QUATERNARY HISTORY OF THE LOWER ST. LOUIS RIVER AND ESTUARY, LAKE SUPERIOR, NORTHEASTERN MINNESOTA

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ABSTRACT

Field research was conducted during the summer of 1999 to determine the extent of possible buried stable landsurfaces along the St. Louis River and estuary. The identification and description of these surfaces was accomplished by three methods: location of paleosols, reconstruction of the paleogeography, and determination of sedimentation and incision rates along the river. Core drilling results show evidence of 5 laterally extensive organic layers within the estuary. The Loss on Ignition method of organic and inorganic carbon analysis was used along with magnetic susceptibility in to identify the surfaces. ^{14}C analysis returned dates ranging from nearly modern for the shallow layer, to almost 1,900 yrs. BP for the deepest. Paleogeographic studies centered around the identification of a subaqueous outwash delta deposited in Glacial Lake Duluth by the Superior Ice Lobe, and the location and relative dating of abandoned meanders along the lower St. Louis River, which has been divided into 3 reaches based on geomorphology. Known dates for abandoned landsurfaces were combined with the elevation of those surfaces above the modern river channel in order to determine the rates of incision along the river. Downcutting has occurred slowly in Reach 1, upriver from the Thomson Reservoir, were the river is controlled by the underlying bedrock. Reach 2 is found mostly in Jay Cooke State Park where the St. Louis River has incised 90 m into the surrounding lake plain. Sedimentation in Reach 3 ranges from 30 to 80 cm per 100 yrs. The sedimentation and incision rates were applied to landsurfaces upon which archaeological sites of unknown age occur. The time of abandonment of the fluvial landsurfaces provides an estimate of the maximum possible age of the archaeological site. In Reach 3, the level of Lake Superior controls the location of sites. A combination of fluctuating lake levels throughout the Holocene and differential tilt in the Superior Basin has buried and submerged shoreline and estuary sites from 9,500 to 6,000 yrs. BP and 3,000 to 0 yrs. BP. These results may aid future archaeologists in the search for deeply buried archaeological sites, as well as provide initial estimates of the maximum age new and previously known archaeological sites.

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INTRODUCTION

The St. Louis River flows into western Lake Superior at Duluth, Minnesota. The Duluth-Superior Harbor is located within the estuary that the St. Louis River forms with Lake Superior. Since its formation approximately 6,000 yrs. BP, the St. Louis River estuary has supported a lush environment, consisting of lake, river, plain, and highland areas. The abundance of wildlife and vegetation, and the diversity of environments, make it a highly probable location for Archaic, 8,000 to 3,000 yrs. BP, and Woodland, 3,000 yrs. BP to European contact, settlements.

The lower St. Louis River can be divided into 3 main reaches based on geomorphic expression. Reach 1 occurs up river from the Thomson Reservoir. The morphology of the river in this reach is controlled by the exposed bedrock in the area. Reach 2 is from Thomson Reservoir to the power dam at Fond du Lac. In this region, the river is deeply incised into the surrounding Glacial Lake Duluth lake plain. Between the power dam and Minnesota and Wisconsin Points is Reach 3. The St. Louis Estuary occupies this stretch of the river.

The location of paleosols within the estuary, and a detailed knowledge of the subsurface stratigraphy provide a context within which deeply buried archaeological sites may be more efficiently located. Five buried stable landsurfaces within the study area were identified: paleosol 1, 25 - 50 cm deep, paleosol 2, 100 - 150 cm deep, peat 1, 160 - 250 cm deep, peat 2, 320 - 390 cm deep, and wood 1, 400-470 cm deep. These layers were identified by combining field description of core with total inorganic and organic carbon analysis, and magnetic susceptibility. The calibrated 14C dates obtained for the surfaces are: paleosol 2, 250 to 5 yrs. BP, peat 1, 404 to 315 yrs. BP, peat 2, 930 to 740 yrs. BP, and wood 1, 1895 to 1715 yrs. BP. This stratigraphy and chronology record a complex history of downcutting and filling of the St. Louis River and estuary.

Rates of incision and sedimentation within the reaches were calculated based on stratigraphic relations, downcutting of the St. Louis River, and 14C dates obtained from sediment cores. Incision has occurred most rapidly in Reach 2. Sedimentation rates in Reach 3 vary from 30 cm per 100 yrs. to as much as 80 cm per 100 yrs., but is minimal in the other reaches. Map interpretation and sedimentological analysis were used to construct the paleogeomorphology of the study area. The Glacial Lake Duluth lake plain and a subaqueous outwash delta are exposed throughout Reaches 2 and 3, and have been deeply eroded by the St. Louis River. This geomorphic and sedimentological study was undertaken in order to determine the possible extent of buried archaeological resources within the St. Louis River valley and estuary and to provide estimates of the maximum ages of new and previously recorded archaeological sites.

GEOLOGICAL SETTING

The geologic history of northeastern Minnesota is varied and complex. Bedrock in the area boasts ages ranging from the Archean through the Proterozoic Eras, while surficial deposits date from the Late Pleistocene through the Holocene Epochs. Surficial processes continue to modify the landscape today. The evolution of the St. Louis River cannot be separated from the surrounding geologic influences. Late Precambrian rifting created a structural basin, which was later scoured by ice sheets to become the Superior Basin. The basin helped control the location of ice lobes along the margin of the Laurentide Ice Sheet, and provided the topographic control for the formation of Lake Superior and the St. Louis River estuary. Likewise, the modern river morphology is partially controlled by the properties of the material it flows across.

Pre-Holocene Geologic History of the Western Lake Superior Region

Throughout its length, the St. Louis River and its tributaries flow across a variety of glacial sediments, the Thomson Formation, Fond du Lac Formation, Northshore Volcanics, and Duluth Complex (Fig. 1). Much work has been undertaken in order to understand the geology, especially Quaternary Geology, of Minnesota and around the Superior Basin. Early Work by Winchell in the late 1800s laid the foundations of bedrock geology in northeastern Minnesota. Later work by Schwartz (1949) added much to the description and interpretation of the rocks, and the Geology of Minnesota series by Sims and Morey (1972) remains an excellent reference for bedrock geology. These works provide much of the basis for the following discussion.

Modern studies on the North Shore have been carried on by numerous individuals, including John Green (1989,1992), while the sedimentary rocks have been studied by Morey and Ojakangas (1970) among others. The majority of the St. Louis River Drainage basin is underlain by the Thomson Formation. An age of 1.85 to 1.9 billion years old is estimated for this unit. The range is constrained by the 1.9 bya age of the underlying iron formation (Hemming, et. al., 1996), (Fralick and Kissin, 1998) and the 1.85 bya time of metamorphism of the formation (Keighin, et. al., 1972). It is composed predominately of slates and metagreywackes. The thickness has been reported as at least 760 m to the east (Wright et. al., 1970), and up to 6,100 m. A regional structural folding can be observed in most outcrops, with fold axes trending almost east-west. North of the village of Fond du Lac, and along most of the north shore of Lake Superior, are the rocks of the North Shore Volcanic group. These are basaltic to rhyolitic

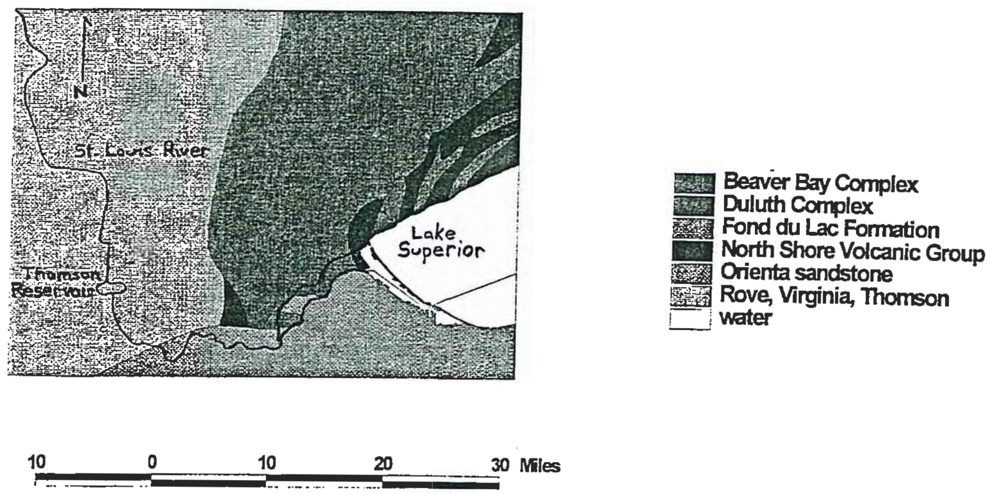


Figure 1. Geologic map of the St. Louis River and surrounding area.

lavas that have a regional northeast dip. They have a thickness of approximately 6,340 m, and are 1.1 billion years old. Much of the harbor of Duluth and Superior is underlain by the Duluth Complex. This Formation consists of peridotites, troctolites, and olivine gabbro. In places, layering is apparent. The unit is greater than 6,100 m thick, and is younger than, and in places contemporaneous with the North Shore Volcanics, while it is older than the Fond du Lac Formation. Further down the river, in Jay Cooke State Park, the red Fond du Lac Formation is exposed. It is composed of arkosic sandstones and interbedded shale. The thickness of this formation is unknown, but Schwartz suggests that it is a minimum of 610 m. Outcrops of sandstone commonly display trough crossbedding. The rocks are latest Precambrian in age, approximately 1 billion years old.

Despite much activity in Northeastern Minnesota, the next geologic signature was left by glaciers in the late Pleistocene. Leverett (1928) began work on the glacial history of the region. Wright (1970) expanded and formalized that work. The glacial history of the St. Louis River Drainage is controlled by three major ice lobes, the Superior Lobe, Rainy Lobe, and the St. Louis Sublobe of the Koochiching Lobe. The earliest Late Wisconsinin glacial phase in the region is the Emerald Phase (Meyer and Swanson, 1996). This phase of the Superior Lobe is thought to have advanced out of the Superior basin about 20,000 to 25,000 yrs. BP. The Emerald Phase is thought to be correlative with the Alexandria Phase of the Rainy Lobe (Meyer and Swanson, 1996). The St. Croix Phase of the Superior Lobe occurred by 15,000 to 18,000 yrs. BP (Fig. 2). The St. Croix Phase is marked by an advance of both the Superior and Rainy Lobes to the southwest. The ice terminus is recognized by ice-marginal deposits collectively termed the St. Croix Moraine. The eastern portions of this moraine were deposited by the Superior Lobe, and contain its characteristic red tills, while the western portion was deposited by the Rainy Lobe, and tends to be more brown in color. Following the maximum at the St. Croix Moraine, the history of the Superior and Rainy Lobes diverges. The Rainy Lobe slowly retreated at least 320 km possibly throughout the Automba Phase, depositing at least three recessional moraines before readvancing to the Vermillion Moraine in northern Minnesota. The Superior Lobe, however, retreated no more than 160 km, and left an abundance of ice-marginal features before readvancing in the Automba Phase to the Mille Lacs Moraine, deposited earlier by the Rainy Lobe. This margin may correlate with the

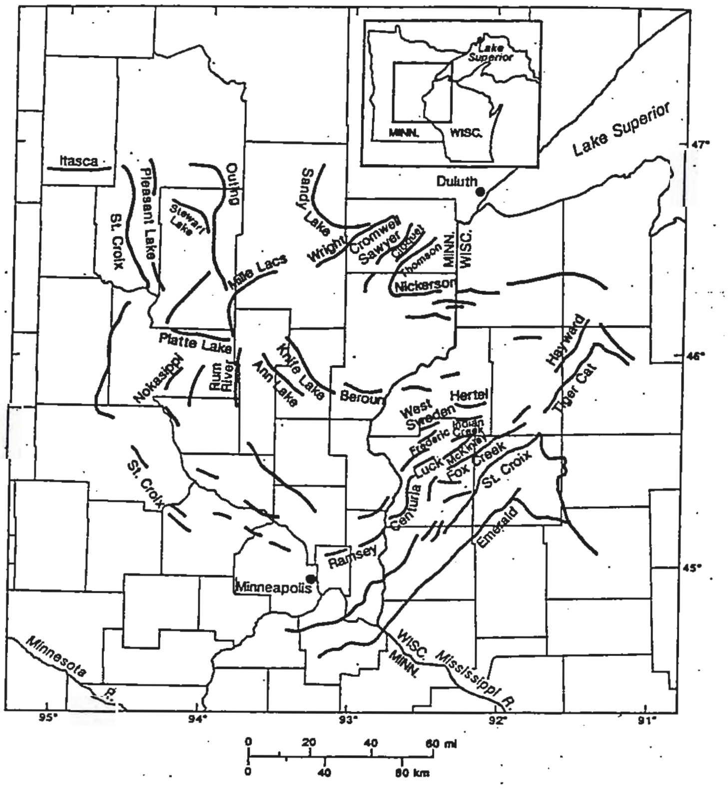


Figure 2. Ice-margin positions of the Superior Lobe in Minnesota. Adapted from Johnson and Mooers, 1998.

Rum River and Frederic Moraines (Johnson and Mooers, 1998) (Fig. 2), and the Highland Moraine to the north. At the beginning of the Automba Phase, the Superior Lobe extended to the Mille Lacs Moraine, blocking the southern drainages of meltwater from the Rainy Lobe, resulting in the formation of Glacial Lake Upham I and Aitkin I. Meltwater from the Superior Lobe flowed westward into the Lake Upham I basin, and consequently down the Mississippi River (Wright and Watts, 1969). Towards the end of the Automba Phase, the Superior Lobe began retreating back into the Superior Basin and a lower drainage to the St. Croix River may have opened (Wright and Watts, 1969). This would have caused a drainage change in Lake Upham I, and brought about an eastward drainage down the St. Louis River and into a proglacial lake occupying the Superior Basin. No dates exist for the material deposited during the Automba Phase, but it must have occurred between the St. Croix and Split Rock Phases, giving a minimum bounding range of 13,500 to 18,000 yrs. BP (Wright and Watts, 1969). The Superior Lobe then retreated in several steps back into the Superior basin, forming a proglacial lake that was later overridden during the Split Rock Advance. At this time the St. Louis River channels were occupied again. Outwash from the Superior Lobe formed the Sawyer and Cloquet outwash plains (Fig. 2). Once more outwash flowed northwest to Lake Upham, where it drained into Lake Aitkin and the Mississippi River. As the Superior Lobe was retreating from the Split Rock Phase maximum, the St. Louis Sublobe advanced over the lake plains of Glacial Lakes Aitkin I and Upham I. The retreat was approximately 32 km, and was followed by a readvance to the Thomson-Nickerson Moraine of the Nickerson Phase (Fig. 2). The St. Louis Sublobe ice front during the semicontemporaneous Alborn

Phase is marked by the Culver Moraine. The Nickerson-Alborn Phase is thought to have occurred around 12,000 yrs. BP. (Wright and Watts, 1969). With the stabilization of the Superior Lobe at the Nickerson-Thomson Moraine in the Nickerson Phase, drainage from the St. Louis Sublobe was diverted around the ice margin in a series of channels (Wright et. al., 1970) (Fig. 3). The first channel was a diversionary channel around the Superior Lobe at the Nickerson maximum and into the Kettle River. As the Superior Lobe retreated, consecutively lower levels were cut first through the Cloquet and then Thomson Moraine. The second and third channels, 1 and 2 in Figure 3, at 381 m and 369

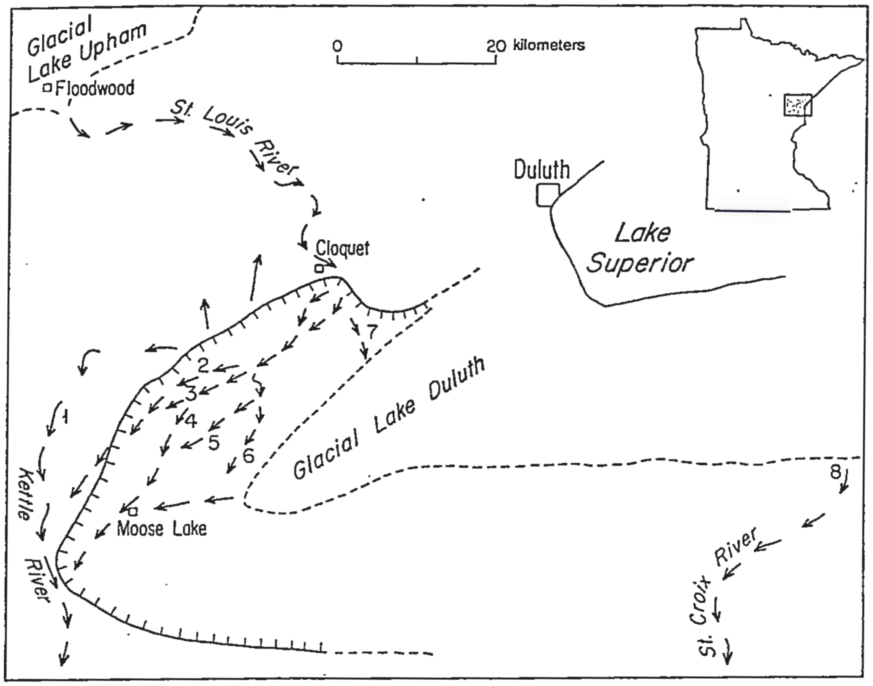
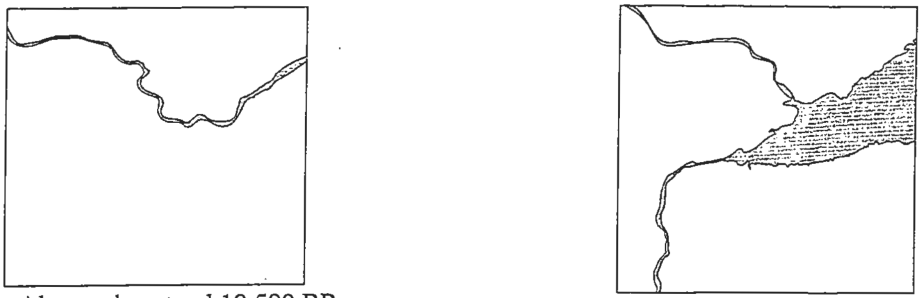


Figure 3. Diversionary channels of the St. Louis River. From Wright, Mattison, and Thomas, 1970.

Nickerson-Alborn Phase >11,500 BP

Glacial Lake Duluth 11,000 BP

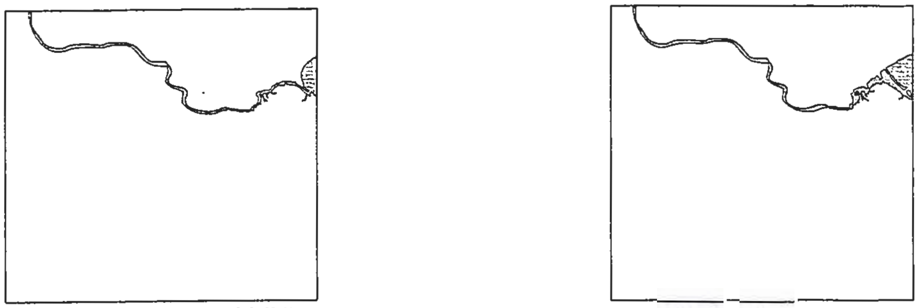


Post-Algoma lowstand 10,500 BP

Duluth highstand 9,500 BP

Houghton lowstand 9,000 BP

Nipissing highstand5,500 BP



Sault lowstand2,000 BP

Modern lake level

Figure 4. Paleogeography of the St. Louis River and Lake Superior.

m respectively, lead to Glaisby Brook. Further retreat from the Thomson Moraine caused two more channels, 3 and 4 on Figure 3, to be cut at 363 m and 360 m near Scanlon. These two, along with the Scanlon channel at 351 m (Wright et. al., 1970), 5 on Figure 3, drained into the Moose River. Channel 6 on Figure 3 at 344 m breached the Thompson Moraine before turning west towards Moose Lake, and the Kettle River. This channel may have flowed into Glacial Lake Nemadji, the predecessor to Glacial Lake Duluth, 348 m. After the Superior Lobe had retreated enough to hold Glacial Lake Duluth, a final channel breached the Thompson Moraine, and Glacial Lake Upham II drained along the channel occupied by the modern St. Louis River into Lake Nemadji. Shortly after the retreat of the Superior Lobe, Glacial Lake Duluth drained in a succession of steps to the Post-Algoma level (Farrand and Drexler, 1985) (Fig. 4). Clayton et. al. (1992) recognized two further advances of the Superior Lobe, the Porcupine and Lakeview Phases, on the basis of moraines in northwestern Wisconsin that may be the Wisconsin

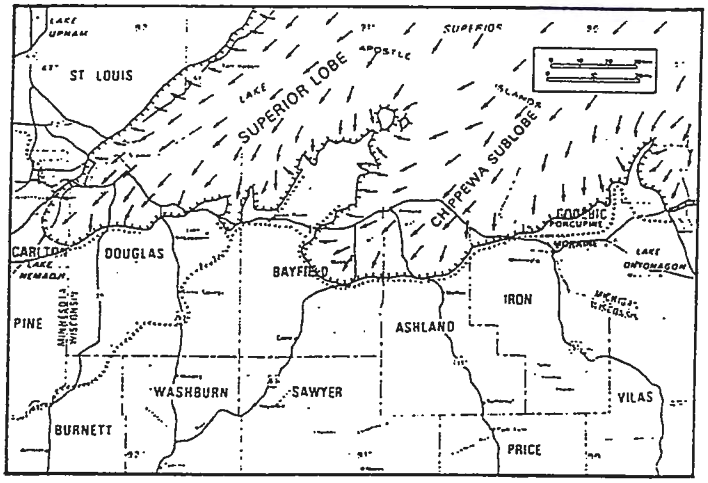


Figure 5. Ice-marginal position of the Porcupine Phases of the Superior Lobe in Wisconsin. Adapted from Carney, 1996.

correlative of the Marquette advance (Fig 5). The Lakeview Phase occurred about 9,900 yrs. BP (Fig 6). This advance is thought to have caused a temporary rise in lake level back to Glacial Lake Duluth levels (Fig. 7).

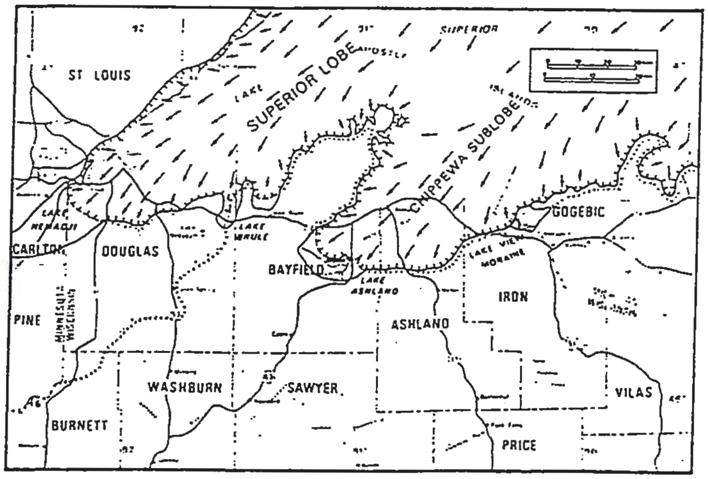


Figure 6. Ice-marginal position of the Lakeview Phase of the Superior Lobe in Wisconsin. Adapted from Carney, 1996.

Late Glacial and Holocene History of Lake Superior

The remainder of the Holocene saw the final retreat of ice from the Superior Basin, and reduced fluctuation in the level of Lake Superior. Since the retreat of the Superior Lobe, the lake level has been controlled by the glaciotectonic rebound of its outlets. The rate of rebound is not consistent across the Superior Basin. An axis of zero relative uplift runs from the St. Marys River outlet to around the international border of Minnesota and Canada. North of this axis, the relative rebound rate is 30 cm per 100 yrs. South of this axis, the basin is flooding at a rate of 30 cm per 100 yrs.

