BRANTFORD TUFA MOUNDS EARTH SCIENCE ANSI
Guelph District, Southcentral Ontario

Protection History

The Brantford/Hardy Road tufa site has been known for some time by local residents and conservationists but has not been previously described or recommended for designation. Immediately adjacent to the site is a provincially significant wetland (PSW) located within a former channel of the Grand River.

Setting

The tufa mounds site is located on the upper part of the Grand River Floodplain within the City of Brantford (Figure 1). It lies north of the river and immediately south of Hardy Road in a rural/agricultural area currently undergoing urbanization. The tufa deposit is adjacent to a cut-off meander bend of the Grand River at the base of a secondary river terrace. The surrounding floodplain has been used for intensive agriculture but the remaining in-situ tufa site is forested under mature hackberry trees (*Celtis occidentalis*).

A large gravel pit is located above the highest river terrace immediately northwest of the site. An approximately 80 m section of the former river channel north and northeast of the main tufa deposit has been in-filled by local terrace materials to allow farming access to the area south of the cut-off channel. The main tufa site must have extended eastward into this area but was partially destroyed by grading and ploughing activities. Abundant small fragments can be found on the fill surface and in the adjacent field. In addition, it is known that blocks of tufa had been removed for use as foundation stone in a nearby barn.

The site is currently within a development block that is being proposed for a housing development. The developer of this site has agreed to protect the PSW and the hackberry trees. This will also result in the protection of most of the remaining in-situ tufa but adjacent housing will impinge on the eastern edge of the tufa.

Earth Science Features

The tufa mounds site has been visited on two occasions (Oct. 19/04 and Nov. 16/04) to assess the nature of the deposit and potential earth science values. This report includes a detailed surficial map (Map 1) which has been prepared from field data and aerial photographs.

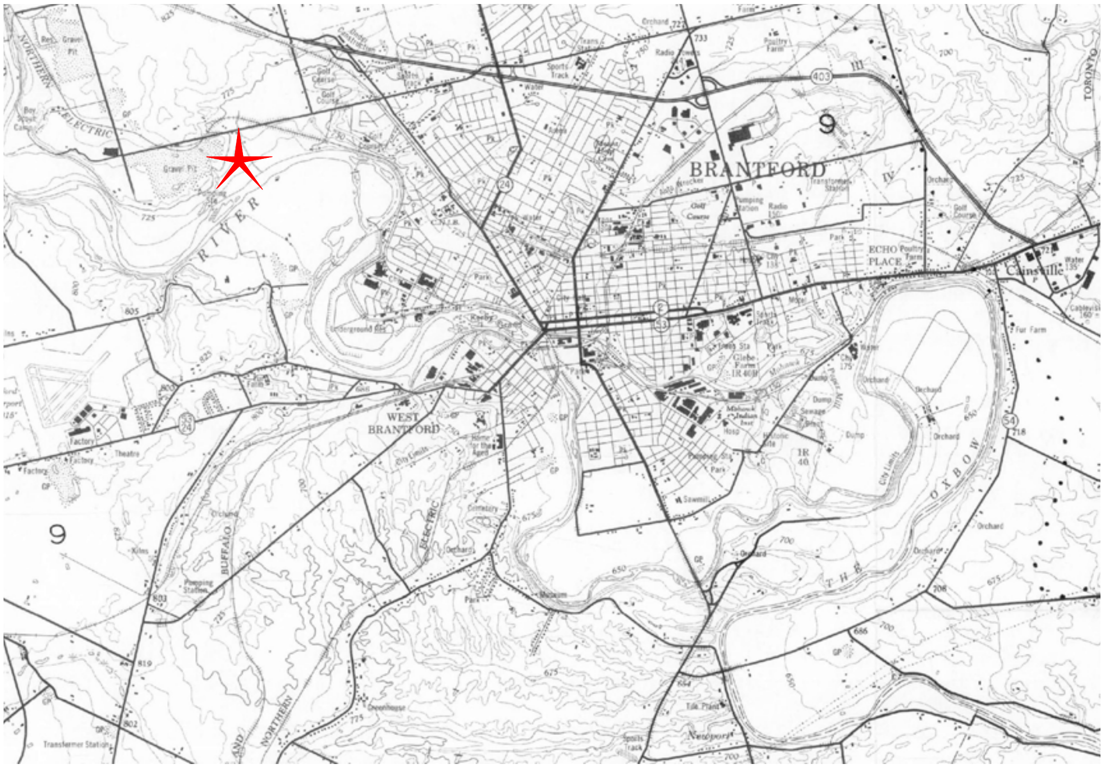


Figure 1: Site location in Northwest Brantford (NTS 40P/1).

