Multiple stream captures in a glacial spillway: Huns' Valley, Manitoba

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Introduction to the Region

The Manitoba Escarpment:

In the Riding Mountain area (see Figure 1 for general location), Manitoba Escarpment is formed by outcroppings of Cretaceous shales, which rise 230 to 425 m above the Manitoba Plain (Figure 2). Tyrrell formulated the basic stratigraphic nomenclature in 1890 and 1892. Since then, Kirk (1930) and Wickenden (1945) have presented additional descriptive information and subsequent revisions to the stratigraphic nomenclature. Bannatyne (1970) has further investigated the properties of the cretaceous shales and summarized the stratigraphy of the Manitoba Escarpment. Most recently, McNeil and Caldwell (1981) have published a comprehensive Geological Association of Canada Special Paper revising the Cretaceous System in the Manitoba Escarpment. Figure 2 illustrates the formations and members present in the Riding Mountain area and Table 1 provides additional information regarding the physical characteristics of these members.

Following an interval of erosion of Jurassic rocks, deposition of the Cretaceous beds began. The sandstone and shale beds of the Cretaceous Swan River Group are thought to indicate a transition from the terrestrial Jurassic environment to a marine environment (Wickenden 1945). Throughout most of the Cretaceous, continued subsidence resulted in the deposition of marine shales and limestone beds. The members of the Ashville and Favel formations and the Morden Shale and Niobrara formations were deposited during this interval. Near the end of the Cretaceous the axis of deepest sedimentation, formerly centred in Saskatchewan, shifted eastward and resulted in the deposition of the Pierre Shale and Boissevain formations. This displacement is believed due to

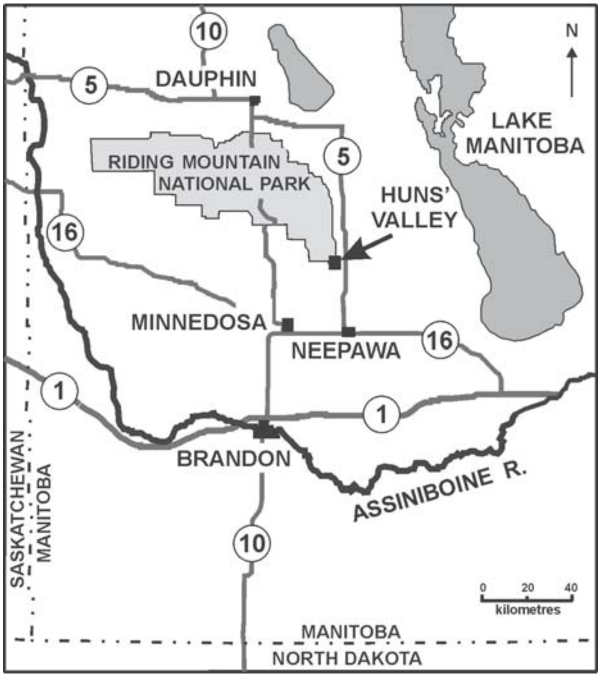

Figure 1: *South-Western Manitoba.*

initial orogenic uplift of the Rocky Mountains. The main uplift resulted in the withdrawal of the seas from the Interior Plains and cessation of Cretaceous sedimentation.

The advent of the Tertiary is characterized by continued emergence, subsequent erosion and pediplanation (Douglas et al. 1970). Bird (1972) suggests that the general process of scarp retreat in Tertiary times established the Manitoba Escarpment at its present-day geographic location 190 to 240 km west of the Precambrian Shield. No Tertiary deposits have been found on the Riding Mountain Uplands and it is believed that the pre-Pleistocene topography of the Riding Mountain area is closely approximated by the bedrock topography (Klassen et al. 1970).

Glacial History of the Riding Mountain Uplands:

The last glaciation of the Riding Mountain area occurred during the late Wisconsinan (20,000 - 12,000 B.P.). Glacial ice covered the entire region and generally flowed towards the southeast, (Klassen 1965).