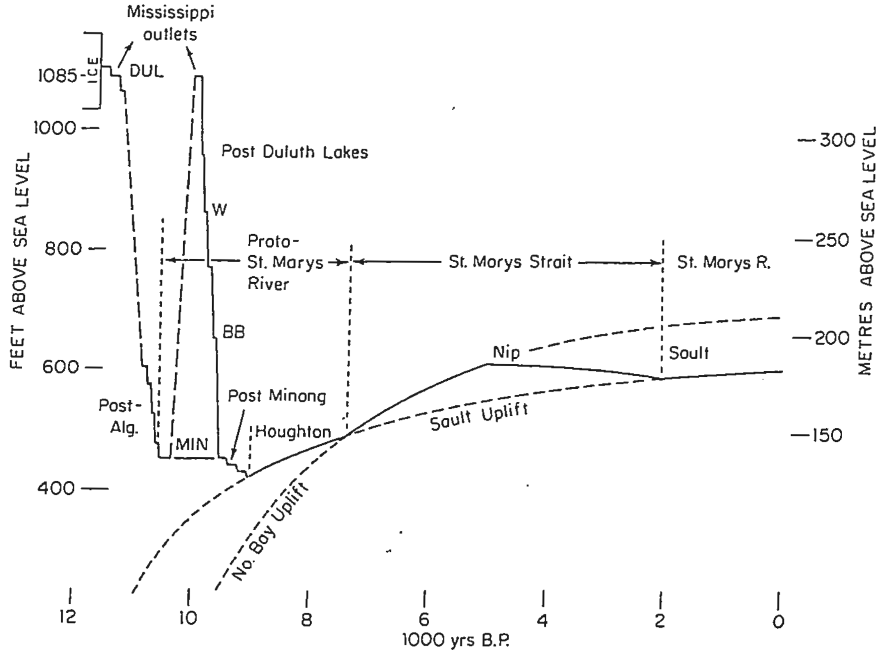


Figure 7. Lake level for the last 12,000 years. From Farrand and Drexler, 1969.

Around 9,500 yrs. BP, the Sault outlet took over Lake Superior while it was at the Houghton Lowstand, approximately 120 m above sea level (Fig. 7). Rebound of the outlet slowly raised the elevation of the lake until the North Bay Uplift overtook the Sault about 1,000 years later. During this interval, Lake Superior was at a common level with the adjacent Great Lakes. The North Bay Uplift continued to rise, increasing lake levels culminating in the Nipissing Highstand, 186 m, 6,600 yrs. BP. At this time, erosion of the North Bay outlet was abandoned for the Port Huron, and the lake receded to 178 m at the Sault Lowstand, 2,200 yrs. BP. Once more the Sault Uplift controlled the St. Mary's River, separating Lake Superior from Lake Michigan, and began the 30 cm per 100 yrs rise to the modern level at 183 m (Fig. 7). (Farrand and Drexler, 1985)

Geomorphology of the St. Louis River and Estuary

The lower St. Louis River can be broken into three sections based on the geomorphology. From Jay Cooke State Park to the Cloquet River, Reach 1, the river flows across the Thomson Formation. The bedrock is not easily eroded, separating this part of the river from down river. The gradient of this reach varies from as much as 1/200 near Cloquet to no more than 1/4000 further up river. The average gradient is 1/3000. North of Cloquet, the river has cut down as much as 150 feet into the surrounding glacial deposits. Much of the incision in this reach occurred early in the Holocene. It is characterized by wide abandoned channels and sweeping meanders

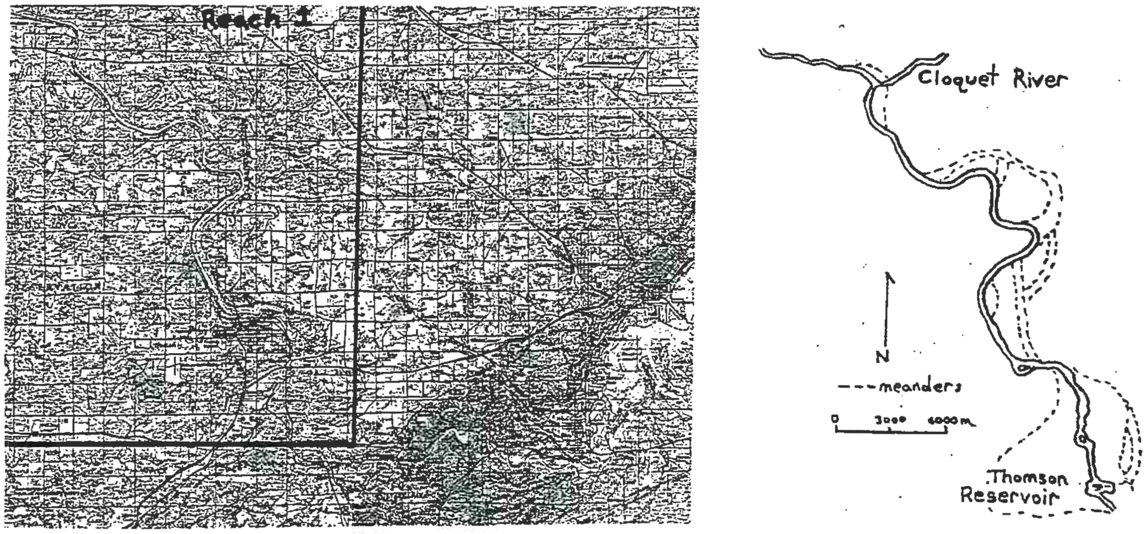


Figure 8. Geomorphic features of Reach 1, lower St. Louis River.

(Fig. 8). Islands in the lower portion of this reach are primarily bedrock, while those up river tend to be fluvial features. Pebbly clays and silts dominate the stratigraphy in this reach, with some glacial outwash deposits.

In Jay Cooke State Park, Reach 2, the river flows through Glacial Lake Duluth lake clay. The clay is much more easily eroded, allowing the river to incise deeply in this region. Within this reach, the average gradient is 1/300, but it varies from 1/1000 near the power dam to as much as 1/40. The primary feature of this region is the deep entrenchment of the St. Louis River into the surrounding sediments. At its greatest extent, the river has cut more than 90 m into the lake plain. Meanders in this reach are smaller than in Reach 1. Abandoned meanders are lobate, and perched high above the modern river. Numerous points, spits, and terraces occur within this reach (Fig. 9). In

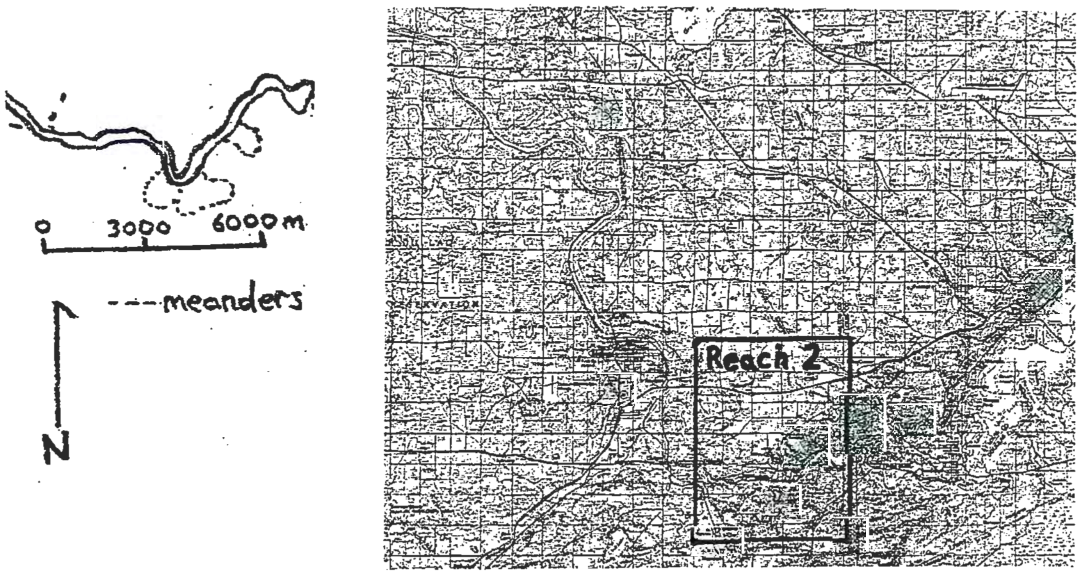


Figure 9. Geomorphic features of Reach 2, lower St. Louis River.

Reach 2, the stratigraphic sequence is composed mostly of silt and sand, with channel lag and glacial sediments occurring deeper. Fluvial processed are continually reworking the sediments. This has created an environment in which the vertical thickness of fluvial deposits is seldom more than 5 m.

From Fond du Lac to Minnesota and Wisconsin Points, Reach 3, Lake Superior controls the elevation. This reach is dominated by the St. Louis River Estuary. After the recession of the Superior Lobe from the Superior Basin, lake level dropped to more than 60 m below the current lake level of 183 m (Farrand and Drexler, 1985). At this time, the St. Louis River cut down into the clay and outwash deposits. The differential tilt of the Superior Basin has caused lake levels to increase, flooding the old river channels and creating the estuary and bays. There are an abundance of points and islands in the

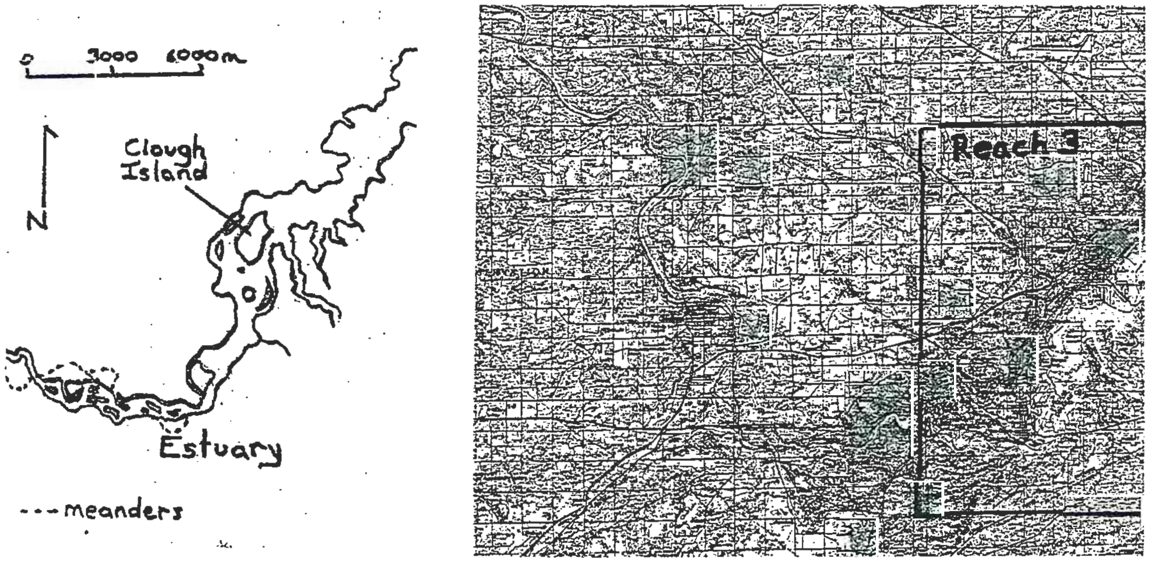


Figure 10. Geomorphic features of Reach 3, lower St. Louis River.

estuary (Fig. 10). In Reach 3, the river lies about 12 m below the surrounding glacial lake plain. Sedimentation rates are around 30 to 80 cm per 100 yrs. Sequences within the estuary contain sand and silt interbedded with peat and wood layers to about 5 m. Underlying these sediments are clay and finally sandy silt.

Fluvial landforms identified along the entire lower St. Louis River include terraces, points, spits, islands, and abandoned meanders. The location of representative profiles, and cross-sections are given in Figure 11. Three segments of a terrace at 213 m, not associated with abandoned meanders, were identified in Reach 2, one in Sec. 1, T48N, R16W (Fig. 12a), a second on a point in Sec. 15, T48N, R16W, and one in Sec. 11, T48N, R15W.

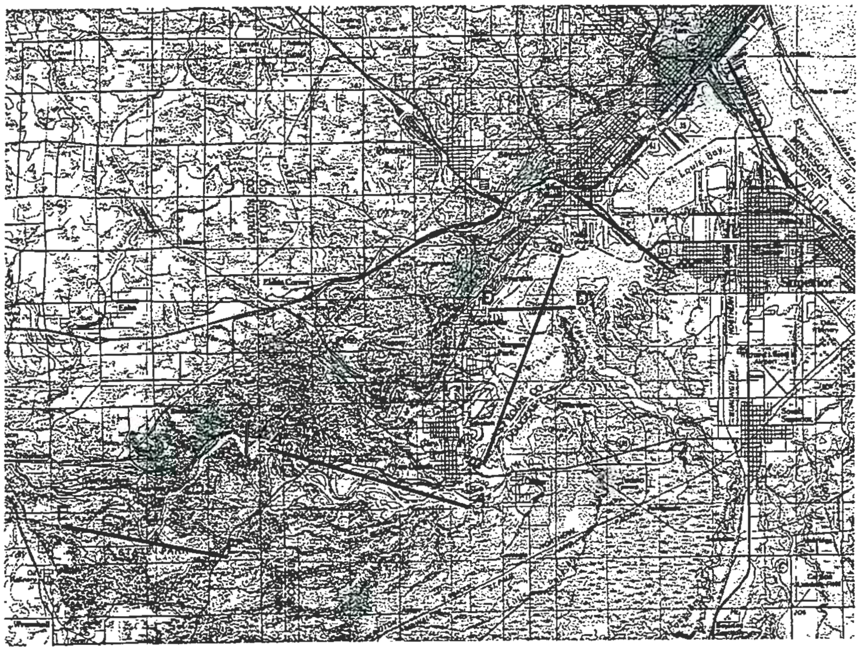


Figure 11. Location of topographic profiles and cross-sections.

Numerous points extend along the river. The four major points, occurring in Reach 3, are: by Fond du Lac Park in Sec. 7, T48N, R15W; southeast of New Duluth, Minnesota in Sections 10 and 11, T48N, R15W; north of Oliver, Wisconsin in Sec. 2, T48N, R15W; and on the northern side of Dwight's Point in Sec. 19, T49N, R14W. Two spits extend into the St. Louis River in Reach 3, one in the town of Fond du Lac, Sec. 8, T48N, R15W, and another between Fond du Lac and New Duluth, Sec. 9, T48N, R15W. There are numerous low islands in the St. Louis River that are depositional features. Two

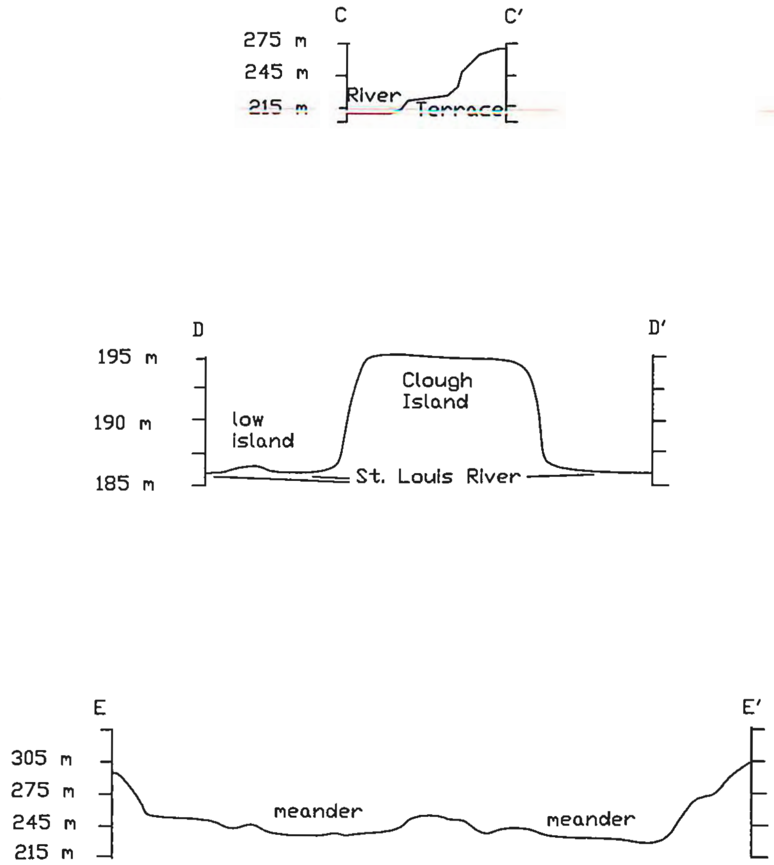


Figure 12. Topographic profiles, a (C-C'), b (D-D'), and c (E-E'), of selected geomorphic features.

islands in Reach 3 are not associated with the others, Spirit Island and Clough Island (Fig. 12b). These two islands are erosional remnants of a subaqueous outwash delta associated with the end of the Nickerson Phase of the Superior Lobe.

Twenty meander scars were identified along the St. Louis River from the Cloquet River to Lake Superior (Fig. 13). Meanders 1-3, at elevations of 384 m; 378 m and 375 m, respectively, are found north of Cloquet in Reach 1. Meander 4 is found southeast of Cloquet at an elevation of 347 m. These four are located within Reach 1. The fifth and sixth meanders, 241 m and 238 m, are located in Reach 2. These two are entrenched into the lake clay in the Jay Cooke State Park area. Meanders 7 and 8, at 375 m and 350 m, are found in Reach 1. Incised into the clays of Jay Cooke State Park, in Reach 2, is meander 9 at 226 m. The tenth and eleventh meanders occur at elevations of 369 m, and 332 m. Meanders 10 and 11 are found within Reach 1. Meander 12 occurs in Reach 2 at

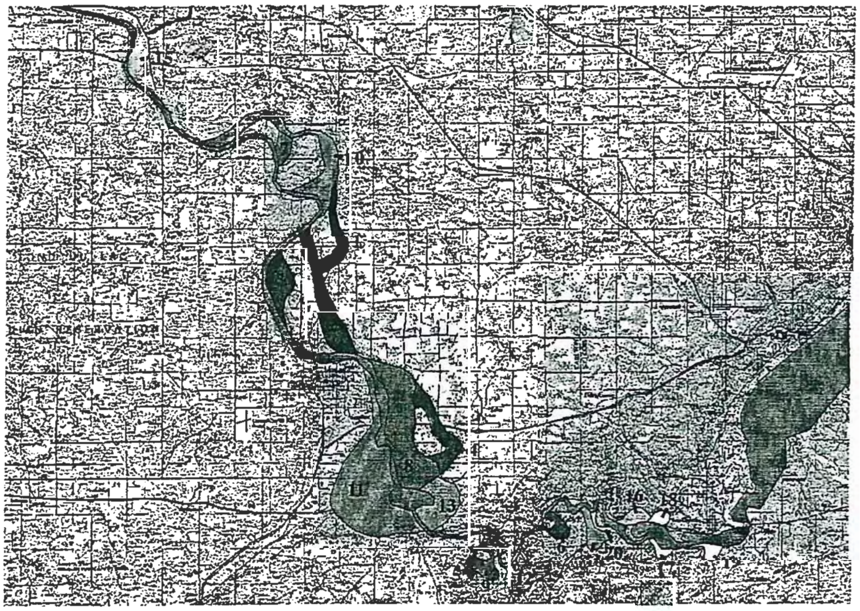


Figure 13. Abandoned meanders of the lower St. Louis River.

223 m. East of the Thomson Reservoir in Reach 1, at 329 m is meander 13. At 192 m meander 14 is found in Reach 2near the Minnesota Power Dam. The last meander in Reach 1 is meander 15 at 369 m. Meanders 16-20 reside at elevations of 187 m to 184 m. These five meanders are in Reach 3 of the lower St. Louis River near Fond du Lac.

There have, only been two serious studies of the St. Louis River estuary. William Loy's papers (1962,1963,1964) concentrated on the coastal landforms of Minnesota and Wisconsin points, and ignored the formation of the rest of the river and estuary. Barlaz (1983) reviewed some of Loy's ideas, and added to the stratigraphic interpretation of the harbor. Both Loy and Barlaz relied on core logs from other sources to develop their stratigraphies. While general trends are recognizable, additional coring is needed to refine the sequence.

ARCHAEOLOGICAL HISTORY

It is believed that the earliest humans to enter North America were large game hunters, who migrated to the continent from Asia around 15,000 BP. (Fagan, 1995). At this time, Beringia, or the Bering Land Bridge, was exposed, opening the migration route for Pleistocene fauna and hunters. There is, however, evidence that the time scale of migration and occupation could be earlier than has been previously thought (Dillehay, 1997). These early immigrants continued to move and multiply until they inhabited the entire continent. The lives and activities of these people left a signature of debris on the earth, which we use to try to reconstruct the lost cultures. The first recognizable signature, or tradition, in North America is the Paleoindian. Evidence of Paleoindian occupation is usually thought to begin shortly after migration, and exist until around 8,000 BP. The remains of the Paleoindian tradition are large lanceolate points, with earlier forms exhibiting flutes, and later forms lacking them. The Paleoindian tradition is followed by the Archaic tradition, lasting from 8,000 BP to 3,000 BP. The Archaic begins with the appearance of side or corner notched projectile points. Copper also became commonly used in Northern Minnesota during the Archaic Period. Following the Archaic came the Woodland tradition, spanning the time range from 3,000 BP. until European contact. The Woodland tradition includes pottery, burial mounds, domesticated plants, and lithic technology. In Late Woodland period the use of a bow and arrow was introduced. The artifacts and sites left behind by the people are used to attempt to reconstruct their lives and cultures. The identifiable archaeological record in Minnesota begins with the Paleoindians. The state was mostly ice-free by 11,700 BP.

(Mulholland, et al., 1997), and was inhabitable from this time on. The retreat of the ice sheets formed a pocket of subaerial exposure, possibly vegetated, in east central Minnesota, that may have been inhabitable earlier than the rest of the state. Minnesota lies at the intersection of three different environments (Fig. 14), Conifer/Hardwood Forest, Deciduous Forest, and Prairie. Throughout much of the Holocene, southwestern Minnesota has been mainly prairie, grading into deciduous forest in the central regions. Central to northcentral Minnesota is a lake-dominated environment, with coniferous forests in the north. During the Hypsithermal episode, a global warming trend which peaked in intensity around 6,500 to 6,000 BP (Fagan, 1995), these regions shifted north and northeast. The ecology has changed greatly from when the first human entered what

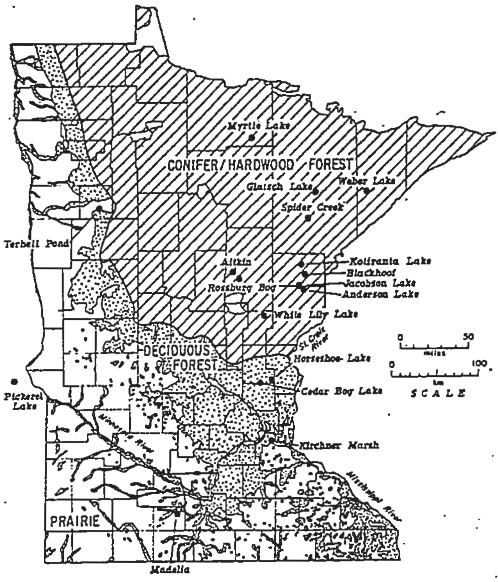


Figure 14. Environmental Settings in Minnesota. From Wright and Watts, 1969.

is now Minnesota. These varying ecological regions also influenced where and how people lived. Bison hunters spent most of their time on the prairies, while horticulturalists preferred the central lakes (Dobbs, 1988). The product of these differences is that the prehistoric peoples of Minnesota are divided not only by time, but also by geography. The complex environmental conditions have lead to even more complex archaeological conditions.

Paleoindian Period

The Paleoindians are best known as large game hunters, specializing in the Pleistocene megafauna. This conception seems to hold true on the prairies, but the Paleoindians occupied more diverse environments, and must have adapted to local flora and fauna with the large game hunter being just one of the adaptations. The tradition known as Paleoindian is represented in Minnesota by four cultures: Clovis, Folsom, Plano, and Dalton-like (Dobbs, 1988). These are all linked by a common tool kit, including: unifacial end and side scrapers, gravers, wedges, and bifacial ovate and lanceolate knives, and hafted fluted or non-fluted point

Archaic Period

The Archaic Period brought about a diversification of prey and an increase in the exploitation of resources in the forests. The proposed dominance of bison on the plains seems to be replaced by hunting a variety of mammals. Within the forests, many animals, large and small, were hunted, and the gathering of nuts and berries became more prevalent. The diagnostic artifacts of the Archaic are the side or corner notched projectile point and groundstone tools. The exceptional craftsmanship, and reliance on exotic materials that was so common in the Paleoindian is abandoned for more crude stone working with local materials. The archaic is often divided into Early, Middle, and Late, based on projectile point evolution, and inferred hunting techniques. This classification is valid only for southern Minnesota. In the north, the Early Archaic is poorly represented, and the Middle is virtually nonexistent. This may be due to either a lack of people in the area for these periods, or a lack of archaeological survey results due to vegetative cover and remoteness of many areas. Water levels were also known to be lower during this time period and many of Archaic sites are probably now underwater. For these reasons, the Archaic period in this area is divided on a geographic basis. Northern sites, on the Canadian Shield, are collectively known as Shield Archaic. The culture of the plains peoples in the western part of the state is called Prairie Archaic, and the Lake Forest Archaic is found in the lake-strewn forest environment. In the lower Great Lakes and further east, the Eastern Archaic is recognized.

