DEPOSITIONAL HISTORIES OF VERMONT ALLUVIAL FANS

A Thesis Presented

by

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ABSTRACT

Alluvial fans are complex, long-lived features of the Vermont and New York landscapes. The locations of 34 alluvial fans were mapped in Vermont, with an additional 25 alluvial fans mapped in the Catskills region of New York. These fans are situated on river terraces and in glacial valleys.

The stratigraphy of five alluvial fans in Vermont was investigated using multiple backhoe trenches and radiocarbon dating of wood and charcoal in order to determine the depositional history of each alluvial fan. The fans range in volume from 1,300 to 14,500 m^3, and in age from 200 to 13,320 years before present. All five fans contain evidence suggesting episodic deposition, including layers of gravel and cobbles. Periods of little or no fan aggradation are indicated by the development of now-buried soils. Aggradation on these fans may be the result of increased local storm magnitude, frequency, duration, or landscape disturbance.

The youngest fan, located in Maidstone, Vermont, accumulated its entire volume of 4770 m^3 within the last 150 to 200 years. An alluvial fan at Bristol, Vermont, shows rapid aggradation events at around 9,300 years BP and 4,000 years BP, with a smaller event at 3,200 years BP. These three depositional events are separated by times of little deposition with minor A-horizon soil development. In Eden Mills, Vermont, an alluvial fan shows rapid deposition early in the fan's history, from 13,300 to 12,900 years BP, followed by moderate deposition to 9,500 years BP. There is evidence of channel incision followed by rapid filling at 6000 years BP. Small amounts of deposition on the fan ensued until historic clear-cutting of the adjacent hillslope triggered approximately 3000 m^3 of material to be deposited on the fan surface; close to a meter of vertical aggradation over the past 100 years. The alluvial fan in Bridgewater, Vermont shows the majority of its aggradation between 3000 to 6000 years BP. The fifth alluvial fan that was investigated, located in Hancock, Vermont, has poor dating control, but also shows a characteristic sequence of rapid aggradation episodes interrupted by periods of fan quiescence as evidenced by large gravel units which overlie buried A and B soil horizons. Comparisons of aggradation on the five alluvial fans revealed very little correlation, indicating that intense, localized storms are more influential in triggering deposition than regional storm systems. However, periods of fan surface stability are correlative, indicating that hillslope stability may be linked to climate.

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My advisor, Paul Bierman came up with the initial proposals for paleostorm research in New England, and found funding for this research. I would like to thank Paul for inviting me to participate in this project, and for his constant encouragement and enthusiasm.

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CHAPTER 1: Introduction

Purpose

Alluvial and debris fans are direct, low resolution recorders of hillslope erosion. In humid regions, the majority of natural hillslope erosion is the result of large amounts of precipitation (Kochel, 1990). Previous work in Vermont (Church, 1997; Zehfuss, 1996; Bierman et al., 1997) has suggested that hillslope erosion is simultaneous within a specific drainage basin and occurred at specific times in the past.

The objectives of my study are twofold: (1) to understand alluvial fan development in the humid-temperate environment of New England and (2) to determine whether hillslope erosion and subsequent fan deposition due to large storm events occur at the same time over large areas. In order to address these objectives, I mapped, trenched, studied, and dated the stratigraphy of five alluvial fans within different drainage basins in Vermont. My research is part of a larger project to examine the paleostorm history of Northern New England using lake and alluvial fan sediments (Brown et al, 2000; Brown, 1999; Jennings et al, 1999; Noren et al, 1999; Bierman et al, 1997; Church, 1997; Li, 1996; Zehfuss, 1996).

preservation of organic material because the soil remains below the water table for most of the year. The moisture keeps the soil in an anoxic condition, which prevents decomposition of organic material.

Selection of Fans for Study

During the reconnaissance phase of my thesis research, I traveled around Vermont and eastern New York identifying alluvial fans that could be used in my study. Because my goal was to trench the fans, I only recorded the locations of alluvial fans that were small in size (less than 10 m high at the apex), easily accessible by roads, and devoid of dense vegetation. In total, I mapped the locations of 45 alluvial fans in Vermont and 25 alluvial fans in the Catskills region of New York. The location of these alluvial fans are shown in Figures 1.1 and 1.2, and described in Appendix A. The scattering of fan locations throughout the two states may be biased by my inability to locate fans in forested areas, and my reconnaissance method of driving along easily accessible roads. For example, I looked for alluvial fans in the Adirondack region of New York, but the dense vegetation made locating alluvial fans extremely difficult.

All of the fans I have identified in Vermont and New York are located in valleys with flat valley floors abutting very steep mountainsides (Figure 1.3). A drainage must also be present in order to carry sediment to the valley floor and form an alluvial fan. For example, some valleys in the Catskills seemed ideal for alluvial fan formation and preservation, yet no alluvial fans had formed at the base of the hillslopes. The lack of alluvial fan formation there may be the result of a lack of erodable material and small streams on the hillslopes.

Final selection of the alluvial fans for trenching was based on landowner permission and fan condition. Because the Catskill fans were too far away from the Vermont fans to spatially compare their depositional sequences, I decided to only trench alluvial fans in Vermont. The five trenched alluvial fans, located in Eden Mills, Hancock, Maidstone, Bristol, and Bridgewater Corners, are widely spaced across Vermont in order to examine the influence of regional storms on the depositional history of all five alluvial fans.

Significance of Research

My research is the first comprehensive study of humid alluvial fan development in New England. I have logged and described the stratigraphy of five alluvial fans in Vermont in order to determine their depositional history. This research focuses on understanding the temporal and spatial distribution of hillslope erosional and depositional processes in these fans. The frequency and volume of depositional events on each fan records pre-historic, storm-induced erosion on the adjacent hillslopes and historic ground surface disturbance from logging. Using this information, I have examined whether deposition was simultaneous in different river basins, a finding which would indicate a strong climatic influence on hillslope erosion rates in Vermont.

Outline

This document presents field observations, data, and conclusions of my study in 'journal article thesis' format as outlined by the Graduate College of the University of Vermont. I begin with a comprehensive literature review in Chapter Two that includes information on alluvial fan development, New England climate history, and related Vermont research. The bulk of my methods, data, and conclusions are presented as a journal article for submission to the *Geological Society of America Bulletin* in Chapter Three. This article focuses on the timing of storm-induced depositional events within five alluvial fans in Vermont. I have chosen to submit the article to the *Geological Society of America Bulletin* due to the large number of figures, which require more space than many other journals will allow. Also, I have extensive, detailed notes on the stratigraphic units of the five study fans, which are too lengthy for the article. The *Geological Society of America Bulletin* allows such information to be stored in a data repository which is accessible to the public. This repository submission follows the article in Chapter Four. Chapter Five summarizes the entire thesis, including the importance of this research.

A comprehensive bibliography is presented after the thesis chapters. Appendix A contains data on field mapping of alluvial fans in Vermont and New York. Survey data and aggradation rate calculations appear in Appendices B and C, respectively. Appendix D shows the outlined drainage basins for each trenched alluvial fan. Appendix E provides suggestions for logistical planning of further studies.

Figure 1.1 Alluvial fan locations in the Catskills region, New York as indicated by the black dots (adapted from Reader's Digest Association, 1969).

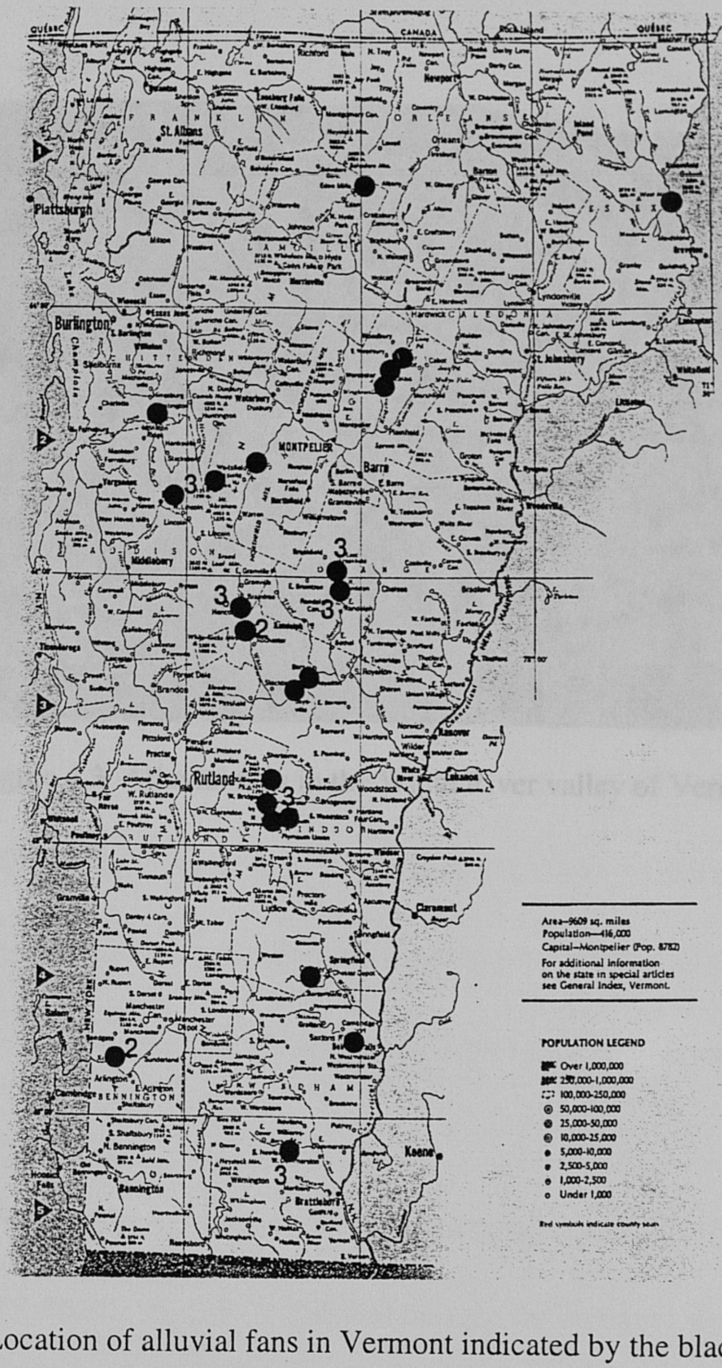

Figure 1.2 Location of alluvial fans in Vermont indicated by the black dot; number indicates more than one fan at that site location (adapted from Reader's Digest Association, 1969).

Figure 1.3 Alluvial fans in the White River valley of Vermont.

CHAPTER 2: Literature Review

An alluvial fan is a cone-shaped accumulation of water-deposited sediment formed at the interface between steep hillslopes and flat valleys where streams exit confined channels (Figure 2.1). Deposition of sediment at these locations is due to the increase in width, and decrease in depth and velocity of the stream as the water spreads out in the unconfined valley (Rachocki, 1981). Alluvial fans are found at all latitudes and in a range of climates (Rachocki, 1981). Fans range in scale, but not in general shape (Ritter et al., 1995), and the gradient and radius of alluvial fan deposits are inversely proportional (Rachocki, 1981). The shifting nature of deposition on the fan surface through a network of distributary channels creates the characteristic fan shape despite differences in sediment grain size (Rachocki, 1981) The highest point of the fan, where the stream emerges from the confined drainage basin, is referred to as the apex of the fan (Ritter et at, 1995; Rachocki, 1981). Likewise, the fan toe is defined as the distal portion of the fan.

Traditionally, most fan research has focused on alluvial fans of arid regions (Ritter et al., 1995; Rachocki, 1981). The arid fans are frequently studied because of their large size, ease of accessibility, good preservation condition (i.e. not eroded, incised or developed), and because of their proximity to some of the pioneering universities in geomorphologic research (Rachocki, 1981). However, alluvial fans are also common landscape features in humid and temperate climates (Ritter et al., 1995), and are especially prevalent in areas glaciated during the Pleistocene due to the steep gradient of glaciated hillslopes (Rachocki, 1981).

Alluvial fans as documentation of upstream hillslope erosion rates

Alluvial fans are the end product of the geomorphic processes acting in the upstream basin (Bull, 1991) and can preserve information about upstream hillslope processes and the rates at which they are occurring. For example, the frequency of deposition on alluvial fans may reflect climate (transport limited conditions) or the length of time needed for generation of surficial material, e.g. sufficient substrate weathering (erosion limited conditions) on adjacent hillslopes (Bull, 1991). Bull (1991) found that in arid regions, bedrock hillslopes of schist and quartzite require more rainfall to initiate sediment development and movement than hillslopes of granite or amphibolite, which weather more rapidly.

Distinct bedrock types will have differing responses to changes in temperature and precipitation; Bull (1991) suggests that clast composition in alluvial fans may give a rough estimate of climatic conditions. For example, clasts composed mostly of granite may indicate an arid environment during the time of deposition on the fan surface. In fans fed by bedrock-floored stream channels, the size of the clasts may also indicate the amount of time allowed for in situ colluvium formation before sediment movement is initiated (Bull, 1991). However, in tectonically active regions, weathering and erosion processes can be accelerated by high amounts of bedrock fracturing (Pierson, 1980).

In humid and densely vegetated regions, bedrock erosion rates may correspond poorly with alluvial fan depositional rates over the short term. Vegetation on hillslopes will increase the amount of chemical and physical weathering occurring and enhance colluvium development on the hillslope (Bull, 1991). However, the root strength of the vegetation, especially trees, will provide more cohesion to the soil, stabilizing the hillslope despite the increased amount of sediment development (Bull, 1991).

Alluvial fans located in areas glaciated during the Pleistocene may have drainage basins formed in unconsolidated sediments. In these regions, large alluvial fans may form rapidly, due to the mobile nature of the basin sediments. Rachocki (1981) found that the low compactness of glacial and glaciofluvial sediments in northern Poland were conducive to forming alluvial fans with radii up to 1.5 km since the early Holocene. Alluvial fans with smaller gullies in glacial sediments, and fan radii of tens of meters, were found to have formed within the past 200 to 300 years (Rachocki, 1981).

Alluvial fans as recorders of climate change

There is some disagreement in the literature about the ability of alluvial fans to record changes in climate. According to Bull (1991, p. 146), changes in regional hillslope erosion rates will result only from "*large* and *prolonged* shifts in climate, not from minor climatic variations lasting less than 1 ky" (emphasis added). He adds that stream flooding is more sensitive to small climatic changes, and may be a more useful proxy for frequent meteorological events. Rachocki (1981) argues that alluvial fans are poor recorders of climate change because of their inability to preserve quantifiable information about climatic conditions such as precipitation and temperature. He adds that climate changes can only influence the rate of alluvial fan processes, and not the nature of those processes, making it difficult to observe changes due to climate in the fan stratigraphy (Rachocki, 1981). For example, fan dissection may be the result of increased precipitation, a lack of sediment supply, or even tectonic activity (Rachocki, 1981).

Alluvial fans may be poor indicators of climate changes due to multiple controls on hillslope erosion and downstream depositional rates. Bull's study in the Charwell River basin of New Zealand (Bull, 1991) revealed that the response time of a particular sub-basin to climate change depended on three basin characteristics: (1) drainage-basin area (which influences available stream power), (2) lithology (which influences bedrock

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In contrast, many recent studies found a strong correlation between alluvial fan deposition and individual storm events, or small climatic changes. For example, Allen (1999) used pollen records from an alluvial fan in southwest Ireland to show that depositional events correlated with vegetation changes (the demise of woodlands) as well as changing climate, including a switch to wetter conditions. Kochel et al. (1997) used alluvial fans to estimate the influence of 5-year wet/dry cycles in San Diego, California on hillslope erosion rates. They found that the increase in vegetation during wet periods decreased the amount of overall hillslope erosion and the number of debris flows. However, the increased stream power caused significant channel erosion and fluvial deposition on alluvial fans. The deposition consisted of hyperconcentrated flow deposits on 20% of the fan surfaces, identified by the lack of stratification and the patchy imbrication of clasts (Kochel, et al. 1997).

Kochel and Johnson (1984) used the ages of buried soil horizons in alluvial fans in Virginia to determine that the fans were constructed by infrequent deposition during large rainstorms having a 3000 to 6000 year recurrence interval. Wells and Harvey (1987) document thirteen alluvial fans that developed during a brief (2.5 hour) and intense storm in northwest England. These newer findings suggest that it may be possible to use alluvial fan deposition to get a low-resolution record of climate change, or even to track storm frequency. Kochel (1987) suggested that alluvial fans could be useful recorders of climate change when combined with studies of more climate-sensitive landforms, such as river floodplains.

Another example of alluvial fan deposition due to large storm events comes from Pierson (1980), who witnessed repeated debris flows and streambed incision within a ravine in New Zealand during a storm event that lasted several days. The streambed incision initiated by the large amount of precipitation (32 cm over three days) destabilized the hillslopes, causing the debris flows. The easily destabilized hillslopes were attributed to the highly fractured nature of the bedrock, although small areas of the hillsides had been deforested as well (Pierson, 1980). Sediment deposition near the mouth of the ravine was confined to debris-flow levees. Deposition further from the mouth of the ravine, on the lower alluvial fan, was as a sheet deposit with a thickness of one to two meters (Pierson, 1980). Total sediment deposition during the three-day event was equivalent to thousands of years of sediment discharge by average fluvial processes in this ravine (Pierson, 1980).

Ballantyne and Whittington (1999) point out that alluvial fan deposition is usually attributed to either anthropogenic influences, climate changes, or extreme meteorological events. The alluvial fan they studied, in the central Grampian highlands of Scotland, has a stratigraphy of sand or gravel strata separated by peat layers that developed during times of fan surface stability. They radiocarbon-dated the peat layers and analyzed pollen grains from two stratigraphic sections to determine the reason for each period of fan aggradation. The preservation quality of each pollen grain was used to determine if the pollen was deposited in situ (providing an accurate representation of vegetation types in the basin at that time) or re-worked from eroded sediment upstream. The pollen with good preservation quality indicated that there was no human interference in the catchement and no long-term significant climate changes in the region (Ballantyne and Whittington, 1999). Ballantyne and Whittington concluded that the fan was deposited in several short, intense depositional events during unusually large storm events. Although the alluvial fan as a whole is over 2000 years old, the actual depositional events may have occurred during only a few hours (Ballantyne and Whittington, 1999).

Anderson et al. (2000) analyzed pollen preserved in peat layers interbedded with alluvial fan and debris cone sediments in southwestern Ireland. Radiocarbon dating of peat layers overlying inorganic units showed a clustering of aggradation during 230-790 calibrated years A.D. and at 1510 calibrated years A.D. (Anderson et al., 2000). These clusters coincide with shifts to wetter conditions from 550-740 A.D. and the Little Ice Age in the 16^{th}-19^{th} centuries (Anderson et al., 2000). Based on their pollen data, which suggested vegetation removal and grazing practices during those time periods, Anderson et al. (2000) attributed alluvial fan aggradational periods to a combination of human activity coupled with changes in climate.

It may be misleading to assume that depositional strata on alluvial fans preserve the timing of the largest storms through a region. Twidale (1997) examined the formation of many historically developed landforms in varied settings. He noted that in the cases of rapid gully formation or hillslope erosion, that there had been a gap of decades between the timing of watershed disturbance (usually vegetation clearance), and the meteorological event that triggered the gullying or hillslope movement. Twidale concluded that this time gap is dependant on the time necessary for the decay of tree roots, weathering of sediment, and the loss of soil cohesion rather than on the magnitude of the triggering storm event. In many cases, it was not the largest storm after watershed disturbance that initiated the hillslope erosion. Hence, the rapid development of any particular landform could be the result of a combination of factors over a long time period rather than just the increased precipitation from one storm event (Twidale, 1997).

Differentiation of stream-flow, debris-flow and hyperconcentrated-flow deposits in alluvial fan stratigraphy

Hillslope material is transported to the alluvial fan surface as a multiphase fluid composed of water, sediment and air. The multiphase fluid can be classified as either stream-flow, hyperconcentrated-flow or debris-flow depending on velocity, sediment concentration, and water content (Figure 2.2; Selby, 1993). During stream-flow, sediment and air bubbles are suspended in the water and do not interact. Stream-flows do not have a yield strength, and hence behave as Newtonian fluids (Selby, 1993). As the proportion of sediment increases and particles begin to interact, the fluid will develop a yield strength and become non-Newtonian (Selby, 1993). Debris-flows are non-Newtonian fluids with high yield strengths, typically due to a high clay content (Selby, 1993). Hyperconcentrated-flows fall between stream-flows and debris-flows in proportion of sediment to water, with small but measurable yield strengths (Figure 2.2; Selby, 1993).

Identifying the rheology of alluvial fan deposits contributes to understanding the history of fan formation. Jackson et al. (1987) differentiate alluvial fans in the Canadian

Rocky Mountains formed by fluvial activity from those formed by debris-flows. They used three criteria to define a debris-flow deposit: (1) poor-sorting and matrix-supported clasts, (2) debris-flow levees and lobes on the fan surface, and (3) oversized lone boulders on the fan surface transported by the debris-flow (Jackson et al., 1987). Debris-flow deposits were also found to have a slope of greater than four degrees (Jackson et al., 1987). Fluvial fans lacked debris-flow levees and lobes, and did not have oversized boulders in the stratigraphy or on the surface. Jackson et al. (1987) subdivided the fluvial deposits into moderately-sorted channel deposits, well-sorted and imbricated bar deposits, and laminated overbank deposits.

Kochel and Johnson (1984) based their interpretation of debris-flow deposits in central Virginia on seven observations. Evidence of poor sorting with coarse texture, indistinct stratification, sharp basal contacts, and the absence of current structures were assumed to eliminate the possibility of fluvial transport because they do not represent braided channel deposits (Kochel and Johnson, 1984). Further observations of superelevated debris or boulders in the stratigraphy, inverse graded bedding, and the preservation of rip-up clasts were used as the decisive evidence that a particular deposit is a preserved debris-flow (Kochel and Johnson, 1984). In a later study, Kochel and others (1997) interpret deposits with poor sorting, indistinct stratification, and patchy imbrication to be from hyperconcentrated flow.

Soil development on alluvial fans

Soil profile development is an important indicator of alluvial fan surface stability, and can provide a relative dating tool within the fan stratigraphy. Previous work has been done specifically on the development processes forming soil profiles on alluvial fan surfaces (McCraw, 1968; Cox and Mead, 1963; McKellar, 1960), although more recently, soils in alluvial fan stratigraphy have been examined mainly as a dating tool (Zehfuss et al., 1998; Pierson, 1980; Bierman et al., 1997; Kochel and Johnson, 1984). McCraw's 1968 study of alluvial fans in the Otago region of New Zealand examined differences in soil profile development based on location on the fan (head or toe), precipitation amount, and fan age. On small, moderately sloping (<10 º) alluvial fans, soils at the fanhead are shallow and usually consist of stony, loamy sands overlying porous gravel deposits (McCraw, 1968). Soils in the mid-fan area consist of a patchwork of shallow, sandy loams over gravel deposits, with deeper soils overlying patches of fine-grained deposits (McCraw, 1968). The finest material is carried out to the toe of the fan where deep silt or sandy loams develop over fine-grained sediment (silt or fine sand) which is compacted with increasing depth (McCraw, 1968). Gleying can occur due to the poorly-drained nature of the fan toe deposits (McCraw, 1968). This spatial soil pattern will migrate away from the hillslope as the fan increases in size and finer-grained deposits are overlain by courser deposits, or as sediments are redistributed due to stream incision on the fan surface (Gerrard, 1992).

McCraw (1968) also classified soil development on alluvial fan surfaces by climate and age. On fans of similar age, McCraw found that in areas with an average rainfall of 14 inches per year, alluvial fan soils had a coloring of yellow-gray to yellow-brown (McCraw, 1968). In areas with an average rainfall of 80 inches per year, alluvial fan sediments developed into podzolized yellow-brown soils (McCraw, 1968). Comparing fans of differing ages on adjacent river terraces, McCraw found that the youngest fans (located on the modern floodplain) showed no soil development. Alluvial fans of intermediate age exhibited weakly-developed A-horizon coloration and structure, with faint B-horizon coloration (McCraw, 1968). The older fans (located on the highest terrace) contained well-developed soil profiles with strong olive-brown coloration and subsoil claypans. The oldest fans also displayed some leaching of the A-horizon (McCraw, 1968).

Gerrard suggests that soil development on the alluvial fans of Otago, New Zealand can be attributed to different landscape evolution processes, dependant on fan age (Gerrard, 1992). Alluvial fans with no soil development are still actively evolving, with hillslope erosion being caused by anthropogenic disturbances (Gerrard, 1992). Fans with weakly-developed soils are the result of alluvium development since 1000 BC, and fans with well-developed soils may be as old as the end of the last ice age (Gerrard, 1992; Cox and Mead, 1963; McKellar, 1960). The oldest alluvial fans, located on high terraces, may pre-date complete glacial retreat and possibly formed during an interstadial period (Gerrard, 1992).

Radiocarbon dating of buried soils

Buried soils can provide an ample amount of organic material for dating alluvial fan stratigraphy; however, these dates can be misleading. During soil genesis, organic material will accumulate on the surface of the alluvial fan. This organic material will accumulate non-uniformly and be in varying states of decomposition (Geyh et al., 1971). Bioturbation of the soil horizon by animals and roots will mix organic materials of varying ages and compositions (Geyh et al., 1971). As a result, the radiocarbon age of this material can only provide a mean residence time that lies somewhere between the beginning and end ages of soil formation (Geyh et al., 1971; Scarpenseel, 1971).

Holocene climate history of New England

Studies of lake records in the northeastern USA have led to a generalized understanding of New England's Holocene climate history. Davis et al. (1980) used pollen records from lake sediments in New Hampshire to specify four episodes of climate change in New England during the Holocene. Davis et al. (1980) found that New England was generally cooler than at present from 12,000 to 9,000 ^{14}C years BP. From 9,000 to 5,000 ^{14}C years BP, there was a shift to warmer and drier conditions, with variable climate during the shifting to the present climatic conditions at 2,000 ^{14}C years BP (Davis et al., 1980).

Based on pollen records from six New Hampshire lakes, Spear et al. (1994) suggested that New England climate was warmer than present from 6,000 to 4,000 years BP, and that the cool, moist climate of today was established around 2,000 years BP. Spear et al. (1994) also found that the period of 7,000 to 4,000 years BP was associated with a higher frequency and intensity of thunderstorm and tropical hurricane systems. Based on lake levels in Owasco Lake in New York, Dwyer et al. (1996) found that climate was generally wetter from 13,000 to 11,000 ^{14}C years BP, and from 9,000 to 7,000 ^{14}C years BP. Drier periods correlated with lower lake levels during 11,000 to 9,000 ^{14}C years BP and 5,000 to 3,000 ^{14}C years BP (Dwyer et al., 1996).

Li (1996) used pollen records from two Vermont ponds to reconstruct a vegetation history since the last glacial maximum. Based on species compositions, Li found that Vermont was generally cooler than present from 12,610 to 10,040 ^{14}C years BP (Li, 1996). A rapid warming phase happened at around 10,000 ^{14}C years BP, leading to a warmer and drier climate that lasted until 7,860 ^{14}C years BP (Li, 1996). From 7,860 to 4,730 ^{14}C years BP, the Vermont climate was warmer and moist (Li, 1996). The warmest and driest period in Vermont Holocene history occurred from 4,730 to 1,680 ^{14}C years BP, with a return to a cool and humid climate after 1,680 ^{14}C years BP (Li, 1996).

Related research in Vermont

Recent studies in Vermont have examined the nature of hillslope erosion due to climate and anthropogenic disturbances. In 1997, Church studied two alluvial fans in the Huntington River Valley and suggested that hillslope erosion contributed sediment to Vermont alluvial fans in three ways: 1) erosion due to clearing of vegetation, 2) erosion triggered by catastrophic storms, and 3) erosion from continual soil creep into feeder channels which is washed onto the fan during large storms. Fan aggradation rates calculated by Church show that the amount of deposition on both fans was high during the early Holocene (1.1 and 3.7 m^3y^{-1}), but moderate over the next 8 ky (< 0.2 m^3y^{-1}). Aggradation rates increased dramatically to 2.3 and 7.0 m^3y^{-1} after colonial settlement 180 years ago. Both of the alluvial fans studied by Church contain a buried soil horizon determined to be just pre-European settlement in age, based on ^{14}C dating of charcoal above and below the paleosol. An abundance of charcoal in the paleosol layer suggests that the native forest was cleared by settlers using slash and burn methods (Church, 1997). Fan aggradation rates at both of the study locations increased dramatically after hillslopes were cleared of vegetation. Hills adjacent to the two fans were re-forested during the 1940's and aggradation rates have dropped on both fans in recent years (Church, 1997). Church determined that 11% and 25% of each fan's total volume was deposited as a result of erosion following historical deforestation.

Zehfuss (1996) studied three alluvial fans situated side-by-side on a low river terrace of the Huntington River in detail. A paleosol A-horizon was found in the three fans, representative of the stable, pre-settlement forest floor. The volume of sediment deposited on two of these fans was determined to be 5,000 m^3 since settlement, or one-third of the total fan volume (Zehfuss, 1996). Post-settlement deposition on the third fan was calculated to be two-thirds of the fan's total volume (5,500 m^3). These numbers reflect a tenfold increase in vertical aggradation rates on the alluvial fans resulting from the historical clear-cutting of forests (Zehfuss, 1996).

The results of Church and Zehfuss show that times of increased erosion can be correlated between alluvial fans that have drainage basins experiencing the same phenomena. In other words, if two different hillslopes with erodable material are exposed to the same series of storms, or to the same extent of vegetation removal, both hillslopes will erode and fans below them will aggrade. Since all five of these fans are located in the same river valley, they experienced the same erosional effects from frequent, large storms and human interaction.

Brown et al. (2000) suggested that inorganic deposits in lake cores from Ritterbush Pond, Vermont can be attributed to intense storm events that caused erosion of the surrounding hillslopes. Based on the three historic storms, only one of which is preserved in the lake cores, the pre-historic storms indicated by inorganic sediment in the Ritterbush Pond cores are likely to be large enough to trigger hillslope failure (Kochel, 1990; Brown, 2000). Bierman et al. (1997) compared the results of lake and fan studies (Brown, 1999; Church, 1997; Zehfuss, 1996; Li, 1996) to other studies of the Holocene paleoclimate in New England, and concluded that hillslope erosion is sensitive to both climate and land-use changes. They suggest that if hillslope erosion is acting in response to large, regional disturbances, then records of that erosion may be correlated across a large area of the northeastern USA. Thus, it is plausible that alluvial fans throughout New England may contain similar records of large, regional storms, and/or environmental disturbances.

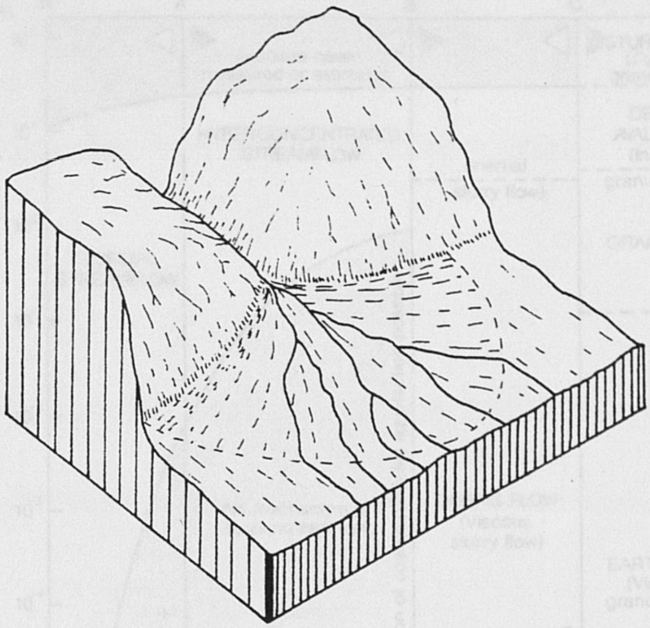

Figure 2.1. Schematic of an alluvial fan (from Rachocki, 1981).

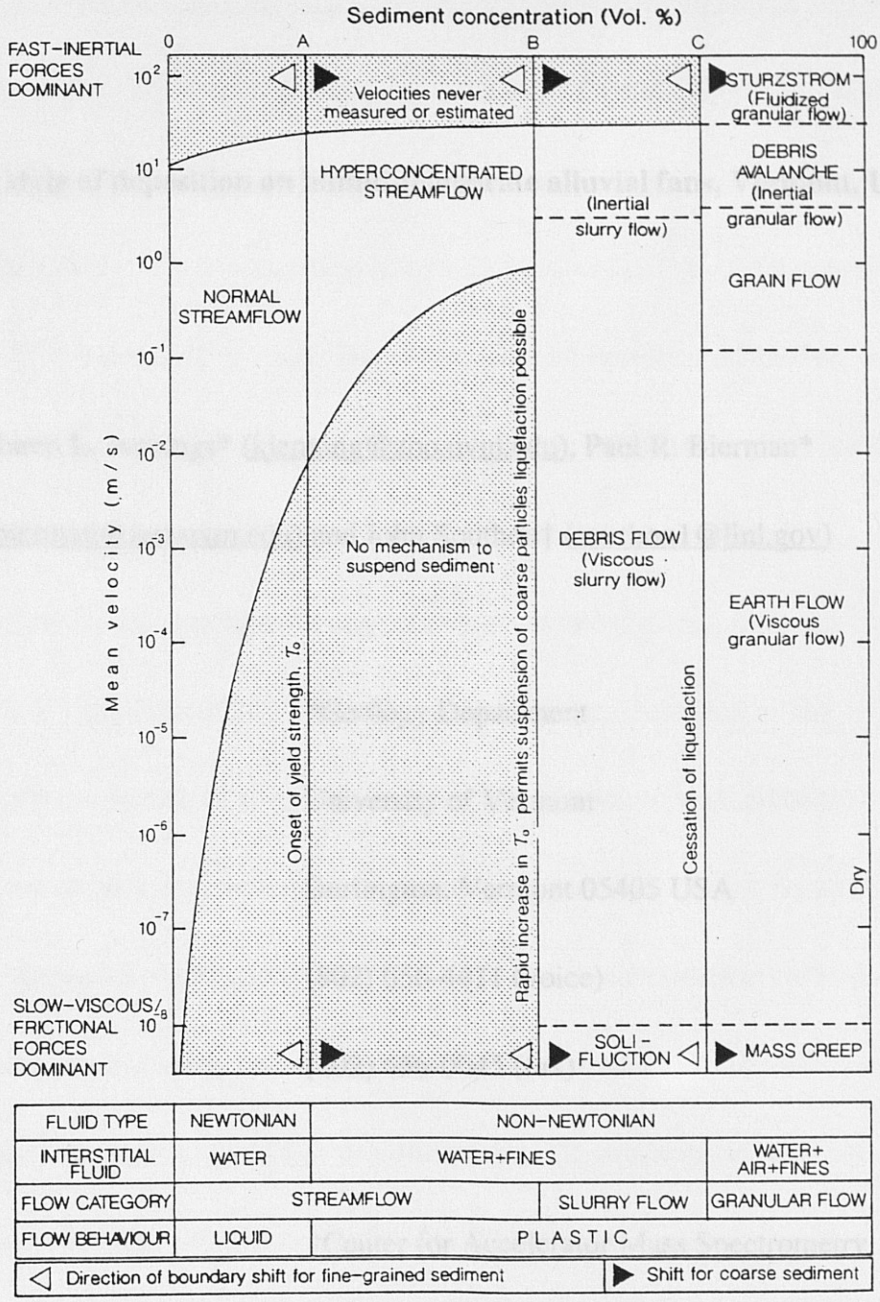

Figure 2.2. Rheological classification of natural fluids (from Selby, 1993).

Boundaries A, B, and C are dependant on grain size and have been based on a coarse, poorly sorted sediment composition.

CHAPTER 3: Paper for submission to *Geological Society of America Bulletin*

Timing and style of deposition on humid-temperate alluvial fans, Vermont, U.S.A.

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ABSTRACT

Alluvial fans in the once-glaciated, mountainous landscape of humid-temperate New England preserve a long record of deposition and thus, hillslope erosion. Using multiple backhoe trenches and radiocarbon dating of wood and charcoal, we determined the depositional history of five small alluvial fans (1,300 to 14,500 m^3) that range in age from 200 to 13,320 calibrated ^{14}C years BP. Three alluvial fans located on river terraces have depositional records constrained by the age of the terrace on which they are situated. The other two fans preserve records that extend back nearly to deglaciation.

All five fans contain evidence suggesting episodic deposition, including layers of gravel and cobbles. Periods of little or no fan aggradation are indicated by the development of now-buried soils. Contemporary fan aggradation, exacerbated by deforestation, results from increased runoff during high-intensity storms. By analogy, similarities in aggradation rates on three of the five fans indicate times of increased storminess throughout Vermont from 10,000 to 9,600 calibrated ^{14}C years BP, and from 3,650 to 3,540 calibrated ^{14}C years BP. Synchronous stable surfaces on two fans suggest a lack of storminess from 3000 to 3500 calibrated ^{14}C years BP. Four of the five fans aggraded rapidly during the past 200 years in response to land clearance, the only time during the Holocene that hillslopes were devegetated (Davis and Jacobson, 1985).

INTRODUCTION

Alluvial fans are the product of geomorphic processes acting in drainage basins (Bull, 1991); thus, fans can be used to quantify rates and patterns of hillslope erosion resulting from natural phenomena, such as large storms or forest fires (Meyer et al., 1992; Meyer and Wells, 1997), and human-induced change, such as clear-cutting (Brazier et al., 1988; Macklin et al., 1992; Bierman et al., 1997). Arid-region alluvial fans have been extensively studied because they are large, accessible, and highly visible landscape elements (Bull, 1991). Humid region fans, because they are in general smaller, more heavily vegetated, and less prominent, have received less study (Pierson, 1980; Rachocki, 1981; Jackson et al., 1987; Ritter et al., 1995; Ballantyne and Whittington, 1999). Debris and alluvial fans of the Southern Appalachian Mountains have been characterized (Kochel and Johnson, 1984; Mills, 1987; Eaton et al., 1997); however, the sedimentary record of alluvial fans in humid-temperate, northeastern North America has not been described, nor has it been used, to quantify fluctuating rates of hillslope erosion throughout time.

Mapping and trenching of alluvial fans in Vermont provide the first detailed data on the location, stratigraphy, age, behavior, and depositional rates of alluvial fans in humid, northeastern North America. These fans are located in the Green Mountains, part of the larger Appalachian Range that extends along eastern North America. The Green

Mountains are characterized by steep basins that open onto wide, flat-bottomed valleys. During the last glacial maximum, Vermont was covered by the Laurentide icesheet (Dyke and Prest, 1987). As the ice margin retreated about 13,000 radiocarbon years ago (15,000 calibrated years BP, Ridge et al., 1999) glacial sediment was deposited (Meeks, 1986). As local base levels dropped, Vermont streams began to cut downward through the glacial sediment, forming terraces in many valleys (Whalen, 1998).

Alluvial fans began to form on these terraces and in glacial valleys. In this paper, we describe the stratigraphy of five such fans and provide 50 radiocarbon dates to constrain their depositional history. Together, these data reveal the temporal distribution of deposition and the relative importance of episodic sediment delivery to fan development. From these data, we calculate rates of deposition and infer a record of paleostorms and paleostorm frequency.

BACKGROUND

In order for deposition to occur on alluvial fans, sediment must be eroded and transported from the drainage basin. This requires either a reduction in the amount of forest cover, which reduces effective soil cohesion originally provided by root networks (Ziemer, 1981; Meyer et al., 1992), or an increase in the amount or duration of local rainfall (Pierson, 1980; Kochel, 1987). Previous studies of humid-region fans demonstrate that very large storm events are capable of triggering fan deposition even in fully forested regions (Kochel, 1990; Wells and Harvey, 1987; Pierson, 1980). Thus, humid-temperate alluvial fans may preserve a low-resolution record of regional storm events and climate change (Kochel, 1990; Bierman et al., 1997; Allen, 1999).