The late Wisconsinan deglaciation of the Riding Mountain Uplands was associated with the Lockhart Phase of Glacial Lake Agassiz (11,600

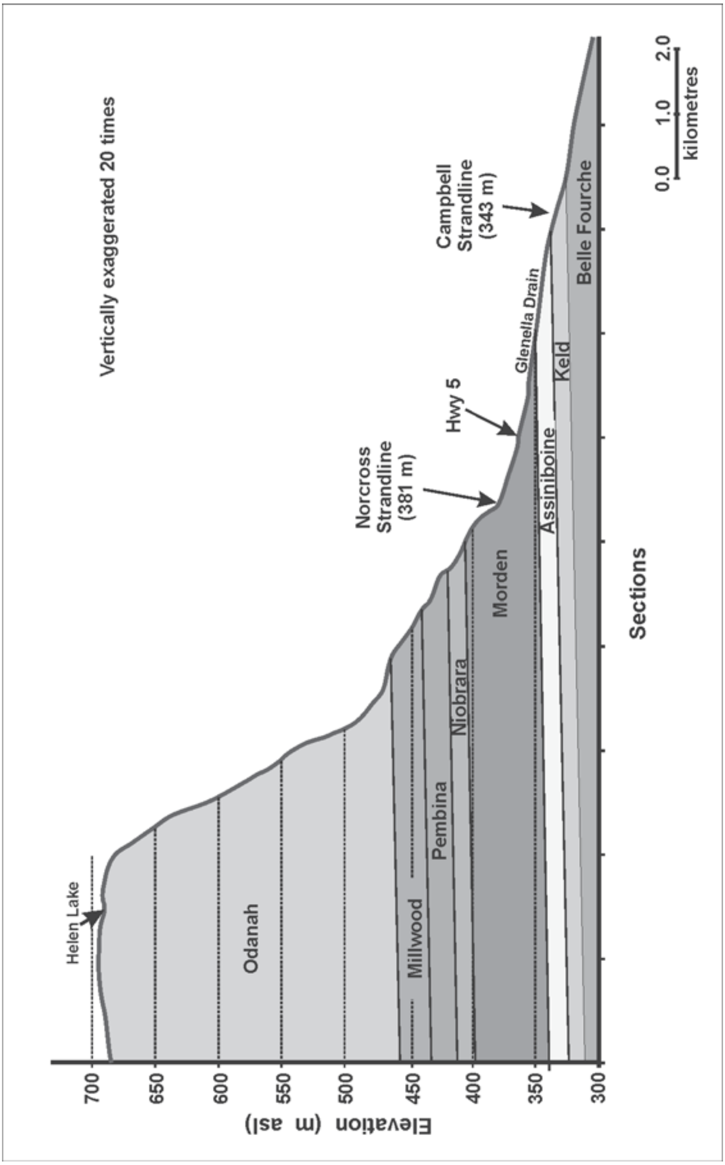

Figure 2: *Cross-section of the Manitoba Escarpment, Riding Mountain, Manitoba.*

Table 1: *Cretaceous Formations of the Manitoba Escarpment.*

FORMATION	MEMBER	BED
Boissevain		
Pierre	unnamed member	
	Odanah	
	Millwood	
	Pembina	
	Gammon Ferruginous	
Niobrara	unnamed member chalky shale	
	unnamed member calcareous shale	
Morden Shale		
Favel	Assiniboine	Marco Calcarenite
	Keld	Laurier Limestone beds
Ashville	Belle Fourche Shale	Ostrea beloiti beds
		fish-scale marker beds
	Westgate	
	Newcastle Sandstone	
	Skull Creek Shale	
Swan River		

- 10,800 B.P.). During the waning of the Falconer advance (post 11,400 B.P.) (Fenton et al. 1983), a large area of glacial ice stagnated on the Riding Mountain Uplands. Subsequent downwasting generated a drainage network consisting of several supraglacial lakes, spillways and meltwater channels (Figure 3). Meltwaters generally drained southward into Glacial Lake Hind (McGinn 1991). Many of these glacial rivers eroded their ice beds and incised into the substratum. Glaciofluvial sediments were deposited as sandurs, eskers and kames. Sub-aqueous fans were deposited in the supraglacial lakes and a major delta was built into the north end of