Woodland Period

The transition from Archaic to Woodland has an extremely variable boundary. Classic Woodland culture includes new manifestations such as pottery, burial mounds, and horticulture or agriculture, and later bows and arrows,. These innovations did not suddenly appear concurrently over the entire continent. On the contrary, pottery appears later in northern Minnesota, and never shows up in more northern latitudes where the Shield Archaic tradition persisted. The traditional Eastern Woodlands classification of the Woodland into Early, Middle, and Late, does not hold true for Minnesota. The southeast is the only part of the state which may be said to exhibit an Early Woodland phase. Because of the missing Early Period, the Woodland in northern Minnesota is often divided into Initial and Terminal, which correspond with Middle and Late respectively.

The archaeology of Minnesota is a temporal and spatial maze. Traditional period separations such as the Early Woodland make little sense in most of the state. Early Paleoindian sites in Minnesota have not yet been confirmed. This may be due to there being an insufficient population in the state at the time. This also may be due to the sites being buried under significant amounts of sediment, or being underwater. Problems with the application of dating techniques to suspected Early Paleoindian sites have led to the continuation of this debate. The Archaic Period, more than the others, is based on geography. With the exception of the perhaps nonexistent Old Copper Culture, cultural designations in the Archaic span thousands of years, and in the case of the Shield Archaic, thousands of kilometers also. The Woodland Period in northern Minnesota is more akin to Canadian classifications than those for the majority of the United States, and whether pottery came to northern Minnesota after the experimental thick-walled pottery called crudwear, or the Mississippi Valley people moved north is yet to be resolved.

LABORATORY AND FIELD METHODS

The primary field method utilized for this study was sediment coring. The 2.5 cm split spoon was chosen for its ability to obtain continuous sediment cores, and the ease of transport. By adding extensions, depths to about 10 m can be sampled by this method. Where exposed, surficial sediments were described and sampled. Three methods were used to accurately identify paleosols. Descriptions of color, texture, and grain size provided initial assignments of stable land surfaces.

Selected cores were then analyzed for total organic and inorganic carbon content by the Loss on Ignition (LOI) method (Dean, 1974). LOI gives both the weight percent of organic carbon and the weight percent of carbonate present in a sample. The organic carbon content of a sediment can be used to aid in the identification of paleosols. During the soil forming process, roots and organic material are concentrated in the upper part of the soil profile. After a soil is buried, the organic material remains. A second process at work at the same time is leaching. As ground water percolates through the soil, it leaches $CaCO_3$ from the upper part of the profile, and deposits it in the lower.

Magnetic susceptibility was used to verify the assignments that were made based on the field descriptions and LOI analysis. The magnetic properties of some minerals, especially magnetite, have long been used to aid in the identification of paleosols. During the soil forming process finer grains are concentrated in the upper portion of the profile. The process of leaching also removes carbonate, thereby enriching the soil in magnetite. A well developed soil should be recognizable by a higher magnetic susceptibility, and more abundant and finer grain size for the magnetic minerals. (Maher,

1998) (Singer, et al., 1996)

The ^{14}C method of age dating was chosen for its applicability to Quaternary studies. This method was particularly well suited to this study because of the nature of rivers. Stable land surfaces in close proximity to rivers, and abandoned river channels often become heavily vegetated. This plant material provides an excellent organic source for dating the surface.

Field Work

Field work was carried out during the summer and fall of 1999, with checks during the winter and spring of 2000. Field work included sediment cores and location and description of sediment exposures. Initial core locations were chosen from USGS 7.5" Quadrangles based on probability of extensive Quaternary sedimentation, and overall coverage of the study area (Table 1).

Cores were taken manually using a 2.5 cm diameter split spoon, and 5 cm diameter open and Dutch augers. The split spoon was 1 meter in length. Cores were taken in 20 cm intervals. This was done in order to minimize compaction of the sediment that can occur with longer sections of core. Extensions of 1 m were added to the handle with every meter increase in core depth. When the sediment was too compact or the split spoon tip was deflected, the tip was removed and an auger tip was attached to the handle. The 5 cm auger head was also used to obtain a larger sample size for thin peat layers. Samples were taken for each distinct interval within the cores. In cases of peat or wood layers, duplicate samples were obtained. In two locations, 3, Sec. 9, T48N, R15W; and 4,

Text Name	Field Name (Appendix A)
Core 1	1, Sec. 2, T48N, R15W
Core 2	1, Sec. 5, T48N, R15W
Core 3	1, Sec. 7, T48N, R15W
Core 4	2, Sec. 7, T48N, R15W
Core 5	3, Sec. 7, T48N, R15W
Core 6	4, Sec. 7, T48N, R15W
Core 7	5, Sec. 7, T48N, R15W
Core 8	6, Sec. 7, T48N, R15W
Core 9	1, Sec. 8, T48N, R15W
Core 10	2, Sec. 8, T48N, R15W
Core 11	3, Sec. 8, T48N, R15W
Core 12	1, Sec. 9, T48N, R15W
Core 13	2, Sec. 9, T48N, R15W
Core 14	3, Sec. 9, T48N, R15W
Core 15	4, Sec. 9, T48N, R15W
Core 16	1, Sec. 10, T48N, R15W
Core 17	2, Sec. 10, T48N, R15W
Core 18	1, Sec. 11, T48N,R15W
Core 19	1, Sec. 14, T48N, R16W
Core 20	1, Sec. 15, T48N, R16W
Core 21	1, Sec. 19, T49N, R14W
Core 22	1, Sec. 23, T49N, R15W
Core 23	1, Sec. 25, T49N, R15W
Core 24	1, Sec. 26, T49N, R15W
Core 25	1, Sec. 1, T48N, R16W
Core 26	2, Sec. 1, T48N, R16W
Core 27	3, Sec. 1, T48N, R16W
Core 28	4, Sec. 1, T48N, R16W
Core 29	Vine Oxbow, Sec. 8, T48N, R15W

Table 1. Text identification and location of St. Louis River cores.

Sec. 9, T48N, R15W, samples were taken in 10 cm increments throughout the length of the core. This was in order to provide a check for the field assignments of intervals. Core logs were recorded in the field, and included: depth, soil horizon (if applicable), color, texture, structure, consistency, inclusions and boundary type. Reconnaissance for and description of sediment exposures occurred simultaneously with the core studies.

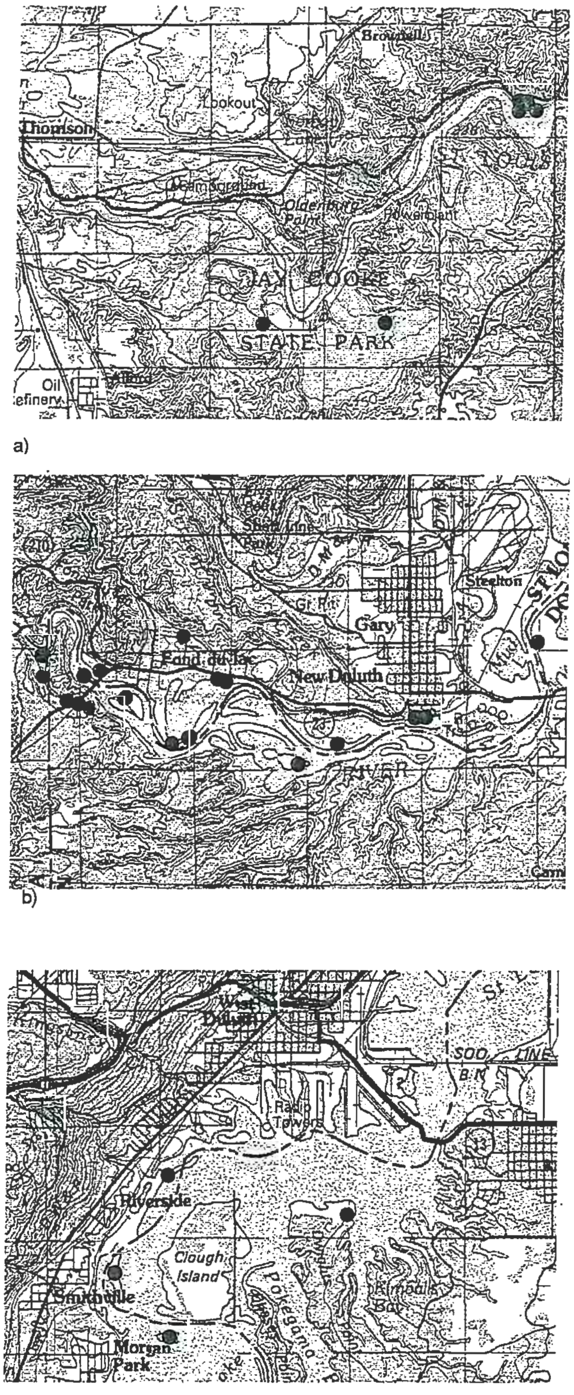


Figure 15. Core sample locations near Fond du Lac (a), Gary/New Duluth (b), and in the estuary (c).

Numerous exposures can be found along the St. Louis River, and surrounding areas. Locations were recorded in a field notebook, and plotted on 7.5" Quadrangles. Description of the sediments was also recorded. Where appropriate, sketches of the exposures were made. Units judged to be important, based on grain size and sedimentary structures, were sampled for further description. Initial core locations were chosen based on geomorphic map interpretation (Fig 15, a-c). Land surfaces that did not evolve from the St. Louis River were rejected first. Fluvial landforms that were identified include terraces, points, spits, islands, and abandoned meanders. The location of representative profiles, and cross-sections are given in Figure 11. Due to inaccessibility, only the terrace segment in Sec. 1, T48N, R16W was cored. Four of the points along the St. Louis River were examined in detail with one or more cores. They are: by Fond du Lac Park in Sec. 7, T48N, R15W; southeast of New Duluth, Minnesota in Sections 10 and 11, T48N, R15W; north of Oliver, Wisconsin in Sec. 2, T48N, R15W; and on the northern side of Dwight's Point in Sec. 19, T49N, R14W. Three cores were taken on the two major spits into the St. Louis River, in the town of Fond du Lac, Sec. 8, T48N, R15W, and between Fond du Lac and New Duluth, Sec. 9, T48N, R15W. Islands that were cored include; the eastern most island in Sec. 7, T48N, R15W; Nekuk Island near Fond du Lac in Sec. 8, T48N, R15W; the southern most island in Sec. 9, T48N, R15W; the island approximately 300 m south of Clough Island in Sec. 25, T49N, R15W; the island directly east of Smithville Minnesota in Sec. 26, T49N, R15W; and Tallas Island, northeast of Riverside, Minnesota in Sec. 23, T49N, R15W. Vegetation and a lack of accessible trails inhibited field work on many of the meanders. The meanders that were studied include two major plateaus in Jay Cooke State Park, in Sections 14 and 15, T48N, R16W; the meander west of the town of Fond du Lac in Sec. 7, T48N, R15W; and the fourth in the town of Fond du Lac, Sections 5 and 9, T48N, R15W. Meanders were identified from 7.5 minute Quadrangles and 30-meter Digital Elevation Models, both from the U. S. Geological Survey. Relatively recently abandoned meanders are easily recognized on topographic maps. Arcuate plateaus near the modern river level are interpreted as meanders. In three cases; meanders 12, 18, and 20, oxbow lakes still make up part of the area. The accurate mapping of older meanders becomes problematic due to intense erosion. By applying different coloring schemes, hill shades, and aspects to the 30-m DEM's, older meanders can be more easily recognized and mapped.

Laboratory Analysis

The loss on ignition (LOI) method of total organic carbon (TOC) analysis measures the mass loss of sediment after burning the sediment at 550° C and 1000° C. The mass loss after heating to 550° C is due only to organic carbon. The mass loss from 550 C to 1000° C is due to the evolution of CO_2 from $CaCO_3$ in the sample. This is used to calculate the amount of $CaCO_3$ in the sample.

The LOI analysis was performed at the University of Minnesota, Duluth Archaeometry Lab. 108 samples collected from 25 cores were analyzed for TOC content (Appendix B). Crucibles were dried overnight at 100° C, and cooled in a dessicator. They were then weighted, and 1 to 5 grams of sediment were added. The crucibles were then dried again at 100° C overnight to drive off water, and weighed once more. This gives the dry sample weight. The crucibles were then placed in a muffle furnace at 550°

C for one hour. Samples were removed to a dessicator to cool. The weight was then measured again. This is the Burn 1 weight. The crucibles were placed back into the muffle furnace at 1000° C for one hour. The samples were removed once more to a dessicator to cool, and the final weight was measured. This is the Burn 2 weight. Once all measurements have been made, the weight percent of organic carbon can be determined by the following equation:

$$\text{Weight \% Organic Carbon} = \text{Burn 1(Wt. TOC lost)} / \text{dry weight} * 100.$$

The weight percent CO_2 lost is needed to determine the weight percent of $CaCO_3$ in the sample. Weight percent CO_2 lost is calculated by the equation:

$$\text{Weight \% } CO_2 \text{ lost} = \text{Burn 2 (Wt. } CO_2 \text{ lost)} / \text{dry weight} * 100.$$

The weight percent $CaCO_3$ is then calculated using the equation:

$$\text{Weight \% } CaCO_3 = \text{Wt. \% } CO_2 \text{ lost} / 0.44$$

where 0.44 is the fraction of CO_2 in $CaCO_3$. The concentrations of organic carbon and carbonate are plotted against depth to obtain the profile.

The low field magnetic susceptibility of a sediment is measured directly using a susceptibility bridge. Anhysteretic remnant magnetism is measured by imparting a new magnetic signal to the sample, and measuring the field produced in a superconducting rock magnetometer. X_{ARM} is more sensitive to finer grained magnetite, while X is sensitive to the total mass of magnetite. The relative grain size and concentration of magnetite in sediments is determined by plotting the anhysteretic remnant magnetism, X_{ARM}, against the lowfield magnetic susceptibility, X (Fig. 16). The slope of the sample gives an estimate of the mean grain size of the magnetic particles, while the distance from the origin is proportional to the concentration of magnetite in the sample. Magnetic susceptibility was measured on 8 cores. The samples were chosen based on the results of the total organic carbon analysis. A total of 74 samples were measured from cores; Cores 1, 3, 9, 11, 14, 15, 18, and 27. The samples were first disaggregated and packed tightly into P1 (5.28 cm^3) sample cubes. The analysis was done at the Institute for Rock

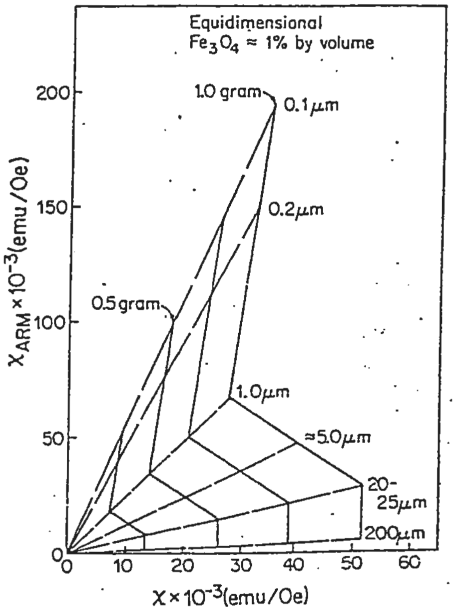


Figure 16. Model for the determination of grain size and concentration of magnetite in sediments. From King, et. al., 1982.

Magnetism, at the University of Minnesota, Twin Cities. Samples were demagnetized using a decaying 100 mT alternating field. The anhysteretic remnant magnetism, X_{ARM}, was imparted with a 0.1 mT biasing field. The X_{ARM} was then measured in a G2 cryogenic superconducting rock magnetometer. The low field susceptibility of the samples was measured using a Bartington susceptibility bridge. Due to their fine grained nature, the magnetic grains in the sample were interpreted to be single domain. Because of this, dual frequency susceptibility was not investigated.

^{14}C Dating has been used for many decades to date organic material. The dating method is based on the accumulation and decay of the ^{14}C isotope compared to the stable ^{12}C and ^{13}C isotopes. ^{14}C is radiometric and is only formed in the atmosphere by the bombardment of ^{14}N by neutrons. The $^{14}C/^{12}C$ ratio in the atmosphere is relatively constant world wide. The ratio does however fluctuate over time. These fluctuations are well known and documented from tree ring studies and Uranium series dating. These are used to calibrate the dates after analysis (Appendix D). While alive, all terrestrial creatures remain in equilibrium with the atmospheric carbon ratio through assimilation via the food chain and respiration. Once an organism is dead, new ^{14}C is not added to the organic matter, and the fixed ^{14}C decays away with a half-life of approximately 5730+/-40 years. For material older than 60,000 years BP, the radiometric carbon has decayed to such small quantities that dates become unreliable. The useful range for radiocarbon dating is from modern to 40,000 years BP (Rapp and Hill, 1998).

Six samples from four cores were selected for ^{14}C dating (Table 2). Two samples,

Sample Number	Beta Analytic ID	Conventional Radiocarbon age	2 sigma calibrated age
156-176cm, 1,Sec 8, T48N,R15W	Beta 139719	150 +/- 40 BP	290-5 BP
330-360cm, 1,Sec. 26, T49N, R15W	Beta 139720	920 +/- 40 BP	930-740 BP
201-218cm, 1,Sec. 8, T48N, R15W	Beta 139721	390 +/- 40 BP	515-420 and 405-315 BP
456-460cm, 1,Sec. 26, T49N, R15W	Beta 137922	1880 +/- 40 BP	1895-1715 BP
184-195cm, 1, Sec. 15, T48N, R16W	Beta 137923	4400 +/- 40 BP	5225-5190 and 5060-4860 BP

Table 2. Raw and Calibrated ^{14}C data.

156-176 cm and 201-218 cm, Core 9, consist of plant material and come from the low spit into the St. Louis River near Fond du Lac. Samples from 330-360 cm and 456-460 cm, Core 24, were composed of plant material and wood respectively, and were collected on the island east of Smithville in the St. Louis Estuary. 184-195 cm, Core 20, is comprised of wood from the abandoned meander at 226 m in Jay Cooke State Park. The last sample, 30-35 cm, Core 29, was from a core taken in the small oxbow lake south of Fond du Lac and consists of wood and plant material. All analyses were performed by Beta Analytic Inc. Prior to shipping, the samples were sorted, and the organic material concentrated.

RESULTS AND DISCUSSION

Stratigraphy

Within Reach 3, near Fond du Lac, sedimentary sequences are dominated by sand and silt. Most cores were stopped by gravel size clasts (Fig. 17). The two possible origins for the large clasts are glacial drift and channel lag. If the gravel was glacial drift, a wide variety of grain sizes would be expected. The gravel is coarse grained, and lacks clays and silts, and is interpreted to be channel lag deposits. From the radiocarbon dates, an average vertical accretion rate can be calculated from the core data. Sedimentation rates are not constant over time. Increased erosion up river causes increased sedimentation down river. Averaging the deposition for all of the cores provides a good estimation for the late Holocene. Sediment accumulation in the river channel has been

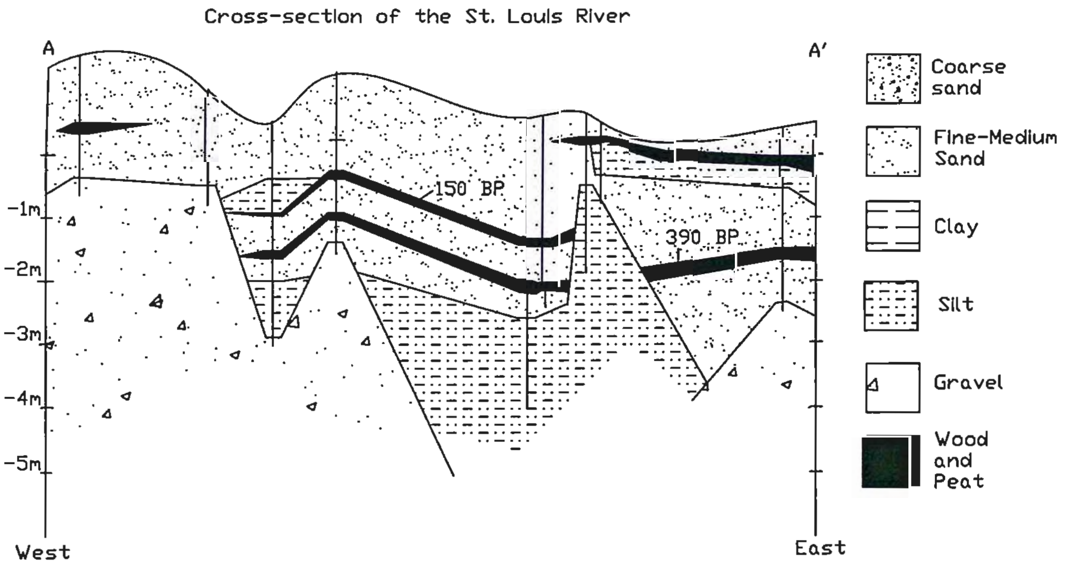


Figure 17. Cross-section, A-A', along the St. Louis River between the Fond du Lac dam and the Oliver Bridge.

occurring at a rate of 30 to 80 cm per 100 yrs. Substantial reworking of the channel has taken place, however, and the total vertical thickness of fluvial deposits in Reach 3 up river from the Oliver Bridge seldom exceeds 5 m. Closer to Lake Superior, the stratigraphic relations become more consistent. The top 1 m is dominated by brown pebbly sands and silts. From 1-2 m, lighter brown fine sands and silts, lacking pebbles are found. Occurring below the silty section is a 2 m thick sand and organic layer. Three distinct plant and wood layers occur within the brown fine to medium sand, at depths of 200-230 cm, 320-390 cm, and 400-470 cm respectively (Fig. 18). Because Lake Superior was transgressing during this period of time, these landsurfaces are most likely not continuous over great distances. In order to create stable land within the estuary during transgression, points and flood plains would have to be created through deposition of sediments rapidly eroded from upstream. This would create stable landsurfaces that

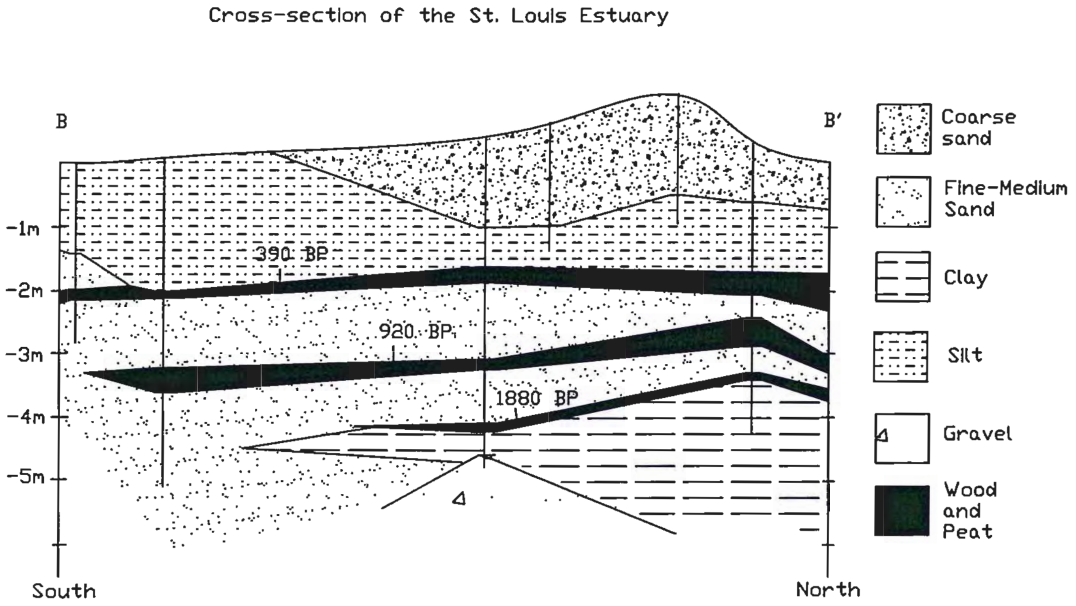


Figure 18. Cross-section, B-B', in the St. Louis River Estuary, between the Oliver Bridge and the Interstate Bridge.

could be vegetated above the water level in the estuary. This sandy layer is typically underlain by gravel nearer the river, and red clay in the middle of the estuary. Additional cores taken by the Minnesota Department of Transportation, and the U. S. Army Corps of Engineers provide deeper interpretations (Figs. 19 and 20). The sections along the

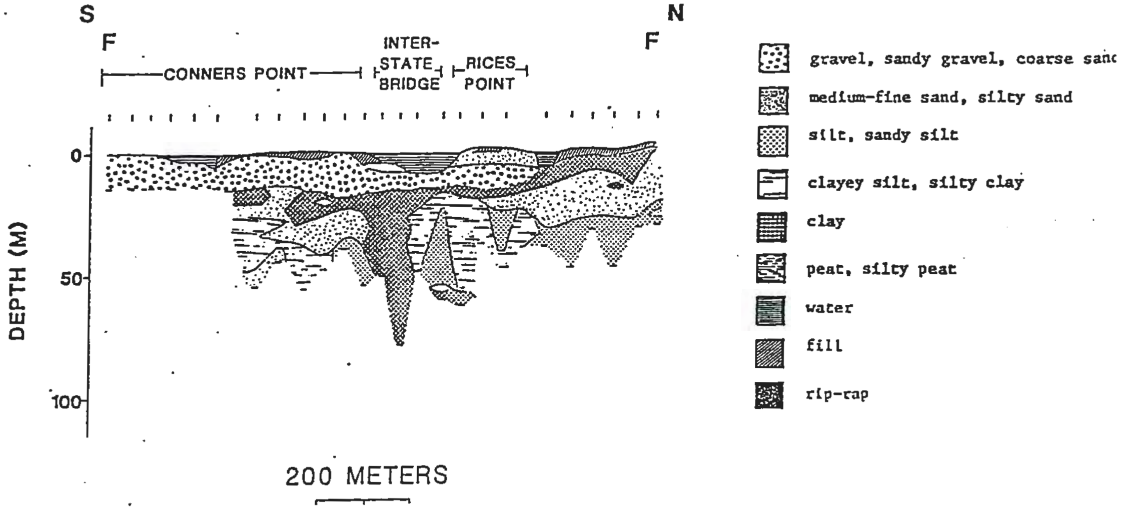


Figure 19. Cross-section, F-F', along the Interstate Bridge. From Barlaz, 1983.