The potential for landslides and debris avalanches to take place during extreme precipitation events has been well-documented in forested, humid-temperate hillslopes (Ratte and Rhodes, 1977; Kochel and Johnson, 1984; Orme, 1990; Kochel, 1990; Eaton et al., 1997). Debris torrents and avalanches have been recurrent features over the past 3,400 years in old-growth forests of northwest North America (Orme, 1990). Based on historical debris-flow data from the southern Appalachian Mountains, Kochel (1990) suggested that hillslope failure was common above certain precipitation intensity/duration thresholds. Multiple, synchronous debris flows during large storm events have been documented in humid-temperate regions of New Zealand (Pierson, 1980), England (Wells and Harvey, 1987) and the USA (Kochel and Johnson, 1984; Eaton et al., 1997; Wieczorek et al., 1996).

There is a strong correlation between alluvial fan deposition and individual storm events. Sediment deposition on stable Virginia fan surfaces during Hurricane Camille in 1969 was indicative of episodic geomorphic processes that have formed the fans over thousands of years (Williams and Guy, 1973). Rachocki's (1981) three-year study of small alluvial fans revealed that long, low-intensity precipitation events did not cause sediment deposition; only one high-intensity storm during the study period supplied material to the fan surface. Wells and Harvey (1987) document thirteen alluvial fans that developed during a brief (2.5 hour), intense storm in northwest England. Buried soil horizons in Virginia alluvial fans demonstrate that the fans were constructed by infrequent deposition during large rainstorms having a 3000 to 6000 year recurrence interval (Kochel and Johnson, 1984). During an intense storm, total sediment deposition on a New Zealand alluvial fan equaled thousands of years of sediment discharge by average fluvial processes (Pierson, 1980). Radiocarbon-dated peat layers from a 2000 year old alluvial fan in Scotland revealed that depositional events occurred during intense storms lasting only a few hours (Ballantyne and Whittington, 1999).

OBSERVATIONS OF MODERN PROCESSES

Observations of contemporary deposition on Vermont alluvial fans suggest that aggradation occurs rapidly during intense storms and runoff events. In 1998, the Champlain Valley of Vermont experienced an anomalously wet early summer, which culminated in two intense storms that deposited 4.6 cm of rain on June 26 and 5.8 cm of rain on July 2 (National Oceanic and Atmospheric Administration data). The two storms, each lasting several hours, caused widespread flooding along the western Green

Mountains. During these storms, sand, gravel, and cobbles were deposited on three Vermont alluvial fans fed by partially re-vegetated basins (Bierman et al., 1997). Over half a meter of sediment piled up against trees on the partially-forested apex of one fan, with isolated, thin lobes of sand and fine gravel deposited distally on grassy pasture. Deposition of sand and gravel also occurred on the Bristol fan (Figures 3.1 and 3.7), which has a fully re-vegetated drainage basin. During a separate storm event in September of 1998, sediment associated with gully incision in a river terrace blanketed a fan located on the terrace below (Figure 3.2A). These observations suggest that changes in regional hillslope erosion rates need not be driven by large, extended shifts in climate (Bull, 1991), but are also sensitive to episodic but rare meteorological events.

METHODS

We used field reconnaissance to map the location of 45 alluvial fans in Vermont and selected five widely separated fans for study based on preservation and access (Figure 3.1). Each of the five fans (Eden Mills, Maidstone, Bristol, Hancock, and Bridgewater Corners) was investigated in detail (Figure 3.3, Data Repository File 4.DR1). In order to understand better the stratigraphy of each fan and collect samples for dating, two intersecting backhoe trenches were dug into each fan. One trench was oriented across the fan, referred to as the *top trench*, and labeled on the cross-sections as

A-A'. A second trench on each fan was oriented downfan, labeled on the cross-sections as B-B', and referred to as the *stem trench*. Fan units were logged onto gridded mylar at 1:20 scale based on a string grid. Before leaving each site, we dug one to three meters deeper in each trench in order to determine the stratigraphy of lower fan units. The sediment composition of these deeper pits was roughly characterized, and the base of the fan determined by a combination of the sediment type and elevation correlation with the surrounding landscape.

Over 300 samples of organic material were collected and fifty radiocarbon were dated: 35 discrete pieces of charcoal, 11 discrete pieces of wood, and 4 amalgamated soil samples. An additional 18 charcoal samples dissolved during preparation and could not be dated. Samples chosen for dating were prepared for accelerator mass spectrometric radiocarbon analysis at Lawrence Livermore National Laboratory using standard methods including acid and repeated base washes. Radiocarbon dates were calibrated using the online version of CALIB 4.2 (Stuiver et al., 1998).

The surface of each fan and location of trenches were surveyed from three benchmarks using a combination of Trimble RTK (real time kinematic) differential GPS (4400) and a Pentax total station. Aggradation rates based on radiocarbon ages and the survey data were calculated assuming that alluvial fan geometry is reasonably modeled as a portion of a right circular cone (Data Repository Figure 4.DR2).

RESULTS

Alluvial fans in Vermont preserve sub-parallel depositional strata, erosional unconformities, and multiple buried soils that represent alternating periods of fan surface stability and fan aggradation since late glacial times. The abundance of buried organic material in the fans allows dating; the coarse-grained (sand and gravel) nature of most depositional units, along with observations of modern processes, suggest that these fans accumulated through a series of episodic events that disrupted stable, soil-forming intervals.

Alluvial fans directly record the timing of hillslope runoff events in both the depositional strata and unconformities they preserve. The alluvial fan record is low resolution, allowing identification of only the largest events, those capable of leaving a deposit or unconformity of thickness and extent sufficient for identification and dating. Both scour and deposition are indicative of significant flow on fan surfaces and thus we suggest that both are directly related to hydrologic events, or storms. Scouring of fan surfaces requires an increase in runoff. Likewise, deposition, especially of gravel and cobbles, requires an increase in sediment transport over normal processes.

The New England landscape has been heavily forested from deglaciation until Western colonization (Davis and Jacobson, 1985) with no evidence of widespread fires or blight (Brown et al., 2000); thus, we interpret pre-historic fan deposition and scour events as the result of increased precipitation. Human activity, primarily deforestation at the onset of Western settlement, caused large amounts of contemporary hillslope erosion and deposition on alluvial fans (Allen, 1999; Anderson et al., 2000), often on a much larger scale than natural phenomena (Costa, 1975; Bierman et al., 1997); thus, we interpret accelerated recent fan deposition as the result of human activity.

Field Setting

Alluvial fans of various sizes are found throughout Vermont in glacial and river valleys. The fans we studied are small, 200 to 3,600 m^2 and 1,300 to 14,500 m^3 (Table 3.2). Drainage basins range from 2,800 to 249,000 m^2 (Table 3.2) and all five basins have a history of logging and agricultural use during the past 200 to 300 years. The Maidstone and Bristol fans are fed by ephemeral streams while the other three fans are fed by small perennial streams. The Bristol, Hancock, and Eden Mills drainage basins are formed in thin mantles of till and colluvium overlying weathered bedrock. Drainages at Maidstone and Bridgewater Corners are formed in postglacial fluvial sediments at lower elevations, with glaciolacustrine sediments (Maidstone) and till (Bridgewater Corners) cropping out higher in the basins.

Fan Location

We found alluvial fans in one of two settings, on river terraces and in underfit glacial valleys (Figure 3.4). We refer to fans on terraces as *terrace fans*, and those in glacial valleys as *glacial valley fans*. The oldest fans (Bristol and Eden) were found in glacial valleys, deposited directly on glacial sediments; thus, the entire post-glacial hillslope erosion history has the potential to be preserved in these fans. Basal ages of these *glacial valley fans*, 12,980 (Bristol) and 13,320 (Eden Mills) calibrated ^{14}C years BP, provide minimum limits for the timing of glacial retreat and the initiation of post-glacial hillslope processes.

Terrace fans, such as those at Maidstone, Hancock and Bridgewater Corners, are found where ephemeral drainages dispatch onto river terraces. Many of these *terrace fans* have lost part of their depositional history downstream as drainage basin incision began before fans could be preserved; i.e. sediment entered the trunk stream as a delta, and was washed away during high flows (Figure 3.2B). When the trunk stream migrated and incised, leaving terraces as sediment traps, alluvial fans were preserved. The three alluvial fans on river terraces are 150 (Maidstone), 10,030 (Hancock), and 11,330 (Bridgewater Corners) calibrated ^{14}C years old. Basal dates for such fans represent the age of terrace stabilization, not necessarily the onset of hillslope incision and fan deposition. Alluvial fans on river terraces provide a time-limited record of hillslope erosion, and thus basal ages of *terrace fans* have only indirect climatic significance.

Dating Fans

The five fans all contain significant but differing amounts of organic material, including wood, charcoal, and buried soil A-horizons. The Eden Mills alluvial fan preserved the most organic material; the Bridgewater Corners fan preserved the least. Organic material was more frequent in less permeable silt and sand, rare in gravel or cobble units. Organic material was better preserved in moist and less oxic fine-grained units.

Most of our AMS dates are very precise (1σ, ± 50 ^{14}C years); however, ages assigned to sedimentary units are less precise for several reasons. Charcoal and wood can be reworked from deposits upstream and inner rings of old growth trees may be hundreds of years old when they are deposited. Calibration of ^{14}C ages further decreases precision, particularly in young samples.

For example, we dated ten samples from the Maidstone fan. Below the fan is a layer of twigs and grass (sample M52, Table 3.1; 170 ± 40 ^{14}C years; 150 calibrated ^{14}C years BP) preserved by overbank deposition on the terrace underlying the fan. This date demonstrates that the fan is historic. Above the overbank sediments, eight charcoal and wood samples from the fan range in age from 80 to 470 calibrated ^{14}C years BP and are not in stratigraphic order. Older samples (i.e. sample M1; 470 calibrated ^{14}C years old) were probably from the inner rings of old-growth trees cut down and burned by settlers. Younger charcoal pieces may either be from younger trees or from the outer rings of old-growth trees. One sample of charcoal (sample M15, Table 3.1) has an age of 8,420 calibrated ^{14}C years BP and is probably reworked from terrace sediment upstream.

In order to test the utility of soil ages, we extracted humic acids from two samples (W10 and W17, Table 3.1) and dated them separately (W10H and W17H) from the acid- and base-resistant soil organic material. Dates from soil organic material and from humic extracts differed substantially. For example, sample W17 (organic) has an age of 6,610 calibrated ^{14}C years BP, while sample W17H (humic) is 4,520 calibrated ^{14}C years old. Likewise, the acid- and base-resistant organic material in sample W10 is older (14,200 calibrated ^{14}C years BP) than the humic fraction (W10H, 6,640 calibrated ^{14}C years BP).

The large and systematic differences between the age of the humic extracts and the resistant soil organic material indicates substantial contamination of the paleosol from migrating humic acids. The very old age of W10, which is out of stratigraphic order and older than the basal fan age, indicates that reworked, older organic material is preserved in fan soils. Although the humic acid can be removed from bulk soil organic material during sample preparation, the sources of the remaining organic material remain ambiguous. For the purposes of dating alluvial fan stratigraphy, imprecise and possibly inaccurate mean residence times of soil horizons were not useful to us; hence we relied only on dates from discreet wood and charcoal pieces.

FAN STRATIGRAPHY

We examined each fan's stratigraphy on a unit by unit basis. Doing this, we have identified large gravel units or areas of scour indicative of large runoff events (Figure 3.2C). Detailed stratigraphic unit descriptions are provided for the Eden Mills, Maidstone, Bristol, Hancock and Bridgewater Corners fans in Chapter 4 data repository files (A) and tables (B) 4.DR3A-B, 4.DR4A-B, 4.DR5A-B, 4.DR6A-B, and 4.DR7A-B, respectively. Topographic maps of each field site location and fan are in data repository figures 4.DR3C-D, 4.DR4C-D, 4.DR5C-D, 4.DR6C-D, and 4.DR7C-D, respectively.

Eden Mills Fan

Stratigraphic Observations. The Eden Mills fan, located in a glacial valley below till-mantled hillslopes, is composed of bedded fine sand in abrupt contact with coarse sand and gravel in the upper meter of the fan (Figure 3.2D). Radiocarbon ages range from 13,320 to 80 calibrated ^{14}C years BP (Table 3.1). The topmost 50 cm of the fan are heavily laden with woody debris, including sawn logs ranging from 30 cm to 2 meters in length (Figure 3.5). A piece of a metal horse bridal, an artifact of logging, was found near the surface in the RG unit (Figure 3.5B). Two Ap horizons, a result of plowing for agricultural use, are preserved in the upper meter of the fan at the base of the BAP and S1 units.

In the lower meter of the trenches, fine sand beds contain an abundance of very thin, discontinuous, A-horizon paleosols separated by thin sand layers (Figure 3.2E). The buried A-horizons were identified by their dark color and high organic content. Two sand units in the top trench (Figure 3.5A) also preserved thin E and B-horizons beneath buried A-horizons.

Another gravel unit (CG) at the bottom of the top trench contains large pieces of wood and organic material, including a rapidly buried and well-preserved log (20 cm diameter) at the bottom of the trench (Sample E58; 6,090 calibrated ^{14}C years BP; Table 3.1). The gravel unit around the log is bowl-shaped suggesting that the unit infilled a scoured channel surface (Figure 3.5A). The CG unit can be divided into two sub-units that may represent different pulses of the same depositional event.

The very lowest layer of the fan is gleyed silt about a meter thick (GS). Wood from this unit is 13,320 calibrated years old near the lower contact (sample E71, Table 3.1). In the top trench, the gley silt overlies medium gravel which grades downward into larger gravel (Figure 3.5A). Because the silt is just post-glacial (Sample E71; 13,320 calibrated ^{14}C years BP; Table 3.1), the large, well-sorted gravel below is likely glacial outwash.

Interpretation. The Eden Mills alluvial fan began to accumulate immediately after icesheet retreat. The basal age of the fan is 11,400 ^{14}C years (13,320 calibrated ^{14}C years BP), only 540 ^{14}C years after post-glacial primary productivity was re-established in Ritterbush Pond, 4 km to the west of Eden Mills (elevation of 317 m asl; Bierman et al., 1997). From 13,320 to 12,900 calibrated ^{14}C years BP, half a meter of massive, well-sorted silt was deposited. At 12,900 calibrated ^{14}C years BP, a 0.5 meter-thick organic unit developed. This organic layer indicates a time of fan surface stability allowing for thick A-horizon development. The silt and organic layer is overlain by bedded, fluvial gravel (GG unit, Figure 3.5). The top trench of the Eden Mills alluvial fan contains a large log within this gravel (Figure 3.5A), indicative of flooding and rapid burial, 6,090 calibrated ^{14}C years BP.

Above the gravel, multiple buried A-horizons indicate that the fan experienced cycles of fine sand deposition followed by periods of fan surface stability (buried soils) until 490 years BP, the date just beneath the lowest AP horizon (S1 unit, Figure 3.5B). The buried soils with A/E/B-horizon sequences have much thicker sand units below them than between the multiple A-horizons. This disparity suggests that where more deposition occurs on the fan, it is followed by a longer period of quiescence sufficient to develop thicker soil profiles. The discontinuous nature of the paleosols is likely the result of scouring on the fan surface during large storms.

After the hillslope was logged, the fan experienced rapid aggradation of coarse sand and gravel. Above two agricultural horizons is the abrupt change to large gravel and wood fragments, most likely due to large-scale clear cutting and the resulting increase in hillslope erosion rates. Large gravel lobes, high in the stratigraphy at the southern edge of the top trench, are most likely remnant stream channel deposits left behind as the channel migrated southward to its current position.

Maidstone Fan

Stratigraphic Observations. The Maidstone fan, located on a low terrace of the Connecticut River and fed by erosion of an older, higher terrace, consists of interbedded sand and silt. These units are laterally continuous, except close to the apex of the fan where disturbed by gully migration and erosion (Figure 3.6A). Light-colored, sand units (WS) are well-laminated (Figure 3.2F) and show evidence of cross-bedding in small areas of the fan. Interbedded with the WS units are massive, dark-colored sand units (BS), which have a higher silt content. Most sand units are separated by thin silt layers; silt layers are also found within some laminated sand units.

Only two buried soil profiles appear in the stratigraphy. The higher buried soil is faintly colored, about 5 to 10 cm below the surface, and only appears in the top trench where it merges with the modern topsoil towards the fan margin (Figure 3.6A). The lower buried soil is about 30 cm below the surface and has a black A-horizon, underlain by a leached E-horizon, with a reddened B-horizon beneath the E. This profile is typical of an acidic soil environment, and probably developed under a pine or hemlock forest. At 4.2 meters depth, we found a continuous, 20 cm-thick layer of organic material including moss, branches, leaves, and twigs. This layer represents deposition of organic material from Connecticut River floods and hence provides the most reliable material for estimating the maximum age of the Maidstone alluvial fan (150 calibrated ^{14}C years old, sample M52, Table 3.1). Seven of the eight other ^{14}C ages stratigraphically above are consistent with a historic age for this fan (Table 3.1).

Interpretation. The lack of significant, buried paleosols suggests that the Maidstone fan was deposited rapidly, without periods of stability sufficient to allow soil development. Maidstone fan is the result of historic land disturbance; buried paleosols represent short-lived, stable fan surfaces. The spodosol coloring of the lower paleosol is usually associated with long periods of soil development; however, robust dating indicates that this paleosol can be no more than 200 years old. Soil development occurred at an accelerated pace, a process not uncommon under dense, acidic, Vermont forests (2000 personal comm., W.S. Harper).

Except where the Maidstone fan has been bioturbated by animals (Figure 3.2G) or tree throw (unit TT, Figure 3.6A), it preserves detailed strata and sedimentary structures not observed in the other four, older alluvial fans. Over time, bioturbation from animals, worms and root growth has mixed fan sediments causing a gradual blurring of the stratigraphy and structure.

Bristol Fan

Stratigraphic Observations. The Bristol fan, fed by a till-mantled bedrock hillslope and overlying glacial lake sediments, is composed of interbedded sand, gravel and cobbles in laterally continuous and massive deposits (Figure 3.7). Across the top of both trenches, the fan has a clear Ap (plow) horizon indicated by dark color, platy structure, and an abrupt lower contact. Beneath the Ap horizon is light-colored gravel and coarse sand (UG) that likely reflects a post-clear-cutting pulse of hillslope erosion and sediment deposition (Figure 3.7B). Dates for the Bristol fan range from 12,980 to 3200 calibrated ^{14}C years BP.

The deeper stratigraphy of the Bristol fan is dominated by interbedded, thin, patchy sand and gravel units (units Gr, S, LS, FG, and FG2). These units are interrupted by at least three discontinuous buried A-horizon paleosols. The Gr unit is weakly bedded, indicating fluvial transport, and may correlate with the FG unit in the top trench (Figure 3.7A). The S and LS units are composed of massive fine sand. A large cobble unit (LG), containing clasts up to 20 cm in diameter, is present from 0.5 to 1 m depth in the trenched sediments. The lowest unit of the large trenches is composed of horizontally bedded coarse sand and fine gravel, capped with a layer of massive, medium sand (BS and MS, Figure 3.7B).

The base of the fan grades downward from sand and gravel into fine sand and eventually silt (Figure 3.7B). Below the silt is a layer of bedded medium and fine sand 10,310 calibrated ^{14}C years old (sample B55, Table 3.1). The bedded sand is underlain by well-sorted coarse sand with gravel clasts ranging from 10 to 40 cm. The clasts are not well-rounded and show typical glacial faceting, but do not preserve glacial striations. This coarse sand and gravel unit has an abrupt lower contact with a 10 cm-thick, massive, fine sand unit. Within this deposit is a thick layer of well-preserved organic material 4.9 meters below the fan surface. This organic layer contains hemlock cones and large wood pieces, evidence of a moist, vegetated landscape at this location. Wood in the organic layer dates to 12,980 calibrated years BP (sample B59, Table 3.1), indicating that the glacial lake had drained from the valley and woody vegetation had re-established by that date. A fine sand and fine gravel mixture underlies the organic layer.

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The base of the fan grades downward from sand and gravel into fine sand and eventually silt (Figure 3.7B). Below the silt is a layer of bedded medium and fine sand 10,310 calibrated ^{14}C years old (sample B55, Table 3.1). The bedded sand is underlain by well-sorted coarse sand with gravel clasts ranging from 10 to 40 cm. The clasts are not well-rounded and show typical glacial faceting, but do not preserve glacial striations. This coarse sand and gravel unit has an abrupt lower contact with a 10 cm-thick, massive, fine sand unit. Within this deposit is a thick layer of well-preserved organic material 4.9 meters below the fan surface. This organic layer contains hemlock cones and large wood pieces, evidence of a moist, vegetated landscape at this location. Wood in the organic layer dates to 12,980 calibrated years BP (sample B59, Table 3.1), indicating that the glacial lake had drained from the valley and woody vegetation had re-established by that date. A fine sand and fine gravel mixture underlies the organic layer.

Interpretation. The Bristol fan is the second oldest fan investigated in this study. The base of the Bristol fan, 4.9 meters deep, is no more than 12,980 calibrated ^{14}C years old (sample B59, Table 3.1). The onset of alluvial fan aggradation would have infilled and buried the moist area where the organic material had been accumulating. Later, gravel and sand eroded from the hillslopes above was deposited, grading upward into bedded fine and medium sand by 10,310 calibrated ^{14}C years BP (sample B55, Table 3.1).

A paleosol 5 cm above the LG unit is 4330 calibrated ^{14}C years old (sample B5, Table 1, Figure 3.7A), and charcoal from within the LG unit is 4370 calibrated ^{14}C years old (sample B10, Table 1, Figure 3.7B), indicating a high energy depositional event around 4350 years BP. A paleosol between the lowest two LG gravel lobes in sections 9 through 11 of the stem trench (Figure 3.7B) suggests that at least part of the LG unit may remain from a previous depositional event, with a substantial period of stability before the rest of the unit was deposited.

Above the LG unit, multiple, discontinuous A-horizons in both trenches indicate repeated short periods of fan stability, followed by scouring events. The thin, discontinuous sand and gravel units (units G, S, LS, and FG2) indicate many small depositional events that closely followed one another in time. Based on two dates from the LS unit (B7 and B46, Table 1, Figure 3.7), we can infer that from about 4,000 to

3,000 years BP the fan was accumulating thin units of sand or fine gravel followed by periods of stability sufficient to develop A-horizons.

At Bristol, the stem trench contains over a meter of sediment deposited between the fine sand of the deeper trench (9,380 calibrated ^{14}C years BP, sample B53) and the MS unit (dated as 9,340 calibrated ^{14}C years BP, sample B35, Figure 3.7). This sediment represents a significant depositional event around 9,360 calibrated ^{14}C years BP. The large gravel unit (unit LG, Figure 3.7) represents a storm deposit constrained by samples B10 (4,370 calibrated ^{14}C years BP) and B5 (4,330 calibrated ^{14}C years BP) above the unit, and sample B35 (9,340 calibrated ^{14}C years BP) below it. Samples B45 (4,960 calibrated ^{14}C years BP) and B10 (4,370 calibrated ^{14}C years BP) are from within the smaller Gr unit (Figure 3.7) and represent an event around 4,500 calibrated ^{14}C years BP. Samples B5 (4,330 calibrated ^{14}C years BP) and B7 (3,200 calibrated ^{14}C years BP) are taken very close to paleosol layers (Figure 3.7) and indicate times of relative fan surface stability. Sample B7 (3,200 calibrated ^{14}C years BP) is also just below the UG unit, providing a maximum age for the deposition of that gravel unit.

Hancock Fan

Stratigraphic Observations. The Hancock fan, located on a river terrace below colluvium-mantled bedrock slopes, is composed of interbedded sand, gravel, sand mixed with gravel, and silt which thinly mantle (1.5 to 2 meters) the underlying bedrock topography (Figure 3.8). Radiocarbon ages range from 10,030 to 730 calibrated ^{14}C years BP. Discontinuity of units prevents reliable interpretation of the depositional history and suggests significant cut and fill. Overlapping gravel units in the top trench are most likely channel remnants, with weak cross-bedding in the lower corner of section 6 in the top trench (Figure 3.8A) indicating fluvial activity. Thin, buried A-horizons were present in both trenches, and were underlain by dark red B-horizons in places (Figure 3.8). Soil development cross-cuts stratigraphic units, indicating that soils formed after deposition and truncation of those layers. Often the B-horizon color was present when there was no paleo-A-horizon.

Interpretation. The Hancock fan demonstrates the importance of scour and sediment reworking in the history of fans fed by perennial streams. This fan has a patchy stratigraphy indicating repeated incision and filling by the stream (Blair and McPherson, 1994), possibly orchestrated by channel migration around bedrock outcrops. Alternatively, the discontinuous nature of fan units may indicate deposition of sieve lobes on a shallow gradient surface (Rachocki, 1981; Bull, 1977). Dated pieces of charcoal are not in chronological sequence within the stratigraphy, indicating that the alluvial fan sediments were reworked from further upfan and deposition was not occurring uniformly.

Most charcoal samples were highly decomposed; further evidence of reworking and re-deposition of sediment on the fan surface.

In all cases where a buried B-horizon was present (as indicated by soil coloring) with no overlying A-horizon, the buried soil was overlain by a coarse gravel deposit. This stratigraphy suggests that the fan was quiet, with little or no deposition, while the A and B horizons developed (probably 300 to 400 years, based on soil profile development at the Maidstone fan). The next depositional event on the fan was then large enough to scour the topsoil from the fan (what would have been the preserved A-horizon) and deposit the gravel. Buried A-horizons without the reddened B-horizon beneath indicate shorter periods of fan surface stability (150 – 200 years based on the Maidstone fan).

Bridgewater Corners Fan

Stratigraphic Observations. The Bridgewater Corners fan is composed of interbedded sand and gravel (Figure 3.9) with radiocarbon ages ranging from 14,200 to 3130 calibrated ^{14}C years BP, and one modern sample (Table 3.1). The gravel units are clast supported and slightly imbricated within a fine sand matrix. These units are continuous over 2 to 7 meters in both trenches, indicating a patchy but consistent horizontal pattern of deposition.

Sand units are massive and contain mostly fine sand. These units are patchy in the top trench (A-A') where they are interrupted by large gravel packages, but continuous in the stem trench (B-B') (Figure 3.9). The sand units are periodically interrupted by buried A-horizon paleosols. In general, the stem trench shows a sequential cycle of (old to young) sand-gravel-sand-paleosol (Figure 3.2H).

Fan sediments coarsen to large gravel and cobbles in the deeper portions of the top trench (Figure 3.9A). Silt and fine sand at a depth of 3 meters represents river channel overbank sediments from Broad Brook. At 3.30 meters depth is a deposit of Broad Brook stream-rounded cobbles. Wood from the overbank layer (sample W66, Table 3.1) provided a maximum age of the fan (11,330 calibrated ^{14}C years BP).

Interpretation. The Bridgewater Corners fan's stratigraphy strongly supports a developmental history of continuous deposition of sand interrupted by deposition of gravel during intense precipitation events. A lack of buried organic material in sand layers indicates deposition slow enough that organic material decomposed before being buried deeply enough to be at least seasonally saturated and preserved. Gravel units in the stratigraphy likely represent individual depositional events. As flow in the tributary increases during a storm event, it will begin to erode the till at higher elevations, and transport the gravel clasts to the fan surface. At the end of the storm event, remaining sand from the terraces or the till is deposited onto the fan surface during waning flow. As the upstream hillslopes stabilize and sediment load to the fan decreases, the fan surface stabilizes until the next storm event allowing soil development to occur as an organic-rich A-horizon.

Dates from paleosol layers indicates times of fan stability (Figure 3.10). Samples W30 and W31 are 3,130 calibrated ^{14}C years B and 3,650 calibrated ^{14}C years BP respectively, indicating fan stability at about 3,300 calibrated ^{14}C years BP. Samples W4 and W34 indicate fan stability at 4,960 and 6,020 calibrated ^{14}C years BP, respectively.

Aggradation Rates

Aggradation rates, constrained by dated radiocarbon locations, on the five alluvial fans are different (0.001 to 79.6 m^3/yr) and change over time; however, two periods of significant aggradation are apparent (Figure 3.11). High aggradation rates characterized the Bristol, Eden Mills, and Hancock fans 10,000 to 9,600 calibrated ^{14}C years ago. The Bristol, Bridgewater Corners, and Hancock fans aggraded rapidly 3,650 to 3,540 calibrated ^{14}C years ago. The Maidstone fan is historic and represents 4770 m^3 of aggradation over 150 years or less. The Hancock and Eden Mills fans also aggraded rapidly in historic time, responding to land use changes. The Eden Mills fan collected 3000 m^3 of sediment during the past 100 years, 46% of its volume.

DISCUSSION

Vermont alluvial fans are complex, long-lived landscape features that preserve a complicated history of incision and aggradation, punctuated by buried soils indicative of periods of fan surface stability. Sediments within the fans range in age from immediately post-glacial (13,320 calibrated ^{14}C years BP) to historic. Four of the five alluvial fans aggraded rapidly in response to recent, human-induced landscape changes.

Alluvial Fan Sedimentology and Stratigraphy

Sediment in all five fans was deposited by flowing water. Most fan units were moderately well sorted, with the exception of the Maidstone fan which had very well sorted strata. Grain size ranged from silt to cobbles. Sedimentary structures were best preserved in Maidstone, the youngest fan (cross-bedding and soft-sediment faulting), and the Bridgewater Corners fan (cross-bedding and minor imbrication). The lack of sedimentary structures in the other fans is the result of bioturbation; worm tracks and animal burrows are common. Numerous tree throw scars turbate fan sediment (e.g., unit TT in Figure 3.7B), consistent with pre-settlement forest cover on fan surfaces. None of the fans preserves characteristics indicative of debris flow deposition; there are no matrix-supported clasts, reverse grading, levees, or matrix-dominated units (Blair and

McPherson, 1994). Poorly sorted units may be the result of hyperconcentrated flow; however, most deposition on the five fans is probably fluvial.

Alluvial Fan Development

The five alluvial fans we examined have both similarities and differences. All preserve buried soil profiles, and all are composed of gravel, sand, and silt. Additionally, all fans have course-grained units that have partially eroded finer-grained units below. Fans fed by perennial streams have large, infilled scour channels (Hancock, Bridgewater Corners, Eden Mills). Fans fed by ephemeral streams reveal aggraded contacts with only minor scoured surfaces (Maidstone and Bristol). Prehistoric fan deposition occurred in and around trees in forests, resulting in laterally discontinuous fan stratigraphy.

Fans in separate basins have differing depositional patterns and histories. The Maidstone fan was deposited very rapidly in continuous strata. At Hancock, incision alternates with fill events, possibly the result of bedrock outcrops that concentrate flow. The Eden Mills and Bristol fans preserve most depositional events as continuous units that cover the entire fan surface, in some cases scouring the underlying units. The Bridgewater fan does not appear to have any scouring, but contains very patchy, discontinuous deposits of gravel.

Soil Development

All five fans preserve buried soil horizons. Soil development ranges from thin Ab-horizons, to reddened Bb-horizons, and the beginning of leached Eb-horizon development on the Eden Mills and Maidstone fans. Differences in soil profile development represent relative amounts of time that the fan surfaces were stable and the acidity of the leaching environments. The basal age of the Maidstone fan indicates that less than 200 years was needed to form the sequence of buried A, B and E horizons observed in the stratigraphy of that fan. Buried soil horizons are typically not continuous along more than a few meters of fan trench walls. This discontinuity likely reflects the removal of thin soils by erosion during the initial stages of fan flooding events.

Timing of Fan Deposition – Detection of Paleostorms and Human Impact

Calculated aggradational rates integrate all deposition on the fan over a specified amount of time, and hence integrate gradual with episodic deposition (Figure 4.DR2). Increases in aggradation rates indicate periods of increased sediment yield within a particular drainage, driven by increased storminess or runoff from historic deforestation. Synchronicity of increased aggradation on the five fans is dependant on sediment availability in the adjacent hillslopes, and precipitation sufficient to transport the material to the fan surface. Periods where there is a lack of synchronicity in aggradation on the four pre-historic fans may be the result of insufficient sediment supply, differences in sediment cohesion, or different amounts of precipitation amongst the four drainage basins.

For identifying long-term run off history, and thus the history of storm activity, the Eden Mills and Bristol fans are the most useful because the entire post-glacial depositional history of their respective basins is preserved. The Bridgewater Corners fan, 11,330 calibrated ^{14}C years old, also preserves most of the depositional history of that basin; however, the patchy nature of gravel deposits in the Bridgewater fan and the lack of datable material makes it difficult to identify individual depositional events with certainty.

The Eden Mills fan has high aggradation rates early in the fan history (13,320 to 12, 900 calibrated ^{14}C years BP), consistent with post-glacial hillslopes less densely covered by vegetation during the early stages of fan development (Davis and Jacobson, 1985). Such storms require lesser amounts of precipitation to initiate sediment transport (Church and Ryder, 1972). By 13,000 calibrated ^{14}C years BP, vegetation had re-established on Vermont hillslopes (as evidenced by our 12,980 calibrated ^{14}C years BP wood age at the base of the Bristol fan) and aggradational rates at the Eden Mills fan slow down after 12,900 calibrated ^{14}C years BP.

Aggradation rates have been compared with dated periods of soil formation or storm-induced deposition on the five alluvial fans (Figure 3.11). Synchronous depositional pulses occurred at the Eden Mills and Bristol fans at around 9,300 years BP, accompanied with a slightly higher aggradational rate and possible sediment pulse at the Hancock fan. Another sediment pulse in the Eden Mills fan at around 6000 years BP is correlative with increased aggradation at the Bridgewater Corners fan. Such synchronicity in multiple fans is indicative of a regional storm system or an increase in storminess in the region. Discrepancies in aggradation occur from 6,500 to 3,000 years BP, when there is high aggradation at the Bridgewater Corners fan but low aggradation rates at the other fans, and at 4,500 years BP when a sediment pulse at Bristol occurs during low aggradation at the other fans. High sedimentation at the Bridgewater Corners fan around 5,500 years BP coincides with soil formation at the Hancock fan and low aggradation at the Eden Mills and Bristol fans. Such discrepancies may be the result of intense localized storms that affect only one drainage basin, or the propensity for hillslope failure in a particular drainage.

There is a stronger correlation amongst periods of fan stability as indicated by low aggradation rates or developed soils in the four alluvial fans. Soil profiles developed at around 3,500 years BP on the Bristol and Bridgewater Corners fans coincide with low aggradation on the Eden Mills fan. Likewise, soil development on the Bristol fan at

4,200 years BP coincides with low aggradation rates on the other three fans. Any two of multiple undated paleosols in the Eden Mills fan between the ages of 6,000 and 490 years BP could coincide with these 3,500 and 4,200 year old paleosols in the Bristol fan. From 9,500 to 6,500 years BP, all four alluvial fans show low aggradation rates, indicating slope stability. The two oldest fans, Eden Mills and Bristol, show correlative soil formation around 13,000 years BP. Synchronicity amongst stable periods on the alluvial fans reveals periods of decreased storminess throughout Vermont. Stable periods are more correlative than depositional pulses probably due to the nature of localized effects of storms on individual drainage basins, even during times of increased regional storminess, and the differences in sediment strength and supply on hillslopes in different basins.

Bierman et al. (1997) found that three alluvial fans in the Huntington River Valley of Vermont (Figure 3.1) had high aggradation rates from 9,590 to 8,180 calibrated ^{14}C years BP, and 2,586 to 1,770 calibrated ^{14}C years BP. The timing of these increases in aggradation does not correlate with deposition on the five fans considered in this paper. The lack of temporal correlation in the timing of aggradation between these eight fans, indicates that alluvial fan deposition is more strongly linked to intense localized storm cells than to regional climate trends. This conclusion is supported by our observations of contemporary fan deposition, which occurred in areas of localized, intense storm events.

Four of the five alluvial fans have high aggradation rates during historic time. The Hancock and Eden Mills fans both show the highest aggradation rates (25.7 m^3/yr and 19.5 m^3/yr) during the past 760 and 80 years, respectively. The lack of datable material high in the Hancock stratigraphy means that the historic aggradation rate is averaged with the just pre-historic rate, and our calculations may under-estimate the historic aggradation rate. The Bridgewater Corners fan shows its second highest aggradation rate late in its history with a rate of 0.18 m^3/yr over the past 3650 years. Again, a lack of datable material high in the stratigraphy may result in under-estimation of historic aggradation rates. The Maidstone fan was formed at 80 m^3/yr over the past 150 years. The only fan that shows a decrease in aggradation rates during historic time is the Bristol fan, perhaps because shallow bedrock on the adjacent hillslope constrained the sediment supply to the fan. The historically high aggradation rates on the other four alluvial fans demonstrate the importance of woody vegetation in providing effective soil cohesion on adjacent hillslopes.

Comparison to Other Paleostorm Records

Brown et al. (2000) investigated the timing of terrestrial sedimentation in cores from Ritterbush Pond, Vermont (Figure 3.1). They found clusterings of terrestrially derived layers indicating stormier periods at 1,750 to 2,620, 6,330 to 6,840, and >8,600 calibrated ^{14}C years BP. The timing of these stormy periods does not correlate well with the timing of deposition on the alluvial fans, providing more evidence that hillslope erosion is driven by storm activity in individual drainage basins. Increased storminess from 6,330 to 6,840 may correspond with sediment pulses at the Eden Mills and Bridgewater Corners fans, but all four fans show generally low aggradation during this time frame. However, the quiet period at 3,000 to 3,500 calibrated ^{14}C years BP, indicated by paleosols in the Bristol and Bridgewater Corners fans, does correspond with a lack of storm activity indicated by the Ritterbush Pond sediment cores (Brown et al., 2000). We do not have a dated paleosol from this time period at the Eden Mills fan, which is the closest location to Ritterbush Pond, but any one of the multiple undated soils between 6,090 and 490 calibrated ^{14}C years old could correspond to a quiet period at 3,000 to 3,500 years BP (Figure 3.5).

There is some correlation of increased aggradation during regional wet periods and decreased aggradation during dry periods as documented by other studies (Table 3.8), however the correlations are not uniform across the four alluvial fans. The lack of a strong correlation with regional climate histories reveals the importance of sediment supply, hillslope strength and local, intense storms on alluvial fan development.

Kochel (1990) suggested that the initiation of alluvial fan aggradation in humid-temperate, eastern North America should propagate northward and coincide with the return of tropical moisture (necessary to generate rainfall sufficient to erode and move sediment onto the alluvial fans) following gradual, postglacial, northward retreat of the polar front. Kochel and Johnson (1984) dated Virginia alluvial fan initiation at 11,000 calibrated ^{14}C years BP, coincident with the return of tropical air masses to the mid-Atlantic region (Kochel, 1990). Alluvial fans in Vermont are older than those Virginia, suggesting that fan development may begin as soon as there is a stable surface on which sediment can accumulate, regardless of polar front position. Hence, warmer, tropical air is not necessary to create intense storm events that initiate slope failure and fan deposition.

CONCLUSIONS

Vermont alluvial fans are direct, albeit low-resolution, recorders of hillslope activity. They preserve datable strata of gravel, sand, and silt deposited fluvially during storm events as well as buried paleosols formed during periods of fan surface stability. Erosional contacts between alluvial units indicate scouring and reworking of alluvial fan sediments during deposition. Buried wood and charcoal provide dating control that demonstrates aggradation rates changed over time. Simultaneous periods of increased aggradation on multiple fans suggest times of increased storminess in Vermont, whereas the uniform response of most fans to land clearance in the past 200 years suggest the sensitivity of basin slopes to deforestation.

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Figure Captions

Figure 3.1. Location map of trenched alluvial fans in Vermont. Base map adapted from digital topography map by Chalk Butte, Inc (1994). Inset shows location of Vermont state within the United States of America. EM = Eden Mills, MS = Maidstone, BR = Bristol, HC = Hancock, BC = Bridgewater Corners, HV = Huntington Valley, RP = Ritterbush Pond.