Bedrock Geology:

Bedrock does not outcrop at or adjacent to the tufa mounds site. The bedrock forms a narrow trough under the surface oriented northwest to southeast which feeds into a large bedrock closed depression centered under Brantford, south of the Grand River (Karrow 1963). The bedrock surface is estimated to be approximately 38 to 50 m below surface at the site and the lowest portion of the depression is about 70 m below the river; 3 km to the southeast of the tufa site.

The underlying bedrock surface is composed of the Upper Silurian Salina Formation (Telford 1979). Hewitt (1972) describes this as consisting of grey and red shale, grey-brown dolomite, minor limestone, salt, anhydrite, and gypsum. It consists of eight members, four of which are evaporates. The evaporates are not present everywhere as they are extremely soluble and subject to removal by deep groundwater circulation and by surface waters within the outcrop zone. The Cayuga - Brantford – Paris area is within the outcrop belt but is mostly covered with surficial deposits. It is quite possible that the trough and bedrock depression noted above are the result of the solutional removal of evaporates from this area. Gypsum mining has taken place in the area and several abandoned shafts occur in the valley walls of the Grand River near Paris.

Surficial Geology:

Outline of Events and Terminology:

Figure 2 illustrates the surficial geology of the tufa site and surrounding area. The site lies within the upper floodplain of the Grand River near its main river terrace which was formed by glacial meltwater. Although Figure 2 shows the site to be covered in fine-grained alluvium and muck soils, these occur only on the main floodplain south of the site (Unit 14a, Figure 2). The terrace slope and upper floodplain appears to be dominated by re-worked sandy tills and/or glaciofluvial sands and gravels which form the terrace to the north and west (Units 5d and 7, Figure 2).