Blatnik and Arrowhead Bridges do not provide detailed information, but serve well to form a generalized stratigraphy in the estuary. Throughout the harbor, sandy silt is overlain by clay, and finally sand and gravel. The units thicken towards the northeast in a basinward direction. This represents a fining of sediments from silts to clays at the base, followed by a coarsening back to sands and gravel. Immediately overlying the clay, the deepest wood and plant layer is typically found. As previously stated, dates on the wood, from depths of 4-6 m, yield ages of 1500 to 1800 yrs BP. This confirms the 30 cm per 100 yrs relative rise in lake level at Duluth, and provides an equivalent sedimentation rate for the estuary. The age of the wood layer places it near the Sault lowstand of Lake Superior, 2200 yrs BP (Farrand and Drexler, 1985). At this time, the lake level was low

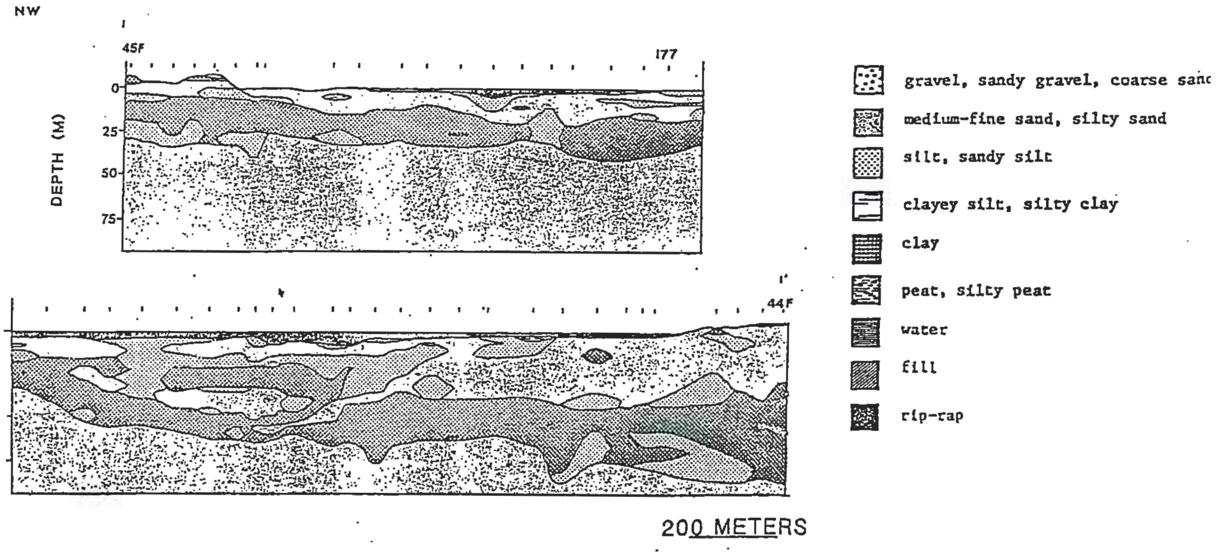


Figure 20. Cross-section, I-I', along the Arrowhead Bridge. From Barlaz, 1983.

enough that the present estuary would not have existed. The region would have been densely vegetated, with a river channel flowing to the lower lake shore. This provides an environment in which trees would be able to flourish where water now resides. Prior to the Sault lowstand, the lake was receding from the 5500 yrs BP Nipissing highstand. The recession would have been a time of lower sedimentation. The highstand should correspond to the clay, from 18-6 m deep, that underlies the wood layer. The fining upward sequence from silt to clay supports the idea of a transgression from lower lake levels up to the Nipissing level at 5500 yrs BP. The following regression to the Sault level is marked by a stable land surface that was vegetated. The steady rise of lake level for the last 2200 years has deposited silt, sand, and gravel in the estuary. Due to intense channel reworking and low sedimentation, firm stratigraphic relations are not found within Reaches 1 and 2. These reaches are dominated by silt, sand, and gravel. The primary force acting in this area is erosion.

Paleosols

Because of the active nature of rivers, the stratigraphy of the St. Louis River is variable and difficult to interpret. There are, however, some stable surfaces and sequences that are repeated throughout the lower reaches of the river. There are five organic layers that are laterally extensive in Reach 3. The youngest paleosol, paleosol 1, was identified by color and texture, as well as correlated with LOI and magnetic susceptibility studies (Fig. 17). It can be traced through four cores, 12 - 15, and is believed to have a subsurface extent of approximately 1.5 km^2. The unit is typically 20-30 cm thick and is composed of a dark mottled soil with abundant roots. It occurs from 25-50 cm below the modern surface, and mainly overlies silts. Deep modern soil and root formation as deep as 75 cm in the area, and channel migration are suggested as causes for the limited extent of the paleosol. In places where the modern soil is well developed, the shallow paleosol has been incorporated into the new soil profile. Paleosol 2 is found at depths of 100-150 cm (Fig. 17). This soil is found within sandier sections.

It is 10-20 cm thick and is composed of peat and roots. The unit can be traced through cores 3 - 5, and 9 - 11. It is interpreted to have a subsurface extent of approximately 3 km^2. A radiocarbon date on plant material from this horizon yielded an age of 290 to 5 BP(150 +/- 40 BP). In many places, channel migration has destroyed this surface. The third layer, peat 1, is very extensive (Figs. 17 and 18). It occurs at depths of 160-250 cm and consists of 10-50 cm thick packages of roots and plant matter. The unit can be traced from the power dam to the harbor. In Core 11, the layer was identified by its magnetic properties, and in Core 14, it was identified from LOI results. In the subsurface, it should occur over more than 21 km^2. Radiocarbon analysis on plant material from this level gave dates in the ranges from 515 to 420 yrs BP or 404 to 315 yrs BP(390 +/- 40 BP). Channel migration has removed evidence for this unit in some locations. Located at depths of 320 to 390 cm is a fourth layer, peat 2, (Figs. 17 and 18). It is 20-50 cm thick, and is composed of dense peaty layers and abundant plant matter. This horizon can be traced throughout the estuary, but has been destroyed by channel migration further up river. The subsurface extent of this layer is as much as 16 km^2. Dates of 930 to 740 yrs BP(920 +/- 40 BP) were returned from radiocarbon analysis of plant material from this layer. A fifth, and deepest layer, wood 1, is found at depths of 400-470 cm (Fig. 18). This relatively thin layer, 10-20 cm, consists predominantly of wood and plant matter. It is extensive in the subsurface from near the Oliver Bridge to the lake, and has a possible subsurface extent of more than 24 km^2. A radiocarbon analysis on wood from this layer yielded a date of 1895 to 1715 yrs BP(1880 +/- 40 BP). This age is supported by dates obtained by Mooers (unpublished) on wood from 450-520 cm, near the Blatnik Bridge, of 1700 to 1500 yrs BP.

Loss on Ignition and Magnetic Susceptibility Analysis

The weight percent organic carbon and carbonate were plotted against depth for the LOI data. The profiles were then examined for peaks in organic carbon, representing concentrations of organic material, and sections leached in carbonate. Intervals displaying only one of these criteria were tentatively designated as paleosols, while those sections displaying both high organic carbon and low carbonate were given more weight. Profiles were also made of the X and X_{ARM} data. The anhysteretic remnant magnetism was also plotted against the low field magnetism to obtain information on the abundance and size of the magnetic grains. Intervals with higher magnetism, and smaller grain size were interpreted to represent paleosols.

Core 1 has two possible paleosols (ig. 21). From 77-98 cm, an increase in X and

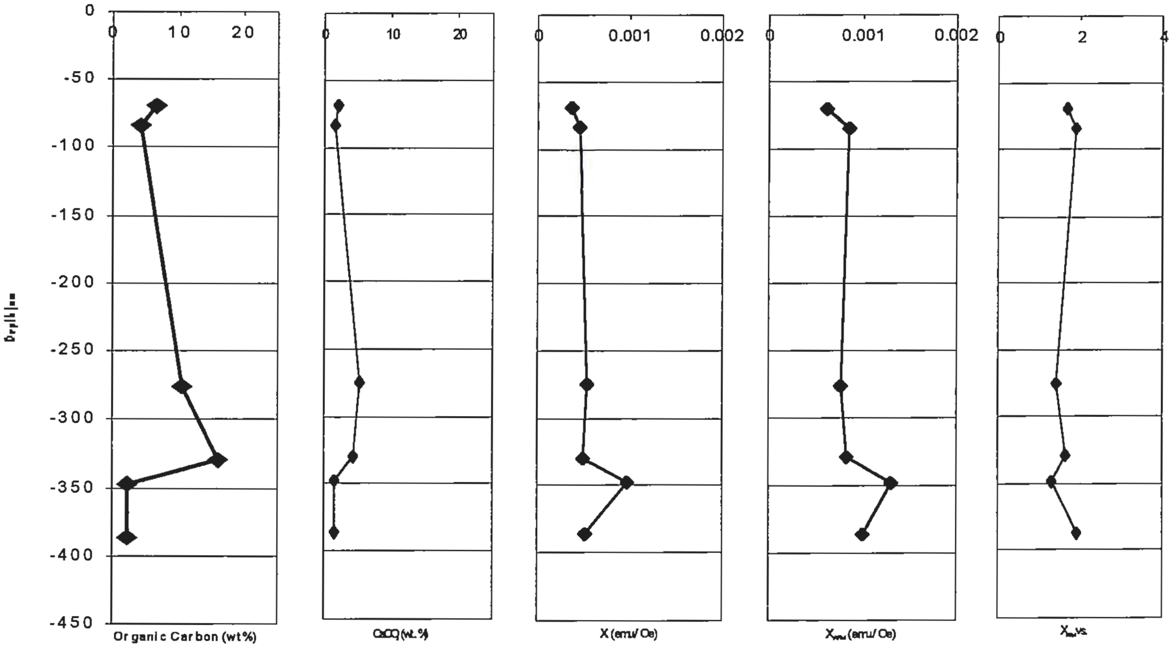


Figure 21. LOI and Magnetic Susceptibility profiles for Core 1.

X_{ARM} is combined with fine-grained magnetic particles. At 324-336 cm there is an the increase in TOC accompanied by a decrease in $CaCO_3$, but there is no accompanying magnetic data. At 385-389 cm there is an increase in TOC. There is also the pattern of high susceptibility and fine grain size. From 336-360 cm, the susceptibility is high, but magnetite is coarse grained. Fluvial processes are suggested for this sediment.

Core 3 shows a steadily decreasing TOC over the length of the core (ig. 22). $CaCO_3$ is leached from the entire core, possibly due to modern pedogenic processes. The core also shows a large increase in magnetic susceptibility at the base of the core. Fine grained magnetite is predominant through the length of the core. At the base of the section, approximately 400 cm, the grain size increases to .001 mm. The coarser nature

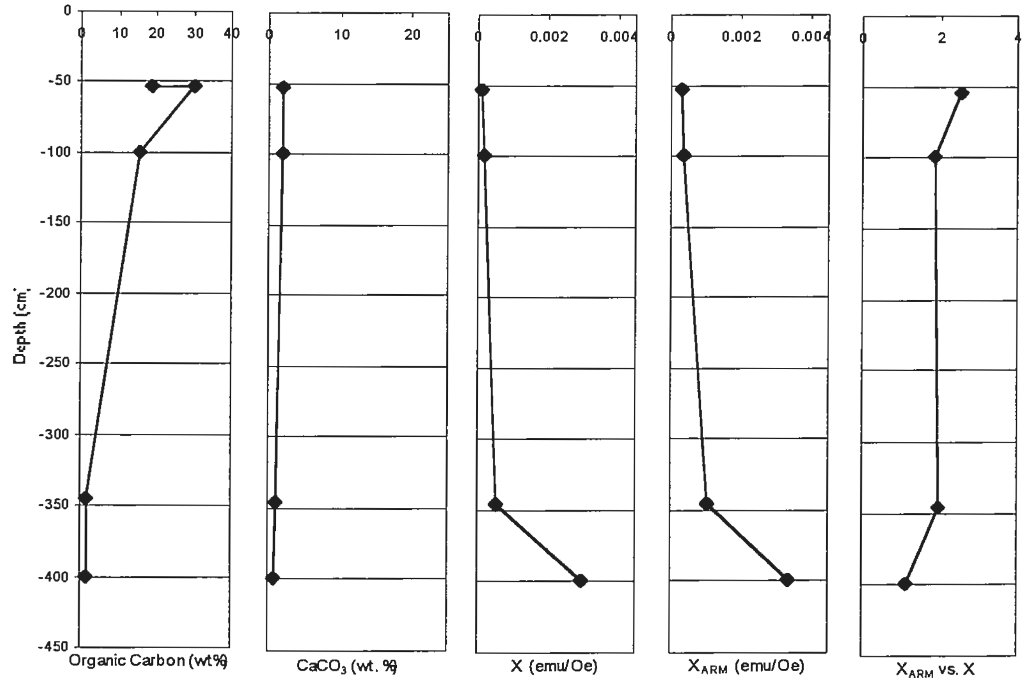


Figure 22. LOI and Magnetic Susceptibility profiles for Core 3.

of the magnetite, as well as the increase in magnetite concentration and susceptibility can be explained by paleogeomorphology. The base of the section is composed of a coarse pebbly sand which probably marks an old location of the main channel of the St. Louis River. Heavy mineral concentration by winnowing out of fine grains provides an adequate explanation for the anomalous behavior. No paleosols are suggested by the magnetic data.

Core 9 is leached of $CaCO_3$ throughout the entire core (Fig. 23) and the organic carbon content is very high with peat layers at 92-95 cm, 136-166 cm, 185-189 cm, and 192-195 cm. These layers all contain fine-grained magnetite. The magnetic susceptibility of these sediments is low, which may be explained by the very low concentration of magnetite in the intervals. The presence of peat along with the high magnetic susceptibility and high TOC's are evidence of intense vegetation in these intervals. From 123-134 cm, there is a jump in magnetite concentration and in total

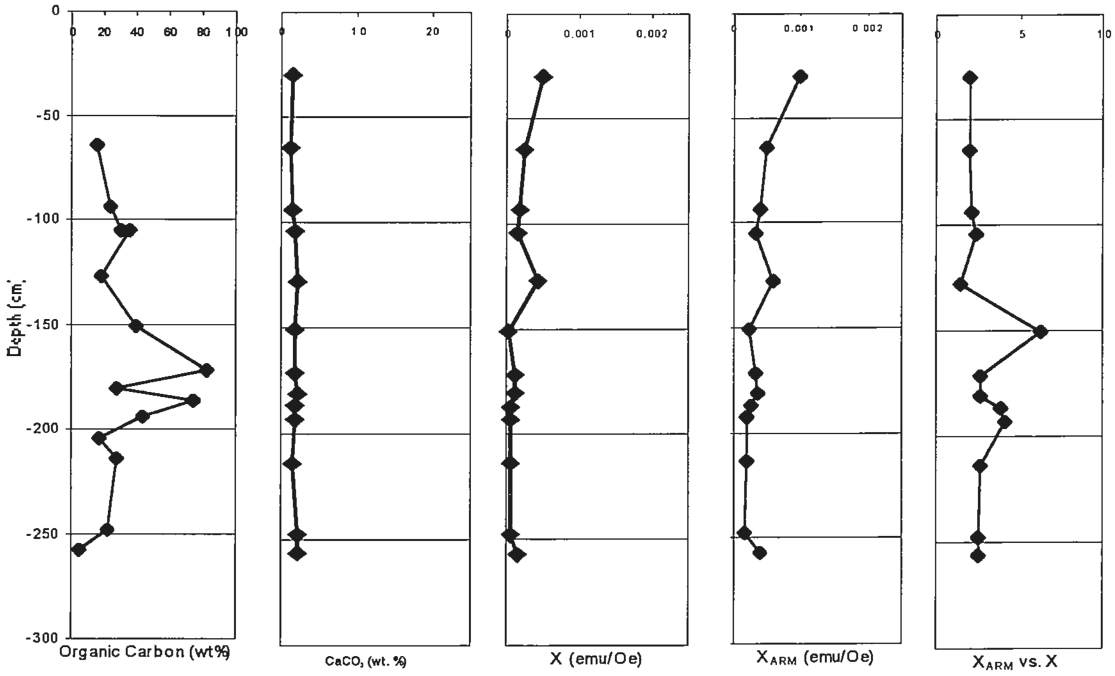


Figure 23. LOI and Magnetic Susceptibility profiles for Core 9.

susceptibility, but the magnetite is coarse grained. Fluvial processes are inferred as the cause. In the section from 136-177 cm, the organic carbon content increases dramatically while there is a minor drop in the $CaCO_3$ content. From 166-185 cm, there is both an increase in overall susceptibility and a decrease in grain size. This represents a possible paleosol. From 250-265 cm, there is again an increase in the magnetic character and concentration of magnetic grains, but the grain size remains coarse. Fluvial processes must once again be considered for this pattern.

Core 11 has two peaks in the X and X_{ARM} (Fig. 24). At 135 cm the magnetite is slightly coarser grained. From 139-145 cm, the $CaCO_3$ is relatively low, and may represent a poorly developed soil. The peak at 183-195 cm corresponds with finer grained magnetite, and may represent a paleosol.

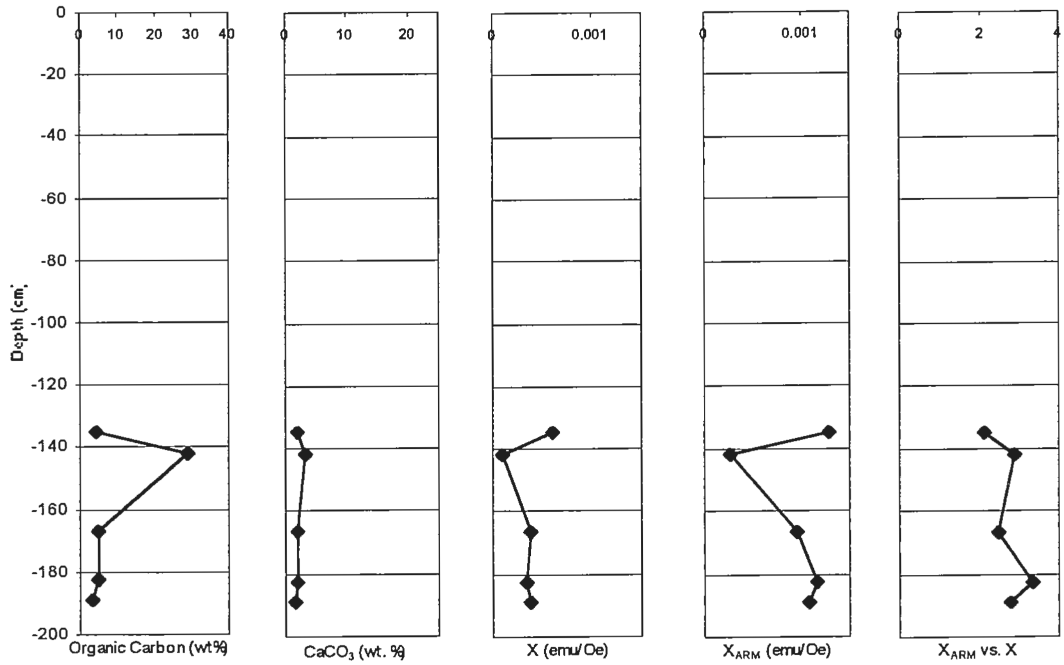


Figure 24. LOI and Magnetic Susceptibility profiles for Core 11.

Core 14 shows one peak in TOC from 70-100 cm (Fig. 25). Carbonate is leached throughout the core, increasing slightly by 200 cm. A general increase in X and X_{ARM} from 30-70 cm along with the very fine-grained nature of the magnetite from 30-50 cm suggests a paleosol. A second paleosol is inferred from 80-100 cm by a peak in the susceptibility and a fine grain size. An increase in TOC from 211-231 cm may represent a paleosol.

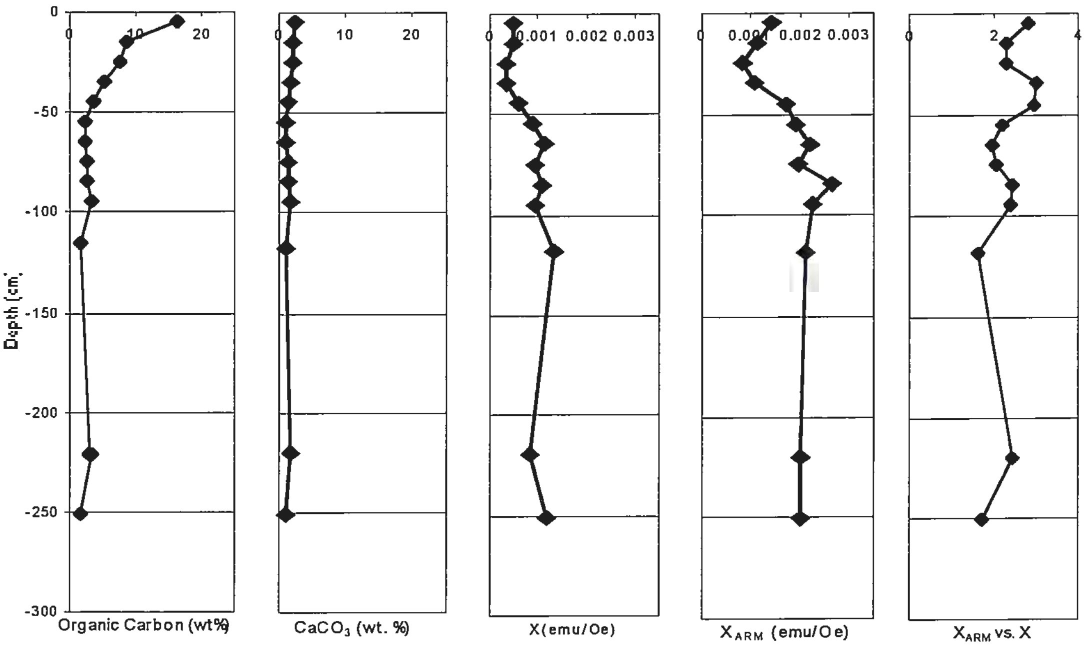


Figure 25. LOI and Magnetic Susceptibility profiles for Core 14.

Core 15 displays evidence of 3 possible paleosols (Fig. 26). An increase in TOC from 20-30 cm is accompanied by a decrease in $CaCO_3$. A peak in X and X_{ARM} at 30-40 cm is accompanied by finer-grained magnetite. This provides strong evidence for a paleosol. A second increase in TOC and decrease in $CaCO_3$ occurs at 80-100 cm. For the same interval, there is an increase in the susceptibility comes at 80-100 cm which is also accompanied by finer grained magnetite. High magnetic susceptibilities are also seen from 188-197 cm and from 267-280 cm. Both of these intervals have fine grained magnetic minerals. An extremely high TOC is seen from 267-280 cm. This interval also has very high $CaCO_3$ content. The high $CaCO_3$ may be evidence of a shorter interval for the formation of the paleosol.