Figure 3.2 A) Sheetflood deposition on an alluvial fan in Huntington, Vermont, September, 1998 B) Fan-delta in stream, sediments will be washed downstream instead of preserved as part of the depositional history C) Large gravel unit representing a storm event in the Bristol fan (Figure 3.7B, unit LG) D) Grain size change from fine sand to coarse sand, gravel and cobbles in the upper meter of the Eden Mills fan as the result of historic logging (Figure 3.5A, column 1) E) Multiple buried A-horizons in the Eden Mills fan represent periods of fan stability (Figure 3.5A, columns 2-3) F) Strata in the Maidstone fan (Figure 3.6B) G) Animal burrow in the Maidstone fan (Figure 3.6B, column 7, not indicated on log) H) Paleostorm deposit represented by gravel, bracketed by two paleosols, Bridgewater Corners fan (Figure 3.10, unit Gr2).

Figure 3.3. A) Topographic map of the Maidstone fan, based on differential GPS and total station data. A-A' is top trench, B-B' is stem trench Contour interval is 0.5 meters. B) Photograph of trenches in the Maidstone fan, view from Vermont Route 102 towards the west.

Figure 3.4. Alluvial fan settings in Vermont. A) Alluvial fans on river terraces, which are not likely to preserve the entire hillslope erosion history. B) Alluvial fans in glacial valleys, which will contain the entire history of hillslope erosion.

Figure 3.5. Stratigraphy of alluvial fan at Eden Mills, Vermont. A-A' is top trench; B-B' is stem trench. Thick, black line or solid black shading represents buried paleosol A-horizons; light gray is leached E-horizon; dark gray shading represents wood fragments. Rocks are outlined and the location of dated samples indicated. Units described in Table 3.3. Interpreted base of fan indicated by dashed line.

Figure 3.6. Stratigraphy of alluvial fan at Maidstone, Vermont. A-A' is top trench; B-B' is stem trench. Thick, black line represents buried paleosol A-horizons. Rocks are outlined and the location of dated samples indicated. Units described in Table 3.4. Interpreted base of fan indicated by dashed line.

Figure 3.7. Stratigraphy of alluvial fan at Bristol, Vermont. A-A' is top trench; B-B' is stem trench. Thick, black line represents buried paleosol A-horizons. Rocks are outlined and the location of dated samples indicated. Units described in Table 3.5. Interpreted base of fan indicated by dashed line (base of fan not reached in A-A').

Figure 3.8. Stratigraphy of alluvial fan at Hancock, Vermont. A-A' is top trench; B-B' is stem trench. Top dashed line is bottom of topsoil coloring. Diagonal stripes indicates reddened soil color from B-horizon development, closer stripes are a redder soil color. Rocks are outlined and the location of dated samples indicated. Units described in Table 3.6. Base of fan is unknown.

Figure 3.9. Stratigraphy of alluvial fan at Bridgewater Corners, Vermont. A-A' is top trench; B-B' is stem trench. Thick, black line represents buried paleosol A-horizons. Rocks are outlined and the location of dated samples indicated. Units described in Table 3.7. Interpreted base of fan indicated by dashed line.

Figure 3.10. Stratigraphy of alluvial fan at Bridgewater Corners, Vermont, section from opposite wall of the stem trench (B-B'). Thick, black line represents buried paleosol A-horizons. Location of dated samples indicated. Units described in Table 3.7.

Figure 3.11. Graph comparing synchronicity of events on the five alluvial fans, y-axis is the same for all five fans and represents time. Aggradational rates are represented by the bar graph, and correspond to individual x-axis rates for each fan. Individual, dated depositional events as indicated by the fan stratigraphy are shown as XXXX, a line between indicates the error margin of dating that brackets the deposit. Thick, black line indicates a dated paleosol layer, a line between indicates the error margin of dates that bracket a paleosol. The depositional events and paleosols are not associated with any aggradation (x-axis) rate value.

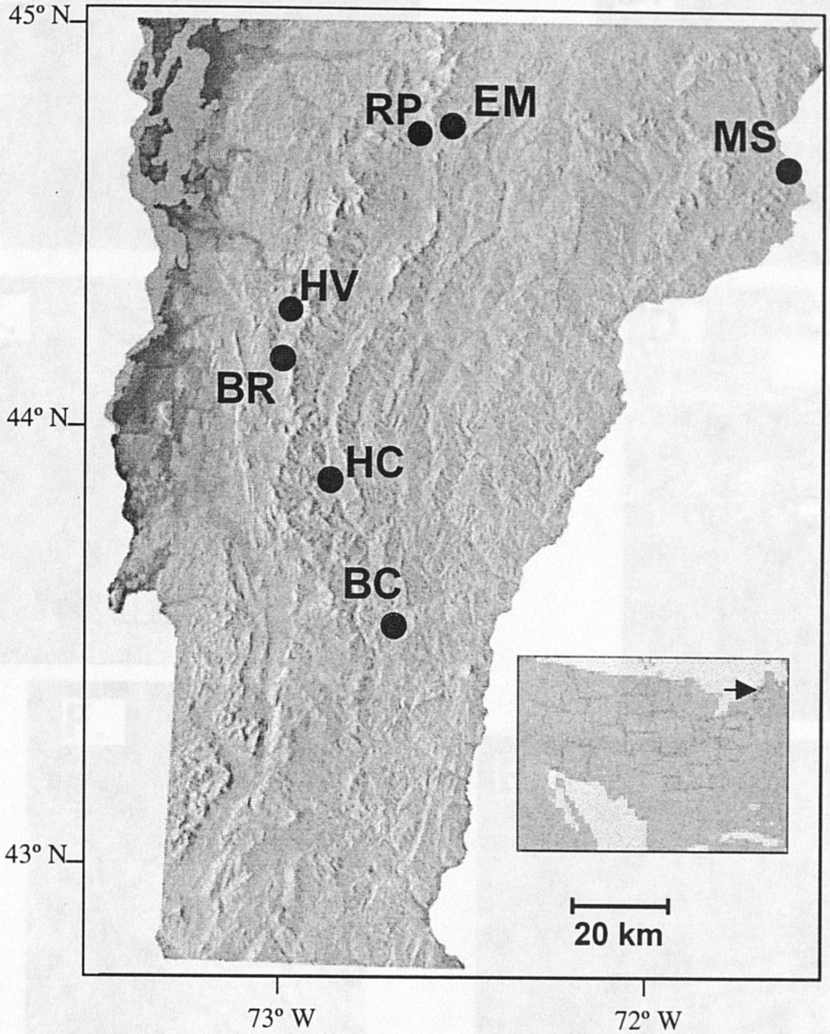


Figure 3.1. Jennings et al.

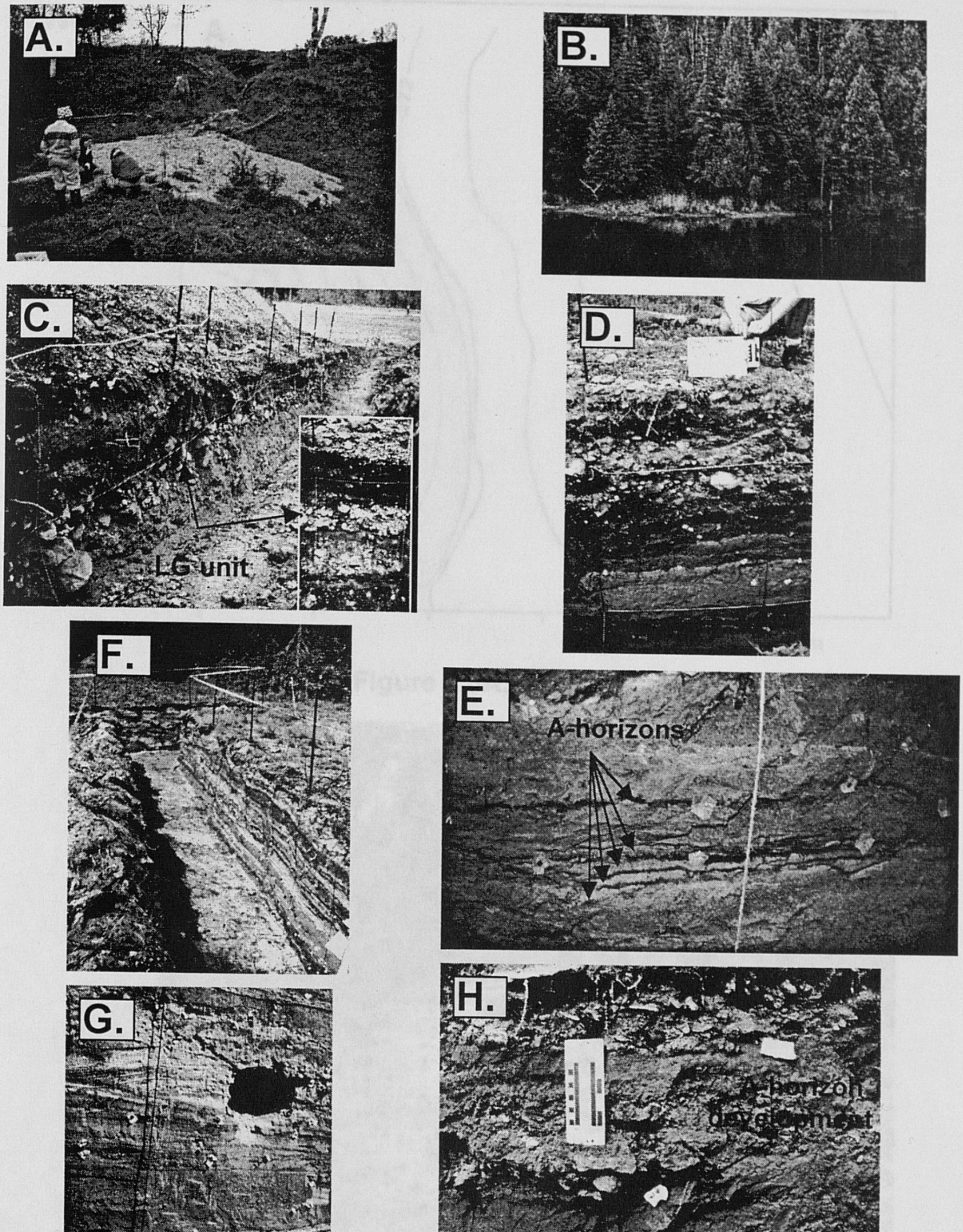


Figure 3.2 Jennings et al.

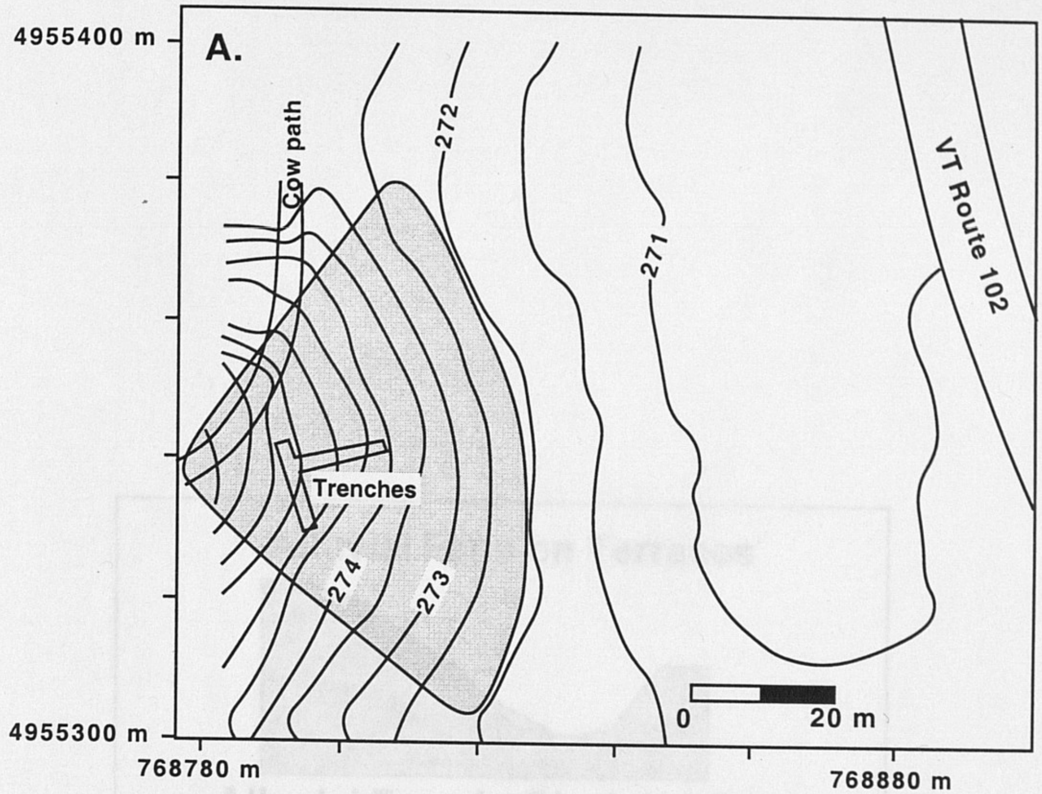


Figure 3.3A. Jennings et al.

Figure 3.3B. Jennings et al.

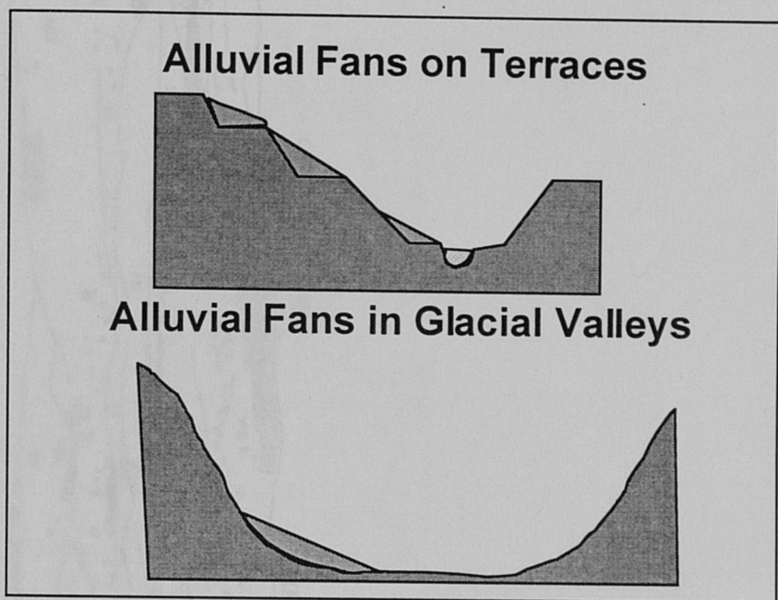


Figure 3.4. Jennings et al.

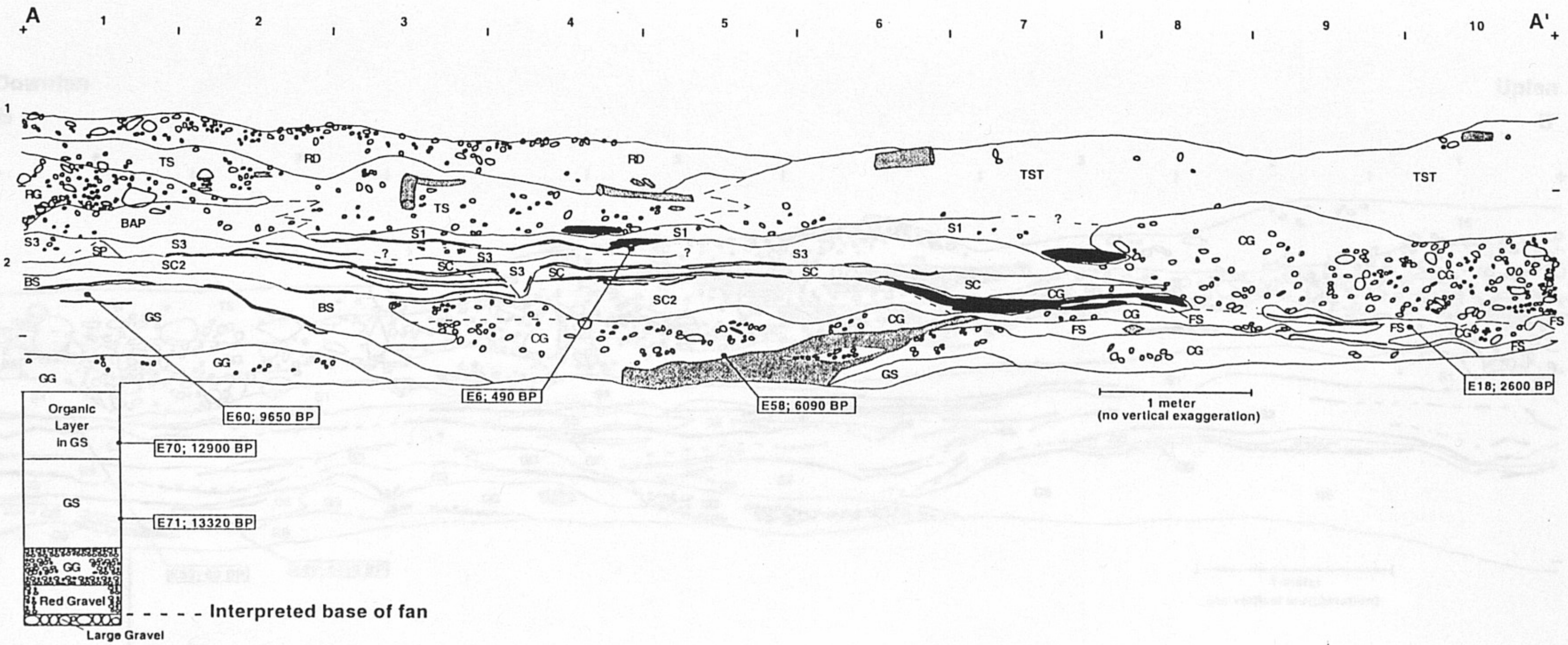


Figure 3.5A. Jennings et al.

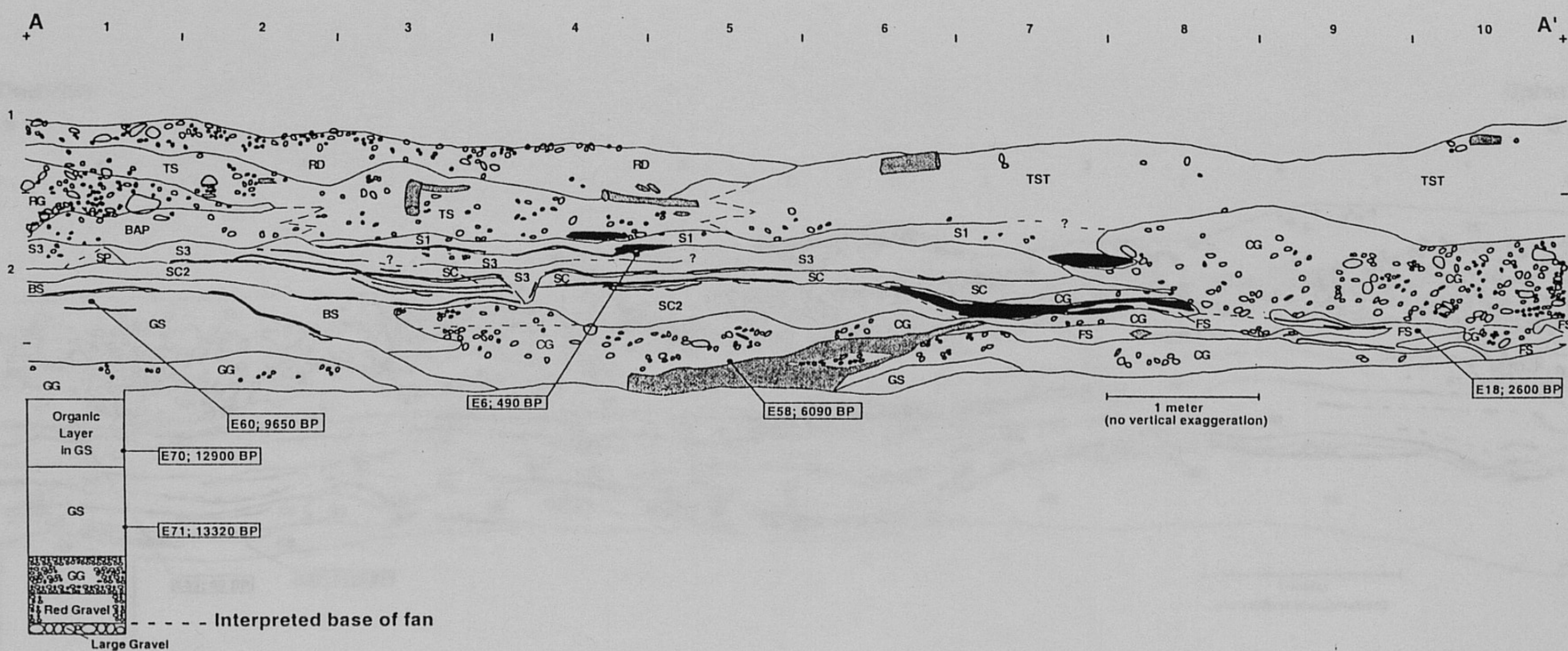


Figure 3.5A. Jennings et al.

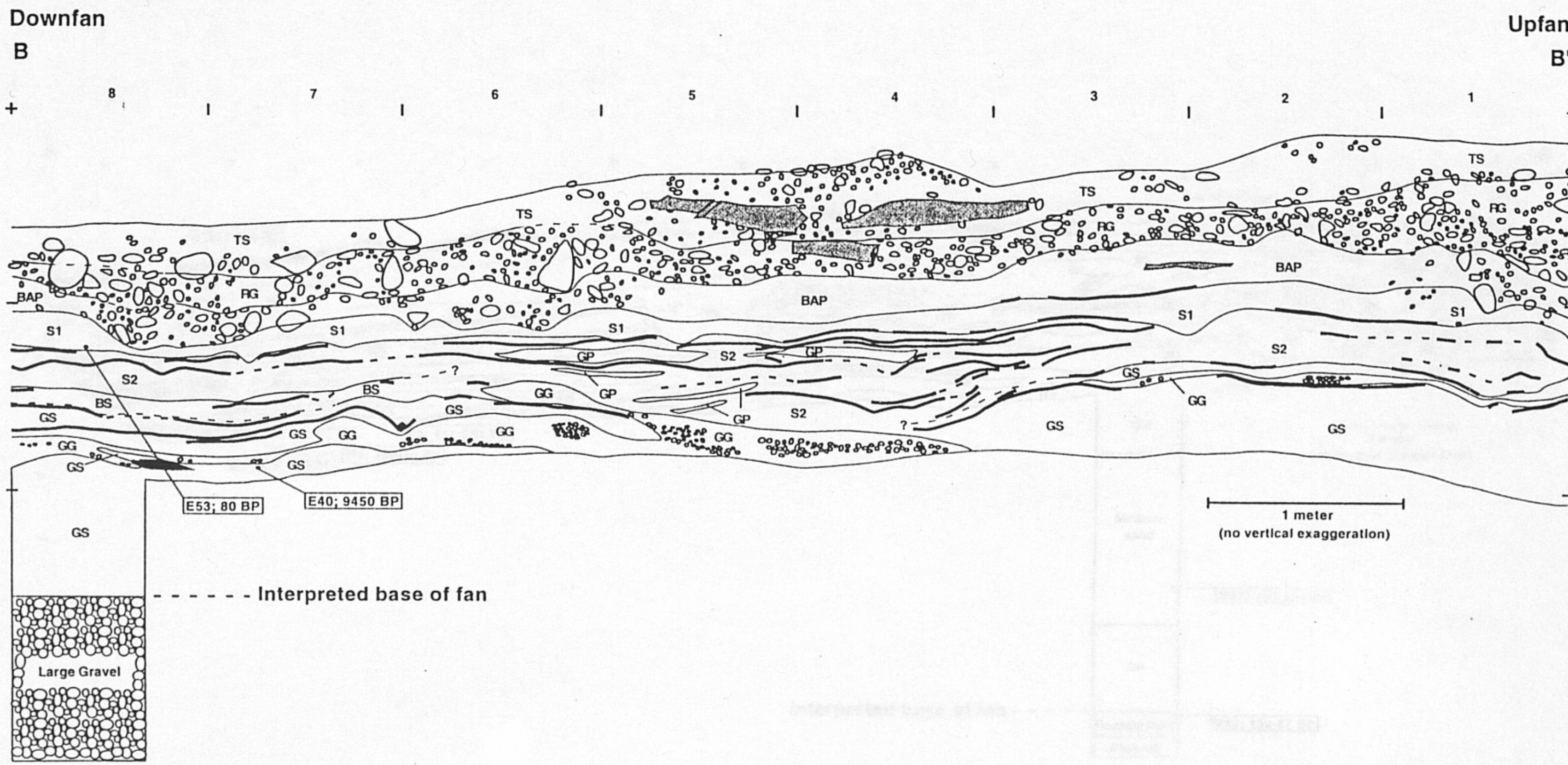


Figure 3.5B. Jennings et al.

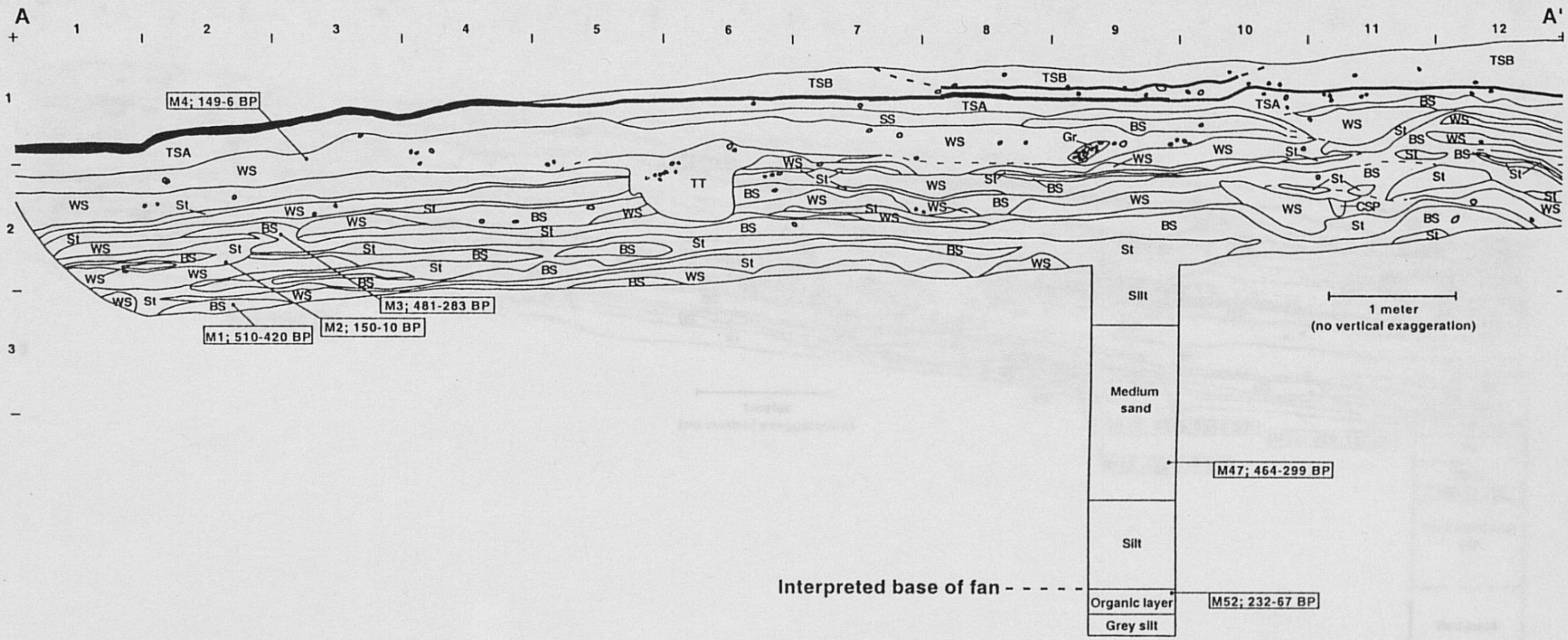


Figure 3.6A. Jennings et al.

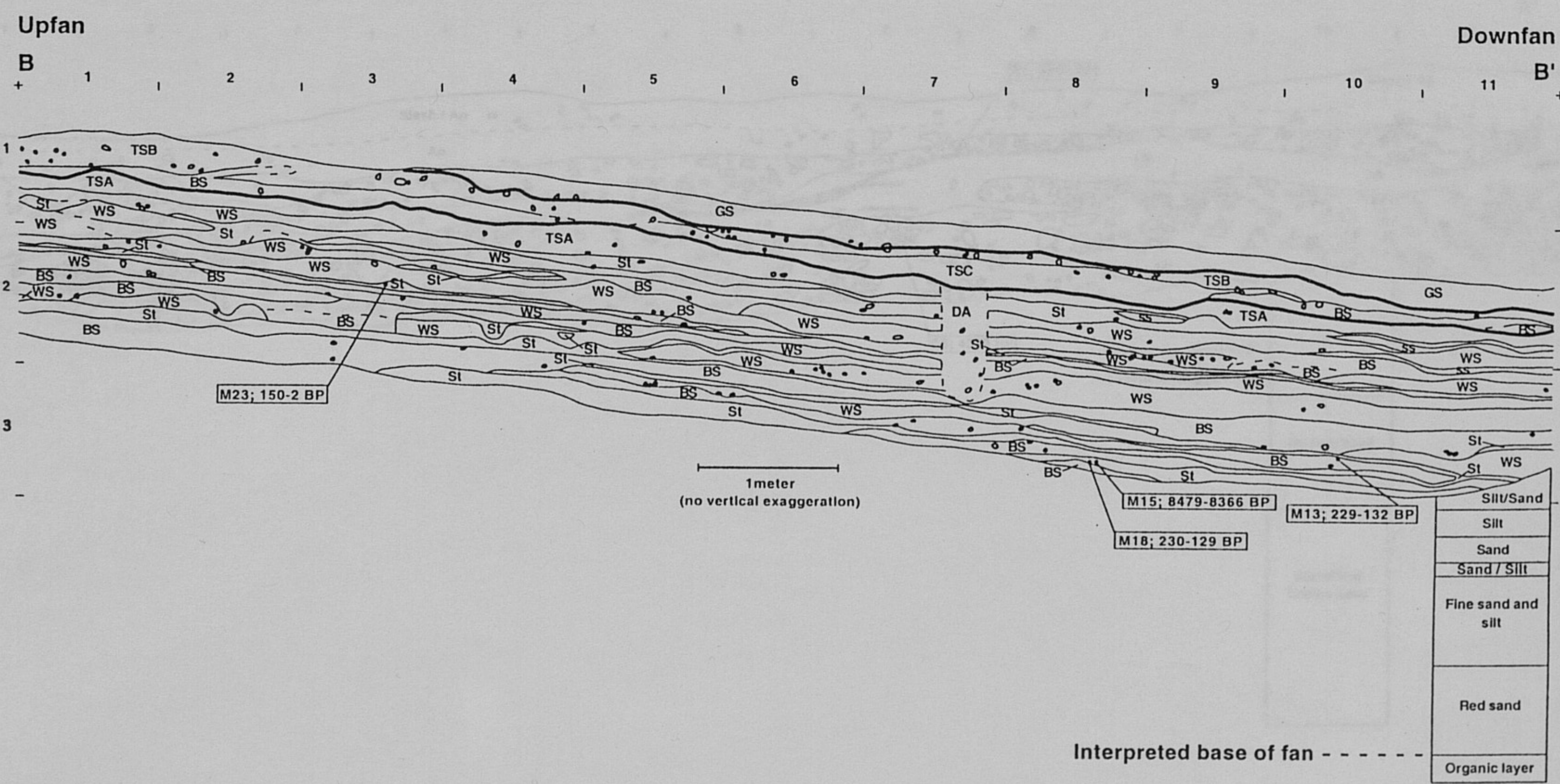


Figure 3.6B. Jennings et al.

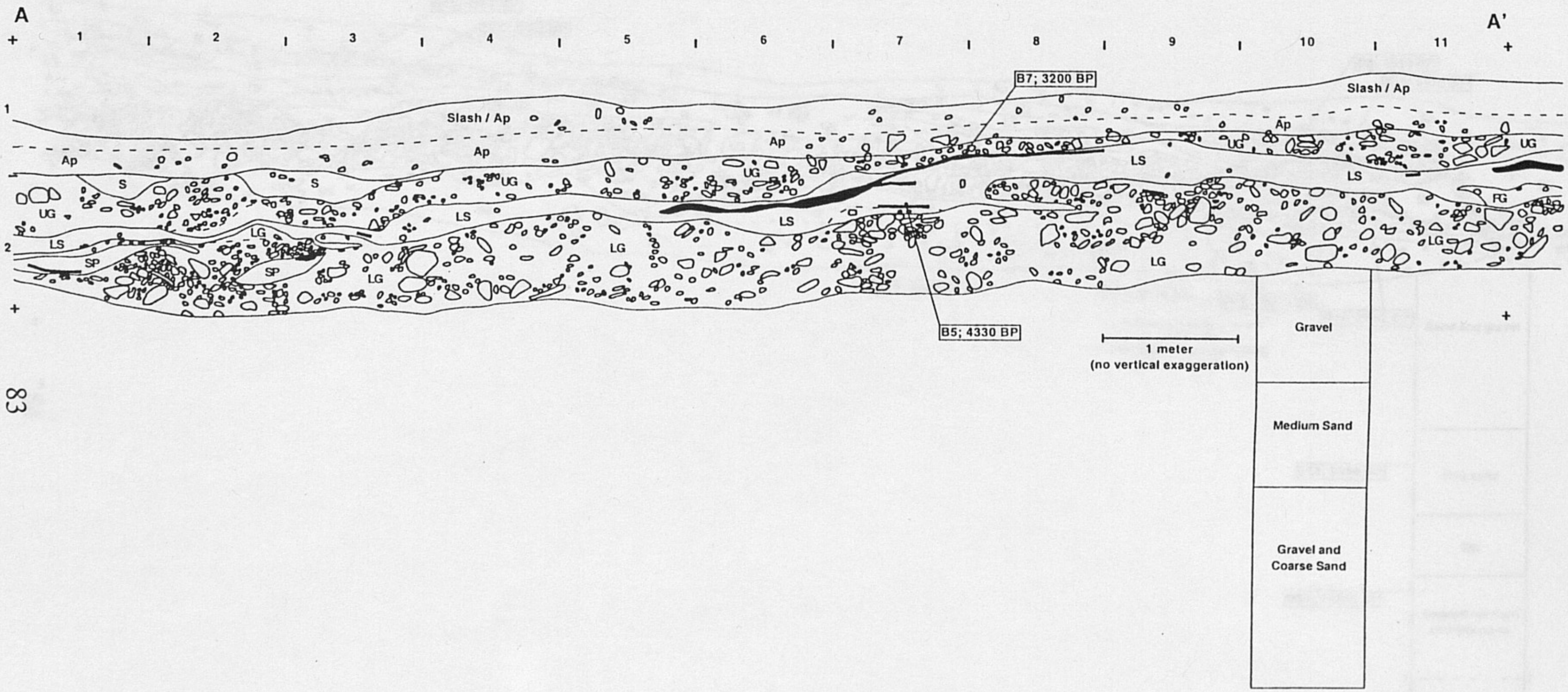


Figure 3.7A. Jennings et al.

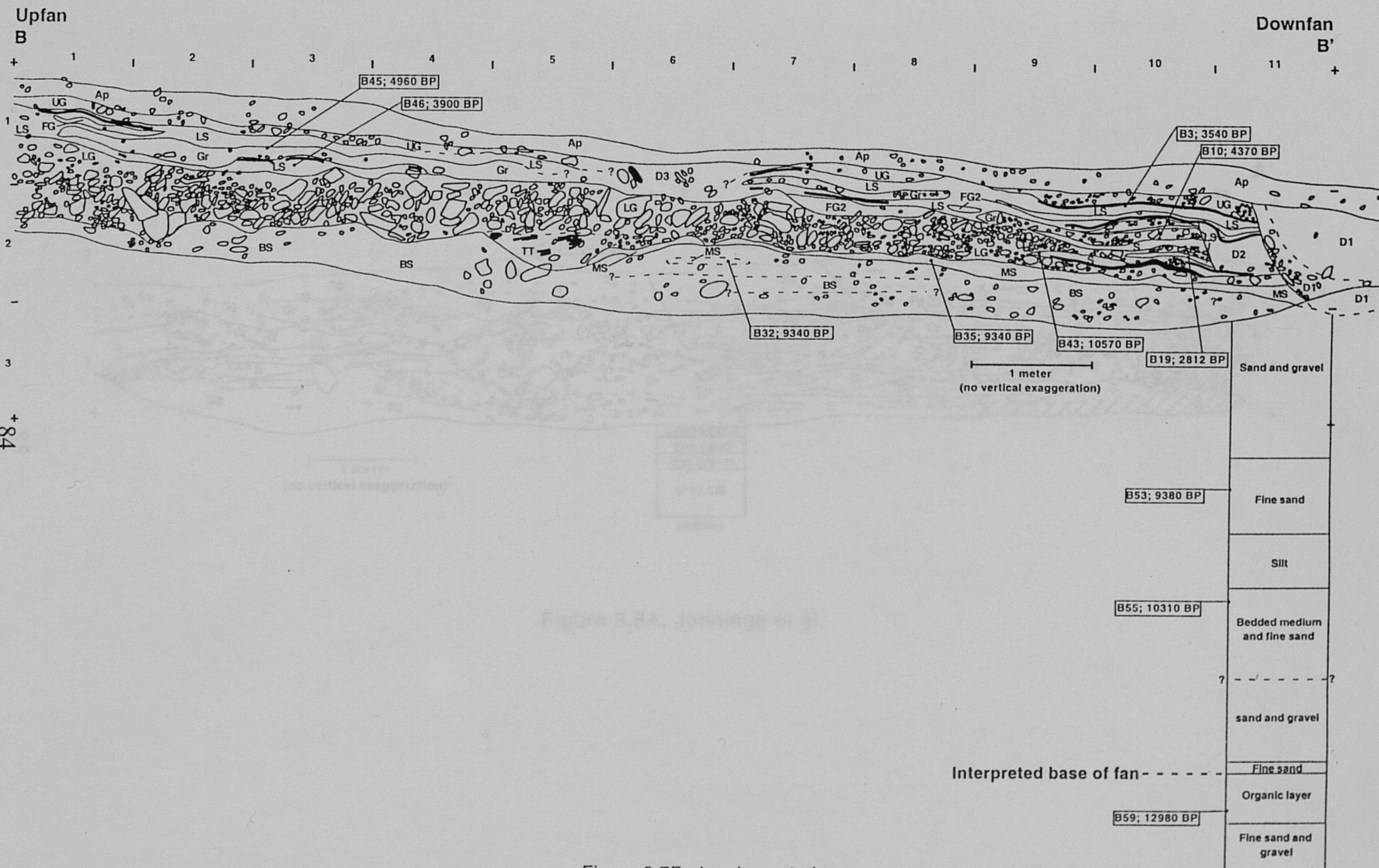


Figure 3.7B. Jennings et al.