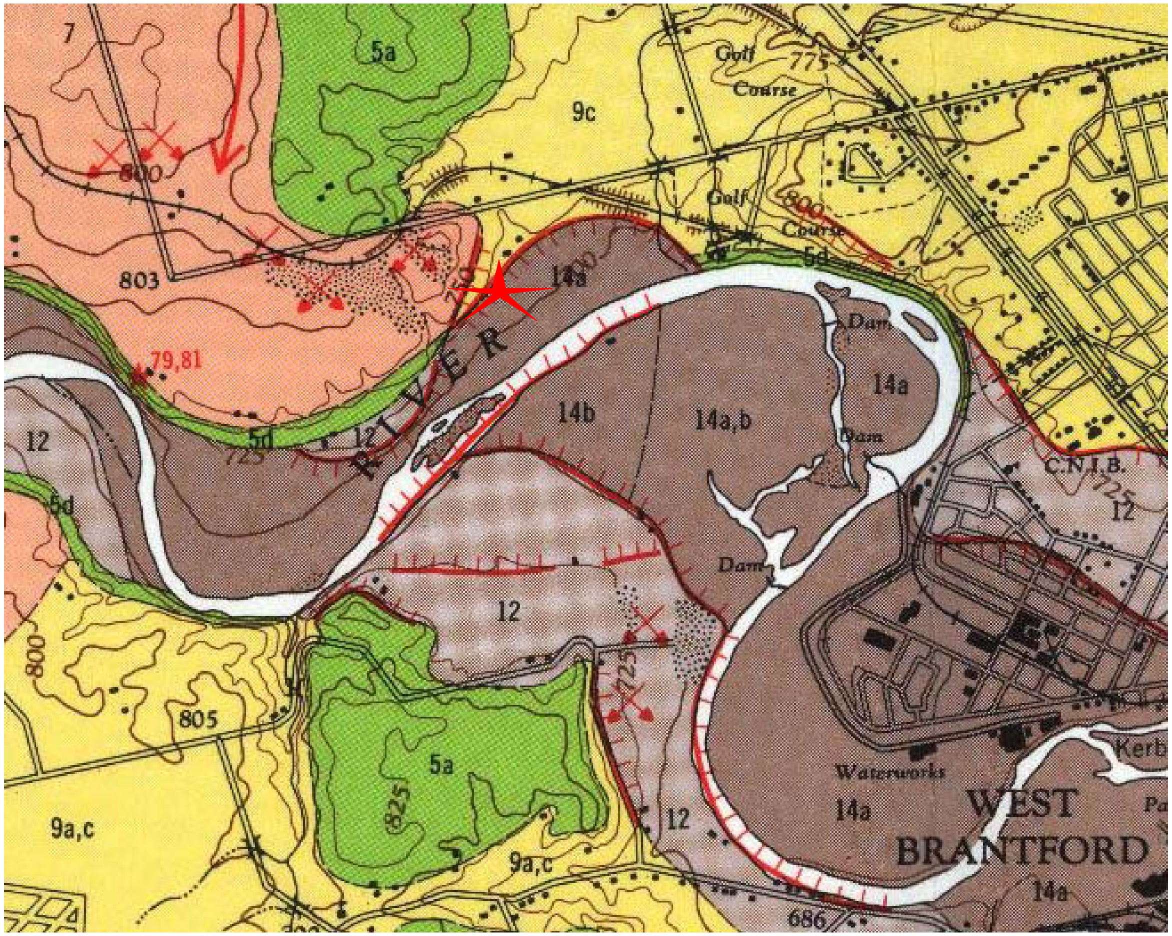
The glaciofluvial deposits occupy a former higher level meltwater channel which flowed from north to south at right angles to the flow of the current Grand River. This channel served as a major meltwater outlet for the ice front which was situated at the position of the Moffat Moraine, virtually coincident with the tufa mound site. The moraine ridge trends north to south and appears in Figure 2 as Wentworth Till (Unit 5a). The larger Paris Moraine lies immediately to the west of the meltwater channel just outside the map area.

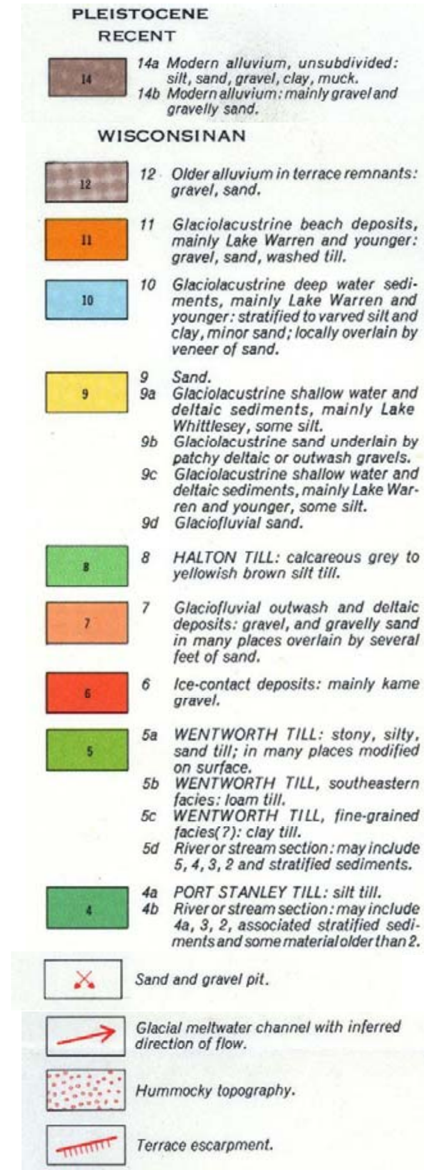
The tufa mounds are not currently active as shown by their general state of degradation and lack of ground water discharge in the immediate vicinity of the tufa. They are not bedrock features as the bedrock surface lies up to 50 m below the surface at this location. They are probably not of pre- or inter-glacial origin as tufa is very weak and would have been removed by subsequent glaciations. Hence, they must have formed after the Wisconsinan glacier retreated eastward from the Moffat Moraine position. Karrow (1968) notes that the Wentworth Till is the youngest till in this area, formed during one of the last advances of the Ontario lobe in the Late Wisconsinan. This till also occurs in the Galt moraine (to the west of the study area) which was formed about 13,400 years ago during a “readjustment of the Erie-Ontario lobe” in the Mackinaw Interstadial (Barnett 1992). Hence, the tufa mounds formed some time after this date.