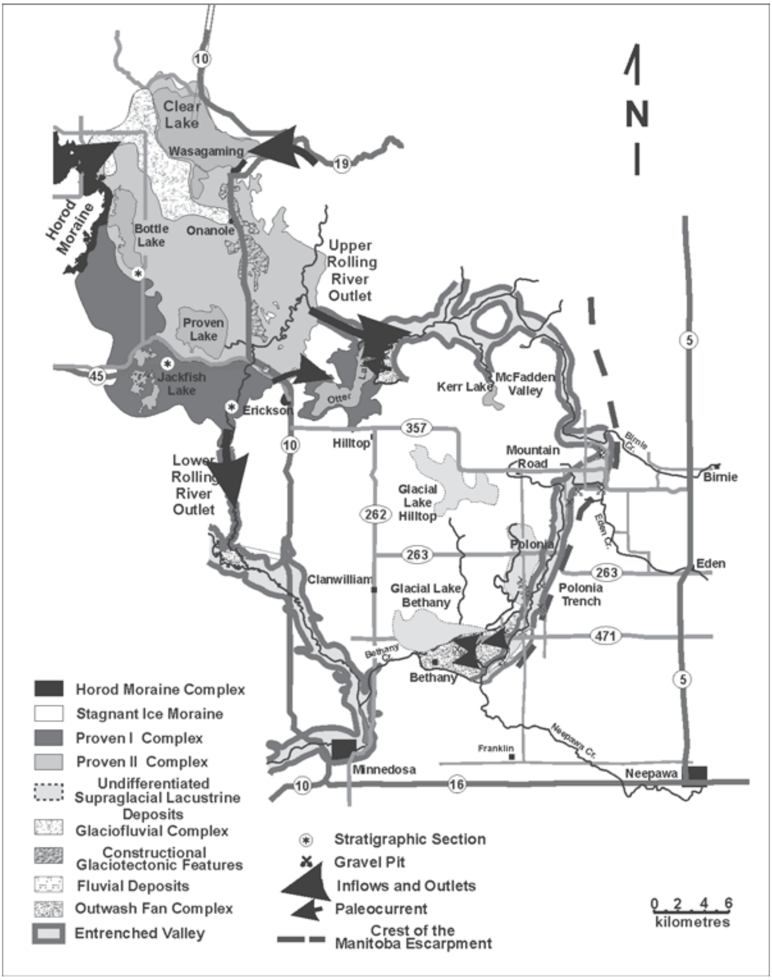

Figure 3: *Surficial deposits in the Glacial Lake Proven basin and the McFadden Valley and Polonia Trench.*

Glacial Lake Hind. As downwasting of the stagnant ice on the uplands continued, the supraglacial lakes drained and an entrenched drainage system developed on the stagnant ice moraine complex.

The McFadden Valley - Polonia Trench Spillway System parallels the crestline of the Manitoba Escarpment and illustrates many physical and sedimentological characteristics commonly associated with glacial meltwater channels (Figure 4). Paleocurrent measurements suggest that the flow was from the north towards the south-south-west through a deeply