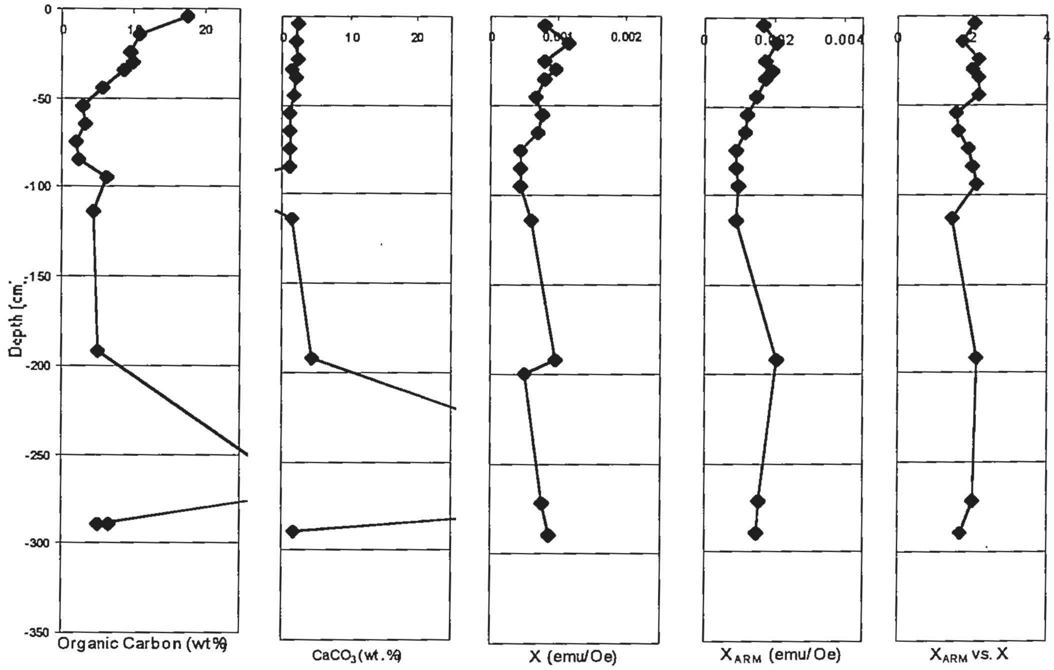


Figure 26. LOI and Magnetic Susceptibility profiles for Core 15.

Core 18 has increased TOC in the interval from 70-180 cm, however the $CaCO_3$ content increases greatly over the later part of the interval (Fig. 27). $CaCO_3$ enrichment is usually seen below well developed soils. The increase in this interval may reflect the high degree of modern pedogenesis. Higher susceptibility from 55-80 cm is due to relatively fine-grained magnetite. The interval from 70-80 cm may represent a paleosol.

Core 18 displays the widest range of grain sizes for the magnetic minerals. The extremely fine grained magnetite from 105-110 cm and its low susceptibility are explained by the sedimentary environment. The fine grains are due to a calm settling basin, allowing the thin clay layer to be deposited. Increased TOC content at 205 cm, and an elevated magnetic susceptibility from 200-210 cm is interpreted as a paleosol.

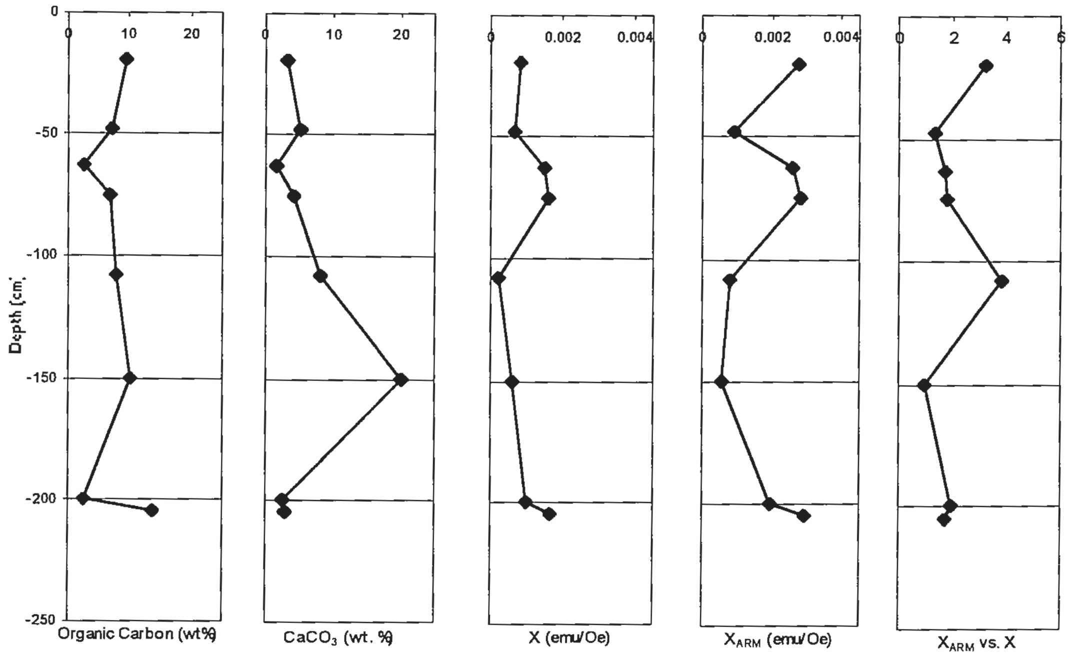


Figure 27. LOI and Magnetic Susceptibility profiles for Core 18.

Core 27 shows evidence of two possible paleosols (Fig. 28). From 60-67 cm and from 100-125 cm there are increases in the organic carbon content combined with decreased $CaCO_3$. There is a slight increase in magnetic susceptibility from 65-67 cm which is also finer grained in nature. This may represent a paleosol. Core 27 has anomalously large susceptibility for the 80-90 cm section which is interpreted to be the result of fluvial processes as the grain size is larger and magnetite is so abundant.

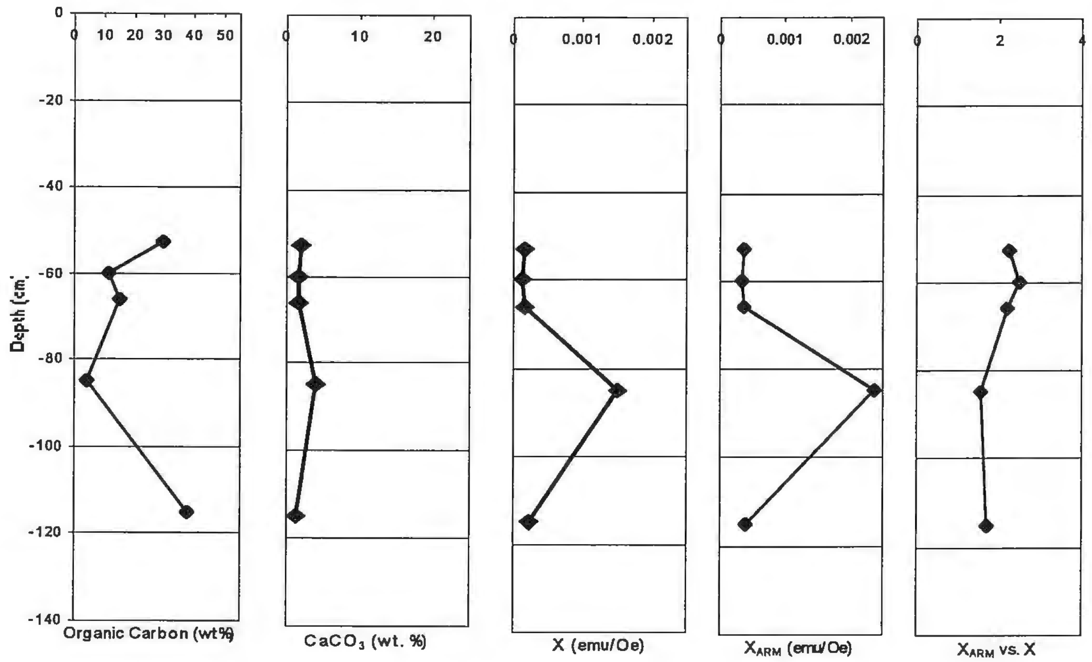


Figure 28. LOI and Magnetic Susceptibility profiles for Core 27.

Paleogeography

The Glacial Lake Duluth lake plain rises from 195 m near Lake Superior to greater than 304 m near Cloquet and Wrenshall. Along most of the river and estuary, the bluffs on either side are composed of massive or laminated red clay. This is the sediment commonly associated with the lake bed of Glacial Lake Duluth. At a few locations in Reach 3 however, fine sand and gravel are exposed. Along Pokegama Bay, Little Pokegama Bay, Spirit Island, and Clough Island, exposures of these sediments may be seen. The fine sand is brown to brownish red in color and typically exhibits climbing ripples (Fig. 29). The crossbedded ripples indicate a paleocurrent from northeast to


Figure 29. Climbing ripples, indicating northeast to southwest currents, Spirit Island.


Figure 30. Coarse gravel channel in sand, eastern Clough Island.

Figure 31. Deformed lake clay, overlying coarse sand, eastern Clough Island.

Figure 32. Slope failure scar in bedded sands, east of Dwight's Point.

southwest. To the east, the sand is interbedded with clay, and eventually grades into red clay. Overlying the fine sand is coarse sand and gravel. The coarse sand is dark reddish brown, and contains pebbles of basalt, rhyolite, agate, and clay clasts. The coarse sand is typically massive, and does not show any sedimentary structures. When present, the gravel is channelized into the sand. (Fig. 30). It has crossbeds approximately 1 meter thick, and commonly occurs in lenses. Overlying the sand and gravel is the red clay. The clay is commonly laminated, and occasionally deformed.(Fig. 31). Numerous small-scale slope failure structures are also seen throughout the area.(Fig. 32) The association and structure of these sediments is suggestive of a delta deposit. Because of the local topography, sloping gently to the northeast, and the paleocurrent towards the southwest, a non-local agent must be responsible for the deposit. The lateral grading of the sand and gravel to clay indicates that the margin of the Superior Lobe was present as an ice dam, and the complex was formed contemporaneously with the clays of Glacial Lake Duluth. All of these features aid in the interpretation of this as a subaqueous outwash delta deposit in front of the receding Superior Lobe.

Along the lower St. Louis River, 20 abandoned meanders were located (Table 3). The relative time of abandonment for each meander was determined using the elevation difference between the modern channel and the meander, and the average incision rate. In the region of the estuary, the river lies about 12 m below the surrounding lake plain. At its greatest extent, the St. Louis River has cut more than 90 m into the lake plain. The youngest age estimate for the final drop in lake levels is given by Farrand and Drexler (1985), as the fall from the Glacial Lake Minong level at 9500 yrs. BP. Radiocarbon analysis on wood from an abandoned meander in Jay Cooke State Park gave a date of

Text Name	Elevation Above Sea Level (m)	Elevation Above St. Louis River (m)	Geomorphic Region
Meander 1	384	25	Reach 1
Meander 2	378	19	Reach 1
Meander 3	375	16	Reach 1
Meander 4	347	13	Reach 1
Meander 5	241	30	Reach 2
Meander 6	238	29	Reach 2
Meander 7	375	12	Reach 1
Meander 8	350	10	Reach 1
Meander 9	226	14	Reach 2
Meander 10	369	8	Reach 1
Meander 11	332	7	Reach 1
Meander 12	223	12	Reach 2
Meander 13	329	4	Reach 1
Meander 14	192	19	Reach 2
Meander 15	369	5	Reach 1
Meander 16	187	4	Reach 3
Meander 17	186	3	Reach 3
Meander 18	184	1	Reach 3
Meander 19	184	1	Reach 3
Meander 20	183	0	Reach 3

Table 3. Elevation and geomorphic location of the abandoned meanders.

approximately 5000 yrs. BP for the final abandonment of that channel. The river has subsequently cut down 12 m from that level. In Reach 1, the St. Louis River flows through the Cloquet Moraine. This moraine was deposited by the Split Rock Phase of the Superior Lobe approximately 13000 yrs. BP. In this area, the river has incised about 30 m. With the knowledge of when the lake level dropped, and the total amount of incision that has taken place, a rough estimate of the rate of downcutting can be made. (Fig. 33). Meanders occurring in Reach 1 were dated using the Cloquet Moraine the original level.

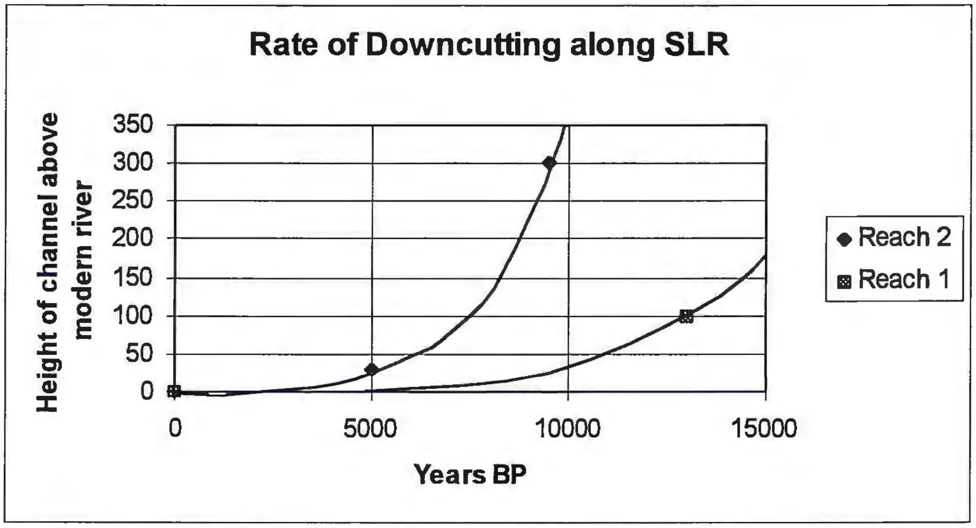


Figure 33. Model for the rate of incision along the lower St. Louis River.

Meanders occurring in Reach 2 were dated using the Glacial Lake Duluth lake plain as the original level. The height of the abandoned meander above the St. Louis River was plotted along the y-axis of Figure 33. The estimated time of abandonment was then obtained by following intersection of the appropriate curve to the x-axis. The oldest channels occur up river from Cloquet, where the early St. Louis River began reworking the Cloquet Moraine almost 13,000 years BP. Meanders 1 and 2 correlate with ages of about 11,000 yrs. BP. The third meander was abandoned less than 10,000 years BP. Meanders 4-6, have ages of approximately 7,000 yrs. BP. Meanders 7-9 are estimated to be from 5,000 yrs. BP. Meanders 10-12 were abandoned around 4,000 yrs. BP. Meanders 13 and 14 were abandoned about 3,000 yrs. BP. Less than 2,000 yrs. BP, meanders 15 and 16 were abandoned. In the last 1,000 years, 17-20 were abandoned.

Archaeological Implications

A survey of site reports from the Minnesota State Historic Preservation Office returned 16 known prehistoric archaeological sites along the St. Louis River (Fig. 34). Four of these sites are located in a group in Sec. 11, T48N, R15W on a low terrace in Reach 2. The sites are listed as precontact. No cultural tradition could be identified from the scattered lithics and debitage. An earliest time of occupation of 3,000 yrs. BP can be estimated by using the average rate of incision for the St. Louis River in Jay Cooke State Park, and the height of the terrace above the river, 5 m. This indicates that the site most likely belongs to the latest Archaic or Woodland tradition. A group of five sites are located in Sections 17 and 20, T48N, R16W, north of Wrenshall, Minnesota. They are

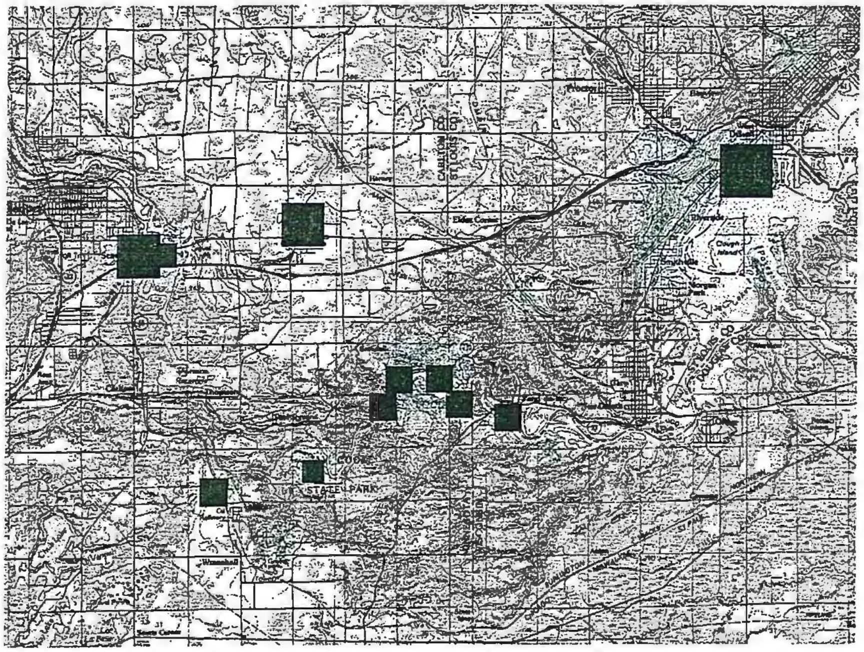


Figure 34. Archaeological Sites along the St. Louis River.

situated on an old shore line of Glacial Lake Duluth. The sites are listed as belonging to the Plano context of the Paleoindian tradition. They were identified by the presence of Agate Basin projectile points, made from Knife River Flint. The time range for the Plano culture is given as 8,500 to 6,000 yrs. BP (Dobbs, 1988). This site was thus occupied long after the retreat of Glacial Lake Duluth. Another precontact site was identified based on debitage on meander 9 in Reach 2. The artifact assemblage was not indicative of any specific cultural tradition, however, a maximum age of 5,000 yrs. BP can be estimated from the time of abandonment of the meander. This site cannot be from the Paleoindian tradition, and should belong to either the Archaic or Woodland tradition. On meander 14 in Reach 2, another general precontact site was identified by lithic debitage. The site is most likely Woodland tradition since this meander was abandoned around 3,000 yrs. BP. Two sites are located in Jay Cooke State Park along the Grand Portage Trail. These have long been known by historic account. The last two sites are found in Sec. 30, T49N, R16W, on meanders 8 and 11 in Reach 3. They are listed as precontact sites and were identified by lithic tools and debitage. The meanders that the sites occur on were abandoned around 4,000 to 5,000 yrs. BP. Using this age, these most likely represent Archaic or Woodland sites. Another four sites in Minnesota were located from historic accounts (Fritzen, 1978). These are located on Minnesota Point, Rice's Point, Indian Point, and Nekuk Island near Fond du Lac. These are listed as early Chippewa villages. A similar search was done of Wisconsin site reports. The search located sites along the Pokegama and Nemadji Rivers, but no sites directly associated with the St. Louis River. One of the many difficulties in archaeological studies is obtaining dates for sites. Knowing the age of a site can aid in the assignment of that site to a specific cultural tradition. For sites along the St. Louis River, approximate maximum ages can be estimated if two criteria are met. The site needs to be on either an abandoned channel, or terrace of the river. It will also be necessary to determine the total amount of incision that has taken place at this location. This method does not give exact ages of occupation, and gives no estimate for the minimum age. It can, however, be useful for narrowing the possible cultural contexts.

The elevation of the surface of Lake Superior controls the location of the shore line, and the environment of the St. Louis estuary. Only when the lake level has been at, or above, its present level can shore lines be preserved. This means that archaeological sites in Reach 1 associated with lower lake levels are most likely under water now. This is especially important in the vicinity of Duluth, where the relative rise in lake level is 30 cm per 100 yrs. Throughout the history of the lake, the shore line has been above modern levels sporadically from about 12,000 to 9,500 yrs. BP, and then again from around 6,000 to 3,000 yrs. BP (Farrand and Drexler, 1985). There is little doubt as to the reason for the sparse archaeological record for estuary and shore line sites: as any cultural remains have been deeply buried by both sediment and water. The location of vegetated levels deep within the estuary sediments demonstrate this idea. The early Woodland sites of 2,000 yrs. BP are 5 m deep in the estuary. The activity of the St. Louis River has destroyed most stable buried land surfaces. These surfaces do exist, and present further possibility of deeply buried archaeological sites within the area.

CONCLUSION

There are five organic layers within the shallow subsurface of Reach 3 of the lower St. Louis River. Total organic carbon profiles confirm paleosol locations, and identify woody layers. Paleosols are further defined by magnetic susceptibility profiles. Plots of X_{ARM} vs. X provide estimates of grain size and concentration of magnetite. The upper two layers, paleosol 1 and 2, are shallow paleosols, 25-50 cm and 100-150 cm deep. The third and fourth layers, peat 1 and 2, are dense peaty accumulations of plant material at 160-250 cm and 320-390 cm. The deepest layer, wood 1, is composed of wood at 400-470 cm. Radiocarbon analysis yielded dates of 250-5 yrs. BP(150 +/- 40 BP) for paleosol 2, 404-315 yrs. BP(390 +/- 40 BP) on peat 1, 930-740 yrs. BP(920 +/- 40 BP) for peat 2, and wood 1 was dated at 1895-1715 yrs. BP(1880 +/- 40 BP). In Reach 3, near Fond du Lac, the sedimentation rate, calculated from the depth and age of the organic layers, is approximately 80 cm per 100 yrs. The high sediment load is due to erosion within Reaches 1 and 2, and fluvial deposits within these reaches are usually no deeper than 5 m due to channel reworking. Stratigraphy within the estuary confirms the 30 cm per 100 yrs. lake level rise, and suggests an equivalent rate for sedimentation in the harbor. The sedimentary sequence in Reach 3 reflects the lake level change in the Holocene. Sediments fine upwards to clays around 16 m of depth, representing the Nipissing highstand. This is followed by the wood layer at 4-6 m, representing the Sault Lowstand. The overlying silts and sands were deposited by the transgressing shore over the Sault age forest.

Exposures of clay, sand, and gravel are found throughout Reach 3 from river level to 195 m. Climbing ripples, scoured gravel crossbeds, and slope failure structures indicate an outwash origin, while interfingering clay places the fan in a subaqueous environment. While the Superior Lobe dammed Glacial Lake Duluth, outwash poured from the ice margin into the lake, forming the subaqueous fan structure. The fall from the Glacial Lake Duluth level caused deep entrenching of the St. Louis River. In the estuary, 12 m of incision has taken place while 30 meters of downcutting has occurred near the Cloquet River. The St. Louis River flows more than 90 m below the lake plain in Reach 2. The total amount that the St. Louis River has entrenched, along with the times of lake recession can be used to determine the rates of downcutting along the river. The time of abandonment of former channels of the river can be determined from their location along the river, and the amount of entrenchment that has taken place subsequent to their disuse. In a similar manner, the maximum age of archaeological sites that occur on fluvial landforms of the St. Louis River can be determined. Due to channel reworking, and high sedimentation rates, deeply buried Woodland sites may be expected in fluvial deposits along Reaches 1 and 2. Only shoreline sites associated with the Paleoindian and Late Archaic would be above the current shore line of Lake Superior and in Reach 3. Within the estuary sediments from 9,500-6,000 yrs. BP and 3,000-0 yrs. BP can be expected to be buried at various depths.

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Appendix A

1, Sec. 2, T48N, R15W , 9-11-99

0-30cm.	Dark brown silty organic peat, loose blocky texture. Gradational transition.
30-61cm.	Brownish red mottled clayey silt, abundant roots, loose. Gradational transition.
61-77cm.	Brownish red silt, mottled, clayey at 74cm. Sharp transition.
77-98cm.	Brown silty fine sand, clayey at 80-81cm, black mottles throughout. Sharp transition.
98-101cm.	Brown medium grained sand, loose. Sharp transition.
101-121cm.	Brownish red silty clay, black mottles, little organics (charcoal?). Sharp transition.
121-169cm.	Brown sandy silt to silty sand, coarsening up to a fine to medium sand. Some organics (possibly roots). Sharp transition.
169-198cm.	Brown sandy silt, coarsening upwards to a fine to medium sand. Sharp transition.
198-230cm.	Brown silty sand coarsening upwards to a fine sand. Sharp transition.
230-286cm.	Brown silty sand, coarsening upwards to a coarse to medium sand, very loose. More compact at base, last 20cm have lots of organics, with a distinct layer at 276cm. Sharp transition.
286-324cm.	Brown coarse to medium sand, loose, slightly organic from 318-320cm. Sharp transition.
324-336cm.	Brown to black sand to sandy silt, abundant wood. Sharp transition.
336-378cm.	Brown to brown red compact silty clay, coarsening upwards to a medium to coarse sand, loose, some organic material at 340cm. Sharp transition.
378-463cm.	Brown coarse sand, some siltier and finer layers, abundant organic material from 385-389cm. Sharp transition.
463->480cm.	Very coarse sand? Would not come up, stopped core at 480cm.