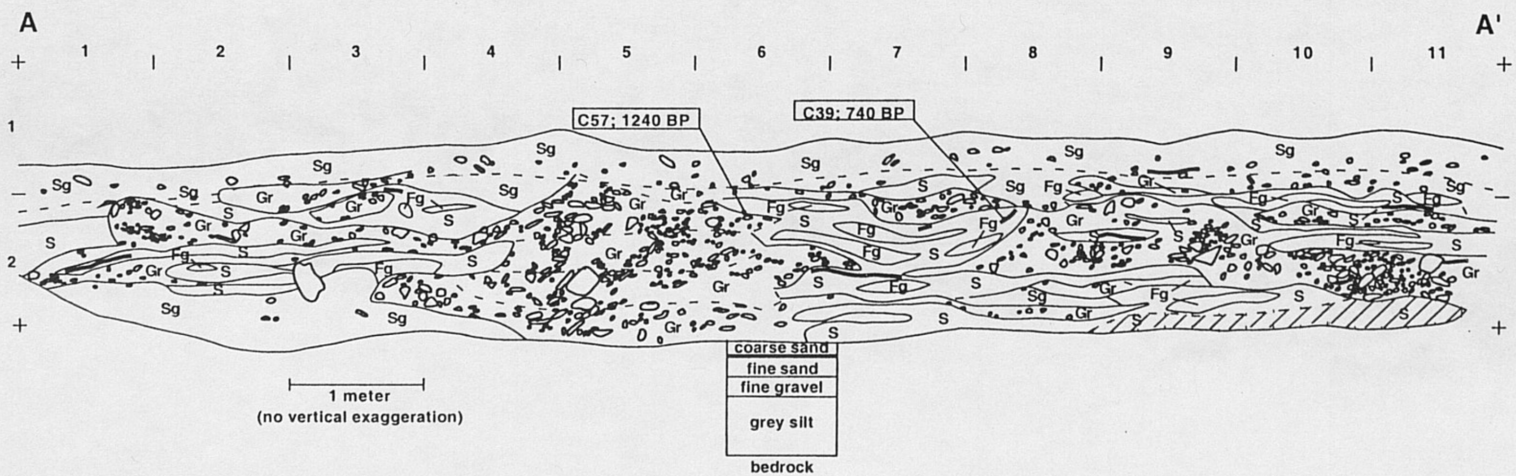


Figure 3.8A. Jennings et al.

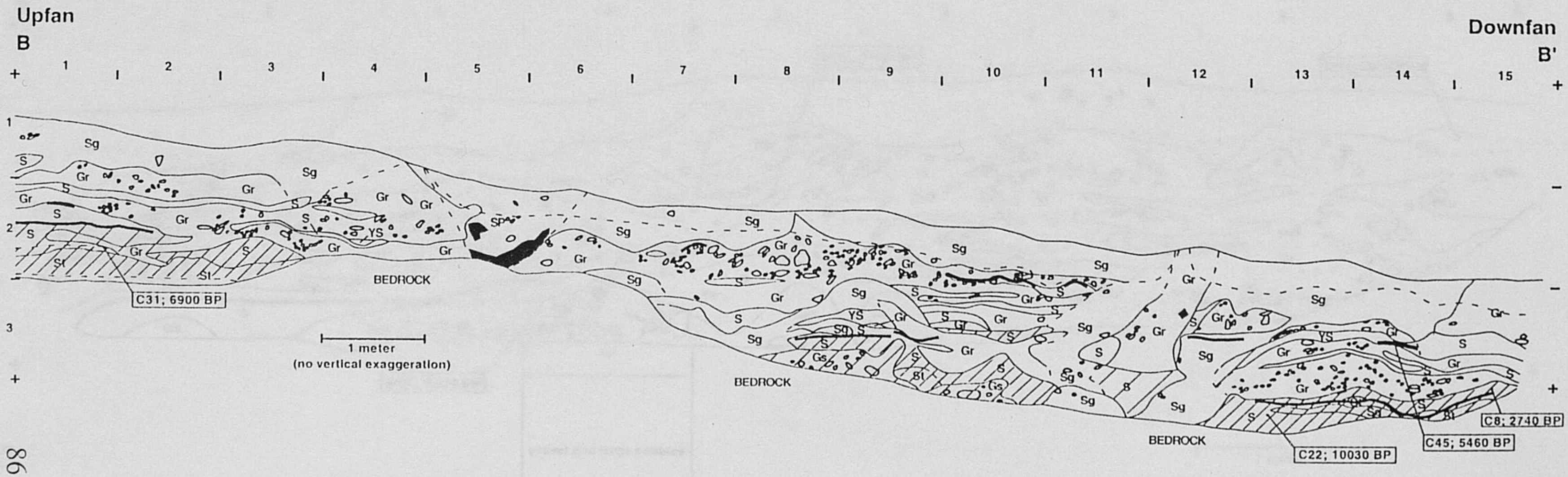


Figure 3.8B. Jennings et al.

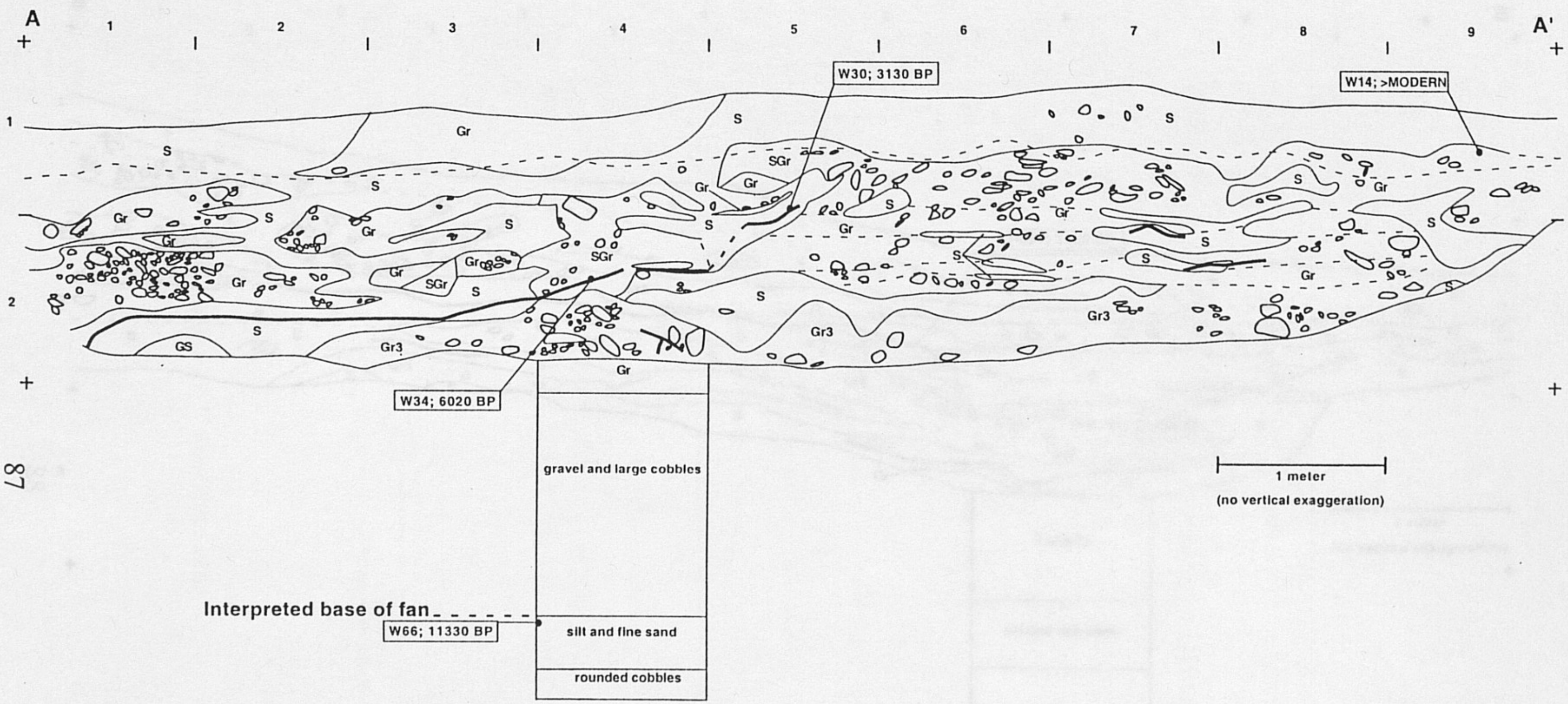


Figure 3.9A. Jennings et al

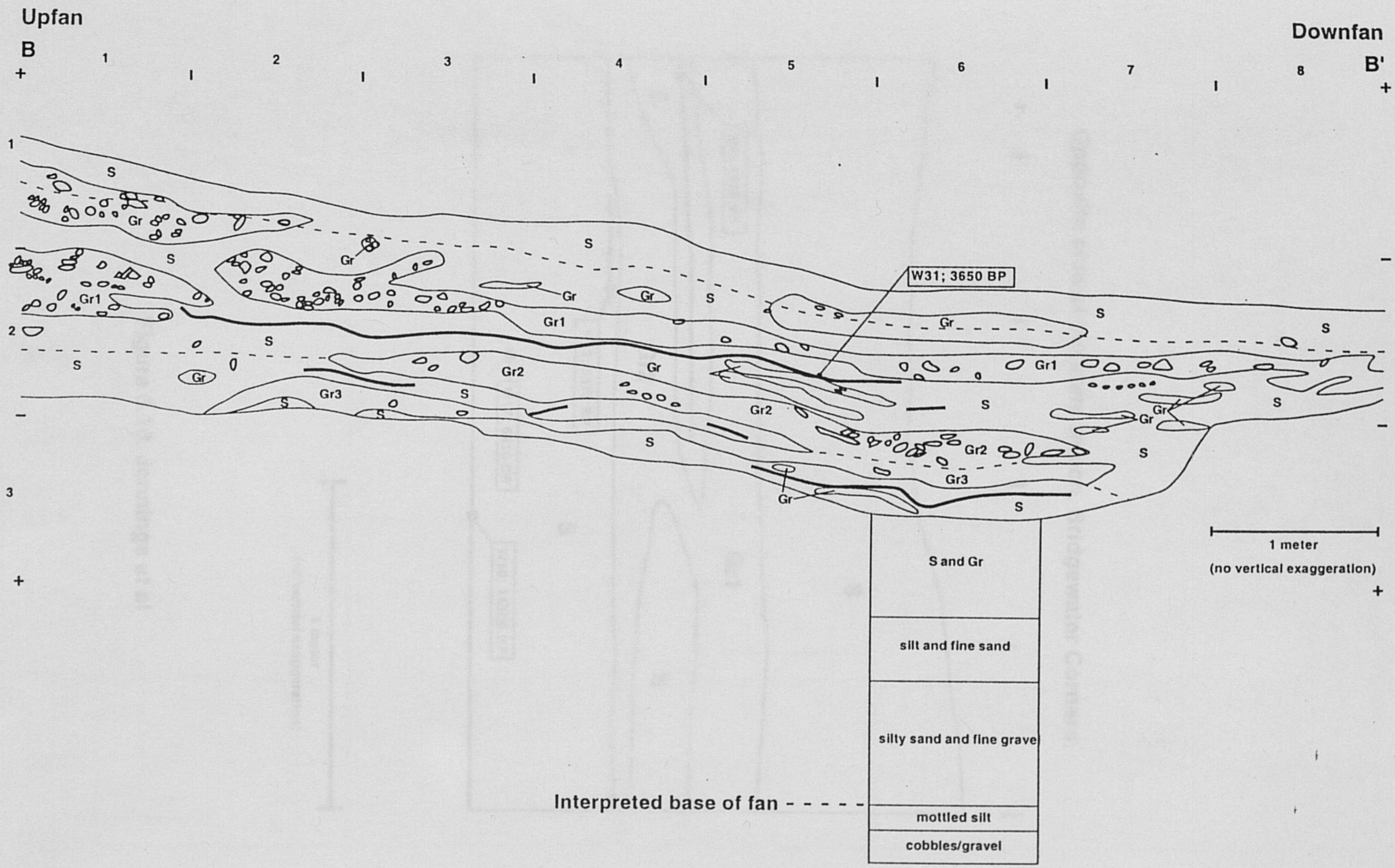


Figure 3.9B. Jennings et al.

Opposite side of the stem trench, Bridgewater Corners.

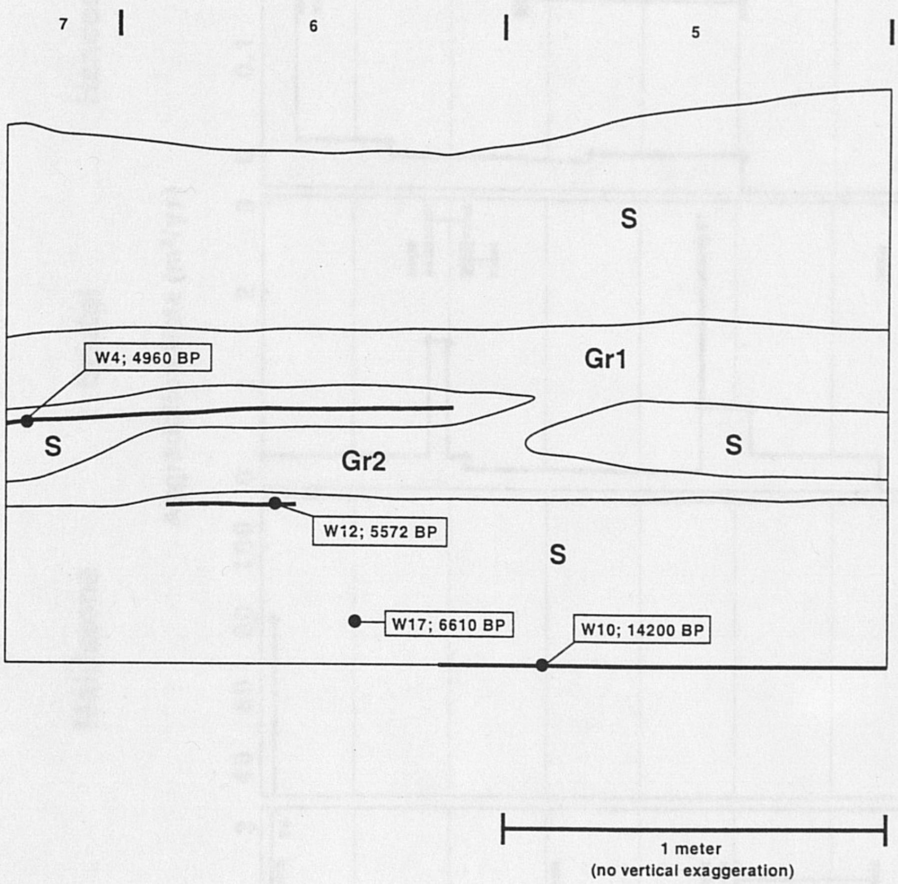


Figure 3.10. Jennings et al

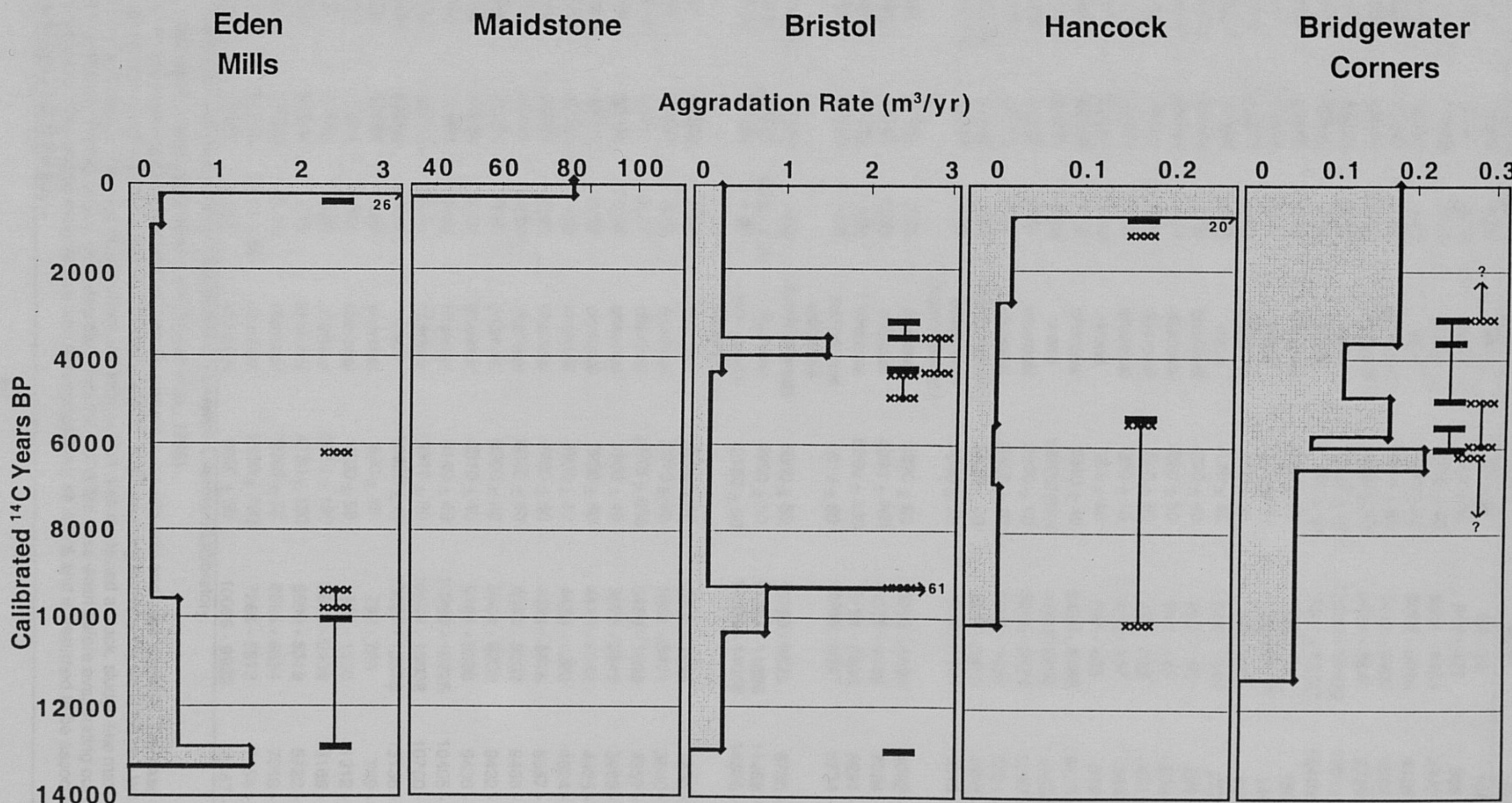


Figure 3.11 Jennings et al.

TABLE 3.1. RADIOCARBON AGES FOR ALLUVIAL FAN SAMPLES, VERMONT

Sample Number	CAMS Number*	Depth (m)	Material	Age (^{14}C years BP)	1 sigma calibrated (BP)†	2 sigma calibrated (BP)†
E53	62288	0.66	wood	90 ± 40	88 - 33	149 - 10
E6	62357	0.70	wood	440 ± 40	518 - 477	539 - 437
E18	67873	1.19	wood	2500 ± 40	2651 - 2488	2740 - 2451
E58	62354	1.36	wood	5320 ± 40	6082 - 5998	6196 - 5990
E40	62287	1.28	charcoal	8390 ± 60	9489 - 9400	9527 - 9266
E60	67870	1.13	charcoal	8640 ± 50	9604 - 9540	9759 - 9528
E70	62356	2.15	wood	10820 ± 40	12982 - 12820	13013 - 12795
E71	62355	2.65	wood	11400 ± 50	13441 - 13337	13488 - 13154
M2	62346	1.10	charcoal	110 ± 40	136 - 59	150 - 10
M4	62348	0.30	wood	110 ± 50	139 - 50	149 - 6
M23	62351	0.82	charcoal	130 ± 40	144 - 66	150 - 2
M52	62350	4.20	wood	170 ± 40	219 - 165	232 - 67
M13	62352	1.35	charcoal	200 ± 40	209 - 147	229 - 132
M18	62448	1.57	charcoal	220 ± 50	213 - 145	230 - 129
M3	62347	0.90	charcoal	300 ± 50	433 - 353	481 - 283
M 47	62349	3.25	charcoal	310 ± 40	432 - 357	464 - 299
M1	62447	1.45	wood	380 ± 40	501 - 433	510 - 420
M15	62353	1.57	charcoal	7640 ± 40	8429 - 8385	8479 - 8366
W14	67871	0.20	wood	>MODERN	>MODERN	>MODERN
W30	67872	0.67	charcoal	2970 ± 50	3213 - 3074	3267 - 2985
W31	57762	0.57	charcoal	3420 ± 40	3705 - 3632	3731 - 3569
W17H	57787	1.18	humic extract§	3620 ± 40	3978 - 3873	4007 - 3829
W17S	57786	1.18	solids from humic extract§	4030 ± 50	4530 - 4424	4646 - 4405
W4	57765	0.75	charcoal	4390 ± 80	5053 - 4850	5092 - 4834
W12	57763	0.90	charcoal	4960 ± 760	6551 - 4809	7324 - 3820
W34	57764	0.95	charcoal	5260 ± 130	6194 - 5909	6291 - 5743
W17	57760	1.18	soil organic material§	5810 ± 50	6668 - 6547	6734 - 6487
W10 H	57788	1.35	humic extract§	5850 ± 50	6730 - 6625	6755 - 6533
W66	57761	2.75 - 3.25	charcoal	9950 ± 50	11344 - 11235	11458 - 11208
W10	57785	1.35	soil organic material§	12150 ± 50	14336 - 14058	14365 - 14041
B7	62296	0.40	charcoal	3000 ± 40	3258 - 3154	3335 - 3069
B3	67867	0.32	charcoal	3310 ± 50	3581 - 3471	3640 - 3442
B19	62451	0.77	charcoal	2610 ± 660	3469 - 1896	4357 - 1267
B46	62292	0.55	charcoal	3600 ± 40	3925 - 3842	3989 - 3823
B5	62297	0.32	charcoal	3900 ± 40	4410 - 4341	4425 - 4230
B10	62450	0.60	charcoal	3930 ± 60	4435 - 4282	4524 - 4224
B45	62291	0.40	charcoal	4400 ± 40	4984 - 4875	5057 - 4857
B53	62449	2.60	charcoal	8360 ± 40	9343 - 9303	9486 - 9270
B35	62294	0.85	charcoal	8300 ± 40	9404 - 9339	9432 - 9240
B32	62295	0.92	charcoal	8310 ± 40	9421 - 9338	9436 - 9243
B55	62290	3.45	charcoal	9140 ± 40	10280 - 10225	10405 - 10214
B43	62293	0.70	charcoal	9370 ± 60	10644 - 10502	10750 - 10395
B59	62289	5.20	wood	10920 ± 40	13027 - 12876	13136 - 12829
C39	67868	0.60	charcoal	860 ± 40	792 - 726	799 - 686
C57	67870	0.46	charcoal	1320 ± 50	1290 - 1230	1312 - 1168
C8	57769	1.08	charcoal	2610 ± 190	2870 - 2439	3169 - 2304
C45	57770	1.15	charcoal	4730 ± 130	5590 - 5319	5722 - 5205
C31	57766	1.15	charcoal	6060 ± 50	6954 - 6854	7018 - 6776
C83	57768	1.15 - 1.30	charcoal	5550 ± 790	7266 - 5572	7954 - 4416
C22	57767	1.51	charcoal	8890 ± 50	10086 - 9922	10187 - 9865

*Center for Accelerator Mass Spectrometry, Lawrence Livermore Laboratory.

†Calibrated using CALIB version 4.2 (Stuiver et al., 1998).

§The soil organics (Samples W10 and W17) were prepared with acid and base washes. The base washes from these two samples were retained and evaporated. The remaining humic acids were labeled W10H and W17H, and dated. The base washes from soil sample W17 also contained a black, sludge-like material that had settled out of solution and was separated from the rest of the base wash before evaporating out the humic acids. The sludge material was then dated separately as W17S and is assumed to be associated with the humic acids in the soil.

TABLE 3.2. DIMENSIONS OF ALLUVIAL FANS AND DRAINAGE BASINS

Fan Location	Volume (m^3)	Surface Area (m^2)	Drainage Basin Area (m^2)
Maidstone	12,200	1,300	2,800
Hancock	14,500	3,600	225,000
Bristol	6,300	2,600	249,000
Bridgewater Corners	1,300	200	41,600
Eden Mills	6,500	1,600	135,000

TABLE 3.3. UNIT DESCRIPTIONS, ALLUVIAL FAN TRENCHES, EDEN MILLS, VERMONT

Unit Identifier	Grain size	Soil color	Notes
(RD) Recent deposition	Medium sand matrix, clasts 1 to 10 cm	2.5Y 4/2	Result of logging road incision and gullying
(TS) Topsoil	Wood fragments and fine sand with 1 to 2 cm gravel and larger clasts (5%)	10YR 3/1	Modern topsoil layer; sediment from post-clearing deposition
(TST) Topsoil - Top Trench	Silt and clay	10YR 3/1	Modern topsoil; sediment from overbank deposition
(RG) Recent Gravels	Fine sand (~15%) and medium to coarse sand matrix mixed with clasts1 mm to 2 cm	2.5Y 4/2	Layer of historic gravel deposition on the surface of the alluvial fan resulting from increased erosion and runoff during historical logging of the hillslope
(BAP) Buried, Ap-horizon	Fine sand and silt	10YR 3/1	Represents plowing of the fan surface prior or concurrent to hillslope clearance
(solid black) Paleosol	Silt and clay	5Y 2.5/1	Buried soil A-horizon (topsoil)
(S1) Sand 1	Fine sand and silt	2.5Y 3/2	Massive sand; also buried Ap-horizon
(S2) Sand 2	Fine sand and silt	2.5Y 4/2	Massive sand with discontinuous buried paleosols
(S3) Sand 3	Fine sand and silt	2.5Y 4/2	Massive sand capped by leached E-horizon
(SP) Sand Patch	Coarse sand matrix with clasts of fine gravel (2 mm) to pebbles (2 to 3 cm)	7.5YR 3/2	Discontinuous unit; grades into S3 unit
(SC and SC2) Silt - Clay	Silt and clay with little fine sand	2.5Y 4/2; E-horizon 5Y 5/2	Massive units separated by thin paleosol layer
(GP) Gravel Patch	Fine to medium sand matrix with fine gravel (2 to 10 mm)	N/A	Discontinuous unit within the S2 unit
(BS) Brown silt	Silt and clay	2.5Y 5/2; E-horizon 5Y 6/2	Massive unit capped with paleosol overtopping a leached E-horizon
(CG) Channel Gravel	Fine sand and silt matrix mixed with coarse sand and fine gravel	10YR 3/1	Represents migrating channel of the feeder stream
(FS) Fine sand	N/A	N/A	Discontinuous unit within the CG unit; similar to SC unit
(GS) Gley silt	Fine sand and silt	6/10 Y Gley	Massive silt unit
(GG) Gley gravel	Medium and coarse sand matrix with fine gravel (0.5 cm) to small pebbles (2-3 cm)	6/5 GY Gley	Lowest unit in the trenches; bedded gravel

TABLE 3.4. UNIT DESCRIPTIONS, ALLUVIAL FAN TRENCHES, MAIDSTONE, VERMONT

Unit Identifier	Grain size	Soil color	Notes
(GS) Gully sand	Fine to medium sand	2.5Y 5/3	Sediment washed downfan from dirt road in gully
(WS) White sand	Fine to medium sand	2.5Y 6/3	Very clean, sheetflow deposit; cross-bedded, braided structures; wavy laminations and unit boundaries
(St) Silt	Silt with little fine sand	Top: 5Y 4/2 Stem: 2.5Y 4/1	Massive unit that separates sand units
(BS) Brown sand	Medium and fine sand	Top: 2.5 Y 4/2 Stem: 2.5Y 5/3	Massive layer with patchy, faint bedding; higher silt content than white sand
(CBS) Coarse brown sand	Medium sand and about 25% coarse sand	2.5Y4/2	Same as (BS) but coarser
(TT) Tree throw area	Medium sand	2.5Y 5/3	Disturbed area where tree fell over
(upper solid black) Upper buried soil	Fine sand	Top: 10 YR 3/2 Stem: 10YR 2/1	Buried soil, poorly developed
(lower solid black) Lower buried soil	Fine sand	A: 2.5 Y 3/1 E:7N gley B:10YR 4/3	Buried soil sequence; becomes topsoil in sections 1-4 of A-A'
(Gr) Gravel	Small cobbles in a medium sand matrix	N/A	Small patch of gravel
(CSP) Coarse sand patch	Coarse sand	N/A	Similar to (CBS)
(TSA) Top sand A	Fine and medium sand	2.5 Y 4/4	Poorly sorted sand unit
(TSB) Top sand B	Fine to medium sand	2.5 Y 5/3	Poorly sorted sand unit; very densely packed from farm animal grazing
(DA) Disturbance area	Medium sand	2.5Y 4/3	Disturbed areas from either tree root growth or bioturbation
(TSC) Top sand C	Medium sand with 30% fine gravel	2.5Y 4/3	Discontinuous unit; grades into silt
(SS) Silt and Sand	Medium to coarse sand with 15% fine gravel	2.5 Y 5/3	Similar to (BS) unit; no bedding

TABLE 3.5. UNIT DESCRIPTIONS, ALLUVIAL FAN TRENCHES, BRISTOL, VERMONT

Unit Identifier	Grain size	Soil color	Notes
(Ap) Ap/Topsoil	Fine sand and fine gravel	10YR 3/2	Plowed A-horizon; top 10-25 cm is slash (pieces of bark, wood and leaves)
(D1) Disturbed area 1	Medium sand	10YR 4/3	Appears to be dug pit, possibly by backhoe
(D3) Disturbed area 3	Fine to coarse sand and gravel	10YR 3/3	Possibly a pit or tree throw
(UG) Upper gravel	Matrix: medium to coarse sand with fine gravel (3 to 6 mm); clasts are gravel and pebbles (1 to 6 cm) with occasional clasts 10 to 15 cm.	2.5Y 5/4	Large depositional event, possibly induced by clear-cutting of hillslope
(solid black) Paleosol	Very fine sand and silt	7.5YR 2.5/1	Buried A-horizon
(LS) Lower sand unit	Fine sand and silt	10YR 3/2	Massive sand unit interrupted by three paleosol layers
(FG) Fine gravel	Medium sand and fine gravel	10YR 4/4	Discontinuous; possibly part of a larger gravel unit
(Gr) Gravel	Coarse sand and fine gravel	2.5Y 4/4	Discontinuous unit with weak bedding
(S) Sand	Fine sand	10YR 3/2	Contains about 10% gravel clasts
(FG2) Fine gravel 2	Coarse sand and fine gravel	10YR 4/3	Possibly part of a larger gravel unit
(D2) Disturbed area 2	Medium and fine sand and fine gravel (1 cm size)	2.5Y 3/3	Another area disturbed by a tree throw
(LG) Lower gravel unit	Matrix: fine to medium sand in top trench, medium to coarse sand in stem trench; clasts range from fine gravel (2 mm) to large cobbles (20 cm); most clasts are pebbles (2 to 5 cm)	Top:10YR 4/4 Stem: 2.5Y 5/4	Represents a large depositional event; can be subdivided into three sub-units
(SP) Sand Patch	Fine sand	2.5Y 3/2	Only in top trench
(TT) Tree throw	Fine sand	2.5Y 3/3	Location of a tree that fell over
(MS) Massive sand	Medium sand	2.5Y 4/4	Homogeneous sand that caps BS unit
(BS) Bedded sand	Medium to coarse sand and fine gravel (2 to 5 mm)	2.5Y 4/4	Can be divided into sub-units as indicated on the cross-section

TABLE 3.6. UNIT DESCRIPTIONS, ALLUVIAL FAN TRENCHES, HANCOCK, VERMONT

Unit Identifier	Grain size	Soil color	Notes
(Sg) Sand and gravel	Fine sand matrix with fine gravel	Top: 10YR 3/3 Stem: 2.5Y 3/3	Matrix supported, 15% coarse fragments
(dashed line) Topsoil boundary		2.5Y 3/2	Color change due to modern soil development at the fan surface
(S) Sand	Medium sand to silt	Top: 2.5Y 3/3 Stem: 10YR 4/3	Massive, semi-continuous unit
(Gr) Gravel	Medium sand to cobbles	Top: 2.5Y 3/2 Stem:10YR 4/3	Clast supported, some faint bedding
(Fg) Fine gravel	Medium sand to gravel	10YR 4/3	Discontinuous, poorly-sorted; may be part of a larger gravel unit
(YS) Yellow sand	Medium and fine sand	2.5Y 4/4	Light-colored, homogeneous unit with weak cross-bedding
(solid black) Paleosol	Fine sand	2.5Y 2.5/1	Buried A-horizon
(SP) Slash pit	Fine sand matrix with gravel	10YR 3/1	Disturbed area that was dug as a pit and filled with organic material
(St) Silt	Silt and fine sand	2.5Y 4/3	Discontinuous unit, shows B-horizon development
(Gs) Gravel and silt	Silt matrix with cobbles	10YR 4/3	Clast supported cobble unit

TABLE 3.7. UNIT DESCRIPTIONS, ALLUVIAL FAN TRENCHES, BRIDGEWATER CORNERS, VERMONT

Unit Identifier	Grain size	Soil color	Notes
(above dashed line) Topsoil	N/A	10YR 3/2	Faint coloration due to recent soil profile development, cuts across stratigraphic units.
(S) Sand	Fine sand and silt	10YR 3/4	Mostly massive, although bedding in localized areas; pockets of stratified coarse sand and fine gravel.
(solid black) Paleosol	Very fine to coarse sand	2.5Y 2.5/1	Buried A-horizon.
(SGr) Sand and gravel	Fine sand and silt matrix with gravel clasts (20%)	10YR 3/4	Transitional unit between sand and gravel units; matrix supported; poorly sorted.
(Gr, Gr1, Gr2, Gr3) Gravel	Gravel, medium sand and small cobbles	10YR 4/4	Weakly imbricated; clast supported; clasts from 3 mm to 10 cm.
(GS) Grey silt	Silt and fine sand	2.5Y 5/3	Massive; isolated gravel (<1%); high moisture content.

Table 3.8. Comparison to New England Records

Other studies	Climate	Timing (years BP)	This study
Davis et al., 1980; Spear et al., 1994; Li, 1996	cool and moist	2000-0	Increased agg. at EM, HC, and BC (may be historic)
Dwyer et al., 1996; Li, 1996	warm and dry	5000-3000	Low agg. at EM and HC; high at BC and BR.
Spear et al., 1994	warmer with more frequent storms	7000-4000	Low agg. at EM, HC, and BR; storms at EM, BR and BC
Davis et al., 1980; Dwyer et al., 1996	warm and wet	9000-7000	Low agg. at all fans
Davis et al., 1980; Dwyer et al., 1996	cool and dry	11000-9000	Moderate agg. at EM and BR; low at BC
Davis et al., 1980; Dwyer et al., 1996	cool and wet	13000-11000	Moderate agg. at EM and BR; low at BC

CHAPTER 4: Data Repository for submission to *Geological Society of America Bulletin*, as accompany to the paper presented in Chapter 3.

DR1: METHODS

Fans were located by identifying areas, on 1:24,000 topographic maps, conducive to fan formation and preservation, such as wide valley floors with adjacent high local relief. Because the fans we studied are small (< 15,000 m^3), they could not be distinguished on topographic maps or aerial photographs. We field checked favorable locations, identified 30 suitable fans, and selected five of these fans to trench (Figure 3.1), maximizing the spatial distribution of selected fans across Vermont.

Surveying

At each field site, three benchmarks were set as reference points using a Trimble Pathfinder ProXR GPS (Global Positioning System). Because the ProXR measures latitude and longitude to within ± 0.3 m, and elevation to within ± 0.5 m, one benchmark was arbitrarily designated at the ProXR coordinates, and the other two benchmarks were established using either a Pentax total station, or a Trimble RTK (real time kinematic) differential GPS (4400), both of which are accurate to within ± 0.05 m. The surface of each fan was surveyed from the three benchmarks using a combination of the RTK differential GPS and the total station. Survey data were processed into topographic maps using Surfer.

Trenching

Two intersecting backhoe trenches were dug into each alluvial fan. Trenches were 8 to 15 meters long and 1.5 to 2 meters wide and deep. In each fan, one trench was oriented across the fan gradient, as close as possible to the apex. Such trenches were referred to as the *top trenches*, and are labeled on the cross-sections as A-A'. A second trench on each fan was oriented down gradient, labeled on the cross-sections as B-B', and referred to as the *stem trench*.

A string grid, 1 meter by 1 meter, was superimposed onto each trench using nails to secure the grid to the trench walls. Individual stratigraphic units were identified using grain size, texture, sorting, and soil color; the boundaries between units were marked with colored nails. Sedimentary structures, such as cross-bedding or laminations, were noted as was soil profile development. Using the string grid as a reference, the outline of the trench and unit boundaries were transferred to a sheet of gridded mylar at 1:20 scale. Rocks with a diameter larger than 5 cm were drawn into the stratigraphic cross-sections. Pieces of wood or charcoal in the stratigraphy were assigned a number, described in detail, located on the cross-sections, and then collected and placed in plastic bottles.

Before leaving each site, we dug one to three meters deeper in each trench in order to determine the stratigraphy of lower fan units.

Radiocarbon Analysis

The number of samples collected for radiocarbon dating (discrete charcoal and wood pieces) ranged from 33 to 69 samples per fan. Fifty radiocarbon samples were dated: 35 charcoal, 11 wood, and 4 soils. An additional 18 charcoal samples completely dissolved during preparation.

Wood or charcoal samples were refrigerated until analysis. Samples chosen for dating were prepared by examination under a binocular microscope to remove any root material or soil particles, and dried at 80°C overnight. Samples were prepared for radiocarbon analysis at Lawrence Livermore National Laboratory where they were repeatedly washed in HCl and NaOH to remove carbonate and humic and fulvic acids. Samples were burned and CO_2 was collected cryogenically and reduced to graphite over Fe for analysis by Accelerator Mass Spectrometry. Radiocarbon dates were calibrated using the online version of CALIB 4.2 (Stuiver et al., 1998).

We also prepared two soil samples for humic acid extraction and dating in order to compare this dating technique to the wood and charcoal dates. The soil organics (Samples W10 and W17, Table 3.1) were prepared with acid and base washes. The base washes from these two samples were retained and evaporated. The remaining humic acids were labeled W10H and W17H, and dated. The base washes from soil sample W17 also contained a black, sludge-like material that had settled out of solution and was separated from the rest of the base wash before evaporating out the humic acids. The sludge material was then dated separately as W17S and is assumed to be associated with the humic acids in the soil.

Calculation of Aggradation Rates

Aggradation rates were calculated assuming that alluvial fan geometry is reasonably modeled as a portion of a right circular cone (Figure 4.DR2). The volume of the fan at the age of any particular sample can be determined by using the equation for volume of a right circular cone, modified by the sweep angle that the fan subtends (*s*). Such modeling assumes that the slope and sweep angle of any fan have remained constant throughout the fan's development. These assumptions are violated by channel migration and cutting and filling of the fan surface. Nevertheless, our calculations provide a rough estimate of aggradation rates over time.

DR3A: RESULTS

Eden Mills Fan

Setting. The Eden Mills alluvial fan, elevation 412 m, is located in a narrow valley that has not been influenced by stream flow since deglaciation (Figures 4.DR3C and 4.DR3D). Currently, the fan is fed by a small but perennially active stream that drains along the south side of the fan. A logging road has been built along the north side of the stream and appears to be concentrating surface runoff onto the lower portion of the road where it is causing erosion. The adjacent Lowell Mountains were heavily logged in the early 20th century, and horses were used to drag the logs to the valley floor (including the surface of this alluvial fan) where they were prepared for shipping (personal comm., 1999, local resident). The drainage basin is underlain by weathered phyllite covered by till and ice-contact sediments (coarse sand and gravel).

Stratigraphic Observations. The Eden Mills fan is composed of bedded fine sand in abrupt contact with coarse sand and gravel in the upper meter of the fan. Radiocarbon ages range from 13,320 to 80 calibrated ^{14}C years BP. The topmost 50 cm of the fan are heavily laden with woody debris, including sawn logs ranging from 30 cm to 2 meters in length. A piece of a metal horse bridal, an artifact of logging, was found near the surface in the RG unit. A layer of gravel on the fan surface is directly traceable to gullying on the logging road (unit RD). Two Ap horizons, a result of plowing for agricultural use, are preserved in the upper meter of the fan at the base of the BAP and S1 units. The logging-related gravel interfingers laterally with the Ap units resulting from agriculture.