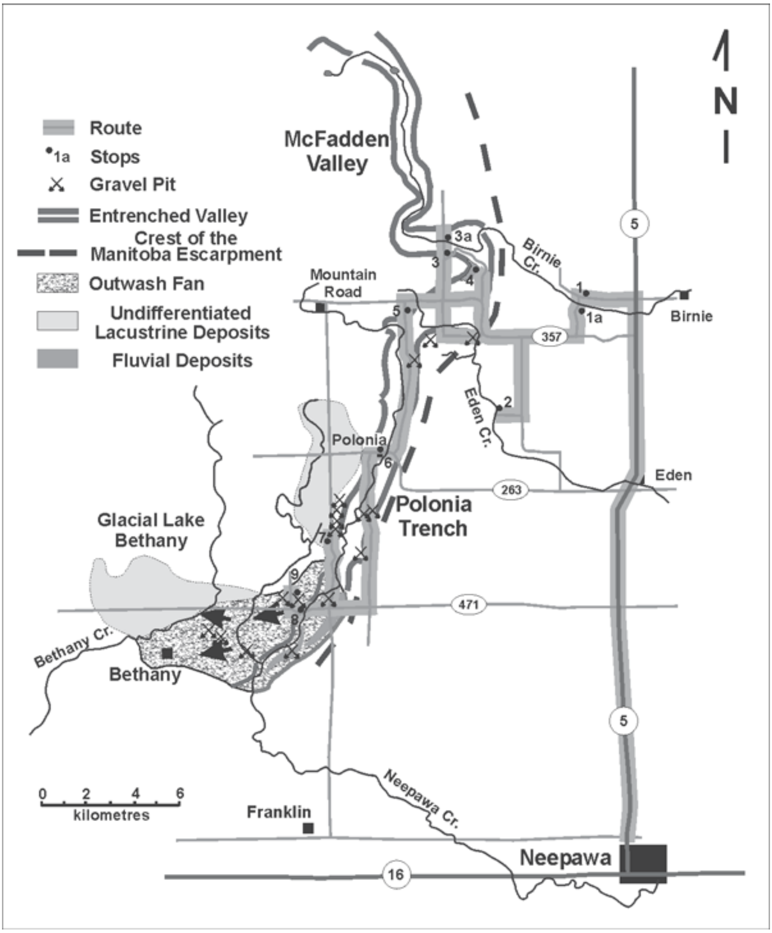

Figure 4: *Route map and stops, Huns' Valley physical geography field trip, PCAG 2002.*

entrenched channel and thence westward across a sub-aqueous outwash fan. In the northern section of the spillway complex, meltwaters were apparently diverted by sub-cropping bedrock hummocks and active glacial ice that created forced bends, associated scour pools and point bar deposits (Stops 3 and 4). Along the length of the valley, terrace deposits indicate an anastomosing stream environment, whereas the valley floor consists of outwash gravels overlain by recent colluviums and alluvial fan deposits. In one area along the west valley side, mudflow flow deposits overlie terrace gravels and there is evidence of active ice overriding the residual terrace deposits. The sandur plain/outwash fan is composed of braid stream deposits that grade into a sub-aqueous fan. The lithologies of the local glacial diamicts, terrace deposits and valley floor sediments are highly correlated.

The Route Description

The field trip route is illustrated in Figure 4. The field trip leaves Neepawa following Highway 5 north to the town of Eden. As you travel north, initially over the northern most deposits of the Assiniboine Delta and later over the Lake Agassiz lakebed, the Manitoba Escarpment is visible to the west. Near the town of Eden the escarpment rises approximately 230 m in relation to the Manitoba Plain. Four kilometres north the route turns west climbing approximately 90 m up the escarpment to the Birnie Creek viewpoint. Stops at the viewpoint and at the bottom of the valley provide an appreciation of the Holocene erosion and a view of Zelena Till and underlying Odanah shales.

Stop 1. Birnie Creek View Point and Photo Stop:

NTS 62J/5 Clanwilliam, UTM 464500 E, 5588200 N
Approximate Elevation: 490 m.

The 60 m deep and 600 m wide valley (locally referred to as "Big Valley") is believed to have formed during the Holocene and headward erosion into the scarp face of the Manitoba Escarpment has led to the capture of the McFadden Valley drainage (Stop 3a).

A 0.5 -1.5 m thick till veneer (the Zelena formation) overlies the Odanah Shale of the Pierre formation. Klassen (1979) suggests that the Zelena formation was deposited during the final stages of glacial ice stagnation during the Late Wisconsinan. Consequently, the Zelena formation represents the uppermost tills and intertill sediments on the Riding Mountain Uplands. Oxidized Zelena Till is usually yellowish brown or very dark grey brown in colour. Fresh (unoxidized) exposures are dark olive grey or very dark grey. The till is massive and of moderate compaction. The prominent clasts in the till are typically the more resistant Interlake region carbonates and shield metasedimentaries as the locally incorporated and softer Odanah Shale clasts have been quickly crushed or abraded to matrix size or terminal grade during glacial transport. Some larger shale clasts are evident but difficult to remove without fracture, so it is difficult to determine a percentage composition of shales. According to Klassen (1979) carbonates constitute approximately 26%-36% of the clasts.