1, Sec. 5, T48N, R15W , 8-9-99

0-40cm.	Dark brown clayey sand, slightly pebbly, loosely compacted. Abundant roots with light tan and black mottling. Last 8cm contained small inclusions of sand. Gradational transition.
40-66cm.	Reddish brown fine silty sand, mottled dark brown. Occasional roots. Sharp transition.
66-75cm.	Brownish red clay with abundant organic material, black and brown mottles. Sharp transition.
75-88cm.	Brownish red clayey silt, cohesive with black and orange mottles. Possibly laminated, very wet. Water table at 85cm. Sharp transition.
88-120cm.	Brown to reddish brown fine sand, non-cohesive. Sharp transition.
120-125cm.	Dark brown to black organic clay. Sharp transition.
125-172cm.	Red to reddish brown sand, non-cohesive. Sharp transition.
172-176cm.	Dark brown to black organic peat layer. Sharp transition.
176-190cm.	Grey/brown cohesive clay. Clay inhibited further penetration.

1, Sec. 7, T48N, R15W , 8-13-99

0-29cm.	Dark brown, silty sand, compact and slightly blocky, becomes mottled orange at 26cm. Large arkosic sand nodule at 24-26cm. Gradational transition.
29-109cm.	Reddish brown fine sand to silty sand, loosely compacted, abundant orange mottles. Organic rich layers at 96 and 105cm. Peat layer from 108-109cm. Sharp transition.
109-174cm.	Grey to grey/brown sandy silt, compacted, occasional brown mottles and organic material disseminated throughout. Some clay rich areas. Organic material abundant at 133 and 146cm. Sharp transition.
174-188cm.	Brown medium to fine sand, poorly compacted. Sharp transition.
188-204cm.	Grey/brown sandy silt, lightly compacted. Organics throughout. Sharp transition.
204-211cm.	Brown fine sand, loose. Sharp transition.
211-217cm.	Grey/brown sandy silt, compacted, occasional organics. Sharp transition.
217-264cm.	Brown fine sand to medium sand. Sharp transition.
264-268cm.	Brown clay, streaked with black, very coherent. Sharp transition.
268-274cm.	Grey/brown fine sand, loose. Sharp transition.
274-282cm.	Grey silty clay, coherent, streaked black throughout. Sharp transition.
282-292cm.	Grey/brown sandy silt, slightly coherent. Sharp transition.
292-299cm.	Brown to grey/brown medium to fine sand, non-coherent. Sharp transition.
299-317cm.	Brown clay becoming grey towards the base, coherent, streaked black throughout. Gradational transition.
317-342cm.	Grey/brown silty sand, occasional coarser lenses. Gradational transition.
342-350cm.	Brownish red medium to coarse grained sand, non-coherent. Core stopped by sand.

2, Sec. 7, T48N, R15W , 8-27-99

0-28cm.	Dark brown silty sand, loose blocky texture, abundant roots. Gradational transition.
28-125cm.	Brown to tan medium sand, loosely compacted. Sharp transition.
125cm-?	Red brown gravel and clay. Stopped at 125cm by rock (gravel).

3, Sec. 7, T48N, R15W , 8-31-99

0-58cm.	Dark brown silty sand, loose, some disseminated organics. Gradational transition.
58-72cm.	Reddish brown coarse sand, loose. Sharp transition.
72-98cm.	Reddish brown coarse sand and wood (modern?). Sharp transition.
98-110cm.	Reddish brown coarse sand, loose. Sharp transition.
110-134cm.	Dark brown silty sand, slightly compact, some rootlets, (paleosol?). Gradational transition.
134-179cm.	Brown medium to coarse sand, loose. Sharp transition.
179cm-?	Gravel, stopped core.

4, Sec. 7, T48N, R15W , 8-31-99

0-20cm.	Dark brown pebbly silty sand, loose, organics abundant. Gradational transition.
20-56cm.	Reddish brown silty sand, slightly compact.
56-69cm.	Brown to brown red silty clay, mottled throughout, (laminated?). Gradational transition.
69-80cm.	Red brown fine sand, loose, mottled. Gradational transition.
80-155cm.	Brown medium to coarse sand, 2-3cm sandstone concretions at 115cm.
155cm-?	Gravel, stopped core.

5, Sec. 7, T48N, R15W , 8-26-99

0-78cm.	Dark brown to black organic silty sand, loose. Sharp transition.
78cm-?	Red brown medium to fine sand, slightly compact.

6, Sec. 7, T48N, R15W , 8-26-99

0-10cm.	Dark brown organic rich pebbly gravel. Possibly fill from the adjacent road. Stopped repeatedly at 5-10cm by gravel.

1, Sec. 8, T48N, R15W , 8-9-99

0-8cm.	Dark brown, fine sand, loose with abundant roots. Gradational transition.
8-54cm.	Mottled brown, light brown sand, lightly compacted with roots. Gradational transition.
54-61cm.	Red brown, fine sand, wet loose. Water table at 60 cm. Sharp transition.
61-69cm.	Brown organic sandy layer, lots of wood. Sharp transition.
69-92cm.	Red brown fine sand. Sharp transition.
92-95cm.	Dark brown organic peat, wood. Sharp transition.
95-102cm.	Red brown fine sand, slightly cohesive. Sharp transition.
102-108cm.	Brown to black organic material. Sharp transition.
108-123cm.	Red brown fine sand, slightly cohesive. Sharp transition.
123-134cm.	Brown to black organic material, wood. Sharp transition.
134-156cm.	Reddish brown, fine sand, loosely compacted. Sharp transition.
156-177cm.	Black peat, dense. Sharp transition.
177-185cm.	Light brown to brown organic rich sand, slightly compact. Sharp transition.
185-189cm.	Black organic peat. Sharp transition.
189-192cm.	Red to reddish brown medium sand, loose. Sharp transition.
192-195cm.	Black organic peat. Sharp transition.
195-218cm.	Brown organic rich sand, compact. Sharp transition.
218-249cm.	Reddish brown sand, moderately compact. Organic peat from 248-249cm. Sharp transition.
249-270cm.	Grey silt with occasional organics. Hole closed in at 270cm.

2, Sec. 8, T48N, R15W , 8-22-99

0-9cm.	Dark brown fine sand, loose, blocky, abundant roots. Gradational transition.
9-51cm.	Reddish brown mottled sand, loosely compacted, roots. Gradational transition.
51-102cm.	Reddish brown medium grained sand, slightly compact. Gradational transition.
102-128cm.	Grey brown fine sand, loose, organic material from 126-128cm, and dispersed throughout. Gradational transition.
128-155cm.	Grey to grey brown sand, loosely cohesive. Sharp transition.
155-157cm.	Dark brown organic material, wood. Sharp transition.
157-250cm.	Red brown silty sand, some coarser sections, loosely compact. Sharp transition.
250-306cm.	Laminated grey/brown clay to silt, well compacted. Sharp transition.
306-460cm.	Interfingered brown to red, clays and silty sands. The hole closed in at 300cm, the last 160cm are suspect.

3, Sec. 8, T48N, R15W , 8-27-99

0-33cm.	Dark brown silty sand, loose, abundant roots. Gradational transition.
33-125cm.	Light brown to tan fine to medium sand, slightly cohesive. Gradational transition.
125-145cm.	Light brown fine sand, roots and organic material at 133cm and 139-145cm. Water table at 130cm. Sharp transition.
145-198cm.	Light brown to orange clayey silt, moderately cohesive, mottled orange throughout, more clay rich in the first 10cm and at 180cm. Wood layer at 185cm. Sharp transition.
198-245cm.	Brown medium to fine sand, loose. Sharp transition.
245cm-?	Gravel, stopped core.

1, Sec. 9, T48N, R15W , 8-9-99

0-32cm.	Dark brown, pebbly sand, loose blocky, abundant roots, some charcoal A Horizon. Sharp transition
32-62cm.	Tan to brownish red silty sand, cohesive, some roots, little charcoal. Gradational transition
62-83cm.	Mottled brown to red clayey fine sand with yellow sandy lenses. Gradational transition.
83-103cm.	Reddish brown to dark brown clayey silt, cohesive with rusty and black mottling being more abundant at the top. possibly laminated. Roots end at 90 cm. Gradational transition.
103-115cm.	Reddish brown clayey silt, very little mottling. More clay rich from 112-115cm.
115cm-?	Yellow brown fine sand, very cohesive, stopped the hole.

2, Sec. 9, T48N, R15W , 8-9-99

0-32cm.	Dark brown clayey sand, loose granular texture. Abundant roots and occasional charcoal. Gradational transition.
32-56cm.	Light red/brown silty clay, becoming more sandy and mottled red from 50-56cm. Few roots. Sharp transition.
56-155cm	Brownish red fine sand with red mottles. Non-compact, very wet. More clay rich from 120-128cm, yellow sand from 128-133cm. Water table at 63cm. Gradational transition.
155-195cm.	Grey to grey/brown mottled sand to silty clay. Possibly laminated at base. Hole closed and prevented deeper penetration.

3, Sec. 9, T48N, R15W , 9-4-99

0-19cm.	Dark brown sandy silt, loose, blocky texture, roots abundant. Gradational transition.
19-86cm.	Light brown sandy silt, loose, more sandy from 55cm. Water table at 50cm. Sharp transition.
86-103cm.	Light brown clay rich sandy silt, compact. Sharp transition.
103-242cm.	Brown medium sand, loose, clayey from 142-151cm, 166-174cm, 192-200cm, 211-217cm, and 227-231cm. Sharp transition.
242-295cm.	Reddish brown coarse sand, loose. Sharp transition.
295cm-?	Gravel, stopped core.

4, Sec. 9, T48N, R15W , 9-25-99

0-11cm.	Dark brown sand, granular structure. Gradational transition.
11-22cm.	Light brown medium to coarse sand, some roots. Sharp transition.
22-41cm.	Dark brown, fine sand, loose, abundant roots, (paleosol?). Gradational transition.
41-56cm.	Light brown fine to medium sand. Sharp transition.
56-84cm.	Brown coarse sand, becoming dark brown and finer towards base. Sharp transition.
84-128cm.	Brown coarse sand, very loose, becomes finer towards base, organic material at 112-117cm. Gradational transition.
128-188cm.	Brown coarse sand, loose. Gradational transition.
188-202cm.	Brown to grey silt to fine sand, disseminated wood. Contains two minor finning upwards sequences. Sharp transition.
202-267cm.	Red coarse pebbly sand, loose. Sharp transition.
267-280cm.	Reddish brown fine to medium sand containing abundant organic material. Hole filled in at 280cm.

1, Sec. 10, T48N, R15W , 8-23-99

0-12cm.	Red brown organic rich clay to silty clay, loosely compacted. Gradational transition.
12-53cm.	Red brown clay, with pebbles, cohesive, organics decrease below 30cm. Stopped at 53cm by rock (gravel?).

2, Sec. 10, T48N, R15W , 8-23-99

0-10cm.	Red brown medium sand, loose, blocky, lots of roots. Gradational transition.
10-48cm.	Red brown medium to coarse sand, minor roots throughout. Stopped at 48cm by rock (gravel?).

1, Sec. 11, T48N, R15W , 8-24-99

0-40cm.	Brown pebbly clay, occasional black mottles, abundant organic material. Gradational transition.
40-55cm.	Brown pebbly clay, Gradational transition.
55-70cm.	Brown medium to coarse pebbly sand, very loose. Gradational transition.
70-80cm.	Dark brown pebbly sand, organics throughout. Gradational transition.
80-105cm.	Brownish red medium sand, slightly coherent, grading into red clay. Gradational transition.
105-110cm.	Red clay, very compact. Sharp transition.
110-120cm.	Reddish brown clay , fissile. Gradational transition.
120-180cm.	Grey/green silt to fine sand, loosely compact, occasional pebbles of basalt. Interfingers with reddish brown clay at the top, and has abundant red clay inclusions from 140cm. Sharp transition.
180-220cm.	Reddish brown pebbly coarse sand, loose, slightly clayey from 195-205cm. Organic layer at 205cm.
220-250cm.	Very loose gravel which would not come up.
250cm-?	Red clay.

1, Sec. 14, T48N, R16W , 9-1-99

0-31cm.	Dark brown silty sand, loose, roots and organic material abundant. Gradational transition.
31-54cm.	Reddish brown, sandy silt, slightly compact, mottled. Gradational transition.
54-142cm.	Dark red brown medium sand, loose, mottled. More silty form 85-90cm. Gradational transition.
142-201cm.	Very loose coarse sand, would not come up. Sharp transition?
201cm-?	Gravel?, core stopped at 201cm by rock.

1, Sec. 15, T48N, R16W , 9-1-99

0-30cm.	Dark brown clayey silt, blocky, abundant roots and charcoal (modern forest fire?). Gradational transition.
30-79cm.	Brown to light brown silty clay , compact, mottled. Gradational transition.
79-105cm.	Brownish red medium sand, loose. Gradational transition.
105-156cm.	Brown silty clay, compact, mottled. Gradational transition.
156-174cm.	Reddish brown clayey silt, slightly compact, red and grey mottles throughout. Gradational transition.
174-209cm.	Brown silty sand, slightly compact, mottled. Disseminated organics, with abundant organic material at 184-195cm and 207-209cm. Sharp transition.

209-245cm.	Brown coarse sand, loose, organic material at 231-234cm. Sharp transition.
245cm-?	Gravel, stopped core.

1, Sec. 19, T49N, R14W , 9-19-99

0-11cm.	Dark brown medium sand, loose, abundant roots. Gradational transition.
11-129cm.	Brown fine to medium sand, slightly coarser towards bottom. Gradational transition.
129-190cm.	Brown to grey very fine sand to silty sand, wet, would not come up in split spoon. Stopped at 190cm by sand?

1, Sec. 23, T49N, R15W , 9-19-99

0-19cm.	Dark brown medium sand, blocky, abundant roots. Gradational transition.
19-134cm.	Light brown medium sand, loose. Gradational transition.
134-160cm.	Brown coarse pebbly sand, very loose. Sharp transition?
160cm-?	Very dense clay? stopped core.

1, Sec. 25, T49N, R15W , 9-18-99

0-27cm.	Dark brown silt, abundant roots and organic material, loose. Gradational transition.
27-82cm.	Brown medium to coarse sand, very loose. Sharp transition.
82-156cm.	Brown medium sand, slightly coherent, abundant organics, clay rich below 130cm, organics decrease below 125cm. Sharp transition.
156-430cm.	Brown fine sand, compact, occasional organics, peat layer at 410cm (roots?). Hole filled in at 430cm.

1, Sec. 26, T49N, R15W , 9-18-99

0-11cm.	Dark brown silty sand, loose blocky texture, abundant organics. Gradational transition.
11-135cm.	Brown to tan coarse pebbly sand, loose. Gradational transition.
135-481cm.	Brown fine to medium sand, compact, disseminated organic material throughout, becomes more clayey towards base. Sandy from 442-456cm. Wood at 160-176cm, 200-210cm, 240-250cm, 325-360cm, and 456-460cm. Sharp transition?
481cm-?	Gravel?, stopped core.

1, Sec. 1, T48N, R16W , 8-10-99

0-17cm.	Dark brown, sandy soil, loose, blocky, with abundant roots and red/brown mottles towards base. Gradational transition.
17-103cm.	Reddish brown silty sand, loosely compacted, few roots ending at 70cm. and dark brown mottles at the top. Rusty mottles start at 35cm. Water table at 90cm. Gradational transition.

103-136cm.	Reddish brown silty sand, with pebbles of granite, shale, arkosic sandstone, and quartz, less than 3mm. Gradational transition.
136-143cm.	Reddish brown clayey sand, very cohesive. Gradational transition.
143-150cm.	Reddish brown medium to coarse sand. Hole stopped at 150cm by rock.

2, Sec. 1, T48N, R16W , 8-10-99

0-14cm	Dark brown loose sandy silt with reddish brown mottles at base, abundant roots. Gradational transition.
14-50cm.	Reddish brown, silty sand, well compacted but crumbly, some roots and mottles at top with most roots gone by 35cm. More clay rich by 35cm. Water table at 25cm. Gradational transition.
50cm-?	Dark brown to reddish brown pebbly coarse sand, including rhyolites, gabbros, and basalts.

3, Sec. 1, T48N, R16W , 8-10-99

0-21cm.	Dark brown silty sand, loose, abundant roots, mottled at base. Sharp transition.
21-64cm.	Reddish brown fine sand, lightly compacted. Sharp transition.
64-95cm.	Reddish brown coarse sand, loosely compacted. Sharp transition.
95-125cm.	Reddish brown coarse pebbly sand, including rhyolite, basalt, and shale. Stopped at 125cm by large pebbles.

4, Sec. 1, T48N, R16W , 8-24-99

0-40cm.	Dark brown silty sand, slightly blocky, loose, roots throughout. Gradational transition.
40-94cm.	Light brown silty sand, slightly compact, becomes more clay rich by 90cm. Gradational transition.
94-165cm.	Light brown silty clay, mottled orange occasionally, very compact. Black mottles from 115-125cm. Gradational transition.
165-203cm.	Black to grey fissile silty clay, mottled brown. Sharp transition.
203-260cm.	Reddish orange lightly compact sandy silt. Stopped at 260cm by rock (till?).

Vine Oxbow, Sec. 8, T48N, R15W

0-38cm.	Brown organic rich silty clay, abundant wood at base, slightly cohesive. Sharp transition.
38-55cm.	Brown to red brown coarse pebbly gravel, very loose. Sharp transition.
55-57cm.	Brown clayey gravel, slightly cohesive. Core stopped at 57cm by gravel.

Appendix B

sample	crucible w	total weigh	burn 1	burn 2	dry	1	2
92599,0-1	10.7914	12.845	12.6741	12.6537	2.0536	1.8827	1.8623
10-20.	10.2808	13.4771	13.3165	13.2856	3.1963	3.0357	3.0048
20-30	10.13	12.1551	12.0664	12.0463	2.0251	1.9364	1.9163
	9.5072	12.1233	12.0007	11.9839	2.6161	2.4935	2.4767
112-117	10.1764	12.5093	12.4619	12.448	2.3329	2.2855	2.2716
188-197	9.2347	13.1906	13.1237	13.048	3.9559	3.889	3.8133
197-202	11.9371	13.3132	13.0596	14.4232	1.3761	1.1225	2.4861
267-280	9.7657	14.5893	14.4513	13.0934	4.8236	4.6856	3.3277
bp	9.1622	12.0737	12.0067	11.9857	2.9115	2.8445	2.8235
bp	7.3966	10.4104	10.3229	10.2995	3.0138	2.9263	2.9029
1154815,1	11.1898	14.7441	14.6122	14.5023	3.5543	3.4224	3.3125
190-195	11.676	13.9339	13.8877	13.8142	2.2579	2.2117	2.1382
154815,20	9.586	11.8702	11.8003	11.7368	2.2842	2.2143	2.1508
231-234	11.0791	12.5126	12.4738	12.4343	1.4335	1.3947	1.3552
91199,66-	9.9534	13.5494	13.4486	13.4167	3.596	3.4952	3.4633
77-98	7.9525	11.5039	11.4381	11.412	3.5514	3.4856	3.4595
265-286	7.4512	11.1603	11.0069	10.92	3.7091	3.5557	3.4688
324-336	7.9668	12.4039	12.0933	12.006	4.4371	4.1265	4.0392
336-360	7.6995	10.7214	10.699	10.678	3.0219	2.9995	2.9785
336-360	7.5204	10.2068	10.185	10.165	2.6864	2.6646	2.6446
385-389	7.3508	10.2832	10.1685	10.1155	2.9324	2.8177	2.7647
83199,72-	9.9375	14.2508	13.9751	13.9418	4.3133	4.0376	4.0043
110-120	8.8918	10.7372	10.5977	10.5722	1.8454	1.7059	1.6804
134-140	9.7989	16.0613	15.985	15.9546	6.2624	6.1861	6.1557
314815,52	16.9612	18.7424	18.488	18.4722	1.7812	1.5268	1.511
60-60	11.2068	14.1385	13.9776	13.9552	2.9317	2.7708	2.7484
65-67	9.2063	11.1998	11.0533	11.0386	1.9935	1.847	1.8323
105-125	8.794	10.4621	10.1541	10.1443	1.6681	1.3601	1.3503
174815,54	9.6567	12.7404	12.4636	12.4361	3.0837	2.8069	2.7794
54	6.8987	8.0678	7.8966	7.8838	1.1691	0.9979	0.9851
a	9.4322	12.8732	12.62	12.5894	3.441	3.1878	3.1572
154915,66	8.467	9.6559	9.3746	9.3563	1.1889	0.9076	0.8893
120-125	8.1173	9.4217	9.0968	9.0851	1.3044	0.9795	0.9678
194815,0-	9.4008	12.6152	12.4549	12.2759	3.2144	3.0541	2.8751
1114815,7	8.3104	12.2258	12.1238	12.0523	3.9154	3.8134	3.7419
205	9.4031	12.297	12.1145	12.0754	2.8939	2.7114	2.6723
184815,62	8.4781	11.2168	11.0068	10.9885	2.7387	2.5287	2.5104
92-95	8.8589	11.4461	11.1486	11.1337	2.5872	2.2897	2.2748
102-108	9.5564	11.2112	10.9578	10.9475	1.6548	1.4014	1.3911
102-108	9.6991	10.6233	10.4597	10.4533	0.9242	0.7606	0.7542
123-134	9.4528	11.2269	11.0649	11.051	1.7741	1.6121	1.5982
136-166	9.5943	11.0216	10.7398	10.7253	1.4273	1.1455	1.131
166-177	9.3016	10.0905	9.7666	9.7605	0.7889	0.465	0.4589
177-185	9.1882	11.946	11.5713	11.5468	2.7578	2.3831	2.3586
185-189	9.6076	10.3766	10.0943	10.0864	0.769	0.4867	0.4788
192-195	8.6759	9.8293	9.5795	9.5692	1.1534	0.9036	0.8933
201-208	9.7836	13.0821	12.8047	12.7767	3.2985	3.0211	2.9931

sample	crucible w	total weigh	burn 1	burn 2	dry	1	2
250-265	9.3801	13.8914	13.7815	13.7398	4.5113	4.4014	4.3597
250-265	9.0919	12.0594	11.9867	11.9595	2.9675	2.8948	2.8676
248-249	8.2873	9.7064	9.5519	9.5377	1.4191	1.2646	1.2504
8.28E+08	8.7821	11.651	11.5988	11.5736	2.8689	2.8167	2.7915
139-145	8.4253	10.0342	9.812	9.7897	1.6089	1.3867	1.3644
163-172	9.2176	14.0399	13.9378	13.896	4.8223	4.7202	4.6784
183	9.4186	12.6892	12.6234	12.5954	3.2706	3.2048	3.1768
184-195	9.4539	13.8934	13.8326	13.8028	4.4395	4.3787	4.3489
8.28E+08	9.2797	14.2247	14.1593	14.1297	4.945	4.8796	4.85
137-145	8.2307	11.2623	11.1156	11.0834	3.0316	2.8849	2.8527
163-175	8.3704	12.1965	12.1038	12.0653	3.8261	3.7334	3.6949
163-175	9.4126	12.9167	12.8405	12.8066	3.5041	3.4279	3.394
484815,8-	8.3288	10.3281	10.2649	10.2451	1.9993	1.9361	1.9163
163-203	8.5299	9.4947	9.4349	9.4123	0.9648	0.905	0.8824
154815,40	7.8866	10.3174	10.1305	10.1005	2.4308	2.2439	2.2139
172-176	8.1154	9.2254	9.0131	9.0013	1.11	0.8977	0.8859
194815,32	7.8992	10.9511	10.9107	10.8884	3.0519	3.0115	2.9892
62-85	8.0845	10.6422	10.5013	10.4731	2.5577	2.4168	2.3886
39,0-10	7.9488	10.5651	10.3657	10.3394	2.6163	2.4169	2.3906
10-20.	8.0677	10.0342	9.9573	9.939	1.9665	1.8896	1.8713
20-30	7.8214	9.1566	9.1104	9.0991	1.3352	1.289	1.2777
20-30	7.8214	9.1566	9.1104	9.0991	1.3352	1.289	1.2777
30-40	8.2714	10.9942	10.931	10.9103	2.7228	2.6596	2.6389
40-50	7.9586	10.2571	10.2211	10.2057	2.2985	2.2625	2.2471
50-60	8.1371	12.0452	12.008	11.9875	3.9081	3.8709	3.8504
60-70	8.0729	10.5525	10.5304	10.5174	2.4796	2.4575	2.4445
70-80	8.0935	10.0862	10.0674	10.0548	1.9927	1.9739	1.9613
80-90	8.2445	10.8309	10.8051	10.7896	2.5864	2.5606	2.5451
90-100	7.9315	11.0518	11.0118	10.9884	3.1203	3.0803	3.0569
103-130	8.1303	10.786	10.7708	10.7586	2.6557	2.6405	2.6283
211-231	8.2347	10.8363	10.8066	10.7875	2.6016	2.5719	2.5528
211-231	7.9626	9.5921	9.5713	9.56	1.6295	1.6087	1.5974
242-260	7.7208	11.3346	11.3135	11.2968	3.6138	3.5927	3.576
174815,34	8.0643	11.5316	11.5098	11.4917	3.4673	3.4455	3.4274
174815,ba	8.2306	11.5243	11.5011	11.4875	3.2937	3.2705	3.2569
49,30-40	7.9347	9.9756	9.8944	9.8747	2.0409	1.9597	1.94
40-50	8.3709	11.5323	11.4499	11.4269	3.1614	3.079	3.056
50-60	8.0925	11.2141	11.1756	11.1607	3.1216	3.0831	3.0682
60-70	7.6992	11.6739	11.6158	11.5971	3.9747	3.9166	3.8979
70-80	8.0138	11.7779	11.7465	11.7292	3.7641	3.7327	3.7154
80-90	8.4066	11.9387	11.9051	11.8859	3.5321	3.4985	3.4793
80-90	7.1645	10.4443	10.4151	10.3976	3.2798	3.2506	3.2331
90-100	8.1961	12.2186	12.01	12.1716	4.0225	3.8139	3.9755
1114815,0	7.8477	10.5301	10.4221	10.3826	2.6824	2.5744	2.5349
40-55	7.721	10.1957	10.136	10.0778	2.4747	2.415	2.3568
55-70	8.5239	11.4758	11.449	11.4282	2.9519	2.9251	2.9043
105-110	7.9058	9.4334	9.399	9.3454	1.5276	1.4932	1.4396
120-180	7.8264	10.9926	10.973	10.6942	3.1662	3.1466	2.8678
180-220	7.9931	11.1397	11.1183	11.0818	3.1466	3.1252	3.0887