In the lower meter of the trenches, fine sand beds contain an abundance of very thin, discontinuous, A-horizon paleosols separated by thin sand layers. The buried A-horizons were identified in the stratigraphy by their dark color and high organic content. Two sand units in the top trench also preserved thin E and B-horizons beneath buried A-horizons.

Another gravel unit (CG) at the bottom of the top trench contains large pieces of wood and organic material, including a rapidly buried and well-preserved log (20 cm diameter) at the bottom of the trench (Sample E58; 6,090 calibrated ^{14}C years BP; Table 3.1). The gravel unit around the log is bowl-shaped suggesting that the unit infilled a scoured channel surface. The CG unit can be sub-divided into two sub-units that may represent different pulses of the same depositional event.

The very lowest layer of the fan is composed of gleyed silt about a meter thick (GS). Wood from this unit has been dated at 13,320 calibrated years BP near the lower contact, indicating that it was deposited soon after glacial retreat. In the top trench, the gley silt overlies medium gravel which grades downward into larger gravel. Because the silt is just post-glacial (Sample E71; 13, 320 calibrated ^{14}C years BP; Table 3.1), the large, well-sorted gravel below is likely glacial outwash.

Interpretation. The Eden Mills alluvial fan began to accumulate immediately after icesheet retreat. The basal age of the fan is 11,400 ^{14}C years (13,320 calibrated ^{14}C years BP), only 540 ^{14}C years after primary productivity was re-established in Ritterbush Pond, 4 km to the west of Eden Mills (elevation of 317 m asl; Bierman et al., 1997). From 13,320 to 12,900 calibrated ^{14}C years BP half a meter of massive, well-sorted silt was deposited. At 12,900 a 0.5 meter thick organic unit developed. This organic layer could indicate a time of fan surface stability allowing for thick A-horizon development The silt and organic layer is overlain by bedded, fluvial gravel (GG unit).

Above the gravel, multiple buried A-horizons indicate the fan experienced cycles of fine sand deposition followed by periods of fan surface stability (indicated by buried soils) until 490 years BP, the date just beneath the lowest AP horizon (S1 unit). The buried soils with A/E/B-horizon sequences have much thicker sand units below them, and indicate that more deposition had occurred on the fan, followed by a longer period of quiescence sufficient to develop thicker soil profiles. The discontinuous nature of the paleosols is likely the result of scouring on the fan surface during large storms.

After the hillslope was logged, the fan experienced rapid aggradation of coarse sand and gravel. Large gravel lobes, high in the stratigraphy at the southern edge of the top trench, are most likely remnant stream channel deposits left behind as the channel migrated southward to its current position. A wood sample found at the bottom of the S1 unit dated at 80 years, indicating that both Ap horizons are indeed historic. Above two agricultural horizons is the abrupt change to large gravel and wood fragments, most likely due to large-scale clear cutting and the resulting increase in hillslope erosion rates.

DR4A: RESULTS

Maidstone Fan

Setting. The Maidstone fan is located 273 m asl on a terrace of the Connecticut River (Figures 4.DR4C and 4.DR4D). It is fed by a small gully that extends to the river terrace above and is currently occupied by a dirt road. The lower river terraces are composed of postglacial fluvial sand and gravel; at higher elevation, they contain glaciolacustrine littoral sediments (well sorted sand). The area was used for logging around the turn of the 20th century (personal comm, 1999, L. Hook). The property was later converted to pasture and the surface of the trenched fan was partially reforested.

Stratigraphic Observations. Radiocarbon ages from the Maidstone fan range from 8420 to 80 calibrated ^{14}C years BP. The fan is composed of interbedded sand and silt in units that are laterally continuous across both trenches, except close to the apex of the fan where beds are less continuous due to gully migration and erosion. Light-colored, sand units (WS) are well-laminated and show evidence of cross-bedding and braiding in small areas of the fan. Interbedded with the WS units are massive, dark-colored sand units (BS) which have a higher silt content. Most sand units are separated by thin silt layers (St); silt layers are also found within some laminated sand units. Many of the sand units contain armored silt rip-up clasts, indicating a source of layered silt in the upstream gully (likely glacio-lacustrine). The silt rip-up clasts may have been deposited onto the fan surface during intense rainstorms, and then washed into the thin silt layers (St)during less intense storms (Rachocki, 1981). Rounded clasts of medium to coarse sand with a red, iron rich cement were found in some sand units, probably emplaced as a rip-up clasts from an oxidized sand unit in the terrace sediments upstream.

Only two buried soil profiles appear in the stratigraphy. The higher buried soil is faintly colored, about 5 to 10 cm below the surface, and only appears in the top trench where it merges with the modern topsoil towards the fan margin. The lower buried soil is about 30 cm below the surface and has a black A-horizon, underlain by a leached E-horizon, with a reddened B-horizon beneath the E. This profile is typical of an acidic soil environment, and probably developed under a pine or hemlock forest.

There is an abundance of soft sediment deformation in the fan stratigraphy, including rippled beds and faulting. The fan was probably deposited rapidly enough that dewatering from the silt layers occurred, causing the soft-sediment deformation. Alternatively, deposition my have occurred during a winter or early spring flood, leaving sediment on top of ice or snow that later melted. Rachocki (1981) found that mud-flows deposited on top of snow-covered alluvial fans was common during the spring thaw, and that intense rainfall was not necessary to generate the mud flows.

At greater depth (2 to 4 meters), the fan stratigraphy contains silt and sand beds, similar to those near the surface. At 4.2 meters depth, we found a continuous, 20 cm - thick layer of organic material including moss, branches, leaves, and twigs. This layer represents deposition of organic material from Connecticut River floods and hence provides the most reliable material for estimating the maximum age of the Maidstone alluvial fan. A wood branch from this layer was 150 calibrated ^{14}C years old, demonstrating that the entire Maidstone fan was deposited during historic time.

Interpretation. The continuous nature of the units in the Maidstone fan suggest that each depositional event blanketed the fan. The sedimentary structures preserved within the WS units indicate fluvial deposition. The low silt content is the result of high-energy flow on the fan that would have carried away fine-grained sediments. Siltier layers may represent a different source, or a low energy flow.

There are no buried paleosols or soil coloring/development below the two near-surface A-horizons. This lack of paleosols suggests that the fan was deposited rapidly, without periods of stability sufficient to allow soil development. The formation of the Maidstone fan is the result of historic land disturbance; the buried paleosols represent short-lived, stable fan surfaces. The higher paleosol was probably buried when the gully was filled with sand by the landowner. The spodosol coloring of the lower paleosol is usually associated with long periods of soil development; however, dating indicates that this paleosol can be no more than 200 years old. Soil development occurred at an accelerated pace, a process not uncommon under dense, acidic, Vermont forests (2000 personal comm., W.S. Harper).

DR5A: RESULTS

Bristol Fan

Setting. The Bristol fan is 191 m asl in a steep-sided valley at the base of Bald Hill, so named because it was devoid of trees until 1950 (Figures 4.DR5C and 4.DR5D). The site has been used for row crops and pasture. The fan is fed by a 3-meter-wide, ephemeral stream channel filled with large quartzite boulders derived from adjacent hillslopes of quartzite and phyllite. During a large storm in July 1998, gravel was deposited on the surface of the fan. However, this deposit is not thick enough to be visible in cross-section.

Stratigraphic Observations. Dates for the Bristol fan range from 12,980 to 3200 calibrated ^{14}C years BP. The Bristol fan is composed of interbedded sand, gravel and cobbles in laterally continuous and massive deposits. Across the top of both trenches, the fan has a clear Ap (plow) horizon indicated by dark color, platy structure, and an abrupt lower contact. The top trench has a thick layer of slash mixed in with the upper Ap horizon. Beneath the Ap horizon is light-colored gravel and coarse sand (UG) that likely reflects a post-clear cutting pulse of hillslope erosion and sediment deposition. The UG unit contains two small sand patches in sections 1, 2 and 3 of the top trench; these sand patches may have been a continuous unit prior to plowing which mixed sediments in the top 0.5 meter of the fan stratigraphy. The UG unit is continuous across the top trench but becomes patchy towards the distal areas of the fan in the stem trench.

The deeper stratigraphy of the Bristol fan is dominated by interbedded, thin, patchy sand and gravel units (units Gr, S, LS, FG, and FG2). These units are interrupted by at least three discontinuous buried A-horizon paleosols. The Gr, FG and FG2 units contain slightly finer gravel in the matrix (3 cm diameter compared to 6 cm for the UG and LG units) and lack the large cobble clasts compared to the UG and LG units. The Gr unit is weakly bedded, indicating fluvial transport, and may correlate with the FG unit in the top trench. The S and LS units are composed of massive fine sand.

A large cobble unit (LG) with clasts up to 20 cm in diameter is present from 0.5 to 1 m depth in the trenched sediments. The matrix of this unit is composed of fine to coarse sand. The unit is mostly clast supported, although sections 4-6 of the top trench are matrix supported. There is a weak imbrication of LG unit clasts in the stem trench. The LG unit thins into three separate fingers in sections 9 and 10 of the stem trench; these gravel fingers are separated by massive sand. The lowest unit of the large trenches is composed of horizontally bedded coarse sand and fine gravel, capped with a layer of massive, medium sand (BS and MS units).

The base of the fan grades downward from sand and gravel into fine sand and eventually silt. Below the silt is a layer of bedded medium and fine sand which dated at 10,310 calibrated ^{14}C years BP (sample B55, Table 3.1). The bedded sand is underlain by well-sorted coarse sand with gravel clasts ranging from 10 to 40 cm. The clasts are not well-rounded and show typical glacial faceting, but do not preserve glacial striations. This coarse sand and gravel unit has an abrupt lower contact with a 10 cm-thick, massive, fine sand unit. Within this deposit is a thick layer of well-preserved organic material 4.9 meters below the fan surface. This organic layer contains hemlock cones and large wood pieces, evidence of a moist, vegetated landscape at this location. Wood in the organic layer dates to 12,980 calibrated years BP (sample B59, Table 3.1), indicating that the glaciers had retreated from the valley and woody vegetation had re-established by that date. A fine sand and fine gravel mixture (possible glacial outwash) underlies the organic layer.

Interpretations. The base of the Bristol alluvial fan is 4.9 meters deep at the bottom of the fine sand unit; the maximum basal age of the fan is 12,980 calibrated ^{14}C years BP (sample B59, Table 3.1) from the buried organic layer. The onset of alluvial fan aggradation would have infilled and buried the moist area where the organic material had been accumulating. Later, gravel and sand from till deposited on the hillslopes was deposited, grading upward into bedded fine and medium sand by 10, 310 calibrated ^{14}C years BP (sample B55, Table 3.1).

Between 4 to 2 meters in depth the alluvial fan accumulated an upward coarsening sequence of silt, fine sand and then sand and gravel. The overlying BS unit represents fluvial deposition of bedded sand and fine gravel that is capped with a massive sand (MS) unit. Missing material from the top contact of the MS unit, and part of the BS unit closer to the fan apex, indicates either scouring of the fan surface during a high energy flooding event, or incision of the fan surface.

A paleosol 5 cm above the LG unit dates as 4330 calibrated ^{14}C years BP (sample B5, Table 3.1), and charcoal from within the LG unit dated at 4370 calibrated ^{14}C years BP (sample B10, Table 3.1), indicating a high energy depositional event around 4300 years BP. This unit separates into three different lobes at the downstream portion of the fan, indicative either of three depositional events that occurred in rapid succession, or of three sediment pulses within one event. A paleosol between the lowest two LG gravel lobes in sections 9 through 11 of the stem trench indicated that at least part of the LG unit may be remnant from a previous depositional event, with a substantial period of stability before the rest of the unit was deposited.

Above the LG unit, multiple, discontinuous A-horizons in both trenches indicate repeated short periods of fan stability, followed by scouring events. The thin, discontinuous sand and gravel units (units G, S, LS, and FG2) may indicate many small depositional events that closely followed one another in time. Based on two dates from the LS unit (B7 and B46, Table 3.1), we can assume that from about 4,000 to 3,000 years BP the fan was depositing thin units of sand or fine gravel followed by periods of stability sufficient to develop an A-horizon. The pulse of sediment just beneath the Ap horizon (UG) suggests that deforestation of the hillslope triggered an increase in deposition on the fan surface.

DR6A: RESULTS

Hancock Fan

Setting. The Hancock fan is on a terrace of the White River, 285 m asl (Figures 4.DR6C and 4.DR6D). The fan is fed by a 2-meter-wide perennial stream that currently infiltrates along the southern side of the fan. The stream channel and adjacent hillslope are underlain by weathered phyllite and schist mantled by a thin layer of colluvium. The stream regularly overflows its channel and sheetfloods the fan during the spring snow melt. A logging road has been built along the side of the stream, capturing flow from the upper reaches of the stream drainage, and causing a new fan to form just north of the older one. Another smaller fan lies just south of the trenched fan, fed by a separate drainage.

Stratigraphic Observations. Radiocarbon ages for the Hancock fan range from 10,030 to 730 calibrated ^{14}C years BP. The Hancock fan is composed of interbedded sand, gravel, sand mixed with gravel, and silt. The fan sediments thinly mantle the underlying bedrock topography, which is only 1.5 to 2 meters below the surface of the fan. Stratigraphy of this fan is extremely complicated with a lack of horizontal continuity of units that make the depositional history practically indecipherable. Overlapping gravel units in the top trench are most likely channel remnants, with weak cross-bedding in the lower corner of section 6 in the top trench indicating fluvial activity. Thin, discontinuous (only 1 to 2 meters long) fine gravel and sand units may be indicative of a shallow fan gradient with a low sediment load that was distributed unevenly across the fan surface.

In the stem trench the bedrock is as shallow as 0.5 meters, interrupting the middle of the stem trench and making it difficult to correlate units downfan of the sub-crop with those up fan. The lowest units in the stem trench are composed of massive silt (St) or silt mixed with cobbles (Gs) — a finer grain size than any of the top trench units. The stem trench shows a general upward coarsening, indicating either higher-flow events, a larger sediment supply upstream, or a closer proximity to the stream channel.

Thin, buried A-horizons were present in both trenches, and were sometimes underlain by dark red B-horizons. The soil development crosses stratigraphic units, indicating that soils formed after deposition of those layers. Often the B-horizon color was present when there was no trace of an ancient A-horizon. Small (2-10 mm) charcoal flecks were abundant in the sand units, but were nearly always in a highly decomposed condition. Most of the charcoal samples from this fan that were selected for radiocarbon dating completely dissolved during sample preparation, indicating a low organic content. Humans have also disturbed the fan surface, as noted by the presence of a slash pit.

There is no evidence of a plow horizon in this fan, although there is weak topsoil development across both trenches.

Interpretation. The Hancock fan displays the importance of scour and sediment reworking in the deposition history of fans fed by perennial streams. This fan has a patchy stratigraphy indicating repeated incision and filling by the stream, or perhaps channel migration around bedrock outcrops. The discontinuous nature of fan units also indicates that most deposition on the fan may be from braided channel deposits on a shallow gradient surface with low sediment load. Dated pieces of charcoal are not in chronological sequence within the stratigraphy, indicating that the alluvial fan sediments were reworked from further upfan and deposition was not occurring in a horizontally uniform fashion. The decomposed nature of most charcoal samples are further evidence of reworking and redeposition of sediment on the fan surface.

Buried A-horizons indicate periods of fan stability and topsoil development on the order of 100 years. Buried B-horizons indicate a further 100 years of fan stability in order to allow the increased soil profile development. In all cases where a buried B-horizon was present (as indicated by soil coloring) with no overlying A-horizon, the buried soil was overlain by a course gravel deposit. This stratigraphy suggests that the fan was quiet, with little or no deposition, while the A and B horizons developed (probably 200 to 300 years). The next depositional event on the fan was then large enough to scour and wash away the topsoil on the fan (what would have been the preserved A-horizon) and deposit the gravel. Buried A-horizons without the reddened B-horizon beneath indicate shorter periods of fan surface stability, closer to 100-150 years.

DR7A: RESULTS

Bridgewater Corners Fan

Setting. The Bridgewater Corners alluvial fan is located in a narrow river valley along Broad Brook, 331 m asl (Figures 4.DR7C and 4.DR7D). The fan has formed on the third river terrace above the stream, and is fed by a small perennial tributary of Broad Brook. The tributary is currently incising along the northern border of the fan where it flows into Broad Brook. On the adjacent hillslope, the stream cuts through two higher river terraces just above the fan location, and through glacial till at higher elevations. Part of the distal fan has been eroded away by migration of Broad Brook.

Stratigraphic Observations. Radiocarbon ages on the Bridgewater Corners fan range from 14, 200 to 3130 calibrated ^{14}C years BP, with one modern sample (Table 3.1). The Bridgewater Corners fan is composed of interbedded sand and gravel units. The gravel units are clast supported and slightly imbricated within a fine sand matrix. These units are continuous over 2 to 7 meters in both trenches, indicating a patchy but consistent horizontal pattern of deposition. In the top trench (A-A'), the gravel units appear as a large sediment package in sections 5 through 7, which can be divided into sub-units and possibly indicate an aggrading channel at this location (Figure 3.12a).

Sand units are massive and contain mostly fine sand. These units are patchy in the top trench (A-A') where they are interrupted by large gravel packages, but continuous in the stem trench (B-B'). The sand units are periodically interrupted by buried A-horizon paleosols. The paleosols appear in the stratigraphy as thin (1 to 5 cm thick), dark-colored, organic-rich layers. In general, the stem trench shows a sequential cycle of (old to young) sand-gravel-sand-paleosol. There is no evidence of a plow horizon in this fan, although there is faint A-horizon development across the top 0.5 m of both trenches. Buried organic material, aside from paleosols, was scarce in both trenches.

Fan sediments coarsen to large gravel and cobbles in the deeper portions of the top trench. Under the fan, silt and fine sand at 3 meters depth represents river channel overbank sediments from Broad Brook. At 3.30 meters depth is a deposit of stream-rounded cobbles, representing a higher level of the Broad Brook channel. Wood from the overbank layer (sample W66, Table 3.1) provided a maximum age of the fan at 11,330 calibrated ^{14}C years BP.

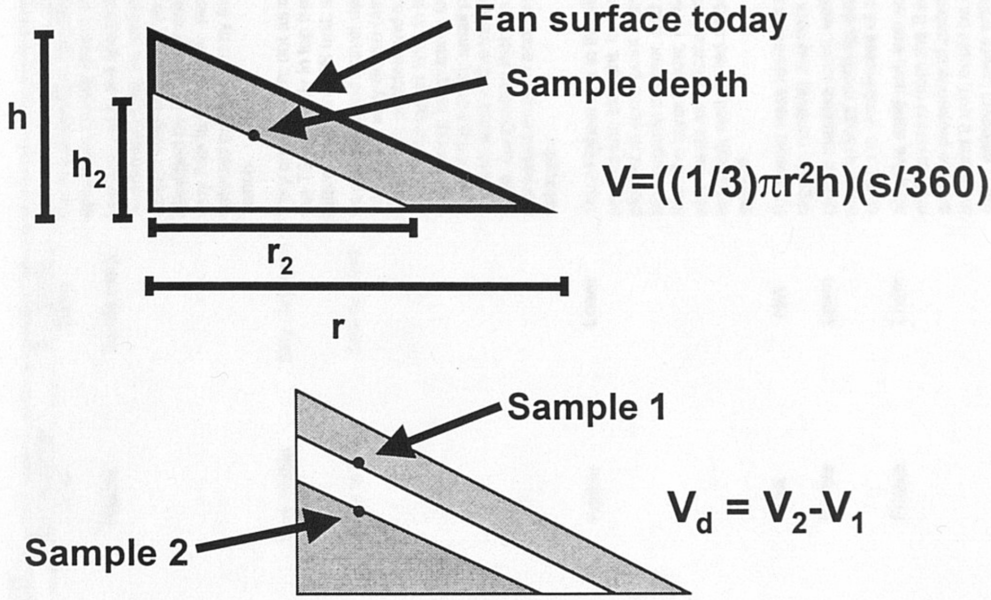
Interpretations. The Bridgewater Corners fan's stratigraphy strongly supports a developmental history based on continuous deposition interrupted by storm events, more so than any of the other alluvial fans in this study. The lack of buried organic material in sand layers indicates a slow depositional rate in these units which would allow any organic material to decompose before being buried.

Gravel units in the stratigraphy are likely to represent individual storm events. As flow in the tributary increases during a storm event, it will begin to erode the till at higher elevations, and transport the gravel clasts to the fan surface. At the end of the storm event, remaining sand from the terraces or the till is deposited onto the fan surface during normal fluvial transport. As the upstream hillslopes stabilize and sediment load to the fan decreases, the fan surface stabilizes until the next storm event allowing soil development to occur as an organic-rich A-horizon.

Radiocarbon dating in order to test this hypothesis was done from above and below one such sediment package with inconclusive results. Two charcoal samples (W4 and W12, Table 3.1) were dated from above and below a gravel unit on the opposite wall of the logged stem trench (Figure 3.10). Our hypothesis was that if the gravel unit was a storm event, the ages of the two samples would be within 500 to 1000 years (the amount of time needed to develop the two buried soils in rapid succession). The uncalibrated ages of W4 and W12 were 4390 ± 80 ^{14}C years and 4960 ± 760 ^{14}C years respectively (Table 3.1). The large error margin on sample W12 is the result of its decomposed condition and low organic content. The two-sigma calibrated ranges of the two samples are 5092 – 4834 calibrated ^{14}C years BP for sample W4 and 7324 – 3820 calibrated ^{14}C years BP for sample W12. The large overlap in dates makes it impossible to tell if the two samples were deposited within 1000 years of each other.

A lack of datable organic material in other gravel units poses a barrier to accurately determining when paleostorms may have happened. However, our dates from paleosol layers indicates times of stability at 3130 (W30), 3650 (W31), 6020 (W34) and 4960 (W4) calibrated ^{14}C years BP. Sample W10 is also from a paleosol layer on the opposite wall of the stem trench, but its age is 14,200 calibrated ^{14}C years BP which is older than the fan's basal age (sample W66; 11,330 calibrated ^{14}C years BP) taken from wood in the river terrace below the fan, suggesting that W10 is reworked from upstream.

Aggradation Rate Calculation



Aggradation rate = V_d / (age difference)

$$V_2 = \left(\left(\frac{1}{3}\right)\pi\left(r_t^{\,2}\right)h_t\right)\times\left(\frac{s}{360}\right)$$

Figure 4.DR2. Height (*h*) is equal to the depth of the sample subtracted from the current height of the fan. Radius (r_t) at time (*t*) can be determined by dividing the height by the slope. The sweep angle (*s*) is measured from survey data. The volume of sediment between two sample locations (V_d) can be determined by subtracting the total volume of the fan for the lower sample from the total volume for the higher sample. The aggradation rate is equivalent to V_d divided by the difference in age of the two samples.

Table 4.DR3B: UNIT DESCRIPTIONS, ALLUVIAL FAN TRENCHES, EDEN MILLS, VERMONT

Unit Identifier	Grain size	Soil color	Soil structure	Soil consistence	Soil texture	Other notes
(RD) Recent deposition	Medium sand matrix with clasts from 1 to 10 cm	2.5Y 4/2	N/A	Loose	Sand	Recent deposition resulting from gullying of the logging road upstream; mostly matrix supported; about 40-50% clasts.
(TS) Topsoil	Wood fragments and fine sand with 5% 1 to 2 cm gravel and larger clasts as indicated on the stratigraphic log	10YR 3/1	Weakly developed fine to coarse angular blocky peds	Friable	Sandy loam	Highest unit in the fan stratigraphy; contains an abundance of wood fragments, as well as entire logs ranging from 0.5 to 3 meters long (indicated on the stratigraphic log); unit was identified by its darker color as compared to the unit below; very firm to the touch, probably has been driven over by vehicles or trampled by livestock; grades into the AP in the top trench.
(TST) Topsoil - top trench	Silt and clay	10YR 3/1	Medium angular blocky peds, weakly developed	Very friable	Silty clay loam	Very organic-rich; not as many wood fragments or rocks as in the TS unit; only in top trench units 6 through 10, and grades laterally into the TS unit; soft to touch; about 20% fine roots.
(RG) Recent gravels	Fine sand (~15%) and medium to coarse sand matrix mixed with clasts ranging from 1 mm to 2 cm	2.5Y 4/2	Fine to medium crumb and fine to medium blocky angular peds	Friable to firm	Loamy sand	Layer of historic gravel deposition on the surface of the alluvial fan; unit is very dense (almost like dried cement) and matrix supported; pebbles and cobbles ranging in size from 3 cm to 20 cm and larger float in the sand/gravel matrix; poorly sorted; no layering; no grading; largest clasts are closer to the distal area of the trench; small patches of the matrix have a siltier content; a log in the trench wall in section 5 reveals a sawn edge, suggesting that this gravel unit may be the result of increased erosion and runoff during historical logging of the hillslope.
(BAP) Buried, plowed A-horizon	Fine sand and silt	10YR 3/1	Very fine to coarse blocky subangular peds	Friable	Loam	Third highest unit in the stratigraphy; defined by its dark color and abrupt, straight, lower contact indicating that it was plowed at some point in the past; has a greasy feel due to a high organic content, and rubs black on fingers; more firm than the layer below; ~5% medium roots; occasional cobble-size clasts as indicated on the stratigraphic log; massive (no layering); well sorted aside from the occasional cobble; not graded.
(A-horizon) Paleosols	Silt and clay	5Y 2.5/1	N/A	N/A	N/A	Paleosols were identified by a greasy feel (indicating a high organic content) and dark color
(S1) Sand 1	Fine sand and silt	2.5Y 3/2	Moderately developed very fine to medium angular blocky peds	Friable	Loam	Unit of massive sand; well-sorted; no grading; no layering; some orange mottling; darker color and straight, abrupt lower contact is reminiscent of an AP layer.
(S2) Sand 2	Fine sand and silt	2.5Y 4/2	Moderately developed very fine to medium angular blocky peds	Friable	Loam	Massive sand unit; well-sorted; no grading; no layering; distinguished from the Sand 1 unit by a slight color change and the presence of paleosol markers along the top contact of the Sand 2 unit; could be further subdivided based on the many paleosol layers within the Sand 2 unit.
(S3) Sand 3	Fine sand and silt	2.5Y 4/2	Fine to medium crumb and coarse blocky subangular peds, strongly developed	Friable	Sandy loam	Unit is capped by a leached E-horizon and sometimes by a thin paleosol; sandier in E-horizon; no layering; well-sorted; no roots or clasts.

(SP) Sand patch	Coarse sand matrix with clasts from fine gravel (2 mm) to pebbles (2 to 3 cm)	7.5YR 3/2	Fine to medium crumb	Loose	Sand	Unit only found in small area of top trench; cemented with Fe which rubs off as an orange-red color; well-drained; poorly sorted; no grading or layering; fines horizontally into the S3 unit.
(SC and SC2) Silt - clay	Silt and clay with a small percentage of fine sand	2.5Y 4/2; E-horizon 5Y 5/2	Fine to coarse angular blocky peds and very fine crumb structure, strongly developed	Friable	Silt loam	Both SC and SC2 are the same material, SC2 is lower in the stratigraphy and separated from SC by a paleosol horizon; . massive and well-sorted unit; less firm to touch than gley silt; has a 1 to 2 cm high leached E-horizon at the top of the unit; sometimes capped by a very thin paleosol; seems to be sandier in E-horizon; no clasts.
(GP) Gravel patches	Fine to medium sand matrix with fine gravel (2 to 10 mm)	N/A	N/A	N/A	N/A	Sand and gravel patches appear discontinuously within the Sand 2 unit; mostly clast supported.
(BS) Brown silt	Silt and clay	2.5Y 5/2; E-horizon 5Y 6/2	Fine to coarse angular blocky peds, strongly developed	Friable	Clay loam	Sometimes topped with a thin, discontinuous paleosol layer; has a leached E-horizon across most of the top 2 cm of the unit in the top trench only; distinguished by the E-horizon and paleosol cap in the top trench, and by its color and texture in the stem trench; no grading or layering; no clasts; well-sorted.
(CG) Channel gravel	Fine sand and silt matrix mixed with coarse sand and fine gravel	10YR 3/1	Fine to very coarse crumb, weakly developed	Very friable	Sand	Clasts are generally rounded, and seem to line up in horizontal layers, though no obvious gradation or sorting; large percentage of 2cm pebbles (about 5 to 10%); interbedded with fine sand (FS, similar characteristics to SC) as indicated on the stratigraphic log; many wood pieces in the fine sand; water seeping through the unit carries Fe which pooled in the bottom of the trench; clast supported; clasts range from 1cm to 10cm; large roots near top of unit in top trench sections 7 to 10.
(FS) Fine sand	N/A	N/A	N/A	N/A	N/A	See notes for Channel gravels, above.
(GS) Gley silt	Fine sand and silt	6/10 Y Gley	Coarse blocky angular peds, strongly developed	Firm	Silt loam	Distinguished based on color and texture; gleyed by the groundwater; yellow tint in the seasonal water table fluctuation area due to Fe oxidation; capped by a very thin and discontinuous paleosol layer; very dense and much firmer to the touch than above units; massive; without roots or clasts; well sorted; no grading.
(GG) Gley gravel	Medium and coarse sand matrix with clasts ranging from fine gravel (0.5 cm) to small pebbles (2-3 cm)	6/5 GY Gley	Fine to medium crumb structure	Loose	Sand	Low in the stratigraphy; turned a gley color by the groundwater table; clast supported with no sorting or grading; no continuous layering, although there are patches where the smaller gravel clasts line up into beds.

Table 4.DR4B: UNIT DESCRIPTIONS, ALLUVIAL FAN TRENCHES, MAIDSTONE, VERMONT

Unit Identifier	Grain size	Soil color	Soil structure	Soil consistence	Soil texture	Other notes
(WS) White sand	Fine and medium sand	2.5Y 6/3	Weakly developed medium crumb and medium angular blocky peds	Very friable	Loamy sand	Very clean, white sand with thin laminations of browish, siltier sand; unit is generally continuous across the trench; some patches of coarse sand exists in small discontinuous strips along the bottom of the unit; not many roots; well-drained; well sorted with very few clasts larger than coarse sand; cross-bedding and braiding structures visible in sections 1 and 2 of the top trench and section 2 and 3 of the stem trench; laminations and unit boundaries are often wavy, especially in the upper stratigraphy; white sand is less continuous than the brown sand units; often has an eroded upper contact.
(St) Silt	Silt with a small proportion of fine sand	Top: 5Y 4/2 Stem: 2.5Y 4/1	Moderately developed fine to coarse subangular blocky peds	Friable	Silt loam	Silt unit was identified by texture and is continuous throughout the trench; always interbedded with sand; the unit is sometimes patchy and often acts as a thin (1 cm) cap to a sand unit; silt units are thicker and more continuous lower in the stratigraphy; very dense and homogenous; poorly drained; well-sorted; silt is firmer and more sorted lower in the stratigraphy; massive; silt also appears as armored rip-up clasts (2 to 3 cm in diameter) in sand units.
(BS) Brown sand	Medium and fine sand	Top: 2.5 Y 4/2 Stem: 2.5Y 5/3	Weakly developed fine to medium crumb and fine to medium subangular blocky peds	Very friable	Loamy sand	Interbedded with silt or other sand units; appears as a massive layer with little or no sedimentary structures preserved except for faint bedding visible in some places; bedding/lamination is more obvious in some units of the stem trench; units are typically continuous across the entire trench; sometimes has an erosive lower contact with white sand; not rippled; stays moist longer than other sand units; often capped by silt in the stem trench; fairly homogeneous; some laminations are thin silt layers within the sand.
(CBS) Coarse brown sand	Medium sand and about 25% coarse sand	2.5Y4/2	Weakly developed fine to medium crumb and fine to medium subangular blocky peds	Very friable	Loamy sand	Same as brown sand but coarser; some isolated patches of fine gravel.
(TT) Tree throw area	Medium sand	2.5Y 5/3	Weakly developed fine crumb and fine subangular blocky structure	Very friable	Loamy sand	Isolated area of sand that cuts off other horizontal units; well-drained; contains a few Fe spots and armored silt balls; a few pebbles present near the top of this unit (see stratigraphy. log); appears that the tree fell to the north because the unit disturbs and caps other units to the north of the larger sand bulge.
(LBS) Lower buried soil	Fine sand	A: 2.5 Y 3/1 E:7N gley B:10YR 4/3	Moderately developed very fine to medium subangular blocky peds	Friable	Sandy loam	Buried soil layer that extends across the entire trench but becomes the topsoil in section 1-5 of the top trench; contains a distinct color sequence of 2 to 3 cm of dark black soil over a thin (1 cm), leached E-horizon over a redder B-horizon (7 cm thick); firmer to the touch than units lower in the stratigraphy; poorly drained; many roots; feels greasy and smears black.

(UBS) Upper buried soil	Fine sand	Top: 10 YR 3/2 Stem: 10YR 2/1	Moderately developed fine to medium subangular blocky peds	Friable	Sandy loam	Distinguished by its faint black color; not continuous across entire fan (either because it was eroded off, or simply has not developed fully); very dry and firm to touch; only about 1 cm thick in top trench, thicker in stem trench; no soil color development beneath this layer; 40% fine and coarse roots; 10 % fine gravel and coarse sand.
(Gr) Gravel	Small cobbles in a medium sand matrix	N/A	N/A	N/A	N/A	Only patch of gravel in the entire fan stratigraphy; matrix sand is identical to surrounding unit; matrix-supported; clasts range in size from 0.5 to 5 cm; no layering or gradation changes; large cobbles are clustered together.
(CSP) Coarse sand patch	Coarse sand	N/A	Weakly developed fine crumb structure	Loose	Sand	Same as coarse brown sand except as noted to the left.
(TSA) Top sand A	Fine sand	2.5 Y 4/4	Moderately developed fine to medium subangular blocky and very fine crumb peds	Friable	Loamy sand	Beneath lower buried soil; top of unit is consistently the leached E-horizon which is a very dry, medium sand with 30% coarse sand mixed in and some fine gravel with occasional pebbles 3-4 cm in diameter; the fine sand is the B-horizon.
(TSB) Top sand B	Fine to medium sand	2.5 Y 5/3	Weakly developed fine to coarse subangular blocky peds	Friable	Sandy loam	Poorly sorted with clasts ranging from 0.5 to 2 cm in size; firmer to touch than units below; some silt layers running through this unit, and firmer to touch higher in the unit; above the upper buried soil this sand becomes very dry, very densely packed and very firm to touch with firm peds; more clasts closer to surface.
(DA) Disturbance area	Medium sand	2.5Y 4/3	Weakly developed fine to medium blocky subangular peds	Very friable	Loamy sand	This unit is a section where the horizontal layering is cut off and the sediment is mixed together, appears to have been disturbed by a tree root or animal burrow; contains about 3 % rectangular silt clasts, 1 to 2 cm in size; poorly drained.
(TSC) Top sand C	Medium sand with 30% fine gravel	2.5Y 4/3	Weakly developed fine to coarse subangular blocky and fine crumb peds	Very friable	Loamy sand	Grades into and out of silt; not continuous, only in one place in fan stratigraphy; a few 1 to 2 cm size pebbles; firm to touch.
(SS) Silt and sand	Medium to coarse sand with 15% fine gravel	2.5 Y 5/3	Weakly developed fine to medium subangular blocky and fine crumb peds	Friable	Loamy sand	Similar to brown sand unit; no laminations.
(GS) Gully sand	Fine to medium sand	2.5Y 5/3	Weakly developed fine to medium subangular blocky peds	Very friable	Loamy sand	Sand from the stream gully fill that has washed onto the fan; firmer to touch closer to fan apex; occasional strips of firmly packed silt; coarse sand and gravel along the base of the unit in stem trench sections 6-7; no lamination; coarse sand in patches; poorly sorted.
(MBS) Massive brown sand	Medium and fine sand	10YR 4/3	Weakly developed fine to medium subangular blocky and very fine crumb peds	Very friable	Sandy loam	Similar to other brown sand unit; seems to be redder than other sands; massive; no structures; fairly homogeneous.

Table 4.DR5B: UNIT DESCRIPTIONS, ALLUVIAL FAN TRENCHES, BRISTOL, VERMONT

Unit Identifier	Grain size	Soil color	Soil structure	Soil consistence	Soil texture	Other notes
(Ap) Ap/Topsoil	Fine sand and fine gravel	10YR 3/2	Strongly developed fine to coarse granular and very fine to coarse subangular blocky peds	Top: Friable Stem: Firm	Loam	Ap layer is covered by 10 to 25 cm of slash (pieces of bark, wood and leaves that have been piled up on the fan surface by the landowner who cuts wood here); abrupt lower contact; Ap also contains large pieces of rotted wood and charcoal; platy and firmer than lower layers; poorly drained; about 5% fine to very coarse roots; about 30% coarse fragments (1 to 3 cm); less slash in stem trench.
(UG) Upper gravel	Matrix: medium to coarse sand with fine gravel (3 to 6 mm); clasts are gravel and pebbles (1 to 6 cm) with occasional clasts up to 10 to 15 cm.	2.5Y 5/4	Weakly developed very fine to fine granular structure	Loose	Sand	Larger clasts are usually thin, long pieces of schist; smaller clasts are quartzite; sandier in section 7 and 8 of stem trench where it is a sandy loam (all other characteristics are the same).
Paleosol	Very fine sand and silt	7.5YR 2.5/1	Moderately developed fine to medium granular and fine to medium subangular blocky peds	Friable	Loam	Identified by color, greasy feel and black streak; discontinuous throughout both trenches; represents buried A-horizon.
(LS) Lower sand unit	Fine sand and silt	10YR 3/2	Moderately developed fine to coarse angular blocky peds	Friable	Loam	This is a continuous layer that is darkish in color; sometimes has discontinuous organic streaks close to the top of the unit; appears to grade downwards to a B-horizon which is the same color as the lower gravel unit, and further grades into a C-horizon at lower depth.
(FG) Fine gravel	Medium sand and fine gravel	10YR 4/4	Weakly developed very fine granular peds	Loose	Sand	Similar characteristics to the lower gravel unit, except lacking the larger clasts; not a very thick unit, possibly a separate, small event; clasts range from 0.5 to 3 cm, but mostly in the 0.5 to 1 cm range.
(Gr) Gravel	Coarse sand and fine gravel	2.5Y 4/4	Weakly developed fine to medium granular and medium subangular blocky peds	Friable	Sand	Discontinuous unit in stem trench; weak horizontal layering in the more sandy patches; may correlate with fine gravel (FG2) unit
(S) Sand	Fine sand	10YR 3/2	Moderately developed very fine to coarse angular blocky peds	Friable to firm	Sandy loam	Contains about 10% coarse fragments of gravel, 2 to 10 mm; not well drained; a few roots; firmer to touch than lower units.
(FG2) Fine gravel 2	Coarse sand and fine gravel	10YR 4/3	Weakly developed medium angular blocky peds	Friable	Sand	Gravel clasts from 2 mm to 3 cm; could be part of Gr unit
(LG) Lower gravel unit	Matrix: fine to medium sand in top trench, medium to coarse sand in stem trench; clasts range from fine gravel (2mm) to large cobbles (20 cm); most clasts are pebbles (2 to 5 cm)	Top:10YR 4/4 Stem: 2.5Y 5/4	Moderately developed medium to very coarse granular peds	Very friable	Top: Loamy sand Stem: Sand	Clasts are composed of quartzite or quartz and are mostly matrix supported in top trench, clast supported in stem trench; some horizontal lamination of fine gravel/sand; matrix sand gets coarser towards apex of fan; unit may be divided into three sub-units; moderately well drained; about 3% medium and fine roots; clasts are weakly imbricated in stem trench; structureless; very well drained and prone to caving; sub-unit fingers are separated by patches of MS unit in stem trench sections 9-11.