Tufa, also referred to as ‘travertine’ or ‘sinter’, is a form of limestone (calcium carbonate - $CaCo_3$). Monroe (undated) defines it as “a mineral precipitate deposited by a mineral spring, either hot or cold…light in color, generally concretionary and compact… extremely porous or cellular…” (Photos 1 and 2). Marl is an unconsolidated variety of $CaCO_3$ and is commonly found in pools or ponds mixed with clay and/or organic materials.

Tufa and marl are depositional features associated with springs, seepages and geysers where waters enriched in calcium carbonate emerge at the surface. The source of calcium is usually limestone or dolostone bedrock undergoing some degree of solution

Figure 2: Quaternary geology of the Brantford tufa mound site and surrounding area (from Cowan 1972).





Site Location

by circulating ground waters. Glacial tills and other unconsolidated surficial deposits composed of these rock materials may also be a source. Ground waters emerging from the rock or deposit are saturated in calcium carbonate at atmospheric pressures found within conduits or pore spaces. Atmospheric pressures of carbon dioxide in the air, (CO_2 is the prime factor in driving the solution process), are lower than those in the rock mass or deposit, causing CO_2 to degas from the aqueous phase into the air on emergence. This results in super saturation of limestone in the emerging water which, in turn, leads to the relatively rapid precipitation of the mineral from the aqueous phase. This process is enhanced by the presence of vegetation which provides a large surface area onto which the mineral can precipitate.

Marl deposits are common in southern Ontario, particularly in association with springs and seepages draining from the Niagaran dolostones (Guelph, Lockport/Amabel formations) which form the surface rocks of the Niagara Escarpment. Many such deposits were utilized during the late 19th and early 20th centuries as a source of lime for the production of Portland Cement (Bruce-Grey Geology Committee 2004). However, tufa deposits are much less common, being found by this author in only a very few localities and in low quantities during many years undertaking karst studies in Ontario.

Large quantities of tufa deposits are commonly found in association with older major karst springs in areas outside of the extent of Pleistocene glaciation. In Canada, the only significant known deposits are associated with large hot springs in the Cordilleran region of British Columbia, Alberta and southern Yukon. Although tufa deposits associated with these hot springs are of significant size, no significant tufa deposits have been described for coldwater springs in this country. It is not clear why these deposits are not common or of significant size other than the relatively short period since glaciation available for their formation.

<u>Landform Feature Description:</u>

Map 1, attached to this report, is a surficial geology map of the study area. The map illustrates the extent of in-tact relict tufa mounds and the possible former extent of these features prior to disturbance by agricultural activities. The information is based on field studies (October 19 and November 16, 2004), interpretation of colour infrared aerial photos (1997) and test pit descriptions provided by Naylor Engineering Associates Ltd. (2003).

Much of the tufa has been disturbed by past activities including the removal of stone blocks for building material (Photo 1), burial by re-grading for farming purposes, and crushing within the plough layer. However, a significant zone of relatively undisturbed tufa occurs within the area of mature hackberry trees immediately south of the former meander of the Grand River (Figure 2). This area consists of flat-lying to low mounds of tufa interspersed with re-worked sandy till materials and marl. The meander channel is currently filled with marl and organic material and is part of a Provincially Significant Wetland. The maximum elevation of the surface of the tufa above the channel is only in the order of 1 to 2 m. The surface area of in-situ tufa is approximately 150 m by 150 m.