In the Riding Mountain region, the Odanah Shale represents the uppermost member of the Pierre formation. It has a maximum thickness of approximately 150 m and consists of olive-grey siliceous shale with interbeds of softer darker olive-grey shale. Fresh exposures are greenish grey when moist. Variations in clay content create hard and soft shale. The shales are jointed and the joints are frequently stained reddish to purplish brown. Ironstone concretions are common. Thin bentonitic beds occur in the lower part of the formation.

Stop 1a. Bottom of Birnie Creek Valley:

NTS 62J/5 Clanwilliam, UTM 464490 E, 5588000 N
Approximate Elevation: 430 m.
Glaciotectonic deformation of Pierre Shale (Odanah Member).

Birnie Creek flows year around. The mean discharge is recorded to be 0.33 $m^3 s^{-1}$ and the highest recorded flood discharges exceed 23.0 $m^3 s^{-1}$.

Although bedrock exposures are not readily eroded by water, Odanah shales have a 4% - 8% absorption and air-dry shrinkage rates. Consequently the shale mechanically weathers rapidly by a combination of hydration and freeze-thaw activity facilitating bank erosion and mass wasting into the stream channel. The low saturated specific gravity (1.8) and blade- or plate-like cross-sectional shape (Cory shape factor of 0.2) enables stream traction and transport.

From the Birnie Creek valley the route is southward to PTH 357 (Mountain Road), then west rising another 85 m up the escarpment. A one-stop detour to the south (1.0 km) provides a view of the entrenched Eden Creek valley.

Stop 2. Eden Creek View Point and Photo Stop:

NTS 62J/5 Clanwilliam, UTM 460800 E, 5583300 N
Approximate Elevation: 565 m.

Eden Creek is ungauged and characterized by intermittent flow. Low flows often infiltrate into the alluvial fan near Eden. The mean discharge is estimated to be 0.04 $m^3 s^{-1}$. Spring freshet discharges and severe storm floods have been metered and can exceed 10.0 $m^3 s^{-1}$.

The headwaters of Eden Creek are located approximately 3.0 km upstream. The valley is 38 m deep and 350 m wide. The 36° active slope of the bank combined with the physical properties of the Odanah shale (see stop 1a) supplies sediment to the stream.

Bentonite layers interbedded with the Odanah Shale provide moisture for the stunted aspen trees contoured along the slope.

Returning to PTH 357, the route rises another 55 m to the crest the escarpment and turning north enters the Eden Creek capture zone - the junction of the McFadden Valley and Polonia Trench. Stops in this area view the deeply entrenched McFadden Valley spillway, the Birnie Creek capture zone and a prominent point bar deposit in a forced meander bend.

Stop 3a. McFadden Valley View and Photo Stop:

NTS 62J/5 Clanwilliam, UTM 458600 E, 5590300 N
Approximate Elevation: 665 m.

The McFadden valley is 55 m deep and approximately 1300 m wide. It is the middle segment of a glacial spillway/meltwater channel draining Glacial Lake Proven and other supraglacial lakes southward along the crestline of the Manitoba Escarpment (Figure 3). The spillway channel is twice as wide as the "Big Valley" of Birnie Creek and four times the width of the Eden Creek valley at stop 2. Much of the valley appears to have been cut through thick deposits of Zelena till. There may be a terrace remnant on the north side of the valley.

Stop 3b. Bottom of McFadden Valley View and Photo Stop:

NTS 62J/5 Clanwilliam, UTM 458600 E, 5590700 N
Approximate Elevation: 610 m.

The stream is fourth order according to the Strahler classification system. Basin length is calculated to be 17 km and the Shreve number is 35.

In the McFadden Valley, meltwaters were apparently diverted from the preferred southerly route by sub-cropping bedrock hummocks, which created forced meander bends and associated point bar deposits. A forced meander bend is morphologically defined as having a radius of curvature/ stream width ratio ranging from 2.5 to 3.0. One kilometre downstream is the elbow of capture where Birnie Creek has captured the Holocene drainage of the McFadden Valley. It is estimated that the capture of the McFadden Valley drainage has quadrupled the watershed area of Birnie

Creek. Georgison, (1985) estimates the normal (prior to capture) watershed area was 18.1 km^2. Birnie Creek watershed now drains 65.4 km^2.