(SP) Sand patch	Fine sand	2.5Y 3/2	Moderately developed fine granular and fine to medium angular blocky peds	Friable	Loam	Only appears in sections 1 - 3 in top trench.
(TT) Tree throw	Fine sand	2.5Y 3/3	Moderately developed very fine to coarse subangular blocky peds	Very friable	Sandy loam	Below LG unit; contains organic patches (with color of 2.5Y 3/2) and some large rocks
(MS) Massive sand	Medium sand	2.5Y 4/4	Moderately developed very fine to medium blocky angular peds	Friable	Sandy loam	Massive, homogeneous sand, 2 to 5 cm thick that caps the BS unit in sections 6-11; contains some charcoal; appears to have an erosional upper contact and depositional lower contact; no roots; no clasts; moderately well-drained but less so than the BS unit; sand with same characteristics also present between fingers of the LG unit in the distal portion of the fan.
(BS) Bedded sand	Medium to coarse sand and fine gravel (2 to 5 mm)	2.5Y 4/4	Weakly developed fine to coarse angular blocky peds	Friable	Loamy sand	Sand and fine gravel is the matrix for larger clasts ranging from 1 to 6 cm; unit is capped by MS unit in sections 6-11; this unit can be divided into sub-units as indicated by dashed lines; unit seems to have been partially eroded by the overlying gravel unit in sections 1-5; unit is interrupted by a tree throw in section 5; moderately well-drained; no roots; about 30 % coarse fragments and 70 % coarse sand.
(D1) Disturbed area 1	Medium sand	10YR 4/3	Moderately developed very fine to coarse angular blocky peds	Friable	Sandy loam	Appears to be a human-dug pit, possibly part of some backhoe work done by property owner last summer; abruptly cuts off natural layers; no visible structures; homogenized sand with a few large clasts; about 3% fine roots (no roots in adjacent fan layering) and some charcoal pieces.
(D2) Disturbed area 2	Medium and fine sand and fine gravel (1 cm size)	2.5Y 3/3	Weakly developed fine granular and fine to medium subangular blocky peds	Very friable	Sandy loam	Interpreted to be another tree throw.
(D3) Disturbed area 3	Fine to coarse sand and gravel	10YR 3/3	Weak fine crumb structure	Very friable to friable	Sand to sandy loam	Area is lined with dark, organic-rich fine sand (color of 2.5Y 3/2) with about 20% gravel (1 cm size); center of area is coarse sand with a color of 2.5Y 5/4.

Table 4.DR6B: UNIT DESCRIPTIONS, ALLUVIAL FAN TRENCHES, HANCOCK, VERMONT

Unit Identifier	Grain size	Soil color	Soil structure	Soil consistence	Soil texture	Other notes
(Sg) Sand and gravel	Fine sand matrix with fine gravel	Top: 10YR 3/3 Stem: 2.5Y 3/3	Weakly developed very fine to medium crumb and fine to medium blocky subangular peds	Friable	Sandy loam	Matrix supported; fine sand matrix with 15% coarse fragments of mostly fine gravel 2 mm to 2 cm size; occasional pebbles up to 4 cm; 5% fine roots; poorly drained.
(dashed line) Topsoil boundary	N/A	2.5Y 3/2	N/A	N/A	N/A	Color change due to modern soil development processes at the fan surface; carries characteristics of identified unit, except for color; 10% very fine and fine roots.
(S) Sand	Medium sand to silt	Top: 2.5Y 3/3 Stem: 10YR 4/3	Moderately developed very fine to medium angular blocky peds	Friable	Sandy loam	Color is redder (10YR 4/4) where shaded on log; massive sand with isolated pieces of gravel from 1 to 3 cm in size; layers are usually continuous over 2-3 meters and bracket (above and below) a larger gravel unit; not well-drained.
(Gr) Gravel	Medium sand to cobbles	Top: 2.5Y 3/2 Stem:10YR 4/3	Weakly developed very fine to fine crumb peds	Loose	Sand	Clast supported and composed of 50% or more clasts larger than coarse sand; many gravel units have clasts only 0.5 to 3 cm in size; gravel units coarsen higher in trench; largest clasts in any unit are 20-30 cm; no obvious imbrication although the 3-4 cm sized pebbles tend to line up in horizontally; no apparent layering; well-drained.
(Fg) Fine gravel	Medium sand to gravel	10YR 4/3	Weakly developed very fine crumb peds	Loose	Sand	Unit appears in isolated patches; poorly-sorted; may be associated with gravel units that are fining laterally; usually bounded above and below by sand; well-drained.
(YS) Yellow sand	Medium and fine sand	2.5Y 4/4	Moderately developed very fine to medium subangular blocky peds	Very friable	Sandy loam	Slightly coarser than other sand units, and lighter in color; no rocks or gravel present in this unit; often overlies a darker brown sand with a wavy contact between the two from bioturbation; mostly fine sand in sections 1 and 2; mostly medium sand, more friable, and lightens to 5Y 5/4 in sections 4 and 13-14; mixed with the darker sand unit in sections 1 and 2; weak cross-bedding in top trench, lower left of grid 2.
Paleosol	Fine sand	2.5Y 2.5/1	Moderately developed fine subangular blocky peds	Friable	Loam	Discontinuous; sometimes weaves through a gravel unit; unit is typically 2 to 3 cm wide; greasy texture and rubs black on fingers indicating a concentration of organic material
(SP) Slash pit	Fine sand matrix with gravel	10YR 3/1	Weakly developed very fine to fine crumb and fine blocky subangular peds	Friable	Loam	This area appears to have been disturbed as it interrupts the fan stratigraphy and contains an abundance of fresh wood fragments; probably a fill pit from vegetation removal in the area; 20 to 30% wood fragments ranging from 1 to 2 cm long and up to 0.5 cm wide; soil matrix feels greasy and rubs black on fingers; 15% coarse fragments of gravel 0.5 to 2cm size and occasional pebbles (4 - 6 cm); 5% fine roots (no roots in surrounding units).
(St) Silt	Silt and fine sand	2.5Y 4/3	Strongly developed fine to medium angular blocky peds	Friable to firm	Loam	Occasional gravel (1 cm size) in isolated pieces or small pockets of 5 to 10 grains; layer is continuous upstream of bedrock outcrop, discontinuous downstream of bedrock; color is redder at top of trench.
(Gs) Gravel and silt	Silt matrix with cobbles	10YR 4/3	Moderately developed fine crumb and fine to medium subangular blocky peds	Friable	Loam	Cobbles supported by a silt and fine sand matrix; cobbles are usually touching, but are isolated in matrix material in some spots; cobbles range from 4 to 20 cm; underlies a buried B-horizon; approximately 20 - 30% coarse fragments.

Table 4.DR7B: TABLE 5. UNIT DESCRIPTIONS, ALLUVIAL FAN TRENCHES, BRIDGEWATER CORNERS, VERMONT

Unit Identifier	Grain size	Soil color	Soil structure	Soil consistence	Soil texture	Other notes
(above dashed line) Topsoil	N/A	10YR 3/2	Moderately developed very fine to medium subangular blocky and very fine to fine granular peds	Friable	Loam	Topsoil cuts across stratigraphic units and was defined based on coloration due to recent soil profile development and slight changes in texture; takes on characteristics of the stratigraphic unit it overprints; 15% very fine to medium roots with occasional coarse roots; more densely packed than underlying units, possibly from animal grazing.
(S) Sand	Fine sand and silt	10YR 3/4	Moderately developed, very fine to coarse, subangular blocky and angular crumb peds	Friable	Ranges from sandy loam to loam	Mostly massive, although bedding in localized areas; pockets of stratified coarse sand and fine gravel are common toward the distal edges of the fan; isolated 1 to 5 cm clasts.
(solid black) Paleosol	Very fine to coarse sand	2.5Y 2.5/1	Moderately developed medium subangular blocky peds	Friable	Loam	Buried A-horizon; greasy feel; no recognizable wood or charcoal fragments; <1% coarse fragments (1-2 cm clasts); some mottling from bioturbation; usually a uniform thickness of about 3 cm.
(SGr) Sand and gravel	Fine sand and silt matrix with gravel clasts (20%)	10YR 3/4	Moderately developed fine to medium subangular blocky and fine crumb peds	Very friable	Sandy loam	Transitional unit between sand and gravel units; higher proportion of sand than gravel units; matrix supported; poorly sorted; 20% coarse fragments; most coarse fragments are fine gravel (3 mm), but also many 2-3 cm size gravel pieces; no bedding or grading.
(Gr, Gr1, Gr2, Gr3) Gravel	Gravel, medium sand and small cobbles	10YR 4/4	Weakly developed fine to coarse granular peds	Loose	Sand	Clast supported; clasts range from 3 mm to 15 cm; larger clasts are closer to the top of the unit in stem trench sections 1-3; clasts are weakly imbricated (especially those in the 2-3 cm range); matrix is medium to coarse sand; over 50% coarse fragments; clasts are more matrix supported within the topsoil layer; clasts are subrounded; lens-shaped units; well-drained.
(GS) Grey silt	Silt and fine sand	2.5Y 5/3	Moderately developed very fine to coarse granular and medium subangular blocky peds	Friable	Loam	Massive; isolated gravel pieces (<1%); high moisture content; larger proportion of silt than other sand units (60-70% silt); no roots.

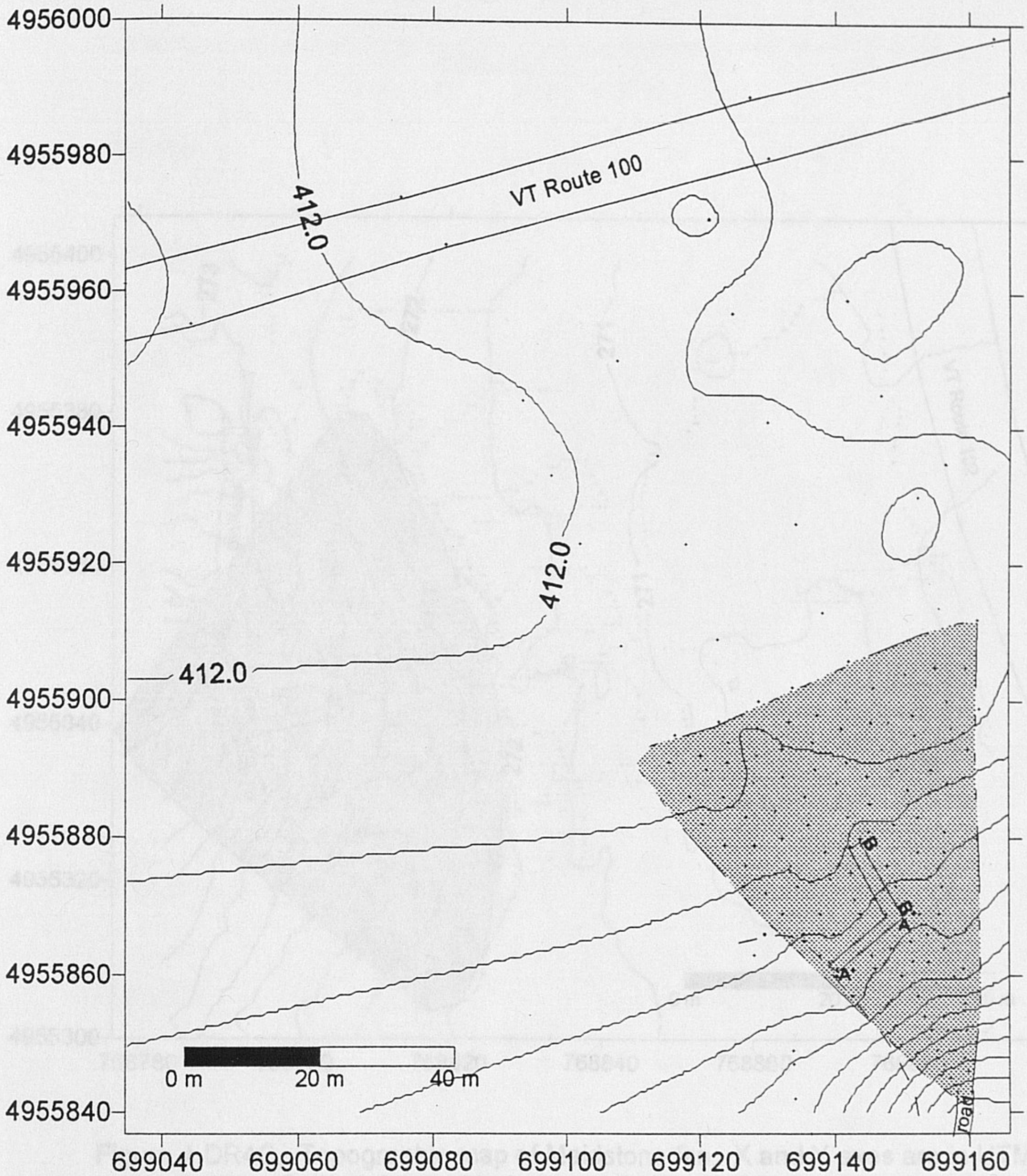


Figure 4.DR3C. Topographic map of Eden Mills fan. X and Y axes are in UTM coordinates. Countour interval is 0.5 meter. Dots are measured survey points. A-A' and B-B' are trench locations.

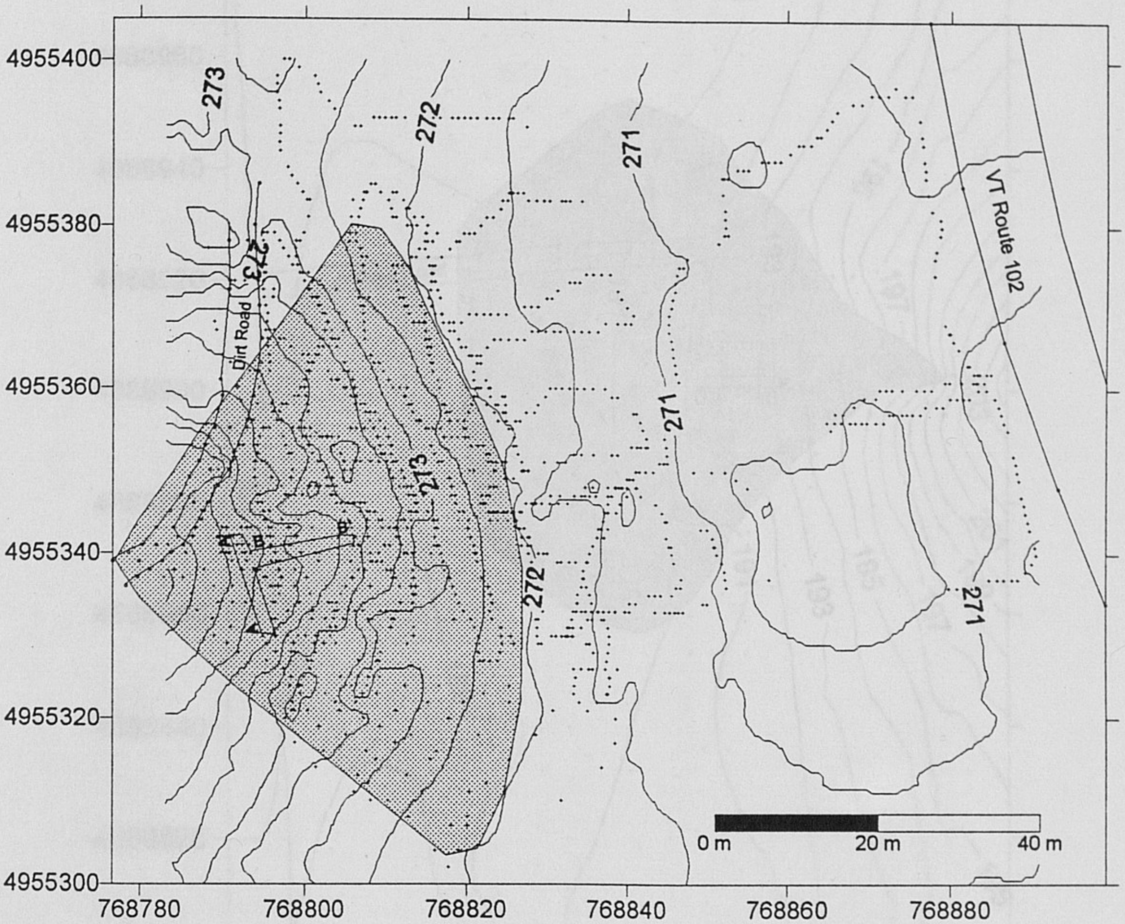


Figure 4.DR4C. Topographic map of Maidstone fan. X and Y axes are in UTM coordinates. Contour interval is 1 meter. Dots are measured survey points. A-A' and B-B' are trench locations.

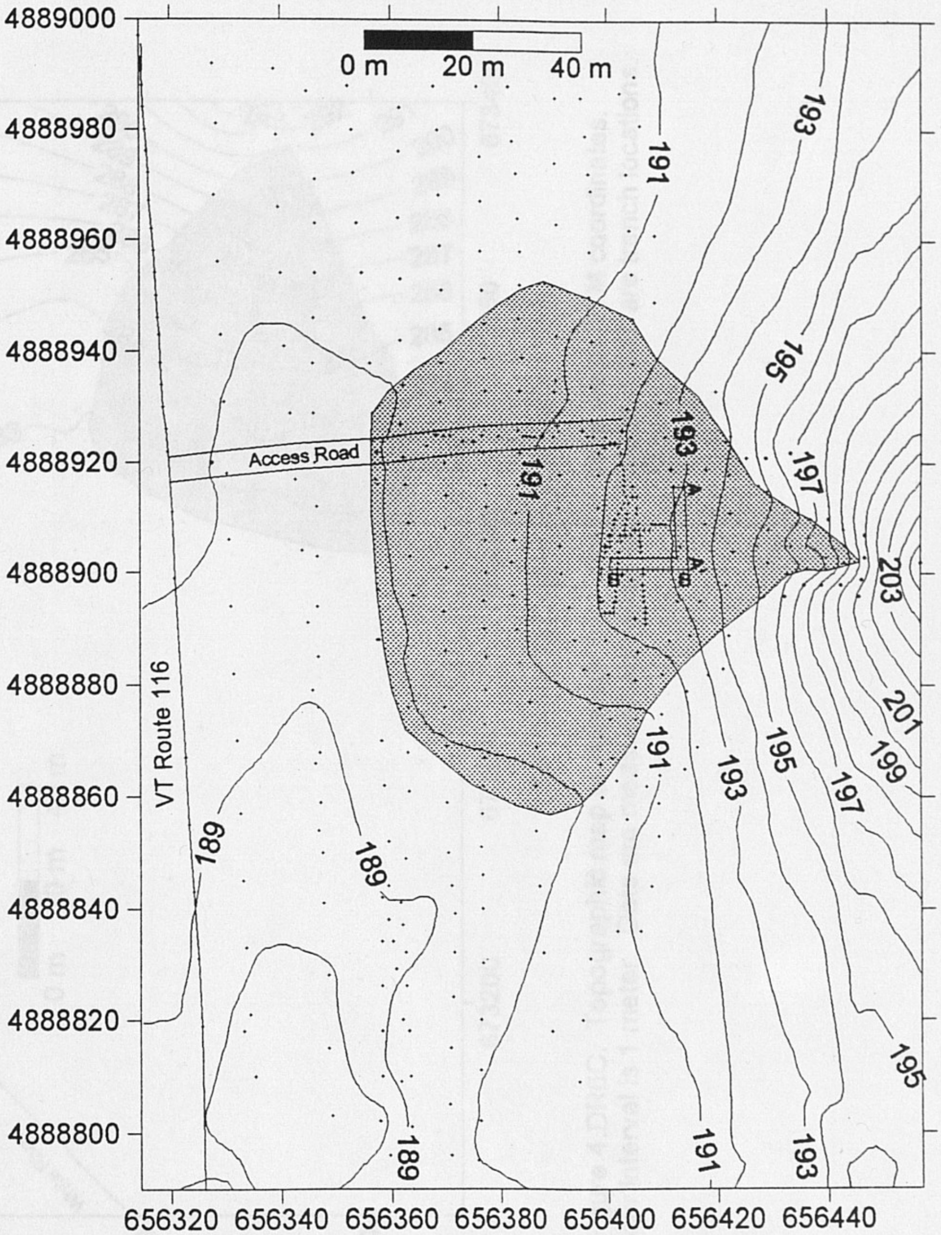


Figure 4.DR5C. Topographic map of Bristol fan. X and Y axes are in UTM coordinates. Contour interval is 1 meter. Dots are measured survey points. A-A' and B-B' are trench locations.

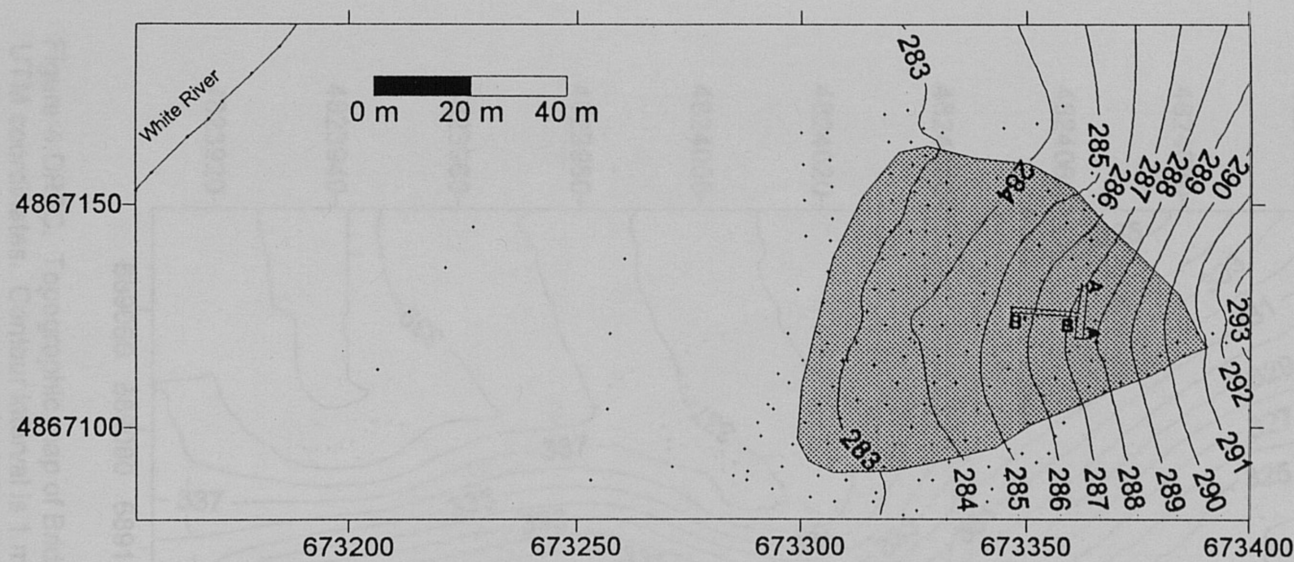


Figure 4.DR6C. Topographic map of Hancock fan. Xand Y axes are in UTM coordinates. Contour interval is 1 meter. Dots are measured survey points. A-A' and B-B' are trench locations.

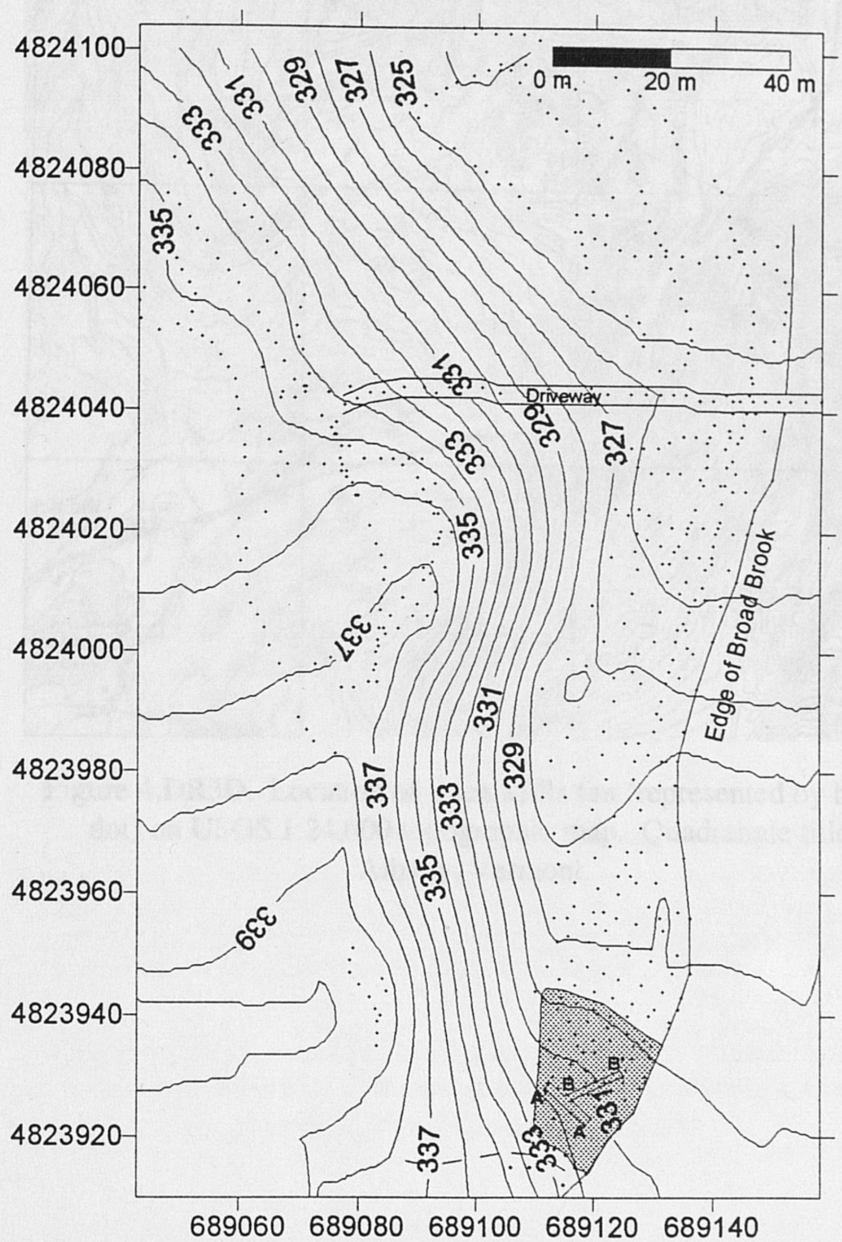


Figure 4.DR7C. Topographic map of Bridgewater Corners fan. X and Y axes are UTM coordinates. Contour interval is 1 meter. Dots are measured survey points. A-A' and B-B' are trench locations.

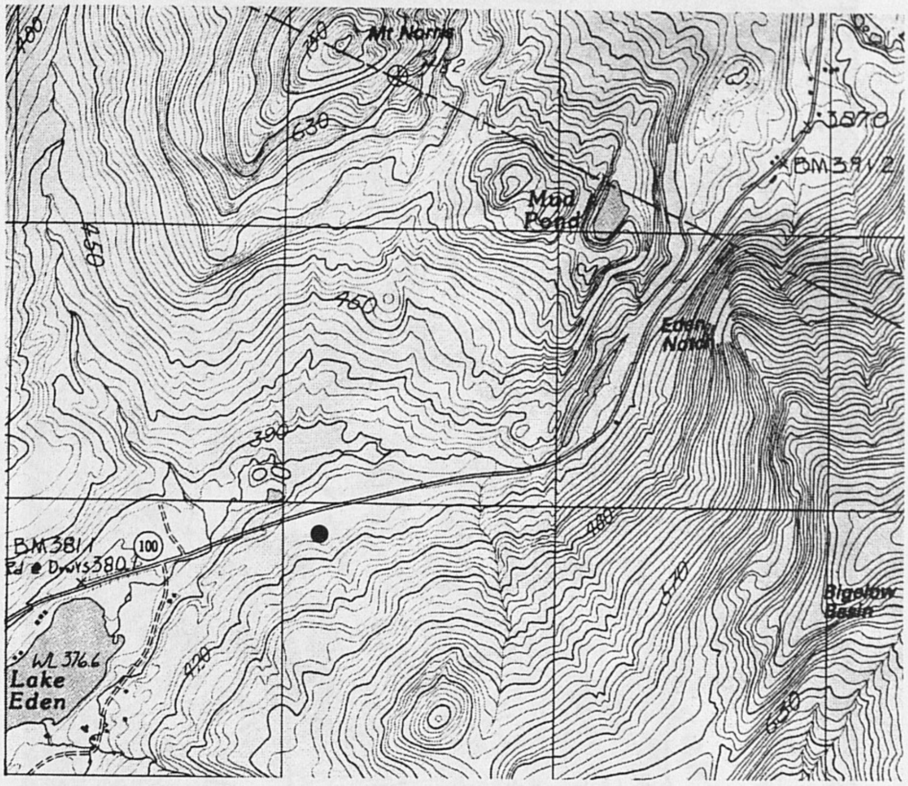


Figure 4.DR3D. Location of Eden Mills fan (represented by black dot) on USGS 1:24,000 topographic map. Quadrangle title: Albany, Vermont.

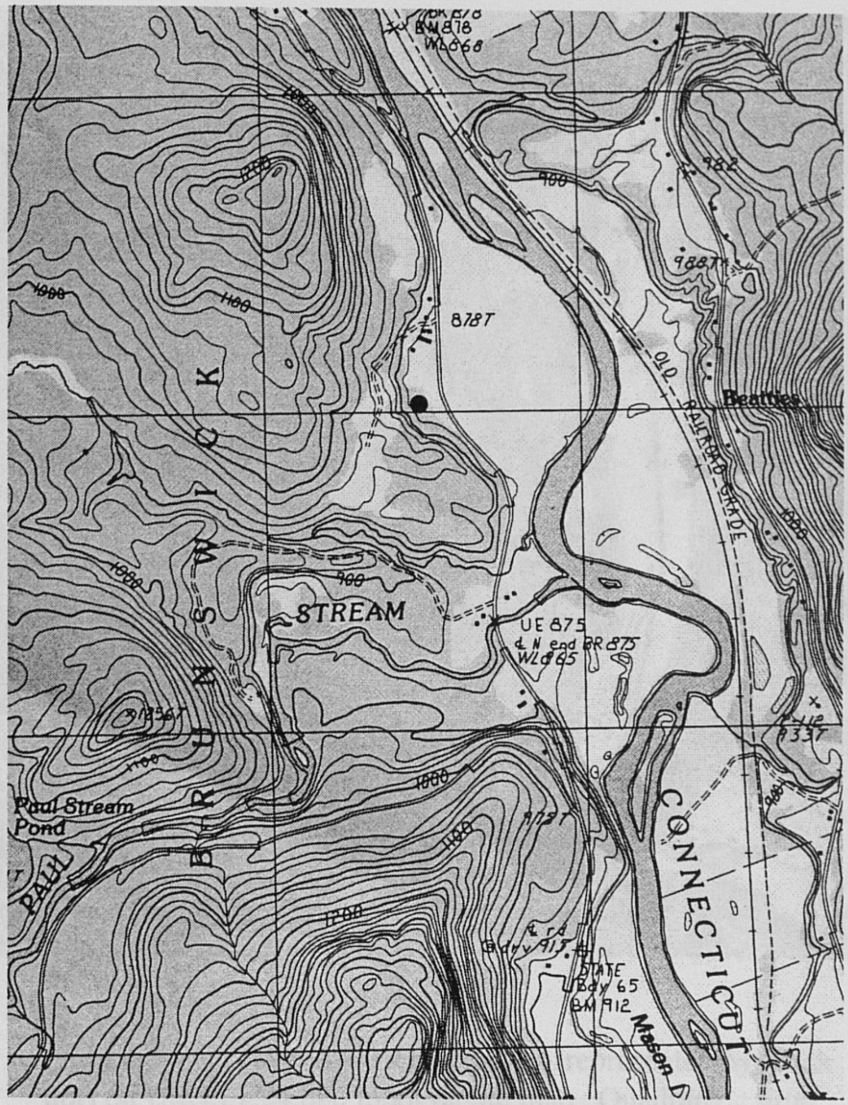


Figure 4.DR4D. Location of Maidstone fan (represented by black dot) on USGS 1:24,000 topographic map. Quadrangle title: Stratford, New Hampshire-Vermont.

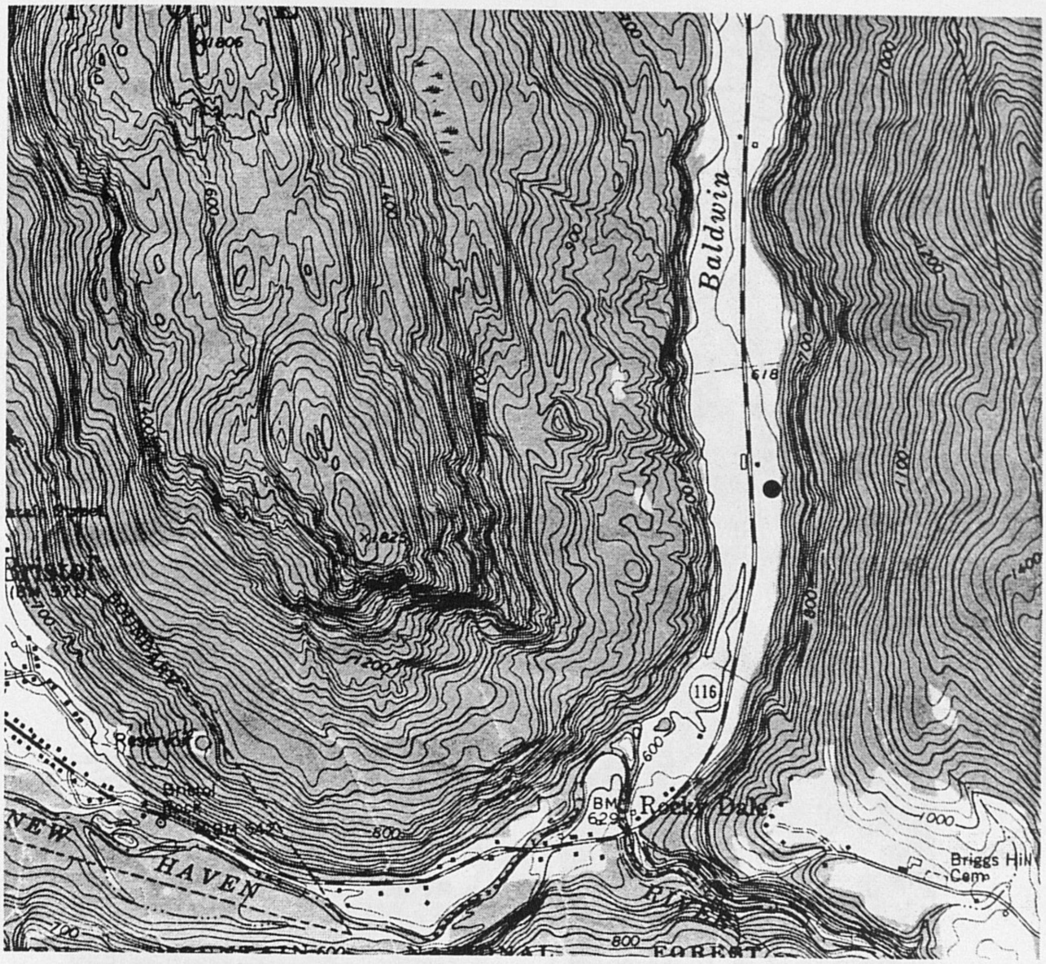


Figure 4.DR5D. Location of Bristol fan (represented by black dot) on USGS 1:24,000 topographic map. Quadrangle title: Bristol, Vermont.

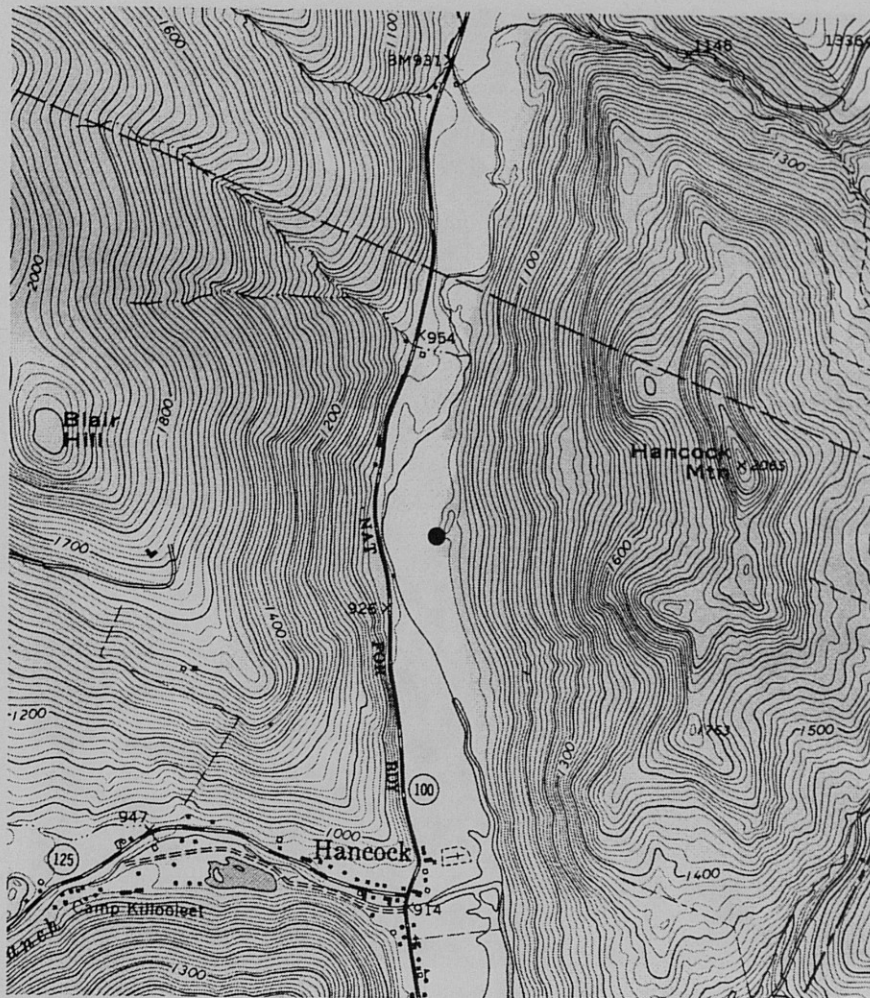


Figure 4.DR6D. Location of Hancock fan (represented by black dot) on USGS 1:24,000 topographic map. Quadrangle title: Hancock, Vermont.