The tufa 'mounds' are very subtle topographically with relief in the order of only 50 to 75 cm and a width of about 4 m (Photo 3). A small opening, about 25 cm across, pierces the surface of the mound (Photo 4). The opening is the upper expression of a 'tube' which slopes at an angle of about 45^o. It is tempting to describe this opening and tube as the original feeder pipe for the emergence, however subsequent root growth or animal burrowing could have been causal.

Immediately east and south of this low disturbance zone is a more disturbed zone consisting of broken tufa pieces and/or marl (Map 1). The tufa fragments are most common west of the small stream which enters from the north. East of the stream only marl is present. It should be pointed out that the extent of marl was interpreted either from direct observation or from the test pit descriptions (Naylor Engineering Associates Ltd. 2003) wherever indicated as "light grey silt" or "light grey organic silt, shells". One auger probe of the stream bed encountered a tufa layer which could have been in-situ. The area to the west of the low disturbance area does not reveal tufa or marl beds in the upper 1 m based on several auger probes, however the re-worked sandy till in this area contains abundant $CaCO_3$ to the surface. This was determined using dilute hydrochloric acid to test for effervescence denoting free carbonates.

The exact origin of the tufa mounds is problematical as there is no on-going indication of spring activity in the immediate vicinity of the deposit. However, a nearby resident has reported a 1994 occurrence of a water spout at this location. The spout rose up to 10 ft in the air (I. Kramer, pers. com.) and flooded the adjacent field in the area of the disturbed tufa for several days. Although no tufa deposits can be identified from this episode, active tufa deposition is currently occurring at a spring southeast of the mounds (see below).

As noted above, the formation of the tufa must post-date the retreat of the Ontario ice lobe from the position of the Moffat Moraine during the Late Wisconsinan/Early Holocene. It is unlikely related to meltwater at this time since the ice front was oriented north-south cutting across the floodplain of the Grand River which formed after the ice withdrew. The Grand River served as a major meltwater channel draining several ice lobes as they retreated from the "Ontario Island" (Karrow 1968, Cowan 1972, Figure 2). This portion of the proto Grand River channel formed after the Ontario lobe withdrew out of the Brantford area.

The location of the tufa, within the second of two river terraces and adjacent to a former meander of the proto-Grand River (Figure 2), indicates that it must be contemporaneous with active channel at this location. The tufa mounds indicate that at the time of formation, groundwaters rich in $CaCO_3$, were under artesian conditions sufficient to rise at least up to about 2 m above the river level at this location. It is not known whether the source of the dissolved limestone was from the underlying bedrock or from the higher adjacent glaciofluvial, glaciolacustrine and till sediments (Figure 2). As noted above, the bedrock is 40 to 50 m below the surface at this location so a bedrock source would require greater hydraulic head than a surficial source. Also, the underlying bedrock in this area – the Salina Formation – is not a confined aquifer. It is actually a recharge zone today. At the time of formation, however, much more water was available in both the groundwater and surface water systems due to recharge from melting glaciers.

The occurrence of both marl and tufa suggest possible alternating surface water levels at the site during the active $CaCO_3$ depositional period. The marl is more indicative of wet/ponded conditions whereas the tufa indicates very shallow to dry conditions. There is no evidence of organic soils overlying the re-worked till in the area of the tufa, thus the alternating water levels may represent periods of over-bank flooding followed by better drained conditions. The marl is often found in association with organic material and usually buried by the re-worked till (Naylor Engineering Associates Ltd. 2003), thus it is possible that the marl formed during an earlier wetter period when more surface meltwater flow was present followed by drier conditions. However, the exact relationships between marl beds and re-worked till is difficult to ascertain given the effects of ploughing.

The process of tufa/marl deposition essentially ended when meltwater flows decreased and the Grand River channel shifted to the south. The springs feeding the tufa site were cut-off with the reduction of surface and ground waters but some spring activity appears to have shifted with the river channel. A series of active springs/seepages occur at the lower river terrace to the southeast of the tufa deposit (Map 1). The seepages are under low artesian head as they can be seen to be ‘bubbling’ to the surface. Minor amounts of actively forming tufa can be found crusted on vegetation in the spring drainage and fragments of relict tufa can also be found in this area.