Stop 4. Point Bar and View of Eden Creek Headwaters and Capture Zone:

NTS 62J/5 Clanwilliam, UTM 459800 E, 5589500 N
Approximate Elevation: 650 m.

The stream is third order according to the Strahler classification system. Basin length is estimated to be 14 km and the Shreve number is 18.

This massive point bar was formed as the flow encountered the active ice of the Red River Lobe spilling over the Escarpment crest and the Odanah shale bedrock sub-crops in the headwaters of Eden Creek. The eastern flow was diverted at first 180^o to the west and then 90^o to the south.

On the inside of this large forced meander accretion surfaces built up. These are composed of generally finer grain deposits (ripple laminated sands up-bar and accreted gravels down-bar). A lag deposit of very large rounded boulders is found at the apex of the forced bend with finer sediments down flow. A calculation of the potential discharge based on these lag deposits was not undertaken due to problems in defining the hydraulic geometry and hydraulic radius (depth of flow). To the south is the elbow of capture where Eden Creek has captured the Holocene flow from the McFadden Valley. Today, Eden Creek drains 33 km^2. It is estimated that the capture has almost doubled the early Holocene watershed area. Georgison (1985) estimates that the normal watershed area for Eden Creek was approximately 18.9 km^2.

The route turns south from Mountain Road along a section road to the Polonia Trench viewpoint.

Stop 5. Polonia Trench View and Photo Stop:

NTS 62J/5 Clanwilliam, UTM 456990 E, 5587600 N
Approximate Elevation: 650 m.

The Polonia Trench represents a relatively straight segment of a Late Wisconsinan spillway channel draining south southwest along the crest of the Manitoba Escarpment (Figure 3). Sinuosity ratios near unity characterize an anastomosing channel. The meltwater stream has entrenched 40-55 m into the Zelena and underlying Pierre formations (Stop

7). The valley is, on average, 1300 m wide. Terrace gravels are common along both rims and occasionally along the east side of the valley.

Dropping into the valley the route travels south along the trench paralleling Stony Creek to the town of Polonia (formerly called “Huns’ Valley”). The route traverses the northern part of the Polonia Trench, crossing a more recent alluvial fan deposit and then rising along the eastern edge of the valley. Remnant terrace deposits are exposed at lower elevations in the valley sides and at higher elevations Zelena till can be observed.

There is a short “historical geography” stop at St. Elizabeth of Hungary church and the Polonia shrine.

Stop 6. Polonia (“Huns’ Valley”):

NTS 62J/5 Clanwilliam, UTM 456000 E, 5581800 N

In August 1885, 17 families (43 individuals) of Austro-Hungarian miners (Magyars, Ruthenians, Czechs, and South Slaves) from Hazeltop Pennsylvania travelled via the Manitoba and Northwestern Railway. They settled on land donated by the M&N railway in Huns’ Valley close to Stony Creek, specifically, Twp 16, Rg 16, Sections 17, 21 and 33. By 1888, there were 30 families (122 individuals) on 30 homesteads. Each homestead had 20-70 acres broken, a team of oxen or horses, 10-16 cattle and pigs and poultry. During the winter the Huns’ Valley settlers cut firewood for Neepawa and the railway.

St. Elizabeth of Hungary Church, constructed in 1902 for approximately $2000, replaced the original church that was located at the cemetery. Huns’ Valley was renamed Polonia in 1921.

From Polonia the route continues southward travelling along the western edge of the trench, dropping to cross Stony Creek and then rising along the eastern rim of the Polonia Trench. Here there are several exposures of outwash sands and gravels deposited prior to channel entrenchment. A thin diamict (approximately 1.0 m) overlies the easternmost glaciofluvial deposits suggesting a overriding of the outwash by a flow till or a readvance (the Marchand Advance) of the Red River Lobe.

The route continues south through the northwestern extension of the Franklin moraine (Marchand advance) to join PTH 477. Turning west then north the route re-enters the southern part of the Polonia Trench, crosses Stony Creek and rises up the western edge of the valley. Here road-straightening construction has exposed the general stratigraphy of the southern part of the Polonia Trench.

Stop 7. A stratigraphic section in the Polonia Trench:

NTS 62J/5 Clanwilliam, UTM 453700 E, 5577500 N
Approximate Elevation: 610 m.

