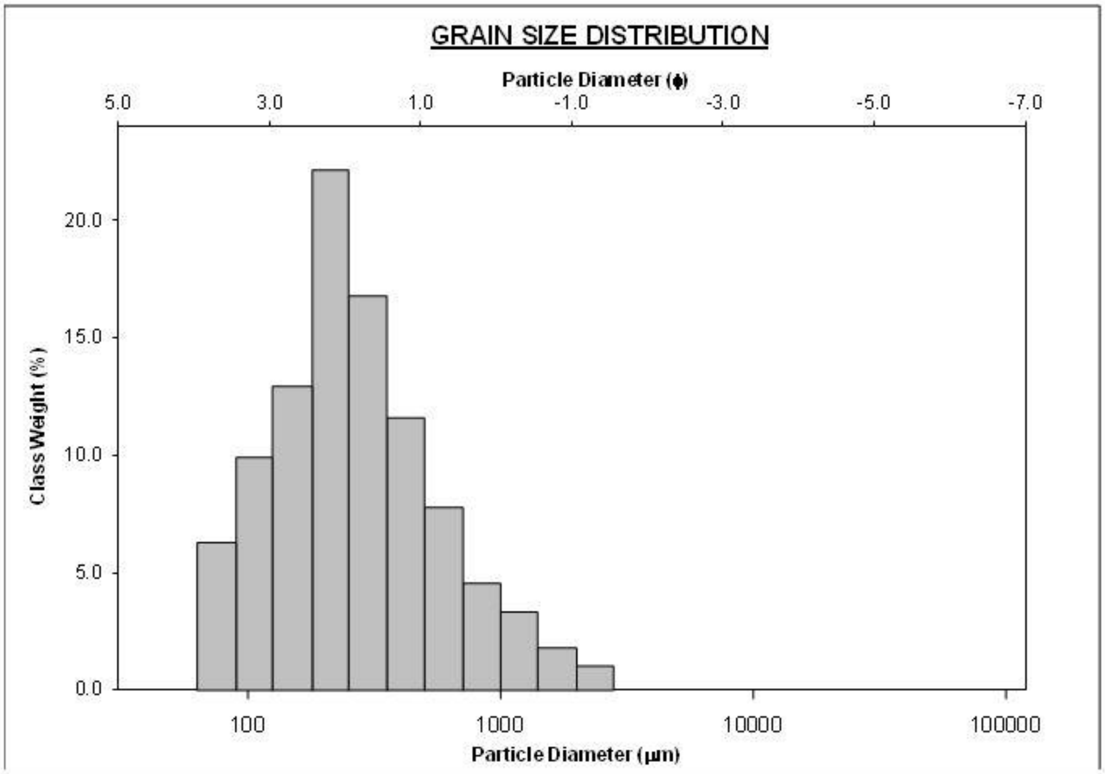

Figure B.3: Screenshot of Gradistat© sedimentary sample statistics page. This program made analysis of particle size analysis much easier than the graphical method.