The reported occasional 10 ft water spouts which occur in the area of the relict tufa mounds may represent artesian 'leakage' during periodic high flow events. Periodic geyser activity may be a response to high rainfall events and/or by pressurization of ground water relating to gypsum mines in the surrounding area.

Sensitivity

The site is extremely sensitive as shown by past impacts relating to agriculture, re-grading and stone excavation. An urban subdivision is currently planned for this location and housing construction would result in the final destruction of the site.

During the course of the November 2004 field work, a field meeting was held with the engineering consultant for the proponent (Mr. Joe Cohoon representing Hampton Estates Subdivision). Issues relating to the destruction of the tufa as well as potential hazards relating to future geyser events were discussed. The proponent has already agreed to protect the hackberry woodlot and adjacent Provincially Significant Wetland but the proposed subdivision plan would still result in several backyards encroaching on the most significant features including the tufa mound shown in Photos 3 and 4. Based on this meeting, the engineer agreed to remove these housing units from the plan (J.

Cohoon, pers. com.). The Candidate ANSI boundaries in this area (Map1) are drawn to reflect this agreement.

Significance

The tufa mounds and features are extremely rare in Ontario. None has been reported in the literature to this date although anecdotal evidence suggest that other tufa areas occur in the Brantford – Paris area. It is not known whether these are similar relict mounds or active tufa deposition relating to current conditions. At least one other site was visited which was found not to be analogous to the current site. The second site (near Paris) involved active tufa deposition from seepages within a valley wall slump.

As noted above, it is generally considered that such quantities of tufa could not have formed post-glacially given the short period of time other than at constant-flowing hot springs. Although the existing site is disturbed, should the remaining features be protected, they offer excellent educational, interpretive, and scientific opportunities. Some interest in further study of these features has already been provided to the author from Dr. Mario Coniglio, a specialist in carbonate deposition at the University of Waterloo.

As such, this site is ranked Provincially Significant. This ranking should be reviewed pending a more detailed theme study of tufa deposition in southern Ontario (see Recommendations).

Recommendations

Proposed boundaries for this ANSI (Map 1) include two individual areas. The boundaries include the main tufa deposit based on the above noted agreement with the proponent's consultant as well as a second area to the east and south. This second area includes the small coldwater stream which intersects possible in-situ tufa and also incorporates the modern springs which have some active tufa deposition. The second area also captures a large part of the modern floodplain of the Grand River. It is recommended that these boundaries be accepted for designation of the ANSI.

It is also recommended that further studies be undertaken by OMNR of known (anecdotal) tufa sites and other possible locations in southern Ontario. This tufa theme study will allow a full assessment of the phenomenon in Ontario as well as provide confirmation of the significance ranking for the present site.

The tufa mounds and marl deposits at the Candidate Brantford Tufa Mounds Earth Science ANSI should be considered for more detailed scientific research including carbonate analysis, further site characterization (tufa/marl relationship, thickness of tufa and marl, mound stratification, etc.), and further analysis of formative processes. As noted above, some interest in this has already been expressed from Dr. Mario Coniglio at the University of Waterloo. Such work could involve Masters level studies of this site and other tufa sites in the Brantford – Paris area.