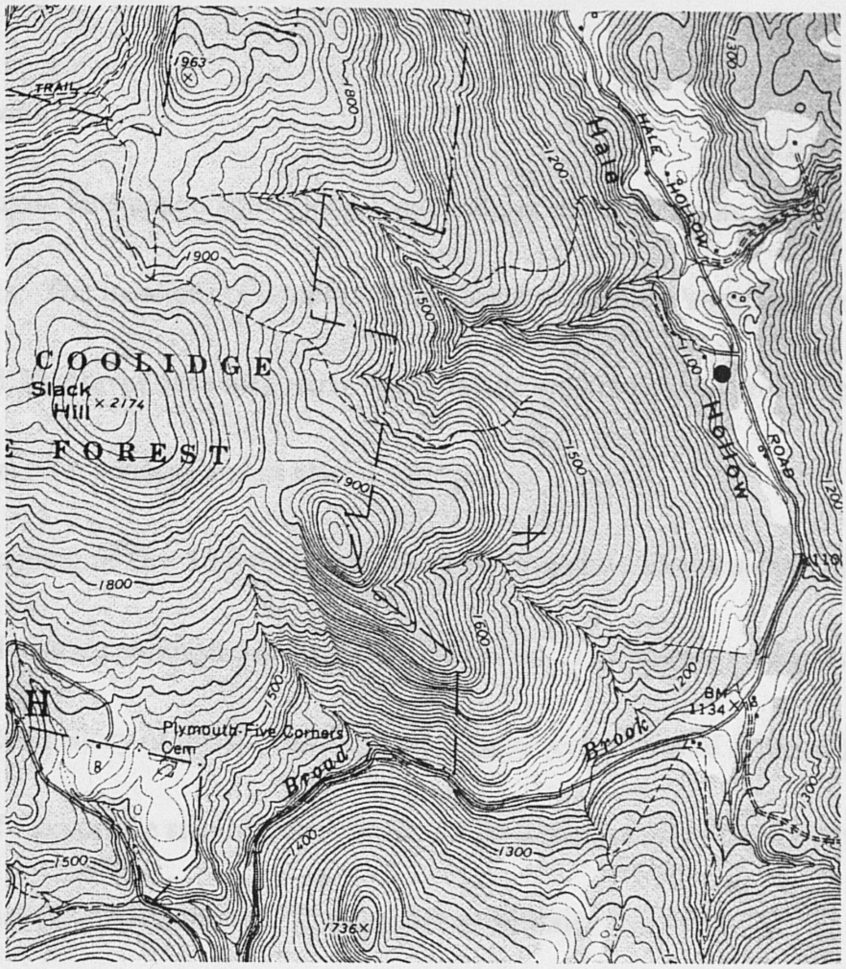


Figure 4.DR7D. Location of Bridgewater Corners fan (represented by black dot) on USGS 1:24,000 topographic map. Quadrangle title: Plymouth, Vermont.

CHAPTER 5: Summary

Conclusions

Alluvial fans are complex, long-lived features of the Vermont and New York landscapes. The locations of 34 alluvial fans were mapped in Vermont, with an additional 25 alluvial fans mapped in the Catskills region of New York. These fans are situated on river terraces and in glacial valleys.

Trenching of five alluvial fans in Vermont revealed a characteristic sequence of sub-parallel strata composed of silt, sand and gravel. The alluvial fans preserve a complicated history of incision and aggradation, as well as buried soils indicative of periods of fan surface stability. Sediments within the fans range in age from immediately post-glacial (13,320 calibrated ^{14}C years BP) to historic.

Vermont alluvial fans are direct, albeit low-resolution, recorders of hillslope activity. They preserve episodic depositional events, with erosional contacts between alluvial units indicating the scour and reworking of alluvial fan sediments during deposition. Buried wood and charcoal provided the dating control for determining aggradation rates and constraining the age of individual depositional events. Comparisons of aggradation on the five alluvial fans revealed very little correlation, indicating that intense, localized storms are more influential in triggering deposition than regional storm systems.

Importance of Research

My results show the strong influence of episodic depositional events on alluvial fan development, including those with perennial streams. The preservation of buried soils in the stratigraphy of all five alluvial fans is strong evidence that sedimentation on the fan surfaces is episodic. Deposition occurs rapidly during geologically short periods of time – the humid region alluvial fans I studied do not gradually and uniformly accumulate sediment over time.

My study is the first to examine 10-12 meter long sections of fan stratigraphy and date an average of 10 radiocarbon samples per fan. This detailed perspective of fan evolution has reveled the complicated nature of fan stratigraphy, including scour and fill, reworking of upstream sediments, and episodic deposition. Hence, studies that evaluate fan evolution based on averaged aggradation rates between widely spaced radiocarbon dates over-simplify the fan history (Bierman et al., 1997, Kochel, 1990).

The oldest ages of buried organic material in the Eden Mills (13,329 calibrated ^{14}C years BP) and Bristol (12,980 calibrated ^{14}C years BP) provide evidence for the reestablishment of woody vegetation in Vermont following glaciation. These dates are similar to the time at which primary productivity in Vermont ponds was established

(Brown et al., 2000), and provide limiting ages for the northward migration of woody vegetation or climatic warming. The presence of woody vegetation at Bristol is also constrained by the timing of glacial lake drainage. Even though it is further south, vegetation recovery occurred later than at Eden Mills because the Bristol site had been under water.

Comparisons of aggradation between the five alluvial fans and other studies (reviewed in Chapter 3) shows that stable periods are more likely to be synchronous between fans across a large region than stormy periods. This is likely due to the patchy nature of intense storm activity, even during wetter periods. Additionally, the hillslope lithology, cohesion, and vegetation will influence the threshold for slope failure, causing hillslopes with differing characteristics to respond differently to the same storm event.

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APPENDIX A: Alluvial fan locations

Vermont alluvial fans (45 total):

Fan Identification	County	Town	Road	Vermont Gazetteer Page	Number of fans at this location	Directions	Notes
A1/A2	Windham	South Newfane	Augerhill Road	22	3	Behind the white house with red barn (next house south of Green Valley Farm). Fan A1 directly behind the white house; fan A2 behind red barn where trees line up between two fields. A third fan just north of A2.	Alluvial fans are on a river terrace (T2 equivalent). A1 would be a perfect study fan - there is a drift road to a gravel pit on the fan surface, but very little disturbance of the fan surface. A2 is cut in half by the modern stream channel and has a logging road on it that diverts the stream flow. The third fan has a small pond dug into the surface of it. No recent deposition on any of the fans.
B1	Windham	Saxtons River/Bellows Falls	Intersection of Davidson Hill Road and Route 121	27	1	Next to 8 door garage/barn. Easily visible from road. On the east side of Davidson Hill Rd near intersection with Rt. 121.	Small alluvial fan with steep channel - probably disturbed and historic age.
C1	Windsor	North Hartland	Route 5	31	1	North of Clay Hill Rd and where the highway goes over Rt. 5. Lemox Farm is on west side of Rt. 5: fan at the back of the cow field.	Alluvial fan fed by three spring-fed channels in river terrace sediments. Channels have low flow year-round and high flow during spring melt. Cows have severely destroyed the surface of the fan (cows have been in that field for at least 50 years).
D1/D2/D3 (Hancock Fan)	Addison	Hancock	Route 100	34	3	About 0.8 of a mile north of Hancock and intersection of Rt. 100 with Rt. 125, just north of the White River scenic overlook turnout. Go down dirt road on east side of route 100, across from a White House. Dirt road goes through the White River to a corn field on the other side. Fans are at the base of the hill.	Three alluvial fans on a river terrace. The two larger fans are fed by perennial streams with separate drianages. The smallest fan (D1), and furthest north, is recent deposition from a large storm in 1998 aggravated by surface water capture on a logging road built next to the largest fan (D2). The two larger fans (D2 & D3) both have recent deposition and stream channels are scoured down to schist bedrock. Fan D1 was destroyed by the land renter in summer of 2000 to prevent further gravel deposition on the corn fields.
D4	Windsor	Hancock	Route 100	34	2	On west side of Rt.100, about 1.5 miles south of Hancock. Just north of a white farmhouse, fans are in the back of a large field.	Two alluvial fans in a cow pasture, very close to the road. Feeder channels do not appear to be active.
D5	Windsor	Rochester	Route 100	34	1	Can see the fan from across the river at fishing access at "River Bend". Just south of a large organic farm with a red barn and cows. Farm is on west side of Rt. 100, less than 0.5 mile north of the National Forest Ranger Office.	Fan with lots of deposition at bottom of hill. Fan is on modern floodplain so is likely to be very young. There is another fan on the next higher terrace, just above where the farm owners are mining sand from the terrace - electrical pole in the fan.
D6	Windsor	Rochester	Route 100	34	1	Located on west side of Rt. 100, about 0.8 mile south of Hancock center, in the very back of a large field.	Fan is at the bottom of a "bowl" in the hill. Not sure it's a fan, but seems to have a channel feeding it.

DX	Windsor	Gaysville	River Road	34	1	Fan in back of field along River Road (north-west side of road), north of Gaysville, about 0.8 mile north of intersection of Lillieville Road with River Road.	The alluvial fan is behind Sam Lewis's house on a river terrace. It is fed by a stream channel that cuts through terrace sediments. The stream has been dammed on the next terrace up to form a small pond next to the Kerr/Ayer's house. During storm of 1998, the road up the hill captured the runoff and incised creating a new alluvial fan to form on the other side of the road to the east.
DY	Windsor	Gaysville/Bethel	River Road	34	1	Long Meadows Farm on River Road (about 1.5 to 2 miles north of fan DX). Go north on River Road until just past the farm. In the back of the field (north-west side of road) before you go around the bend is a large alluvial fan coming off the higher terrace.	None
2X	Orange	North Randolph/East Brookfield	Route 14	34	3	About 1.6 miles south of East Brookfield center, and south of Mckeage Road. Fans are visible on west side of Rt. 14, on the west side of the White River, against the mountain side. Mailbox at the Driveway says "Meadow Brook" and there is a house on either side of Rt. 14 here. Follow the drive west from Rt. 14, towards the hillside The first house is a gray-blue house on the right with a Red Barn on the left. At the time I was there, this house was being rented to a man named Boyd.	Just before the gray house, turn left onto a tractor road that goes into the cornfields. From there, walk towards the hillside to get to the fans. The fans are slightly large for this study, but are well formed and preserved. We inspected the drainage of one of the fans. A small perennial stream was cutting through till banks and had a bedrock channel bottom. Bedrock was shale and phyllite. Active deposition of gravel on the fan surface.
2Y	Orange	East Brookfield	Route 14	34	1	East side of Route 14, south of intersection with Route 65. Fan is just south of intersection of Rt. 14 with East Hill Road.	Fan is in a field behind and slightly south of a Church. Channel is gravelly and scoured down to bedrock. No active deposition. It is possible that the stream has been channelized.
E1	Windsor	Pompanoosic	Route 132	36	1	North side of Rt. 132, very near intersection with Rt. 5. Fan-shaped landform in cowfield with a pond.	No channel and small hill - I think it is probably colluvium and not a fan.
F1	Essex	Arlins	Todd Hill Road	37	1	Go west on Todd Road from Route 102, field is on left before going up the hill. Walk to the back of the field, at the bottom of the hillslope. Stream and fan is to the left of the dirt/grass road that goes up the hill.	Recent gravel and mud deposition on the fan surface. Under-developed feeder stream channel suggests that the fan is completely historic in age.
F2	Essex	Bloomfield	Route 102	37	1	About 4 miles north of North Stratford, on west side of Route 102. Fan in cow field between two hills. Road marker at fan says: 1020 0503 0440	Not active channel, but has a distinctive fan shape.
F3	Essex	Maidstone / Brunswick	Route 102	37	1	About 1 mile north of turnoff to Maidstone Lake, west side of Route 102. Yellow house with Black shutters, well-kept, barn behind house. Fan at back of cow pasture next to house.	Not an ideal fan. Landowner said most of streamflow is during the spring melt.
F4 (Maidstone)	Essex	Maidstone / Brunswick	Route 102	37	2	Fan is south of North Stratford on Route 102. When heading north on Rt. 102 from Guildhall, you will go past the turnoff to Maidstone Lake, go around the bend, down a hill and over a small bridge that is "Bridge 6, VT102" over Paul Stream. After the bridge you will go around a hill and as soon as the field opens up to the left, the fan is right there (fan is 0.6 mi. north of the bridge).	One larger fan and another smaller fan in a cow pasture to the west side of the road. Grey house with white trimmed porch. Large dirt cow path goes up the fan gully of the larger fan. Both fans are on a river terrace with a higher terrace above them.
G1	Chittenden	Buels Gore	Route 17	39	1	Fan at lake at Mt. Ellen, Appalachian Gap.	Fan-delta, but mostly out of water.

G2 (Bristol)	Addison	Bristol	Route 116	39	3	Fans are in a field on the east side of Route 116, at the base of Bald Hill. The property is about a mile south of the junction of Rt.116 with Rt. 17 (Lincoln Gap Road). At the site there is a barn on the west side of the road and a small white house on the east side - just south of the house is a dirt (or grass) access road that goes up onto the trenched fan and continues up the hillside.	North of the House is a huge fan that is very obvious and would be way too large to trench. Another, smaller fan is south of that, closer to the house. The fan I trenched is just south of the house, where the logging road goes up the hill.
H1	Caledonia	Barnet	Route 5	42	1	About 2 miles south of Barnet center on west side of Route 5. Fan in field next to horse barn.	Two channels feeding a fan, one channel is from a spring. The spring has been more active since the Interstate was built 20 years ago. The fan is poorly formed and is probably mostly colluvium - not worth trenching.
H2	Caledonia	McIndoe Falls	Route 5	42	1	Can see the highway from Rt. 5. Field is between highway and Rt. 5, just south of a sign that says "McIndoe Falls." Fan at foot of ridge in right part of field when looking into the field.	I think this is mostly colluvium and not a real fan.
I1 (Eden Mills)	Orleans	Eden Mills/ Lowell	Route 100	53	1	Fan is three miles north of Eden Mills and 0.6 mile north of Lake Eden, on the east side of Route 100, just before going over Eden Notch. Fan in field at bottom of logging road. Logging road has a chain across it and a "No motorized vehicles" sign near the apex of the fan.	Lots of recent deposition - good quality fan fed by a small perennial stream.
K1/K2	Bennington	West Arlington	Sandgate Road	24	2 or 3	Go west on Route 313 from Arlington. At West Arlington turn right (north) onto Sandgate Road. From Sandgate Road take the first right onto a dirt road that runs along Green River (really a small creek). Follow this road along the creek, turn right onto wooden bridge (sign says 'No Motorized Vehicles') that goes over the creek. House is brown log cabin #362. Fans are north of the house, in the back of the field.	Two alluvial fans in the field - possibly another fan further to the north. Swimming hole between the two fans. Active channel on fan closest to the house, but no active deposition. Stream channel is soil and cobbles. Fans would be great for study.
M1	Washington	Warren	Route 100	40	1	About 0.5 mile north of The Sugarbush Access Road on east side of Route 100. In the back of a field next to a White House.	Not a great fan to study.
N1/N2	Orange	East Brookfield	Route 14	40	2	Just north of fan N3. East side of Route 14.	Beautiful fans, but too large for this study.
N3	Orange	East Brookfield	Route 14	34 or 40	1	The fan is on the east side of Route 14, at the intersection of Rt. 14 with Rt. 65. When you drive east on Rt. 65 towards Rt. 14, the fan is obvious.	Very large fan with telephone poles going up the hill above it. Fan is too large for this study.
O1	Windsor	Plymouth	Route 100A	30	2	On south-east side of Route 100A, a mile or two north of the intersection with Route 100.	Two side-by side fans. Very large - too large for this study.
O2 (Bridgewater Corners)	Windsor	Bridgewater Corners / Plymouth	Hale Hollow Road	30	1	Take Route 100A south from Bridgewater Corners. Turn left onto Hale Hollow Road. Continue on Hale Hollow Road for about 2 miles (road will become a dirt road). Turn right at Apple Hill road, which is Todd Menees' driveway.	Small, well-preserved fan on a terrace of Broad Brook. Fan is in the field north of the driveway, just past the bridge over Broad Brook.
O3	Windsor	Killington	Route 100	30	3	Just north of the Gondola on Rt. 100 - east side of road.	Beautiful fans, but too large for this study.
V1	Washington	South Woodbury	Route 14	47	2 or 3	North-east side of Route 14, where the road takes a near 90-degree bend to the west. Across the street from the northern end of Sabin Pond. Fan-shaped hills in back of field behind old barn and house (falling down).	I could not find any sort of drainage gully to feed the fans and hence decided they were probably erosional features instead of alluvial fans.

V2	Washington	East Calais	Sand Hill Road	47	1	About one mile north of East Calais on Route 14, near a bridge on Rt. 14, turn right onto a Sand Hill Road.	White house and gray barn on TH18: Sand Hill Road. Sign on house says "Gilmans." Possible a fan in the field across the street. A well-developed stream comes down the hill into this area, but I am not sure where it goes.
V3	Washington	East Calais	Route 14	47	1	Just south of East Calais (less than a mile) on the east side of the road in a horse field. Across the street from a house with a sign about horseback riding.	Looks like a good fan in the back of a horse field. When I walked around it though, I could not find any sort of a drainage gully and concluded that it was an erosional feature.
991	Windsor	Goulds Mill	Spencer Hollow Road??	27	1	Exit 7 off Route 91. Go west on Route 11. Second (?) right on a road that goes through Goulds Mill. Fan is in a field next to the Paddock Restaurant.	Fan was very brushy, so it was hard to determine fan quality. A small, poorly-developed stream fed to the fan.
992	Windsor	Reedville	Route 11	26	1	Take route 11 west from Chester. Fan is on the north side Rt.11 in an open field, just before an antique store on the south side of the road. The fan is between intersection of Route 11 with Lovell Road and Gunther Road. 0.4 mile west of intersection of Rt.11 with Andover Road.	Well-preserved, small fan on a low terrace, close to the road. A well-formed gully fed off of a terrace above the fan.
993	Windham	Harrisville / Reid Hollow	Green River Road	22	1	Fan is On Green River road east of Harrisville and the intersection with Moss Hollow Road, but not by more than one or two miles. North side of road near some cabins.	Very small fan, vague gully - not well-formed. Stream comes out of a culvert at the top of the terrace above. Fan surface has been obviously bulldozed to control the direction of stream flow.

Un-mapped fan locations I know of in Vermont:

1. Along Route 116 between Burlington and Bristol, both sides of road. However, the fans may be too large for this type of study.
2. Along Pleasant Valley Road between Underhill Center and Cambridge. Gazetteer map 45. Good size fans for this study.
3. Around Lake Mansfield. There is one huge fan-delta near the clubhouse. There are smaller fans in the hollows along the trails.
4. Route 100 between Granville and the trenched Hancock fan, east side of the road. These fans are huge and hence not useful for this type of study.

New York alluvial fans - Catskill Region (25 total):

Fan Identification	County	Town	Road	New York Gazetteer Page	Number of fans at this location	Directions	Notes
A2	Washington	Eagleville, NY / West Sandgate, VT	Camden Valley Road	81	1	Take route 313 west from Vermont into New York. Turn right onto Hickory Hill Road. Right onto Perry Hill Road. Right onto Camden Valley Road. Go about 2 miles up Camden Valley road (just after where the road goes over Camden Creek), turn right onto an unnamed road that goes up the hillside. The fan is on the south side of that unnamed road; east side of Camden Valley Road.	Very large fan in a field. The unnamed road goes alongside the fan and up the hill behind the fan apex. The fan is well-preserved, but way too large for this type of study.
A3	Rensselaer	North Petersburg	Route 22	67	1	On Rt.22 about 0.3 mile south of junction with Rt. 98 (Hollow Road), 2.5 miles south of the intersection with Rt. 7. Fan is on the west side of the road.	Small fan a the back of a field. Not much of a hillslope behind it. Not ideal for this type of study.
A4	Columbia	Red Rock	Route 24 (Clark Road)	53	1	Route 9 south from the town of East Chatham. Go past the intersections with Elliot Road, New Concord Road and Daley Road. At Clark Road (Rt.24) turn left. Fan is about half a mile on the north side of the road.	Road goes over the fan. Small gully and perennial stream feed the fan. Stream is now routed through a culvert which goes under the road. New housing development being constructed on the terrace above. Probably disturbed when the road was built.

A5/A6	Greene	Freehold	Route 67	52	2	From Freehold, follow route 67 for about 0.6 miles. The fans are right by the Municipal Airport. The road goes over the apexes of the fans, and you can see the rest of the fan shape on the south side of the road.	Two small fans, side by side on a river terrace. The road runs over the apexes of both fans. Fan A6 is just west of the Visionscapes sign, and is currently being mined for sand by that construction company. Fan A5 is east of fan A6. Probably both fans were disturbed when the road was built.
A7	Albany	Cooksburg	Route 145	51	1	On Route 145 about .75 mile north of Cooksburg and intersection of Rt. 145 with Rt.81 and 354. Fan is on the east side of the road, just before the 145 intersection with Arnold and Edwards Hill roads.	Fan is in a corn field, at the base of the hillslope. A well developed gully feeds the fan. Probably would be useful to trench for this type of study.
A8	Schoharie	Breakabeen	Route 30	65	1	About 8 miles south of Middleburgh on Route 30 (past the intersection with Route 4). Fan is past the intersection with Route 17, but before going over the creek and the intersection with Lawyer Road. The fan is on the east side of the road, near a small road that loops back around to Rt. 30.	Large, thin fan at the back of a field. Small hillslope above.
A9	Schoharie	Breakabeen	Route 30	65	1	About 8.5 miles south of Middleburgh on Route 30. Fan is on the east side of the road, just past the intersection with Lawyer Road.	Small, thin fan at the back of a field, base of a small hillslope.
B1	Schoharie	Breakabeen	Route 30	65	1	Fan is about 9.5 miles south of Middleburgh on Route 30 (1 mile south of fan A9). From fan A9, you will go past one intersection with small road to the east before getting to fan B1. The hillslope is very close to the road at this point.	Small fan next to the road, fed by a small stream. Covered in brush. Possibly disturbed when road was built.
B2	Schoharie	North Blenheim	Route 30	51	1	Along the south-east side of Route 30, about 2.5 miles north of the intersection with Baldwin Road. North of North Blenheim.	Well-formed fan at the back of a corn field. Not much of a hillslope above it, although there is a small stream feeding it.
B3	Schoharie	North Blenheim	Route 30	51	1	Along the south-east side of Route 30, about 3 miles north of the intersection with Baldwin Road. North of North Blenheim.	Fan at the back of a corn field. Large hillslope behind it than at B2. Fan was covered with brush when we were there, but had a characteristic fan shape.
B4	Schoharie	North Blenheim	Baldwin Road	51	1	Take Route 30 south from North Blenheim. Turn south (left) onto Baldwin Rd which eventually runs along the eastern side of Blenheim Gilboa Reservoir. The fan is only 0.25 mile or less after the turn onto Baldwin Rd, and is on the north-west side of the road.	Small fan in a low, marshy area. Road is raised so the fan is sort of in a gully compared to the road. Not an ideal fan, and would likely run into problems trying to trench so close to the reservoir.
B5/B6	Greene	Lexington	Route 42	51	2	About 1.25 miles south of the intersection of Rt. 42 with Rt. 23A. Fans are near each other on a river terrace along West Kill Brook, on the east side of the road. The brook is between the road and the terrace the fans are on. When we were there, the terrace was a big grassy pasture.	Two well-preserved and small sized fans in a field just south of the Lexington Municipal Building on Rt.42. Probably on the modern flood plain - so they could be very young.
B7	Greene	Lexington / West Kill	Route 42	51	1	About 2.25 miles south of the intersection of Rt. 42 with Rt. 23A. Fan is on the east side of the road, just past a side road that goes off to the west. Fan is in the Vinegar Hill State Wildlife Management Area.	None

B8/B9	Ulster	Mapledale / Seager	Route 49 (Dry Brook Road)	51	2	Take Route 28 to just south of Arkville, turn south onto Dry Brook Rd. (Rt.49). Fans are about 6 miles down Dry Brook Road, just past the intersection with Mill Brook Road, on the west side of the road. At the fan location, Dry Brook is to the east of the road. If you cross over the Brook and it's on the west side of the road, you have gone too far.	Two small alluvial fans in great condition behind a corn field at the base of the hillslope. These fans would be excellent for this type of study.
C1	Ulster	Mapledale	Route 49 (Dry Brook Road)	51	1	Take Route 28 to just south of Arkville, turn south onto Dry Brook Rd. (Rt.49). Fan is about 5 miles down Dry Brook Road, on the west side of the road.	Small fan at the back of an agricultural field (corn?), at the base of the hillslope. Good fan for this type of study.
C2/C3	Delaware	Walton	East River Road	49	2	Route 206 south from Walton. Just south of Walton, turn left onto East River Road. Fans are a little less than a mile down East River Road, and are on the south side of the road.	Two small fans at the bottom of the hillside, on a terrace above the road. The fans are behind a brick house and a wooden fence separates the backyard of the house from the area where the fans are. Great fans for this type of study.
C4	Delaware	Hale Eddy	Columbia Lake Road	49	1	Route 17 south from Deposit for about 5 miles. After Hale Eddy, turn left onto Roods Creek Rd. First left onto Columbia Lake Road. Fan is a little more than half a mile up the road on the southwest side of the road.	Fan is close to road in a pasture with a wood post and barbed wire fence. One small lone tree on the fan surface. Not much of a hillslope behind the fan. A good fan for this type of study.
C5/C6	Otsego	Clintonville	Route 33	64	2	Fans are 5.5 to 6 miles south of Cooperstown on the east side of Route 33. The fans are between the intersections of Rt.33 with Beaver Meadow Road (to the north) and Eggleston Hill Road (to the south). However, that is a large area and there aren't any good landmarks in between, so the fans might be difficult to relocate.	Two small, thin fans at the back of a row crop field, base of the hillslope. Large hillslope behind the fans. Good potential for this type of study.
C7	Otsego	Cherry Valley / Westville	Route 35	64	1	Fan is in Cherry Valley, about 2.75 miles south of Middlefield on Route 35. The fan is on the east side of the road, between the intersections of Rt.35 with Rt.36A (to the north) and Williams Road (to the south), south of a tributary to Cherry Valley creek.	Very well-preserved, small fan at the back of a grassy field. Small channel feeding it - you can see the channel going up the hillside. Good potential to be used for this type of study.
C8	Delaware	Bloomville	Route 10	50	1	About .3 miles north of fan C9 along Route 10. Fan is on the north side of Rt. 10.	Small fan at the base of the hillslope - back of the field.
C9	Delaware	Bloomville	Route 10	50	1	About 5.5 miles north on Route 10 from the Rt.10/Rt.28 intersection in Delhi. About 2 miles south of where Rt.10 intersects with Rt.33 (North Rd.). Fan is on the north side of Rt. 10.	Small fan at the base of the hillslope - back of the field.

Vermont Alluvial Fans:

Fan A1 and drainage

Fan A2

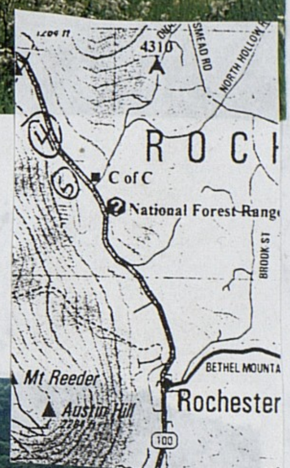

ons River
Scenic Train Ride
Bellows Falls
SKI BOWL RD
DAVIDSON HILL RD
12
121
5

Fan B1

Fan D1

Fan D2 (Hancock Fan)

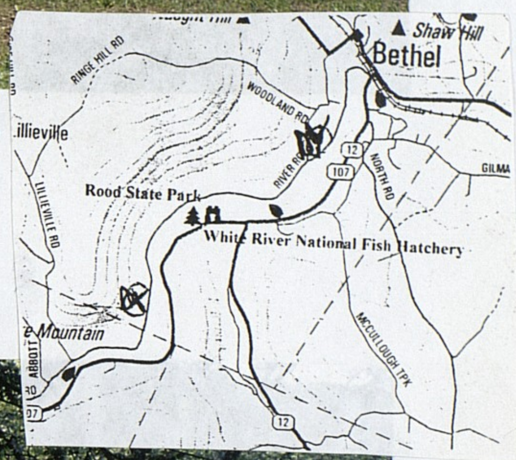
Fan D3

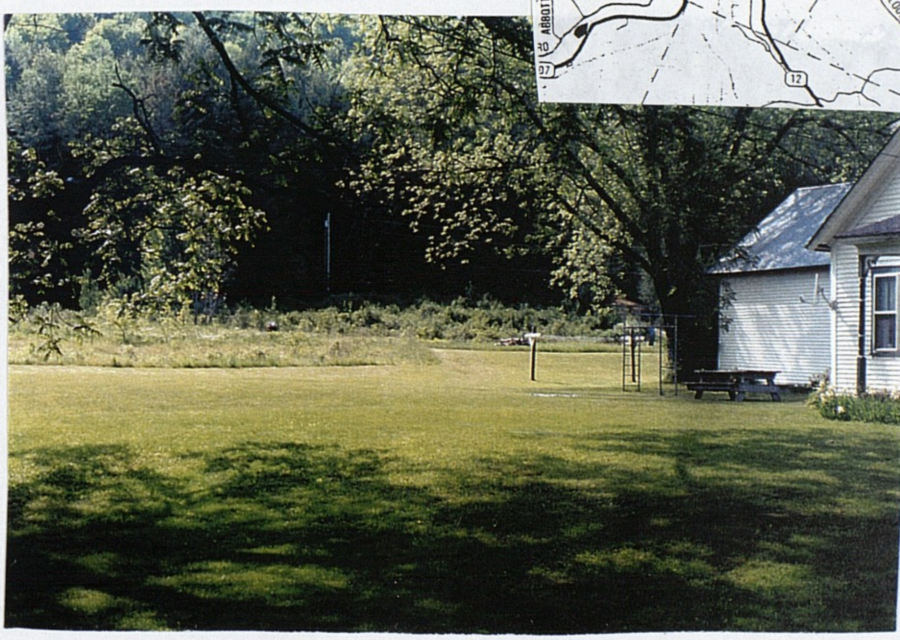

4310
SMEAD RD
NORTH HOLLOW
ROCH
C of C
National Forest Range
BROOK ST
BETHEL MOUNTA
Mt Reeder
Austin Hill
Rochester
100

Fan D4

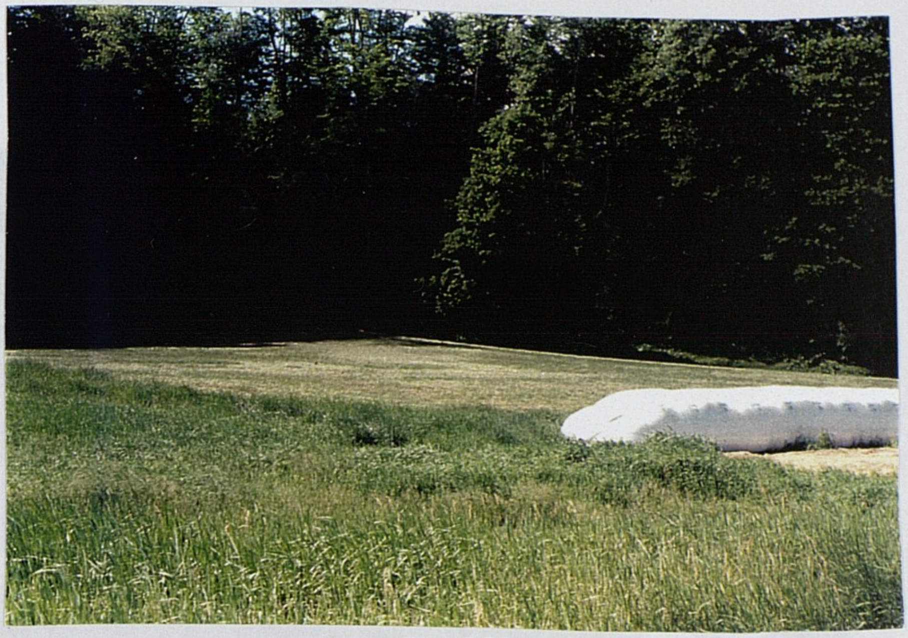
Fan D5

Fan D6


Shaw Hill
Bethel
RINGE HILL RD
WOODLAND RD
Lillieville
LILLIEVILLE RD
RIVER RD
NORTH RD
12
107
Rood State Park
White River National Fish Hatchery
McCULLOUGH TPK



Fan DX

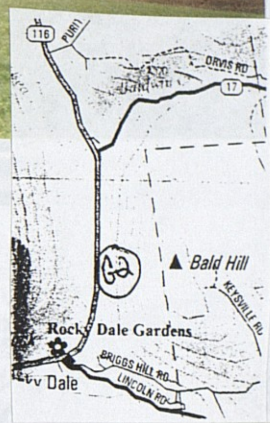


Fan DY

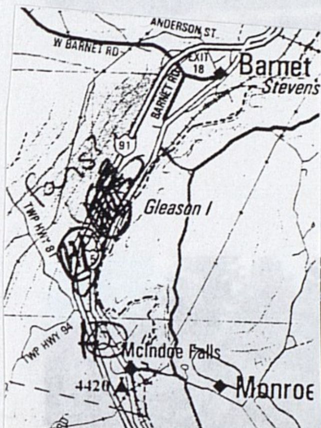
Fan 2X

Fan 2Y

Fan F4 (Maidstone Fan)

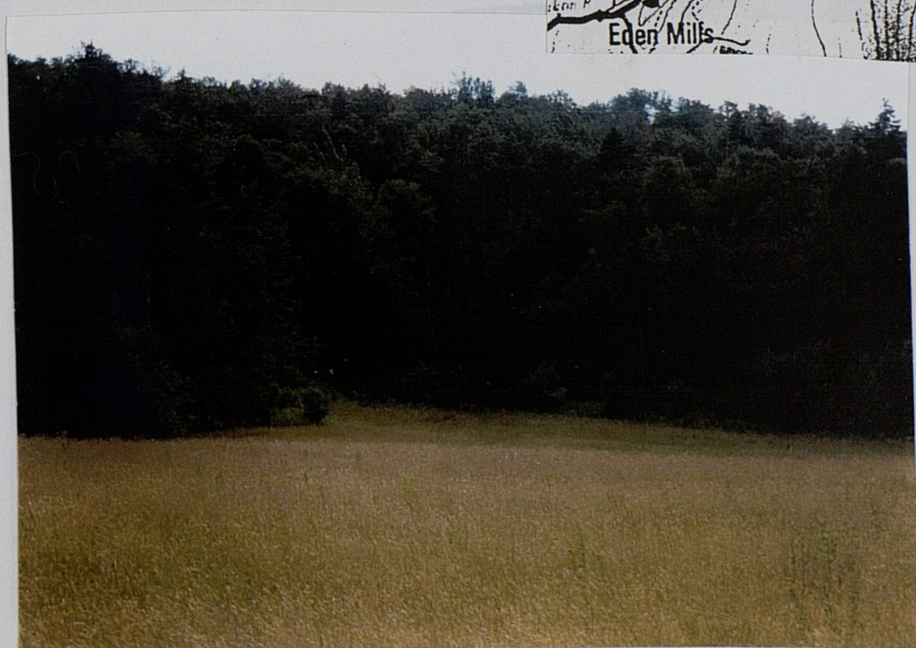


Fan G2 (Bristol Fan)



Fan H1

Fan H2

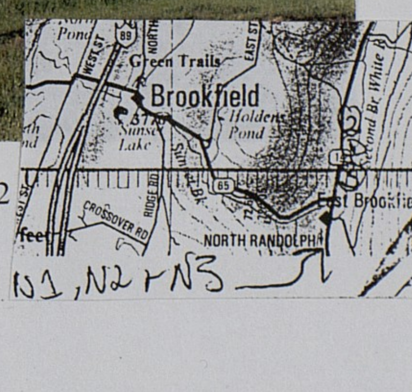


Fan I1 (Eden Mills Fan)

Fans K1

Fan K2

Fan M1



Fans N1 and N2

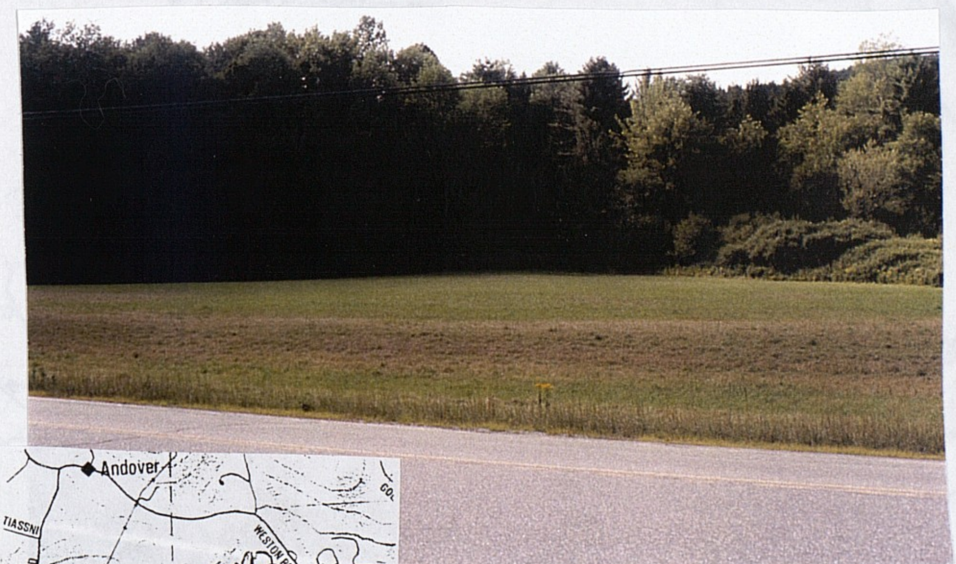
Fan N3

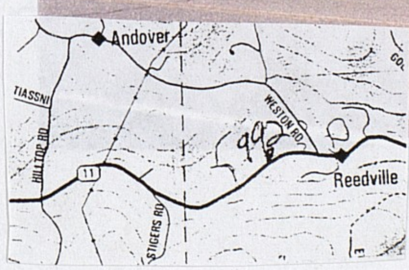
Fan O1

Fan O2 (Bridgewater Corners Fan)