sample	crucible w	total weigh	burn 1	burn 2	dry	1	2
208-218	9.5054	13.8914	13.296	13.2643	4.386	3.7906	3.7589
2104815,1	8.1357	10.9061	10.8702	10.7767	2.7704	2.7345	2.641
20-30	8.1138	10.7721	10.7213	10.5888	2.6583	2.6075	2.475
20-30	7.7922	10.0139	9.9944	9.9415	2.2217	2.2022	2.1493
1104815,b	8.0737	9.247	9.2255	9.1577	1.1733	1.1518	1.084
30-Dec	7.9053	9.4823	9.4503	9.3401	1.577	1.545	1.4348
60-70	7.9052	11.305	11.2051	11.1853	3.3998	3.2999	3.2801
120-130	8.0523	12.3431	12.284	12.2618	4.2908	4.2317	4.2095
314815,80	7.8024	11.2935	11.2532	11.1912	3.4911	3.4508	3.3888
1234915,0	7.9436	10.1394	9.9319	9.9015	2.1958	1.9883	1.9579
20-35	8.1623	12.5038	12.4239	12.4069	4.3415	4.2616	4.2446
1264915,4	7.7674	12.65	12.6162	12.5946	4.8826	4.8488	4.8272

sample	wt.1	wt.2	wt.%o.c.	wt.%co2lo	wt.%caco	residlue
92599,0-1	0.1709	0.1913	17.63732	0.993377	2.257676	80.105
10-20.	0.1606	0.1915	11.01586	0.966743	2.197143	86.787
20-30	0.0887	0.1088	9.752605	0.992544	2.255781	87.99161
	0.1226	0.1394	10.01491	0.642177	1.459494	88.5256
112-117	0.0474	0.0613	4.659437	0.595825	1.354148	93.98642
188-197	0.0669	0.1426	5.295887	1.913597	4.349085	90.35503
197-202	0.2536	-1.11	-62.2338	-99.0916	-225.208	387.4421
267-280	0.138	1.4959	33.87304	28.15117	63.97994	2.14702
bp	0.067	0.088	5.323716	0.721278	1.639267	93.03702
bp	0.0875	0.1109	6.583051	0.776428	1.76461	91.65234
1154815,1	0.1319	0.2418	10.51403	3.092029	7.027339	82.45864
190-195	0.0462	0.1197	7.347535	3.255237	7.398266	85.2542
154815,20	0.0699	0.1334	8.900271	2.779967	6.318106	84.78162
231-234	0.0388	0.0783	8.168818	2.755494	6.262485	85.5687
91199,66-	0.1008	0.1327	6.493326	0.887097	2.016129	91.49055
77-98	0.0658	0.0919	4.440502	0.734921	1.670276	93.88922
265-286	0.1534	0.2403	10.61443	2.342886	5.324742	84.06082
324-336	0.3106	0.3979	15.96764	1.967501	4.471594	79.56077
336-360	0.0224	0.0434	2.177438	0.694927	1.57938	96.24318
336-360	0.0218	0.0418	2.367481	0.744491	1.692024	95.94049
385-389	0.1147	0.1677	9.630337	1.807393	4.107712	86.26195
83199,72-	0.2757	0.309	13.55575	0.772031	1.754615	84.68964
110-120	0.1395	0.165	16.50049	1.381814	3.140487	80.35903
134-140	0.0763	0.1067	2.922202	0.485437	1.103266	95.97453
314815,52	0.2544	0.2702	29.45205	0.887042	2.016006	68.53194
60-60	0.1609	0.1833	11.74063	0.764062	1.736504	86.52287
65-67	0.1465	0.1612	15.43516	0.737397	1.675901	82.88893
105-125	0.308	0.3178	37.51574	0.587495	1.335215	61.14905
174815,54	0.2768	0.3043	18.84425	0.891786	2.026786	79.12897
54	0.1712	0.184	30.38235	1.094859	2.488317	67.12934
a	0.2532	0.2838	15.60593	0.889276	2.021083	82.37299
154915,66	0.2813	0.2996	48.86029	1.539238	3.498268	47.64144
120-125	0.3249	0.3366	50.71297	0.896964	2.038555	47.24847
194815,0-	0.1603	0.3393	15.54256	5.568691	12.65612	71.80133
1114815,7	0.102	0.1735	7.036318	1.826122	4.150278	88.8134
205	0.1825	0.2216	13.96386	1.351118	3.070722	82.96542
184815,62	0.21	0.2283	16.00394	0.6682	1.518637	82.47742
92-95	0.2975	0.3124	23.57375	0.575912	1.308891	75.11736
102-108	0.2534	0.2637	31.24849	0.622432	1.414618	67.33689
102-108	0.1636	0.17	36.09608	0.692491	1.573843	62.33007
123-134	0.162	0.1759	19.04628	0.783496	1.780672	79.17305
136-166	0.2818	0.2963	40.50305	1.015904	2.308873	57.18808
166-177	0.3239	0.33	82.88756	0.773229	1.757338	15.3551
177-185	0.3747	0.3992	28.06222	0.888389	2.019067	69.91871
185-189	0.2823	0.2902	74.44733	1.027308	2.334791	23.21787
192-195	0.2498	0.2601	44.20843	0.893012	2.029573	53.762
201-208	0.2774	0.3054	17.66864	0.848871	1.929252	80.40211
208-218	0.5954	0.6271	27.87278	0.722754	1.642623	70.4846
250-265	0.1099	0.1516	5.796555	0.924346	2.100785	92.10266

sample	wt.1	wt.2	wt.%o.c.	wt.%co2lo	wt.%caco	residlue
250-265	0.0727	0.0999	5.816344	0.916596	2.083174	92.10048
248-249	0.1545	0.1687	22.775	1.000634	2.274169	74.95083
8.28E+08	0.0522	0.0774	4.517411	0.878385	1.996331	93.48626
139-145	0.2222	0.2445	29.0074	1.38604	3.150091	67.84251
163-172	0.1021	0.1439	5.1013	0.866806	1.970014	92.92869
183	0.0658	0.0938	4.879839	0.856112	1.945709	93.17445
184-195	0.0608	0.0906	3.410294	0.671247	1.525561	95.06415
8.28E+08	0.0654	0.095	3.24368	0.598584	1.360419	95.3959
137-145	0.1467	0.1789	10.7402	1.062145	2.413967	86.84583
163-175	0.0927	0.1312	5.851912	1.006247	2.286924	91.86116
163-175	0.0762	0.1101	5.316629	0.967438	2.198723	92.48465
484815,8-	0.0632	0.083	7.312559	0.990347	2.250788	90.43665
163-203	0.0598	0.0824	14.73881	2.342454	5.32376	79.93743
154815,40	0.1869	0.2169	16.61182	1.234162	2.804913	80.58327
172-176	0.2123	0.2241	39.31532	1.063063	2.416052	58.26863
194815,32	0.0404	0.0627	3.378223	0.730692	1.660664	94.96111
62-85	0.1409	0.1691	12.12026	1.102553	2.505802	85.37393
39,0-10	0.1994	0.2257	16.24814	1.005236	2.284628	81.46724
10-20.	0.0769	0.0952	8.751589	0.930587	2.114971	89.13344
20-30	0.0462	0.0575	7.766627	0.846315	1.923444	90.30993
20-30	0.0462	0.0575	7.766627	0.846315	1.923444	90.30993
30-40	0.0632	0.0839	5.402527	0.760247	1.727834	92.86964
40-50	0.036	0.0514	3.80248	0.670002	1.522732	94.67479
50-60	0.0372	0.0577	2.42829	0.524552	1.192163	96.37955
60-70	0.0221	0.0351	2.306824	0.524278	1.191541	96.50164
70-80	0.0188	0.0314	2.519195	0.632308	1.437063	96.04374
80-90	0.0258	0.0413	2.59434	0.599289	1.36202	96.04364
90-100	0.04	0.0634	3.313784	0.749928	1.704382	94.98183
103-130	0.0152	0.0274	1.604097	0.459389	1.044066	97.35184
211-231	0.0297	0.0488	3.017374	0.734164	1.668554	95.31407
211-231	0.0208	0.0321	3.246395	0.693464	1.576055	95.17755
242-260	0.0211	0.0378	1.629863	0.462117	1.050267	97.31987
174815,34	0.0218	0.0399	1.779483	0.52202	1.186409	97.03411
174815,ba	0.0232	0.0368	1.82166	0.412909	0.938431	97.23991
49,30-40	0.0812	0.1009	8.922534	0.96526	2.193774	88.88369
40-50	0.0824	0.1054	5.940406	0.727526	1.653468	92.40613
50-60	0.0385	0.0534	2.944003	0.477319	1.084817	95.97118
60-70	0.0581	0.0768	3.393967	0.470476	1.069263	95.53677
70-80	0.0314	0.0487	2.127999	0.459605	1.044557	96.82744
80-90	0.0336	0.0528	2.446137	0.543586	1.235423	96.31844
80-90	0.0292	0.0467	2.314165	0.533569	1.212657	96.47318
90-100	0.2086	0.047	6.354257	-4.0174	-9.13046	102.7762
1114815,0	0.108	0.1475	9.525052	1.472562	3.346732	87.12822
40-55	0.0597	0.1179	7.176627	2.3518	5.345	87.47837
55-70	0.0268	0.0476	2.520411	0.704631	1.601434	95.87816
105-110	0.0344	0.088	8.012569	3.508772	7.974482	84.01295
120-180	0.0196	0.2984	10.04359	8.805508	20.01252	69.9439
180-220	0.0214	0.0579	2.520181	1.159982	2.636323	94.8435
2104815,1	0.0359	0.1294	5.966647	3.374964	7.670373	86.36298

sample	wt.1	wt.2	wt.%o.c.	wt.%co2lo	wt.%caco	residlue
20-30	0.0508	0.1833	8.80638	4.984389	11.32816	79.86546
20-30	0.0195	0.0724	4.136472	2.38106	5.411499	90.45203
1104815,b	0.0215	0.0893	9.44345	5.778573	13.13312	77.42343
36524	0.032	0.1422	11.04629	6.987952	15.88171	73.072
60-70	0.0999	0.1197	6.459203	0.582387	1.323607	92.21719
120-130	0.0591	0.0813	3.272117	0.517386	1.175877	95.55201
314815,80	0.0403	0.1023	4.084672	1.775945	4.036238	91.87909
1234915,0	0.2075	0.2379	20.28418	1.384461	3.146503	76.56932
20-35	0.0799	0.0969	4.072325	0.39157	0.889931	95.03774
1264915,4	0.0338	0.0554	1.826896	0.442387	1.005426	97.16768

Appendix C

Core ID	J [A/m]	J_J0	Ja/Jr	Am2	emu	emu/Oe	bartington	emu/Oe
174815,54	0.03131	1	0.001	1.65E-07	0.00017	0.000331	12.9	0.000131
a	0.03348	1.0694	0.0054	1.77E-07	0.00018	0.000354	18.7	0.00019
342-350	0.1006	3.2143	0.002	5.31E-07	0.00053	0.001062	53.2	0.00054
base	0.3212	10.2616	0.0052	1.7E-06	0.0017	0.003392	294.5	0.002989
394815,0-	0.1333	4.2566	0.0014	7.04E-07	0.0007	0.001408	49.7	0.000504
10-20	0.108	3.449	0.0012	5.7E-07	0.00057	0.00114	49.4	0.000501
20-30	0.07783	2.4861	0.0083	4.11E-07	0.00041	0.000822	35.2	0.000357
30-40	0.101	3.2267	0.0028	5.33E-07	0.00053	0.001067	35.3	0.000358
40-50	0.1626	5.1928	0.0013	8.59E-07	0.00086	0.001717	57.2	0.000581
50-60	0.1807	5.7725	0.0046	9.54E-07	0.00095	0.001908	85.9	0.000872
60-70	0.209	6.6746	0.0042	1.1E-06	0.0011	0.002207	110.1	0.001118
70-80	0.1878	5.9978	0.0013	9.92E-07	0.00099	0.001983	94.6	0.00096
80-90	0.2504	7.9983	0.0015	1.32E-06	0.00132	0.002644	107.9	0.001095
90-100	0.2136	6.8236	0.0009	1.13E-06	0.00113	0.002256	92.8	0.000942
103-130	0.2009	6.4181	0.0045	1.06E-06	0.00106	0.002122	130.2	0.001322
211-231	0.1893	6.0485	0.0023	1E-06	0.001	0.001999	81.2	0.000824
242-260	0.1892	6.0422	0.0022	9.99E-07	0.001	0.001998	114.9	0.001166
494815,30	0.1638	5.2332	0.0004	8.65E-07	0.00086	0.00173	79.6	0.000808
40-50	0.1402	4.4777	0.0004	7.4E-07	0.00074	0.001481	67.6	0.000686
50-60	0.115	3.6735	0.0519	6.07E-07	0.00061	0.001214	77	0.000782
60-70	0.1072	3.4248	0.0335	5.66E-07	0.00057	0.001132	69.7	0.000707
70-80	0.08282	2.6454	0.0013	4.37E-07	0.00044	0.000875	45.5	0.000462
80-90	0.08278	2.6441	0.0075	4.37E-07	0.00044	0.000874	43.1	0.000437
90-100	0.0919	2.9357	0.001	4.85E-07	0.00049	0.00097	45.5	0.000462
384815-13	0.1229	3.927	0.0014	6.49E-07	0.00065	0.001298	59.6	0.000605
139-145	0.02621	0.8371	0.007	1.38E-07	0.00014	0.000277	9.5	9.64E-05
163-172	0.09075	2.8988	0.0019	4.79E-07	0.00048	0.000958	38.1	0.000387
183	0.1099	3.5092	0.0006	5.8E-07	0.00058	0.001161	34	0.000345
184-195	0.1033	3.3011	0.0027	5.45E-07	0.00055	0.001091	38.5	0.000391
1114815,0	0.2606	8.3256	0.0047	1.38E-06	0.00138	0.002752	83.3	0.000845
40-55	0.0856	2.7345	0.0098	4.52E-07	0.00045	0.000904	64.4	0.000654
55-70	0.247	7.8909	0.0004	1.3E-06	0.0013	0.002608	149	0.001512
70-80	0.2687	8.5827	0.0012	1.42E-06	0.00142	0.002837	156.4	0.001587
105-110	0.07854	2.5088	0.0045	4.15E-07	0.00041	0.000829	21.3	0.000216
120-180	0.05626	1.7971	0.0017	2.97E-07	0.0003	0.000594	58.8	0.000597
180-220	0.1861	5.9437	0.0186	9.83E-07	0.00098	0.001965	100.3	0.001018
205	0.276	8.8168	0.0006	1.46E-06	0.00146	0.002915	164.5	0.00167
314815,52	0.0357	1.1403	0.0018	1.88E-07	0.00019	0.000377	16.4	0.000166
60-65	0.03144	1.0043	0.0058	1.66E-07	0.00017	0.000332	13.2	0.000134
65-67	0.03429	1.0953	0.0064	1.81E-07	0.00018	0.000362	16.3	0.000165
80-90	0.2255	7.2044	0.0107	1.19E-06	0.00119	0.002381	149.5	0.001517
105-125	0.03755	1.1994	0.0064	1.98E-07	0.0002	0.000397	22.7	0.00023
124815,66	0.05943	1.8984	0.0045	3.14E-07	0.00031	0.000628	37	0.000376
77-98	0.08085	2.5826	0.001	4.27E-07	0.00043	0.000854	44.6	0.000453
265-286	0.07246	2.3148	0.0055	3.83E-07	0.00038	0.000765	53.7	0.000545
324-336	0.07857	2.5098	0.0028	4.15E-07	0.00041	0.00083	50.3	0.000511
336-360	0.1235	3.9437	0.0027	6.52E-07	0.00065	0.001304	96.9	0.000984

Core ID	J [A/m]	J_J0	Ja/Jr	Am2	emu	emu/Oe	bartington	emu/Oe
385-389	0.09521	3.0414	0.0054	5.03E-07	0.0005	0.00101	51.4	0.000522
154816,40	0.3047	9.7339	0.0025	1.61E-06	0.00161	0.00322	197.9	0.002009
172-176	0.03031	0.9681	0.0043	1.6E-07	0.00016	0.00032	9.5	9.64E-05
207-210	0.07461	2.3832	0.004	3.94E-07	0.00039	0.00079	47.6	0.000483
231-237	0.1041	3.3262	0.0051	5.5E-07	0.00055	0.0011	73.5	0.000746
184815,8-	0.09449	3.0183	0.0006	4.99E-07	0.0005	0.001	47.9	0.000486
62-69	0.04719	1.5074	0.0077	2.49E-07	0.00025	0.0005	24.6	0.00025
92-95	0.03882	1.2401	0.0053	2.05E-07	0.0002	0.00041	19.4	0.000197
102-108	0.0319	1.0191	0.0071	1.68E-07	0.00017	0.00034	13.9	0.000141
123-134	0.05746	1.8356	0.0034	3.03E-07	0.0003	0.00061	41.7	0.000423
136-166	0.021	0.6709	0.0164	1.11E-07	0.00011	0.00022	3.5	3.55E-05
166-177	0.03163	1.0103	0.0007	1.67E-07	0.00017	0.00033	12.1	0.000123
177-185	0.03434	1.0971	0.007	1.81E-07	0.00018	0.00036	13.4	0.000136
185-189	0.02611	0.8339	0.011	1.38E-07	0.00014	0.00028	7	7.11E-05
192-195	0.01983	0.6335	0.0102	1.05E-07	0.0001	0.00021	5	5.08E-05
208-218	0.01981	0.6328	0.011	1.05E-07	0.0001	0.00021	7.6	7.71E-05
250-265	0.01484	0.4741	0.0152	7.84E-08	7.8E-05	0.00016	6	6.09E-05
248-249	0.03833	1.2245	0.0031	2.02E-07	0.0002	0.0004	16	0.000162
494815,0-	0.1572	5.0208	0.0002	8.3E-07	0.00083	0.00166	79.5	0.000807
10-20	0.1925	6.1499	0.0001	1.02E-06	0.00102	0.00203	114.1	0.001158
20-30	0.1633	5.2151	0.0014	8.62E-07	0.00086	0.00172	78	0.000792
25-30	0.1798	5.7448	0.0003	9.49E-07	0.00095	0.0019	94.4	0.000958
112-117	0.0833	1	0.0024	4.4E-07	0.00044	0.00088	60.4	0.000613
188-197	0.192	2.3092	0.0001	1.01E-06	0.00101	0.00203	94.5	0.000959
197-202	0.0801	0.9611	0.0041	4.23E-07	0.00042	0.00085	49.1	0.000498
267-280	0.144	1.7225	0.0262	7.6E-07	0.00076	0.00152	75.3	0.000764
bp	0.137	1.644	0	7.23E-07	0.00072	0.00145	84.1	0.000854

conversion factors

sample siz	5.28	cm3	or	5.3E-06	m3
SI convers	0.00005	T dc	and	0.5	Oe dc

Appendix D

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24.8:lab. mult=1)

Laboratory number: **Beta-139723**

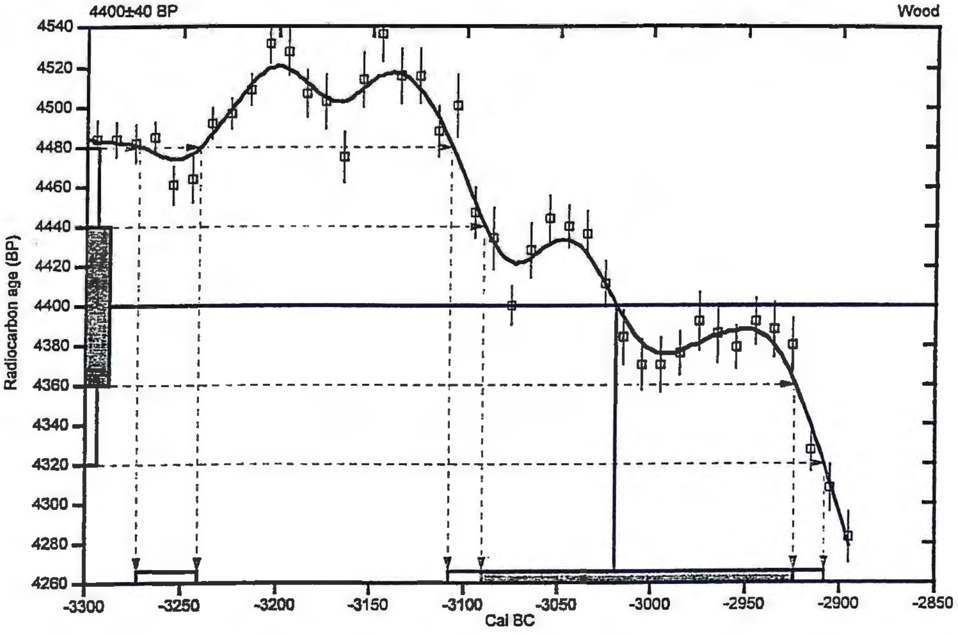
Conventional radiocarbon age: **4400±40 BP**

2 Sigma calibrated results: **Cal BC 3275 to 3240 (Cal BP 5225 to 5190) and**
(95% probability) **Cal BC 3110 to 2910 (Cal BP 5060 to 4860)**

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal BC 3020 (Cal BP 4970)

1 Sigma calibrated result: Cal BC 3090 to 2925 (Cal BP 5040 to 4875)
(68% probability)



References:

Database used
INTCAL98
Calibration Database
Editorial Comment
Stuiver, M., van der Plicht, H., 1998, Radiocarbon 40(3), pxii-xiii
INTCAL98 Radiocarbon Age Calibration
Stuiver, M., et. al., 1998, Radiocarbon 40(3), p1041-1083
Mathematics
A Simplified Approach to Calibrating C14 Dates
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

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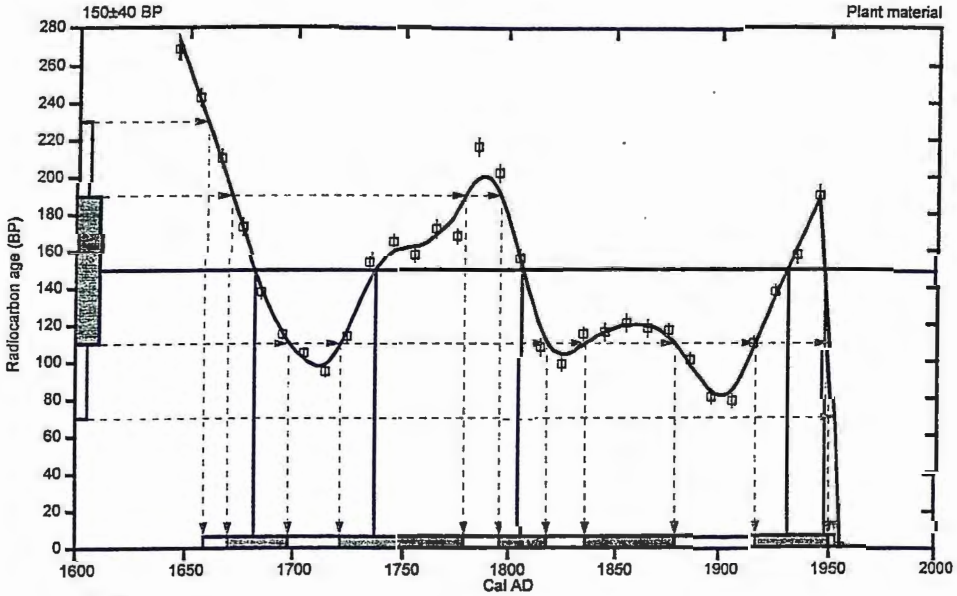
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-27.8:lab. mult=1)