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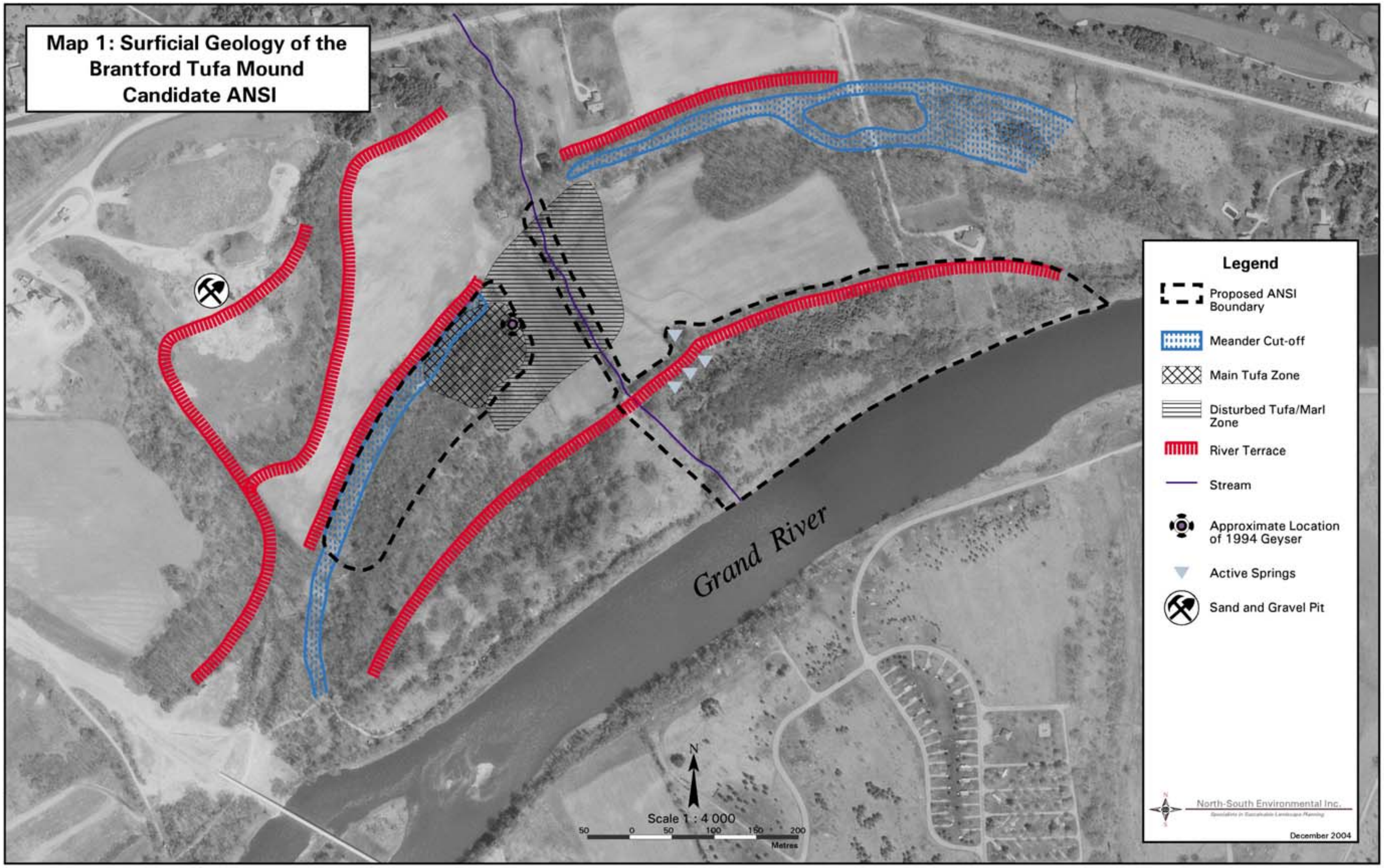
Map 1: Surficial Geology of the Brantford Tufa Mound Candidate ANSI
Grand River
Legend
Proposed ANSI Boundary
Meander Cut-off
Main Tufa Zone
Disturbed Tufa/Marl Zone
River Terrace
Stream
Approximate Location of 1994 Geyser
Active Springs
Sand and Gravel Pit
N
Scale 1 : 4 000
50 0 50 100 150 200
Metres
North-South Environmental Inc.
December 2004

Photographs

Photo 1. Detail of tufa porous tufa stone from block used in the foundation of a small barn near the tufa mound site. The pores are mostly the result of the precipitation of limestone ($CaCO_3$) around vegetative matter which subsequently decomposes.

Photo 2. Flat-lying tufa ‘bedrock’ exposure within relatively undisturbed tufa outcrop zone.

Photo 3. Low tufa 'mound' within the low disturbance zone in the hackberry woodlot. The former channel is about 15 m to the upper right behind kneeling figure. This person is on top of the mound and the auger is positioned in the mouth of the opening.

Photo 4. Opening at top of tufa mound shown in Photo 2.