Approximately 4.0 m of glaciofluvial sands and gravels overlie a relatively thin (2 m) Zelena till. Three metres of Odanah Shale are exposed at the base of the section. At this site, it is believed, the usually thick Zelena formation has been scoured close to the bedrock by glacial meltwaters prior to the deposition of the sands and gravel and the lateral shifting of the main spillway channel.

Returning to 477, turn west, pass through the Stony Creek elbow of capture and turn north.

Slowdown Stop 8. Stoney (Neepawa) Creek:

NTS 62J/5 Clanwilliam, UTM 452400 E, 5575100 N

Stony Creek is a fourth order stream according to the Strahler classification system. Basin length is calculated to be 26.8 km and the Shreve number is 36.

Stony Creek has headwardly eroded into the Polonia Trench and captured the Holocene drainage. Georgison, (1985) estimates that stream capture has increased the watershed drainage area of Stony Creek by 110.9 km^2 to a value of 131.0 km^2. The pre-capture watershed area is estimated to be 20.9 km^2.

The last stop is in the rural municipality of Rosedale gravel pit located near the apex of the sub-aqueous fan deposited by the meltwaters in supraglacial Lake Bethany.

Stop 9. Bethany Fan:

NTS 62J/5 Clanwilliam, UTM 452000 E, 5576400 N
Approximate Elevation: 605m.

The rural municipality of Rosedale gravel pit is located near the apex of the sub-aqueous fan deposited by McFadden Valley-Polonia Trench meltwaters into supraglacial Lake Bethany (Figure 3). Paleocurrent indicators suggest flow towards the west. The coarse gravel and cobble lithologies are predominantly Interlake carbonates and shield metasedimentaries. Fine gravels are predominantly weathered shale. It is believed that the coarser shale gravels have been transported downflow where they comprise the bulk of the outwash fan.

References

BANNATYNE, B.B. 1970 'The clays and shales of Manitoba: Manitoba Department of Mines and Natural Resources' (Mines Branch Publication 67-1)

BIRD J.B. 1972 *The Natural Landscapes of Canada, a Study in Regional Earth Science*. (Wiley, Toronto)

DOUGLAS, R.J.W., GABRIELSE, H., WHEELER, J.O., SCOTT, D.F. and BEYEA, Hr. 1970 'Geology of Western Canada' in *Geology and Economic Minerals of Canada* Douglas, R.J.W. (ed). (Department of Energy Mines and Resources. Ottawa)

FENTON, M.M. MORAN, S.R. TELLER, J.T. and CLAYTON, L. 1983 'Quaternary stratigraphy and history in the southern part of the Lake Agassiz Basin' in *Glacial Lake Agassiz*. Teller, J.T. and Clayton, l. (eds.) Geological Association of Canada Special Paper 23 (University of Toronto Press. Toronto)

GEORGISON, J. P. 1985 *A Comparative Morphometry of Stream Pirate Watersheds Along the Riding Mountain Escarpment to Determine the Occurrence of Resulting Impact of Stream Piracy.* (Unpublished B.Sc. Thesis. Brandon University)

KLASSEN, R.W. 1965 *The Surficial Geology of the Riding Mountain Area, Manitoba-Saskatchewan*. (Unpublished Ph.D. Thesis. University of Saskatchewan)

KLASSEN, R.W., WYDER, J.E. and BANNATYNE, B.B. 1970 'Bedrock topography and geology of southern Manitoba'. (*G.S.C. Paper* 70-51 Map)

KIRK, S.R. 1930 'Cretaceous stratigraphy of the Manitoba Escarpment' *G.S.C. Summary Report* 1929, B, 112B-135B

McGINN, R.A. 1991 'The formation and draining of Late Wisconsinan superglacial lakes on the Riding Mountain Uplands, Manitoba.' *Atlantic Geology* 27, 221-227

McNEIL, D.H and CALDWELL, W.G.E. 1981 *Geological Association of Canada Special Paper 21* (Allen Press Inc. Lawrence Kansas)

WICKENDEN, R.T.K. 1945 'Mesozoic stratigraphy of the eastern plains, Manitoba and Saskatchewan' *G.S.C. Memoir* 239