Laboratory number:	**Beta-139719**
Conventional radiocarbon age:	**150±40 BP**
2 Sigma calibrated result: **(95% probability)**	**Cal AD 1660 to 1955 (Cal BP 290 to 5)**

Intercept data

Intercepts of radiocarbon age with calibration curve:	Cal AD 1680 (Cal BP 270) and Cal AD 1740 (Cal BP 210) and Cal AD 1805 (Cal BP 145) and Cal AD 1930 (Cal BP 20) and Cal AD 1950 (Cal BP 0)
1 Sigma calibrated results: (68% probability)	Cal AD 1670 to 1700 (Cal BP 280 to 250) and Cal AD 1720 to 1780 (Cal BP 230 to 170) and Cal AD 1795 to 1820 (Cal BP 155 to 130) and Cal AD 1835 to 1880 (Cal BP 115 to 70) and Cal AD 1915 to 1950 (Cal BP 35 to 0)



References:

Database used

INTCAL98

Calibration Database

Editorial Comment

Stuiver, M., van der Plicht, H., 1998, Radiocarbon 40(3), pxii-xiii

INTCAL98 Radiocarbon Age Calibration

Stuiver, M., et. al., 1998, Radiocarbon 40(3), p1041-1083

Mathematics

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-27.5:lab. mult=1)

Laboratory number: **Beta-139720**

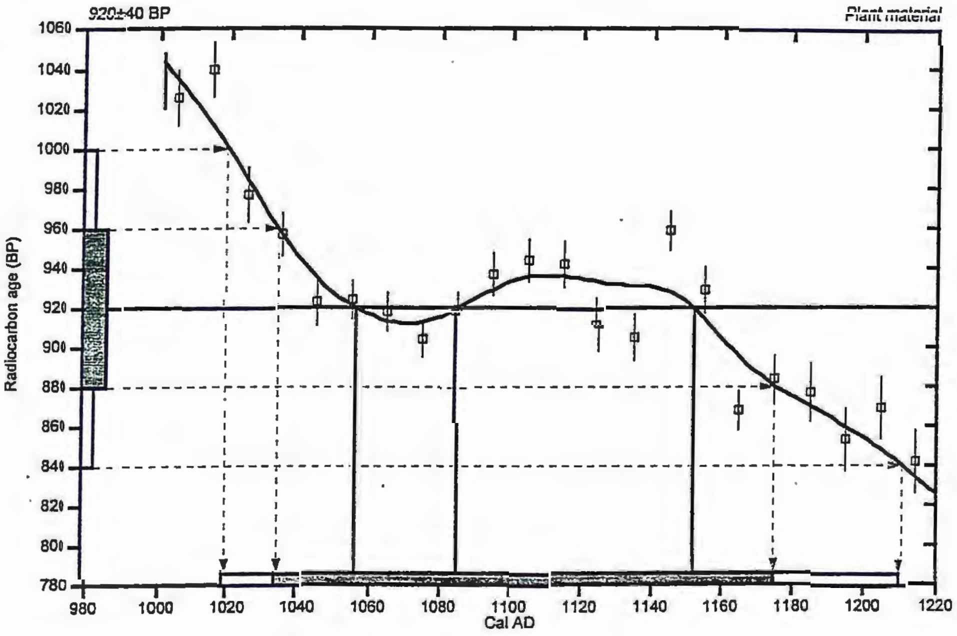
Conventional radiocarbon age: **920±40 BP**

2 Sigma calibrated result: **Cal AD 1020 to 1210 (Cal BP 930 to 740)**
(95% probability)

Intercept data

Intercepts of radiocarbon age
with calibration curve: Cal AD 1055 (Cal BP 895) and
Cal AD 1085 (Cal BP 865) and
Cal AD 1150 (Cal BP 800)

1 Sigma calibrated result: Cal AD 1035 to 1175 (Cal BP 915 to 775)
(68% probability)



References:
Database used
INTCAL98
Calibration Database
Editorial Comment
Stuiver, M., van der Plicht, H., 1998, Radiocarbon 40(3), pxii-xiii
INTCAL98 Radiocarbon Age Calibration
Stuiver, M., et. al., 1998, Radiocarbon 40(3), p1041-1083
Mathematics
A Simplified Approach to Calibrating C14 Dates
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

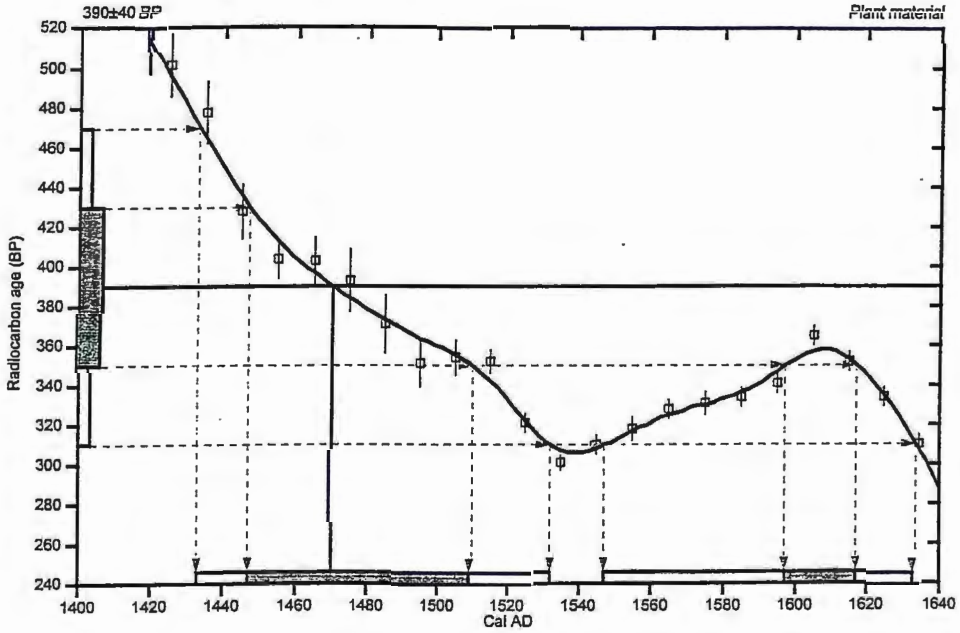
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-27.5:lab. mult=1)

Laboratory number:	**Beta-139721**
Conventional radiocarbon age:	**390±40 BP**
2 Sigma calibrated results: **(95% probability)**	**Cal AD 1435 to 1530 (Cal BP 515 to 420) and** **Cal AD 1545 to 1635 (Cal BP 405 to 315)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal AD 1470 (Cal BP 480)
1 Sigma calibrated results: (68% probability)	Cal AD 1445 to 1510 (Cal BP 505 to 440) and Cal AD 1595 to 1615 (Cal BP 355 to 335)



References:
Database used
INTCAL98
Calibration Database
Editorial Comment
Stuiver, M., van der Plicht, H., 1998, Radiocarbon 40(3), pxii-xiii
INTCAL98 Radiocarbon Age Calibration
Stuiver, M., et. al., 1998, Radiocarbon 40(3), p1041-1083
Mathematics
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-29.2:lab. mult=1)

Laboratory number: **Beta-139722**

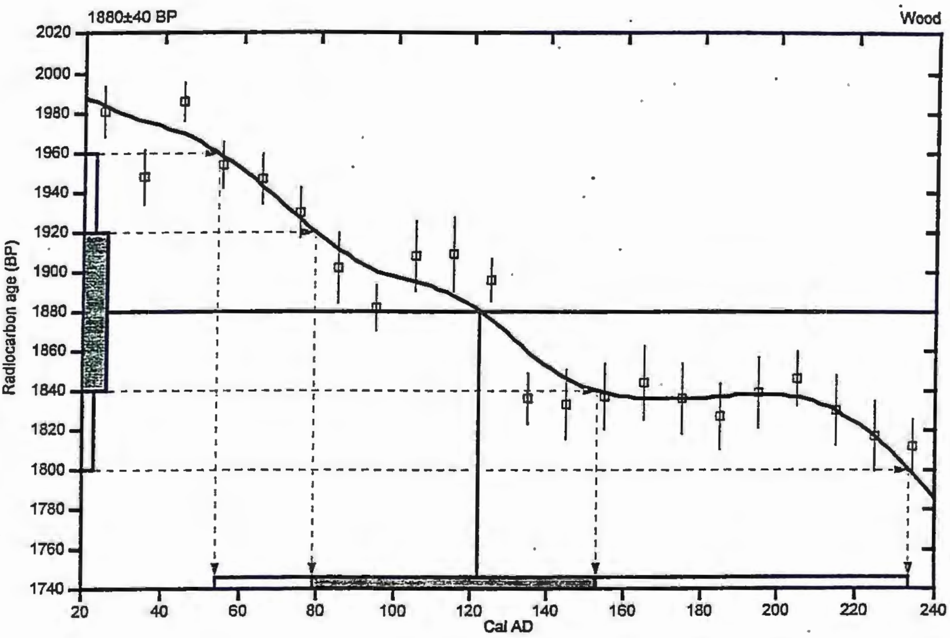
Conventional radiocarbon age: **1880±40 BP**

2 Sigma calibrated result: **Cal AD 55 to 235 (Cal BP 1895 to 1715)**
(95% probability)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 120 (Cal BP 1830)

1 Sigma calibrated result: Cal AD 80 to 155 (Cal BP 1870 to 1795)
(68% probability)



References:

Database used
INTCAL98
Calibration Database
Editorial Comment
Stuiver, M., van der Plicht, H., 1998, Radiocarbon 40(3), pxii-xiii
INTCAL98 Radiocarbon Age Calibration
Stuiver, M., et. al., 1998, Radiocarbon 40(3), p1041-1083
Mathematics
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Appendix E

This list describes all variables in the SHPO's *Archaeological Database*

COUNTY [COUNTY] - Character Field, 20 characters
This information refers to the name of the county in which the site is located. If a single site extends across more than one county, the site will be listed in the database under both counties; however, the SITENUM (see below) will correspond to the county in which the majority of the site lies. (Therefore the "county" need not match that of the site number).

SITE NUMBER [SITENUM] - Character Field, 8 characters
The SITENUM refers to the Smithsonian Institution's trinomial designation and is currently assigned in Minnesota by the Office of the State Archaeologist. All Minnesota sites start with the numerical code "21", followed by a two-letter county code (see attachment for county codes), followed by a number. The number reflects the order of the site in the site file. For example, 21AK0007 is the seventh site assigned in Aitkin County. The convention in Minnesota is to use a four-digit number for each site. The SHPO Archaeological Database also contains site leads that have not been verified by a professional archaeologist. These possible sites use the state and county codes as discussed above followed by an alphabetic designation beginning with the letter a. Each site lead will receive a designation a through z, followed by aa, ab, ac, etc.

SITE NAME [SITENAME] - Character Field, 80 characters
SITENAME is usually designated by the archaeologist responsible for its identification. It is standard procedure to use the landowner's last name, but if it is a common name (e.g., Peterson), a first name is also used. Sites are also named for a local topographic feature, unusual feature, etc. An entry for this category is not mandatory, but used when available. The word "site" is not used in the name in the database, i.e. the Joseph Peterson Site will be listed simply as "Joseph Peterson". If a site has more than one record (i.e., if the site is located in more than one section), the site name should be followed with the record number as follows: (1/3), (2/3), (3/3), etc. If the "site" has been determined to be noncultural, write (NOT A SITE) in this field.

USGS QUADRANGLE [USGS] - Character Field, 50 characters
USGS refers to the name of the USGS 7.5' quadrangle map where the site is located. Write the map name as it appears on the map, including spacing. Exclude the state or province name; i.e. the Redwood Falls, Minn. map is written as "Redwood Falls". Two quadrangle names may be input.

TOWNSHIP [TOWNSHIP] - Numeric Field, 3 characters
RANGE [RANGE] - Numeric Field, 2 characters
SECTION [SECTION] - Numeric Field, 2 characters
The TOWNSHIP field is a two or three-digit number referring to the vertical grid number assigned to the township where the site is located. In Minnesota, all townships are "North"; therefore only the number is given. RANGE is a two-digit number referring to the horizontal grid number. Ranges in Minnesota may be either "East" or "West", and the EASTWEST field is entered as **E** or **W**. SECTION is a one or two-digit number, 1 through 36, corresponding to a square mile within a township/range coordinate. If a site extends through more than one section, each section will be given an individual record. This is necessary to enable database searches by location. The section in which the majority of the site lies will be entered in the first record, with the record number (1/3) written in the SITENAME field.

SITE TYPE DESCRIPTION [DESCRIPT] - Character Field, 25 characters

This field is a short <u>description of site type</u>. Select all that apply (i.e. an earthwork with a documented human burial is listed as **EW, CEM**):

SA - Single Artifact ("findspot")
AS - Artifact Scatter (any site with more than one artifact type)
LS - Lithic Scatter (a site with only lithic materials, i.e. tools, flakes, fire-cracked rock, etc.)
SR - Structural Ruin

TEMPORAL PERIOD [PERIOD] - Character Field, 15 characters
PERIOD refers to the general temporal period of the site.
P - Precontact (10,000 B.C. - A.D. 1680)
C - Contact (A.D. 1680 - 1837)
R - PostContact (Recent 1837 - present)

TRADITION [TRADITION] - Character Field, 30 characters
TRADITION refers to the traditional divisions of Minnesota prehistory, i.e. Paleolndian, Archaic, Woodland, Mississippian, and Plains Village. (see below)

CONTEXT [CONTEXT] - Character Field, 60 characters
CONTEXT refers to the specific prehistoric/historic context of the site as listed in the Minnesota SHPO Historic Contexts. (see below)

For the fields PERIOD, TRADITION, and CONTEXT be as specific as possible. Use only the terms provided below. Complete as many fields as possible with the information existing on a particular site. It may be possible to complete only the first field; for example, a lithic scatter with no diagnostic artifacts should be cited as simply a "precontact site"; a site containing ceramics but no specific types might be cited as "precontact" and "Woodland", etc. Each determination is then followed with a number corresponding to the confidence of the determination, as below:

1 - Confirmed
2 - Suspected

If more than one term applies to a site in a particular field, list all terms, with commas to separate. List in chronological order. For example, a site containing a Folsom projectile point and a Blackduck potsherd and a suspected Archaic component would be cataloged as the following:
PERIOD: P-1
TRADITON: PL-1, A-2, W-1
CONTEXT: Fo-1, Bd-1.

Precontact Period - P
- Paleoindian Tradition - **PL** (11,500-8000 B.P.)
  - Lanceolate Point/Plano - **Pl**
- Archaic Tradition - **A** (8000-2500 B.P.)
- Woodland Tradition - **W** (2500-300 B.P.)

DATING METHOD [DATEMETHOD] - Character Field, 15 characters
DATEMETHOD refers to the method used to determine the time period of the site. Choose all that apply:
rc - radiocarbon dating
style - artifact style/cross-dating

hist - historic accounts
oth- other

LITHICS [LITHIC] - Character Field, 40 characters

PHYSIOGRAPHIC SETTING [SETTING] - Character Field, 60 characters
PHYSIOGRAPHIC SETTING refers to the general landscape of the site area. Choose only the most predominate landscape element.

Stream - Intermittent Stream
River - General Riverine
Terrace - Terrace
Flood - Floodplain
In/Out - Inlet/Outlet
Glacial - Glacial Beach Ridge
Cave - Cave/Rockshelter

REPORTS [ArchReports] - Character Field, 40 characters
Record the number from the **ARCHREP** table pertaining to the most recent reports in which the site form is filed. Input as many reports numbers as necessary.

REFERENCE [REFERENCE] - Character Field, 65 characters
Record the major bibliographic references to the site not listed in the REPORTS.

Andreas - 1874 Andreas Atlas
GeolSurv - Geological Survey (Winchell, Upham)
Brower Nx - J.V. Brower notebook
Brower xxxx - J.V. Brower publication
CHIP - Chippewa National Forest Inventory
Lewis xx - T. Lewis notebook
MHS(CF) - MHS County Miscellaneous File
MHS(DB) - MHS Doug Birk
MHS(FTF) - MHS Fur Trade File
MHS(GTF) - MHS Ghost Town File
MHS(LP) - MHS Les Peterson
MHS(SA) - MHS Scott Anfinson
SAS - Statewide Archaeological Survey
Tryggxx - J.W. Trygg Map/Sheet Number
Wilford XXXX - L.A. Wilford/year, County File Notes
Winchell - N. Winchell (1911)

COUNTY	SITENUM	SITENAME	USGS	TOWNSHIP
Carlton	21CL0002	Thomson Cemetery	Cloquet	48.00000
Carlton	21CL0003	CCC Camp No. 2711	Esko	48.00000
Carlton	21CL0004	Ziebarth (1/2)	Cloquet	48.00000
Carlton	21CL0004	Ziebarth (2/2)	Cloquet	48.00000
Carlton	21CL0004	Ziebarth (1/2)	Cloquet	48.00000
Carlton	21CL0004	Ziebarth (2/2)	Cloquet	48.00000
Carlton	21CL0004	Ziebarth (1/2)	Cloquet	48.00000
Carlton	21CL0005	Silver Creek Historic	Esko	48.00000
Carlton	21CL0006		Cloquet	48.00000
Carlton	21CL0007	Silver Creek Overlook	Esko	48.00000
Carlton	21CL0008		Esko	48.00000
Carlton	21CL0009		Esko	48.00000
Carlton	21CL0011		Esko	48.00000
Carlton	21CL0012		Esko	48.00000
Carlton	21CL0013	Oak Trail Pine Grove	Esko	48.00000
Carlton	21CL0014	Oak Trail Signpost 22	Esko	48.00000
Carlton	21CL0015	Little River Quarry	Esko	48.00000
Carlton	21CL0016	Brooks-Scanlon Mill Complex	Cloquet	49.00000
Carlton	21CL0017	Cloquet Lumber Company Mill	Cloquet	49.00000
Carlton	21CL0018	Old Fond du Lac Village	Cloquet	49.00000
Carlton	21CL0023		Frogner	48.00000
Carlton	21CL0028	Knife River Islad 1	Cloquet	49.00000
Carlton	21CLd	Grand Portage of St.Louis Beginning	Esko	48.00000
Carlton	21CLe	Grand Portage of St. Louis Roche Gal	Esko	48.00000
Carlton	21CLg	Meadowbrook Dairy Farm (2/2)	Esko	49.00000
Carlton	21CLg	Meadowbrook Dairy Farm (1/2)	Esko	49.00000
Carlton	21CLj	Third Lake Mound	Iverson	49.00000
Saint Louis	21SL}			48.00000
Saint Louis	21SL}			48.00000
Saint Louis	21SL}			48.00000
Saint Louis	21SL}			49.00000
Saint Louis	21SL}			50.00000
Saint Louis	21SL}	Nagonab		50.00000
Saint Louis	21SL0799	Arlingtom Avenue Cemetery	Duluth Hei	50.00000
Saint Louis	21SL0800	Rice Lake Road Cemetery	Duluth Hei	50.00000
Saint Louis	21SL0801	Greenwood Cemetery	Duluth Hei	50.00000
Saint Louis	21SL0816	Outer Harbor Breakwater	Duluth	50.00000
Saint Louis	21SL0817	Whitney Brothers Sand and Gravel Hop	Duluth	50.00000
Saint Louis	21SL0818	Dock	Duluth	50.00000
Saint Louis	21SL0819	1908 Dock	Superior	49.00000
Saint Louis	21SL0820	J.C. Mullery Lumber Wharf	Duluth	49.00000
Saint Louis	21SL0821	Erie Pier	West Dulut	49.00000
Saint Louis	21SL0822	Grassy Point Lumber Complex 1	West Dulut	49.00000
Saint Louis	21SL0823	Grassy Point Lumber Complex 2	West Dulut	49.00000
Saint Louis	21SL0824	Windslow Shipwreck	West Dulut	49.00000
Saint Louis	21SL0825	Dock	Duluth	49.00000
Saint Louis	21SL0826	Connie's Landing	West Dulut	49.00000
Saint Louis	21SL0827	Dock	West Dulut	49.00000
Saint Louis	21SL0828	Fond du Lac Dock	Esko	48.00000

RANGE	SECTION	DESCRIPT	PERIOD	TRADITION	CONTEXT	DATEMETHOD
16.00000	8	CEM	R-1		NL-2	hist
16.00000	10	SR	R-1		NL-2	hist
16.00000	17	AS	P-1	PL-1	PI-1	style
16.00000	20	AS	P-1	PL-1	PI-1	style
16.00000	17	AS	P-1	PL-1	PI-1	style
16.00000	20	AS	P-1	PL-1	PI-1	style
16.00000	17	AS	P-1	PL-1	PI-1	style
16.00000	15	SR	R-1		NL-2	hist
16.00000	8	SR, AS	R-1		NL-2	style
16.00000	15	LS	P-1			
16.00000	11	AS	R-1		NL-2	style
16.00000	11	LS	P-1			
15.00000	6	LS	P-1			
15.00000	6	AS	R-1		NL-2	hist
16.00000	2	AS	R-1		NL-2	style
16.00000	2	AS	R-1		NL-2	style
16.00000	1	HD	C-2, R-1		Oj-1, IC-	oth
16.00000	30	SR, LS	P-1,R-1		NL-1	style, hist
17.00000	14	SR	R-1		NL-1	hist
17.00000	10	SR, AS	R-1		IC-1	hist
16.00000	34	LS	P-1			style
16.00000	30	LS	P-2			style
16.00000	1	TR	P-2, C-1, R-			hist
16.00000	1	TR	P-2, C-1, R-			hist
16.00000	22	LS	P-1			style
16.00000	15	LS	P-1			style
17.00000	21	EW	P-2	W-2		
16.00000	11	LS	P			
15.00000	8	AS	C-1			
16.00000	11	LS	P			
15.00000	28	HD	R			
17.00000	8	HD	C			
17.00000	23	HD	R			
14.00000	16	CEM	R-1		NL-2,IR-2	hist
14.00000	16	CEM	R-1		NL-2,IR-2	hist
14.00000	16	CEM	R-1		NL-2,IR-2	hist
14.00000	27	SR	R-1		UC-1	hist
14.00000	27	SR	R-1		UC-1	hist
14.00000	27	SR	R-1		UC-1	hist
14.00000	20	SR	R-1		UC-1	hist
14.00000	4	SR	R-1		UC-1	hist
14.00000	7	SR	R-1		UC-1	hist
14.00000	18	SR	R-1		UC-1	hist
14.00000	18	SR	R-1		UC-1	hist
14.00000	18	SHIP	R-1		UC-1	hist
15.00000	10	SR	R-1		UC-1	hist
15.00000	24	SR	R-1		UC-1	hist
14.00000	17	SR	R-1		UC-1	hist
15.00000	8	SR	R-1		UC-1	hist

LITHICS	SETTING	ARCHREPORT	REFERENCE
	Terrace		Radford (DNR)
	Upland		Radford (DNR)
AB	Glacial	CL-89-03	
AB	Glacial	CL-89-03	
AB	Glacial	CL-89-03	
AB	Glacial	CL-89-03	
AB	Glacial	CL-89-03	
	Terrace	STP-90-02	
	Upland	STP-90-02	
deb	Terrace	STP-90-02	
	River	MULT-90-11	
deb	River	MULT-90-11	
deb, groun	River	MULT-90-11	
	River	MULT-90-11	
	Bluff		D. George (DNR)
	Bluff		D. George (DNR)
deb	Stream		D. Radford (DNR)
tools, deb	River	CL-95-01,CL-95-01,MCH-88-01,THY-87-	IMAC in 1995
	River	CL-91-01, CL-89-02	
	River	CL-93-03, CL-93-01	
deb	Stream		IMA 418
deb	Hill		
	River	MULT-90-12	
	River	MULT-90-12	
pp	River		MHS(CF)
pp	River		MHS(CF)
			MHS(CF)
		SL-90-5	Mulholland and Rapp(199
			MHS(218-7)
		SL-90-5	Mulholland and Rapp(199
			Trygg 14
			MHS(CF)
			MHS(GTF)
	Upland		
	Upland		
	Upland		
	Lakeshore		IMA
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