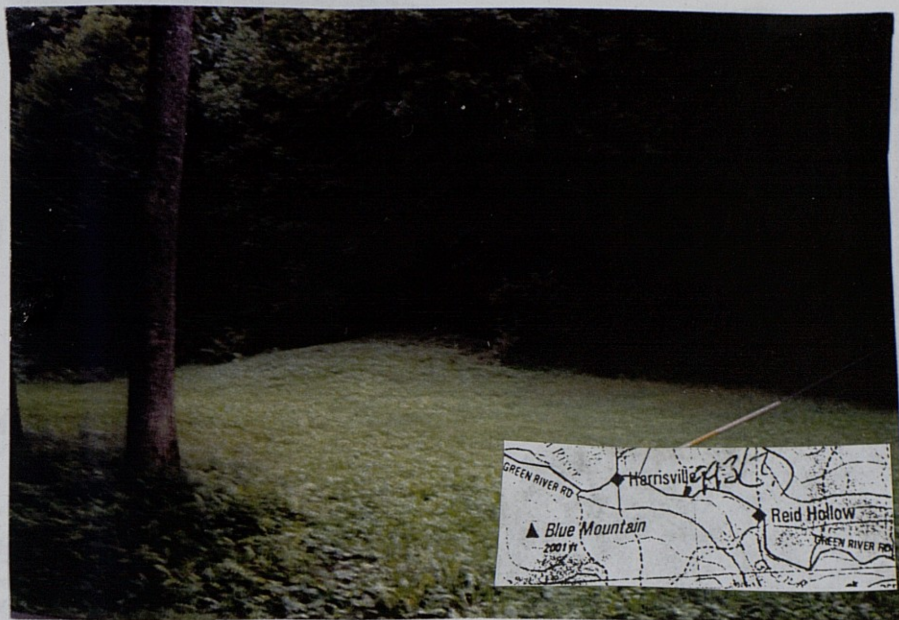
Fan O3

Fan 991



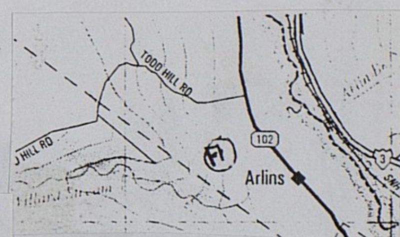


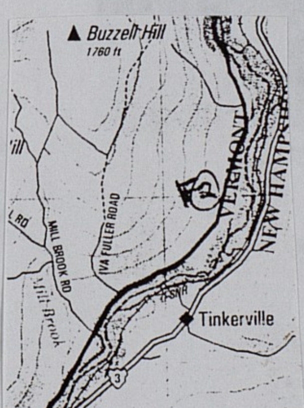
Fan 992

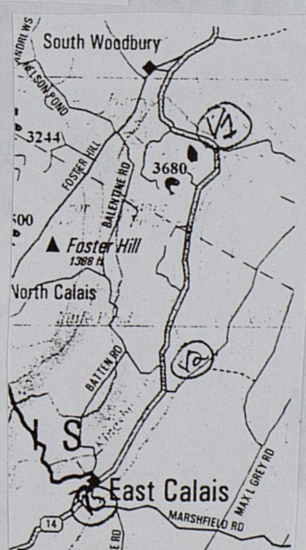

Harrisville
GREEN RIVER RD
Reid Hollow
Blue Mountain
2001 ft
GREEN RIVER RD

Fan 993


North Hartland
Lake Project
WINDSOR CO.
North Hartland
Beauty Hill

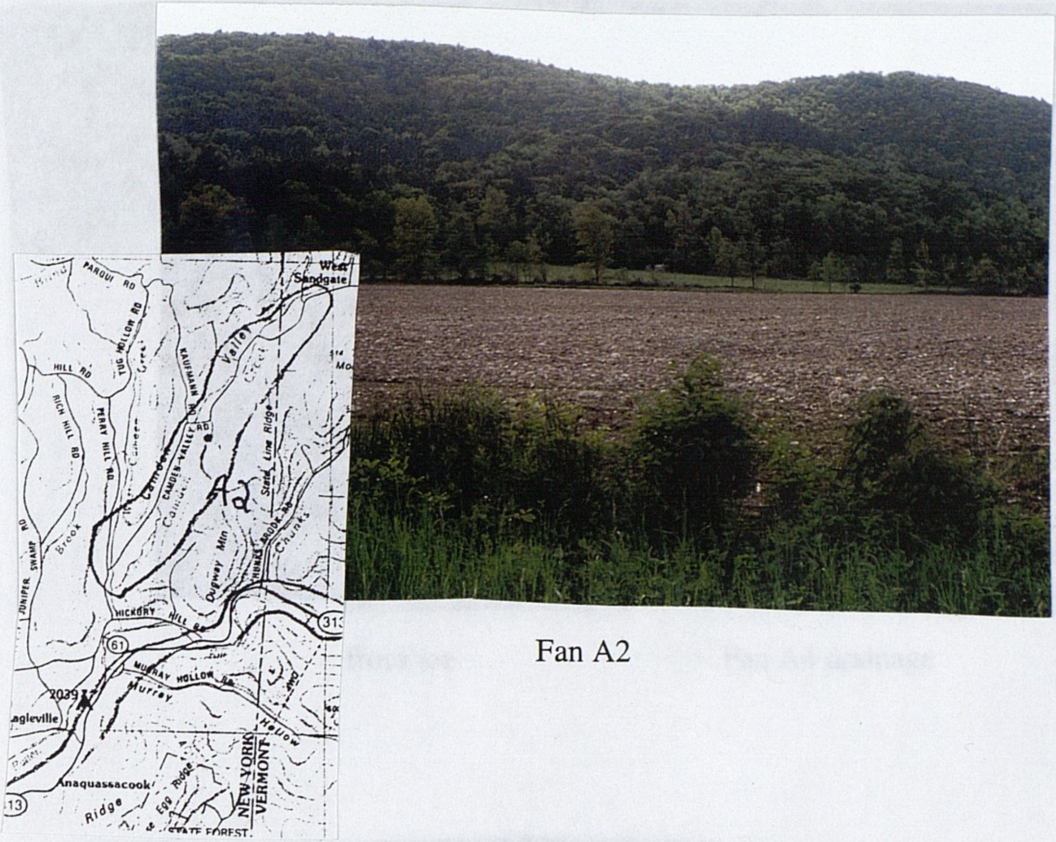

TODD HILL RD
102
Arlins


Buzzell Hill
1760 ft
VERMONT
NEW HAMPSHIRE
MILL BROOK RD
Tinkerville
3

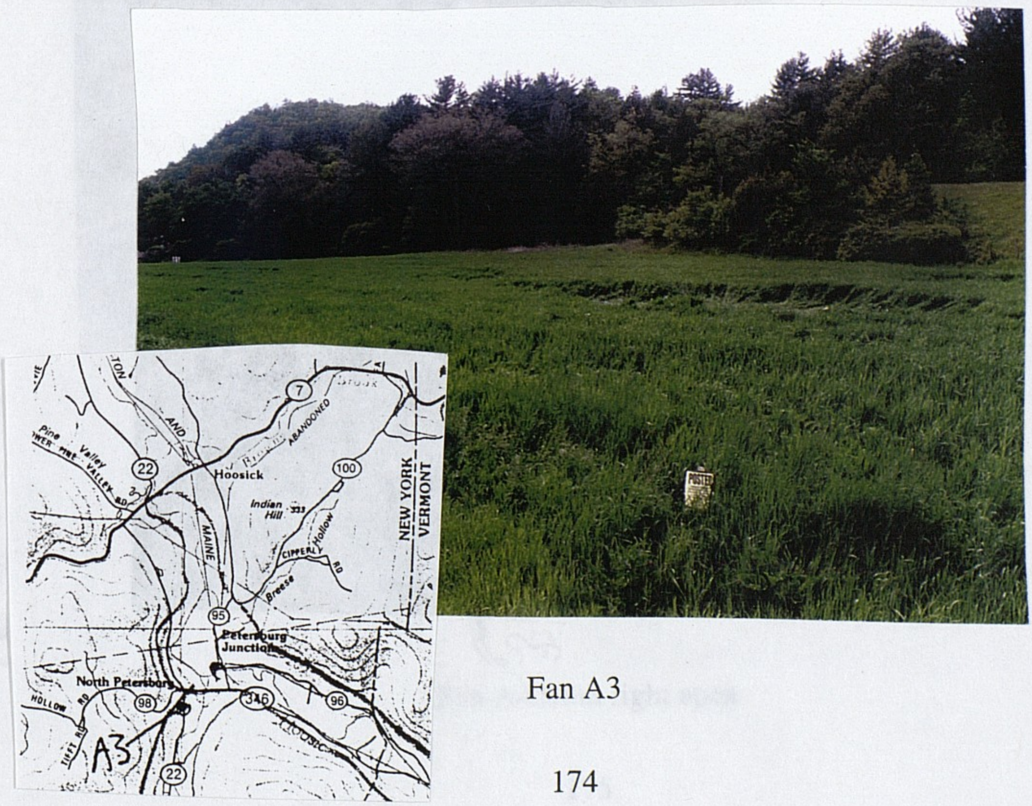

South Woodbury
3244
3680
FOSTER HILL
BALLENTINE RD
Foster Hill
1388 ft
North Calais
BATTEN RD
East Calais
14
MARSHFIELD RD
MAXI GREY RD


NORWICH
132
FLAT RD
HOGBACK RD
WHITE RIVER JUNCTION
Pompanoosuc
91
5
10

New York Alluvial Fans:



Fan A2



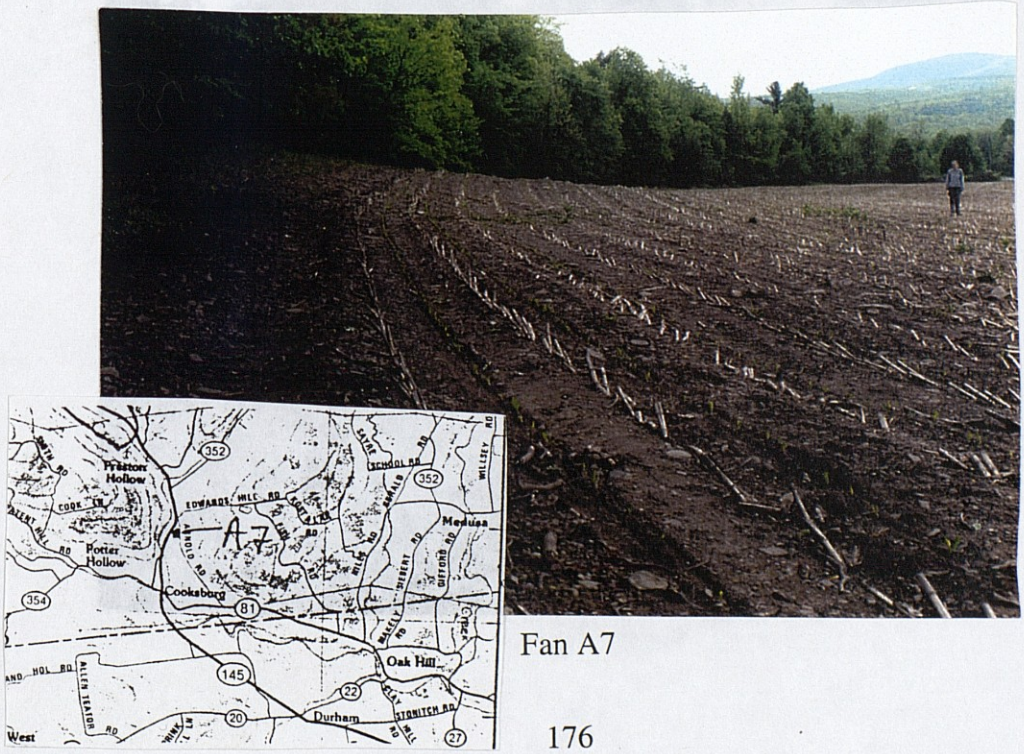
Fan A3

Fan A4 from toe

Fan A4 drainage

Fan A4 from right apex

Fan A6 from left apex

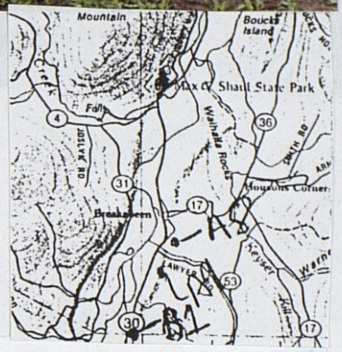


Fan A7

Fan A7 drainage

Fan A7 from toe

Fan A8


Mountain
Boucks Island
Max V. Shaul State Park
Falls
4
36
Joslyk Rd
Walhalla Rocks
31
Breakabeen
17
A8
53
Keyser Kill
30
B1
17

Fan A9

Fan B1

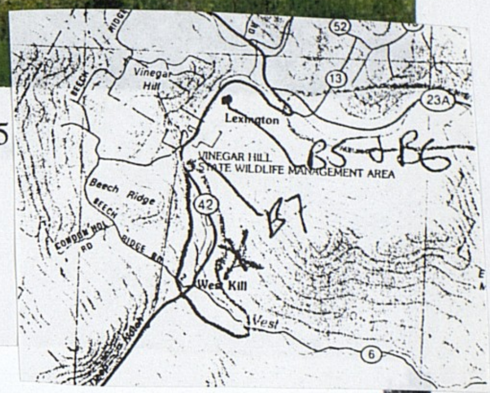
Fan B2

Fan B3

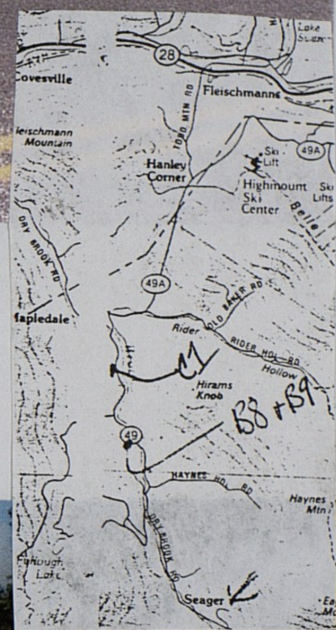

North Blenheim
Creek
KNISKERN RD
DAVE BROWN MT RD
MOWER RD
Owlsville
Brown Mountain
Substa
Powerplant
Mine Kill State Park
2137
B3

Fan B4

Fan B5



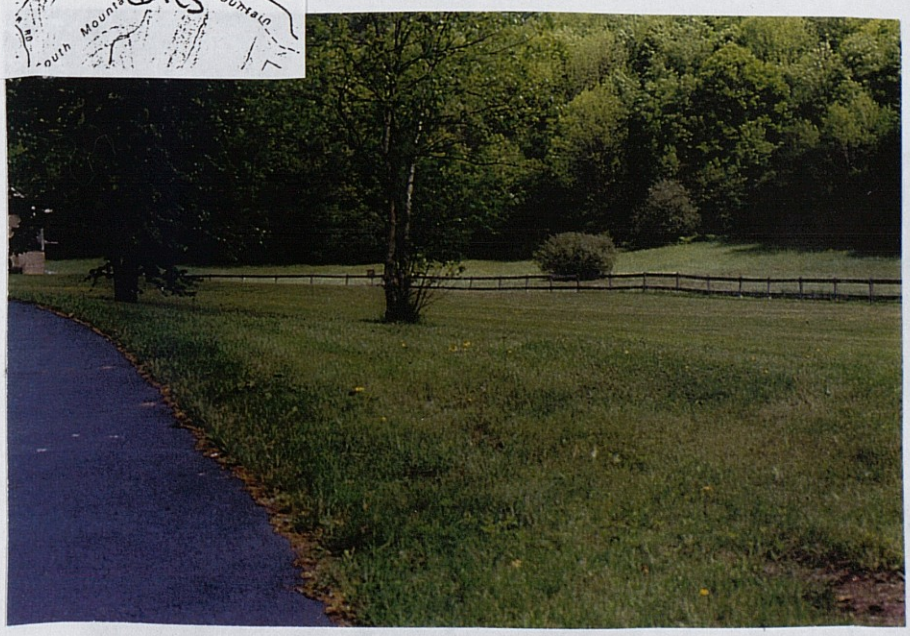
Fan B5 and B6



Fans B8 and B9

Fan C1

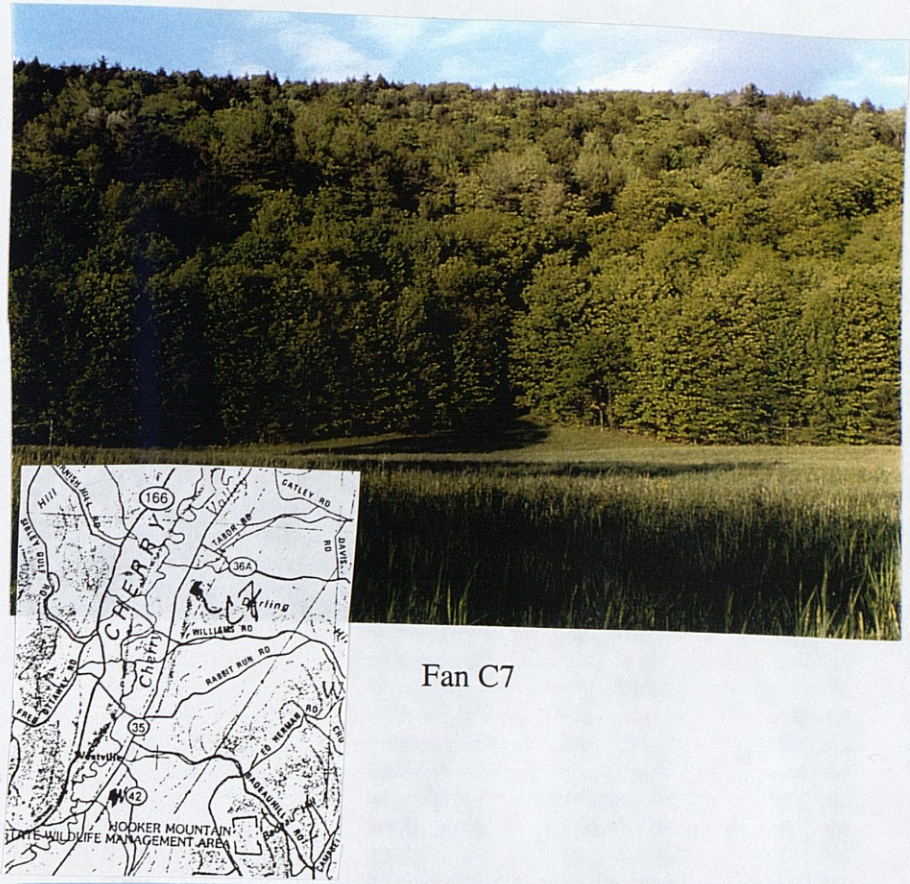
Fans C2 and C3



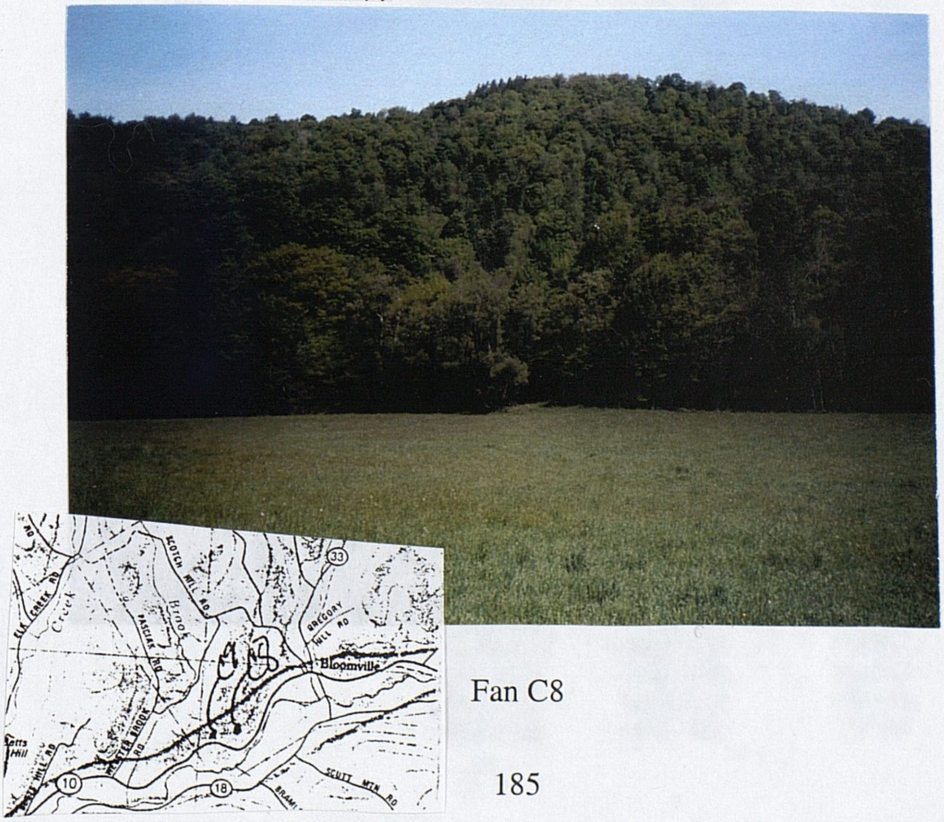
Fan C3

Fan C4

Fans C5 and C6


CHERRY
WILLIAMS RD
RABBIT RUN RD
HOOKER MOUNTAIN
STATE WILDLIFE MANAGEMENT AREA

Fan C7


SCOTCH HILL RD
ELK CREEK RD
Creek
Bloomville
SCOTT MTN RD

Fan C8

Appendix B: Survey Data

Eden Mills alluvial fan

Point Description	**Northing**	**Easting**	**Elevation**
Bench 1	4955896.452	699145.049	412.230
Bench 2	4955971.145	699121.436	411.874
Bench 4	4955885.913	699118.541	412.372
Fan apex/road	4955836.500	699159.800	418.790
Fan apex/road	4955839.409	699160.301	418.441
Fan apex/road	4955843.203	699160.348	417.707
Possible fan apex1	4955842.350	699158.212	417.854
Topo (Right side)	4955845.390	699159.918	417.450
Topo (Right side)	4955848.151	699159.268	416.781
Possible fan apex2	4955844.748	699157.169	417.343
Topo	4955847.183	699156.161	416.786
Topo (Right side)	4955851.261	699159.588	416.201
Topo (Right side)	4955855.411	699159.344	415.323
Right Field Edge	4955859.782	699157.698	414.453
Right Field Edge	4955864.232	699156.287	414.017
Right Field Edge	4955868.780	699155.470	413.876
Topo (Right side)	4955860.483	699159.110	414.291
Right Field Edge	4955872.499	699155.991	413.604
Right Field Edge	4955877.764	699156.431	413.516
Right Field Edge	4955881.227	699156.279	413.278
Right Field Edge	4955887.326	699156.673	413.002
Right Field Edge	4955892.517	699159.904	412.795
Right Field Edge	4955898.484	699161.625	412.409
Right Field Edge	4955904.388	699159.597	412.323
Right Field Edge	4955912.122	699161.305	412.184
Topo	4955908.307	699150.882	412.203
Topo	4955905.386	699142.168	412.156
Topo	4955901.771	699133.856	412.144
Topo	4955899.909	699128.894	412.411
Topo	4955897.084	699123.026	412.471
Topo	4955894.604	699116.525	412.192
Left Field Edge	4955891.153	699115.604	412.234
Left Field Edge	4955882.070	699120.635	412.661
Left Field Edge	4955878.457	699123.888	412.750
Left Field Edge	4955875.421	699127.021	412.911
Left Field Edge	4955872.139	699129.860	413.102
Left Field Edge	4955869.077	699132.427	413.234
Left Field Edge	4955865.935	699135.169	413.512
Left Field Edge	4955863.235	699137.846	413.662
Left Field Edge	4955859.767	699142.014	413.843
Left Field Edge	4955860.594	699146.025	414.007
Left Field Edge	4955860.145	699149.853	414.276
Left Field Edge	4955857.088	699152.243	414.768
Left Field Edge	4955854.124	699153.314	415.182
Left Field Edge	4955851.553	699154.271	415.627
Left Field Edge	4955849.155	699155.187	416.293
Topo	4955848.804	699157.949	416.541
Topo	4955851.265	699156.834	415.992
Topo	4955853.781	699156.178	415.545
Topo	4955856.457	699155.584	415.160
Topo	4955858.840	699155.095	414.526
Topo	4955862.002	699153.850	414.368
Topo	4955861.875	699151.472	414.334
Topo	4955865.360	699153.783	414.110
Topo	4955864.828	699151.256	414.168

Topo	4955864.019	699148.367	413.892
Topo	4955863.135	699145.496	413.826
Topo (Left side)	4955862.714	699128.150	413.400
Stream	4955865.822	699129.668	413.250
Stream	4955864.650	699135.520	413.601
Stream	4955859.349	699140.271	413.717
Stream	4955856.541	699142.681	413.862
Topo (Left side)	4955849.209	699133.918	414.375
Topo (Left side)	4955846.473	699134.001	414.561
Topo (Left side)	4955841.537	699134.073	414.760
Topo (Left side)	4955837.215	699136.529	415.030
Topo	4955865.694	699139.867	413.493
Topo	4955868.984	699143.781	413.481
Topo	4955868.671	699152.566	413.937
Topo	4955873.695	699152.475	413.532
Topo	4955872.859	699149.066	413.561
Topo	4955870.897	699142.992	413.343
Topo	4955869.007	699137.922	413.302
Topo	4955872.281	699134.504	413.044
Topo	4955873.786	699139.368	412.989
Topo	4955874.372	699142.508	413.219
Topo	4955876.115	699147.815	413.358
Topo	4955877.420	699152.464	413.229
Topo	4955882.318	699152.440	413.149
Topo	4955881.257	699148.940	413.011
Topo	4955880.326	699145.106	413.096
Topo	4955877.770	699138.639	412.818
Topo	4955875.969	699133.618	412.989
Topo	4955878.832	699128.300	412.732
Topo	4955880.227	699132.372	412.878
Topo	4955881.481	699136.062	412.812
Topo	4955882.960	699142.013	412.969
Topo	4955884.860	699145.311	412.866
Topo	4955886.441	699150.899	412.938
Topo	4955890.118	699154.382	412.831
Topo	4955889.412	699149.438	412.696
Topo	4955888.446	699144.951	412.644
Topo	4955887.487	699140.414	412.775
Topo	4955885.767	699135.691	412.671
Topo	4955884.119	699131.350	412.790
Topo	4955882.394	699126.989	412.617
Topo	4955885.774	699123.610	412.412
Topo	4955887.280	699128.133	412.527
Topo	4955888.400	699132.255	412.601
Topo	4955889.730	699137.176	412.681
Topo	4955891.210	699141.941	412.544
Topo	4955893.022	699147.156	412.353
Topo	4955894.443	699151.930	412.323
Topo	4955895.741	699157.266	412.380
Topo	4955899.443	699156.774	412.112
Topo	4955898.085	699151.562	412.164
Topo	4955897.198	699148.045	412.118
Topo	4955895.312	699141.142	412.296
Topo	4955894.160	699136.741	412.438
Topo	4955892.823	699132.396	412.528
Topo	4955891.748	699128.645	412.560
Topo	4955890.431	699124.333	412.417
Topo	4955889.501	699121.051	412.360
Topo	4955892.121	699120.286	412.283
Topo	4955894.012	699124.386	412.448
Topo	4955895.324	699128.724	412.525

Topo	4955896.730	699133.248	412.375
Topo	4955898.112	699137.490	412.220
Topo	4955899.773	699141.825	412.166
Topo	4955901.477	699145.939	412.143
Topo	4955903.269	699150.540	412.128
Topo	4955904.357	699155.026	412.144
Field Topo	4955907.720	699108.378	412.059
Field Topo	4955923.105	699102.197	412.069
Field Topo	4955932.854	699097.771	411.829
Field Topo	4955943.853	699093.494	411.975
Rt.100-East edge	4955955.173	699044.092	411.598
Rt.100-East edge	4955966.956	699081.967	412.234
Rt.100-East edge	4955980.190	699130.189	412.612
Rt.100-East edge	4955989.350	699165.926	412.865
Rt.100-West edge	4955997.907	699163.638	412.895
Rt.100-West edge	4955988.443	699127.349	412.626
Rt.100-West edge	4955974.115	699075.185	412.349
Rt.100-West edge	4955961.122	699034.606	411.346
Field Topo	4955949.386	699107.716	412.340
Field Topo	4955935.931	699113.963	412.512
Field Topo	4955923.053	699118.150	412.232
Field Topo	4955908.282	699122.758	412.161
Field Topo	4955912.978	699138.337	412.032
Field Topo	4955926.155	699134.221	412.238
Field Topo	4955941.114	699130.169	412.349
Field Topo	4955956.886	699124.897	412.702
Field Topo	4955958.909	699141.886	413.103
Field Topo	4955945.082	699146.757	412.936
Field Topo	4955930.072	699152.272	411.907
Topo (Right side)	4955879.573	699161.202	413.549
Trench Corner	4955868.313	699150.134	413.894
Trench Corner	4955879.636	699143.796	413.059
Trench Corner	4955878.747	699142.284	412.959
Trench Corner	4955868.771	699147.653	413.516
Trench Corner	4955862.112	699139.063	413.589
Trench Corner	4955860.677	699140.314	413.781
Trench Stake	4955861.179	699140.745	413.763
Trench Stake	4955862.058	699141.829	413.767
Trench Stake	4955862.946	699143.058	413.802
Trench Stake	4955864.209	699144.694	413.676
Trench Stake	4955865.113	699146.152	413.727
Trench Stake	4955866.392	699147.780	413.719
Trench Stake	4955867.375	699149.021	413.884
Trench Stake	4955869.687	699149.680	413.833
Trench Stake	4955871.359	699148.609	413.592
Trench Stake	4955872.491	699148.071	413.505
Trench Stake	4955872.931	699147.903	413.539
Trench Stake	4955874.362	699147.193	413.449
Trench Stake	4955875.920	699146.306	413.310
Trench Stake	4955877.569	699145.227	413.161
End Grid Point	4955876.648	699145.829	413.242
End Grid Point	4955861.368	699141.068	413.858

Maidstone alluvial fan

Point Description	Northing	Easting	Elevation
Bench 1	4955339.368	768812.078	273.609
Bench 2	4955341.557	768787.573	276.400
Bench 3	4955331.155	768810.253	273.505
Bench 4	4955330.226	768786.674	276.185
Topo	4955332.340	768786.723	276.249

Topo	4955334.594	768786.058	276.498
Topo	4955336.457	768785.084	276.722
Topo	4955338.060	768784.022	276.952
Topo	4955336.739	768782.767	277.233
Topo	4955335.287	768783.892	277.106
Topo	4955339.985	768785.372	276.725
Topo	4955337.887	768787.585	276.378
Topo	4955335.995	768788.798	276.198
Topo	4955333.763	768789.437	276.025
Topo	4955332.151	768788.566	276.108
Topo	4955330.119	768788.938	275.873
Topo	4955328.458	768790.515	275.677
Topo	4955330.834	768790.924	275.736
Topo	4955333.837	768791.049	275.862
Topo	4955336.059	768791.153	275.990
Topo	4955338.395	768790.998	275.996
Topo	4955340.155	768790.326	276.110
Topo	4955342.144	768789.938	276.130
Topo	4955342.563	768792.040	275.909
Topo	4955340.477	768792.305	275.891
Topo	4955338.100	768792.327	275.842
Topo	4955335.887	768792.713	275.706
Topo	4955333.586	768792.679	275.620
Topo	4955330.944	768792.532	275.455
Topo	4955327.696	768791.809	275.460
Topo	4955326.569	768795.341	274.930
Topo	4955328.771	768795.259	275.008
Topo	4955331.349	768795.920	275.081
Topo	4955333.449	768796.043	275.267
Topo	4955335.533	768795.745	275.414
Topo	4955338.181	768794.216	277.636
Topo	4955340.586	768793.097	275.743
Topo	4955342.732	768793.327	275.739
Topo	4955343.032	768795.751	275.464
Topo	4955340.660	768795.712	275.484
Topo	4955338.392	768795.936	275.475
Topo	4955336.122	768796.298	275.430
Topo	4955333.781	768796.224	275.331
Topo	4955331.622	768796.238	275.110
Topo	4955329.860	768796.317	274.973
Topo	4955327.337	768796.442	274.878
Topo	4955326.907	768798.187	274.665
Topo	4955329.805	768797.859	274.890
Topo	4955332.677	768797.875	275.123
Topo	4955334.975	768796.815	275.316
Topo	4955336.977	768797.161	275.355
Topo	4955339.186	768796.775	275.442
Topo	4955341.367	768796.107	275.441
Topo	4955343.167	768795.824	275.450
Topo	4955343.000	768798.080	275.170
Topo	4955340.562	768798.044	275.222
Topo	4955338.131	768798.750	275.082
Topo	4955335.855	768798.789	275.020
Topo	4955333.664	768799.220	274.905
Topo	4955330.043	768800.021	274.619
Topo	4955327.608	768798.774	274.664
Topo	4955325.632	768797.443	274.672
Topo	4955323.904	768799.338	274.403
Topo	4955326.882	768800.352	274.418
Topo	4955329.271	768801.273	274.444
Topo	4955332.393	768801.011	274.671

Topo	4955334.772	768800.648	274.795
Topo	4955336.918	768800.208	274.857
Topo	4955339.681	768799.498	275.082
Topo	4955341.947	768799.029	275.100
Topo	4955343.476	768799.193	275.054
Topo	4955342.592	768800.829	274.923
Topo	4955339.851	768801.835	274.869
Topo	4955338.379	768801.676	274.735
Topo	4955335.786	768802.539	274.591
Topo	4955333.251	768802.927	274.518
Topo	4955331.523	768802.528	274.453
Topo	4955331.839	768804.827	274.241
Topo	4955333.506	768805.613	274.191
Topo	4955336.765	768805.754	274.174
Topo	4955339.047	768805.578	274.320
Topo	4955342.300	768805.278	274.332
Topo	4955344.048	768804.394	274.548
Topo	4955344.427	768806.921	274.189
Topo	4955342.373	768807.703	274.123
Topo	4955339.247	768808.155	274.015
Topo	4955336.139	768808.119	273.982
Topo	4955331.646	768808.222	273.789
Topo	4955344.597	768825.753	271.565
Topo	4955344.762	768826.770	271.488
Topo	4955345.476	768828.434	271.291
Topo	4955345.749	768829.462	271.217
Topo	4955346.409	768830.505	271.159
Topo	4955346.841	768831.672	271.150
Topo	4955347.360	768834.744	270.984
Topo	4955347.618	768835.742	270.967
Topo	4955347.354	768837.619	270.931
Topo	4955347.725	768838.711	270.860
Topo	4955347.623	768839.992	270.872
Topo	4955350.004	768848.489	270.758
Topo	4955350.111	768850.660	270.689
Topo	4955349.602	768852.463	270.550
Topo	4955348.821	768853.698	270.440
Topo	4955348.016	768855.146	270.362
Topo	4955336.302	768857.926	270.180
Topo	4955348.163	768841.036	270.779
Topo	4955346.969	768839.985	270.841
Topo	4955345.716	768839.204	270.848
Topo	4955344.451	768838.705	270.931
Topo	4955342.453	768837.659	271.141
Topo	4955341.460	768837.203	271.216
Topo	4955335.536	768834.991	271.141
Topo	4955339.425	768815.541	272.659
Topo	4955341.022	768816.011	272.497
Topo	4955342.284	768816.420	272.417
Topo	4955344.072	768816.396	272.446
Topo	4955344.810	768815.203	272.553
Topo	4955344.515	768813.917	272.699
Topo	4955343.728	768813.042	272.877
Topo	4955342.757	768812.684	272.923
Topo	4955339.359	768813.259	272.907
Topo	4955337.543	768813.311	272.799
Topo	4955335.940	768813.177	272.784
Topo	4955334.401	768813.257	272.731
Topo	4955333.349	768813.338	272.709
Topo	4955332.252	768813.059	272.737
Topo	4955330.920	768813.507	272.678

Topo	4955329.910	768813.475	272.738
Topo	4955329.235	768812.660	272.796
Topo	4955330.802	768810.636	272.300
Topo	4955332.340	768786.723	276.249
Topo	4955334.594	768786.058	276.498
Topo	4955336.457	768785.084	276.722
Topo	4955338.060	768784.082	276.952
Topo	4955336.739	768782.767	277.233
Topo	4955335.287	768783.892	277.106
Topo	4955339.985	768785.372	276.725
Topo	4955337.887	768787.585	276.378
Topo	4955335.995	768788.798	276.198
Topo	4955333.763	768789.437	276.025
Topo	4955332.151	768788.566	276.108
Topo	4955330.119	768788.938	275.873
Topo	4955328.458	768790.515	275.677
Topo	4955330.834	768790.924	275.736
Topo	4955333.837	768791.049	275.862
Topo	4955336.059	768791.153	275.990
Topo	4955338.395	768790.998	275.996
Topo	4955340.155	768790.326	276.110
Topo	4955342.144	768789.938	276.130
Topo	4955342.563	768792.040	275.909
Topo	4955340.477	768792.305	275.891
Topo	4955338.100	768792.327	275.842
Topo	4955335.887	768792.713	275.706
Topo	4955333.586	768792.679	275.620
Topo	4955330.944	768792.532	275.455
Topo	4955327.696	768791.809	275.460
Topo	4955326.569	768795.341	274.300
Topo	4955328.771	768795.259	275.008
Topo	4955331.349	768795.920	275.081
Topo	4955333.449	768796.043	275.267
Topo	4955335.533	768795.745	275.414
Topo	4955338.181	768794.216	275.636
Topo	4955340.586	768793.097	275.743
Topo	4955342.732	768793.327	275.739
Topo	4955343.032	768795.751	275.464
Topo	4955340.660	768795.712	275.484
Topo	4955338.392	768795.936	275.475
Topo	4955336.122	768796.248	275.430
Topo	4955333.781	768796.224	275.331
Topo	4955331.622	768796.238	275.110
Topo	4955329.860	768796.317	274.973
Topo	4955327.337	768796.442	274.878
Topo	4955326.907	768798.187	274.665
Topo	4955329.805	768797.859	274.890
Topo	4955332.677	768797.875	275.123
Topo	4955334.975	768796.815	275.316
Topo	4955336.977	768797.161	275.355
Topo	4955339.186	768796.755	275.442
Topo	4955341.367	768796.107	275.441
Topo	4955343.167	768795.824	275.450
Topo	4955343.000	768798.080	275.170
Topo	4955340.562	768798.044	275.222
Topo	4955338.131	768798.750	275.082
Topo	4955335.855	768798.789	275.020
Topo	4955333.664	768799.220	274.905
Topo	4955330.043	768800.021	274.619
Topo	4955327.608	768798.774	274.664
Topo	4955325.632	768797.443	274.672

Topo	4955323.904	768799.338	274.403
Topo	4955326.882	768800.352	274.418
Topo	4955329.271	768801.273	274.444
Topo	4955332.393	768801.011	274.671
Topo	4955334.772	768800.648	274.795
Topo	4955336.918	768800.208	274.857
Topo	4955339.681	768799.498	275.082
Topo	4955341.470	768799.029	275.100
Topo	4955343.476	768799.193	275.054
Topo	4955342.592	768800.829	274.923
Topo	4955339.851	768801.835	274.869
Topo	4955338.379	768801.676	274.735
Topo	4955335.786	768802.539	274.591
Topo	4955333.251	768802.927	274.518
Topo	4955331.523	768802.528	274.453
Topo	4955331.839	768804.827	274.241
Topo	4955333.506	768805.613	274.191
Topo	4955336.765	768805.754	274.174
Topo	4955339.047	768805.578	274.320
Topo	4955342.300	768805.278	274.332
Topo	4955344.048	768804.394	274.548
Topo	4955344.427	768806.921	274.189
Topo	4955342.373	768807.703	274.123
Topo	4955339.274	768808.155	274.015
Topo	4955336.139	768808.119	273.982
Topo	4955331.646	768808.222	273.789
Topo	4955327.049	768806.685	273.781
Topo	4955324.435	768804.432	273.888
Topo	4955322.946	768802.497	274.107
Topo	4955320.990	768800.314	274.143
Topo	4955319.321	768797.564	274.138
Topo	4955317.113	768798.825	273.802
Topo	4955318.774	768801.737	273.723
Topo	4955320.988	768804.257	273.816
Topo	4955322.224	768806.435	273.605
Topo	4955324.511	768809.323	273.452
Topo	4955324.068	768812.423	273.259
Topo	4955322.264	768808.911	273.453
Topo	4955320.085	768807.256	273.514
Topo	4955317.375	768805.043	273.482
Topo	4955315.657	768802.288	273.590
Topo	4955314.111	768801.441	273.418
Topo	4955311.085	768806.140	272.998
Topo	4955313.054	768806.542	273.109
Topo	4955316.196	768807.565	273.228
Topo	4955318.855	768809.279	273.354
Topo	4955320.537	768811.330	273.202
Topo	4955323.668	768816.561	272.833
Topo	4955321.515	768815.323	272.855
Topo	4955317.762	768813.049	272.967
Topo	4955316.508	768811.215	273.008
Topo	4955314.591	768808.781	273.068
Topo	4955311.486	768807.925	272.956
Topo	4955310.031	768808.173	272.854
Topo	4955310.118	768810.230	272.698
Topo	4955312.473	768812.556	272.695
Topo	4955315.237	768815.587	272.667
Topo	4955320.132	768817.727	272.609
Topo	4955321.855	768819.679	272.528
Topo	4955323.124	768822.146	272.431
Topo	4955323.637	768825.465	272.259

Topo	4955321.484	768825.225	272.246
Topo	4955317.297	768821.482	272.285
Topo	4955315.460	768816.235	272.619
Topo	4955310.683	768814.531	272.485
Topo	4955307.922	768812.901	272.445
Topo	4955304.033	768816.215	272.146
Topo	4955306.407	768818.160	272.176
Topo	4955308.145	768820.044	272.232
Topo	4955311.542	768822.427	272.087
Topo	4955314.830	768825.406	272.074
Topo	4955318.129	768828.598	271.977
Topo	4955320.782	768830.750	271.959
Topo	4955322.517	768833.422	271.768
Topo	4955325.584	768834.456	271.722
Topo	4955325.558	768838.743	271.553
Topo	4955319.988	768838.542	271.596
Topo	4955316.349	768838.486	271.510
Topo	4955313.357	768836.920	271.550
Topo	4955310.195	768831.833	271.732
Topo	4955311.118	768820.465	272.210
Topo	4955306.309	768820.106	272.178
Topo	4955303.277	768819.075	271.943
Topo	4955302.043	768817.721	272.135
Topo	4955346.440	768797.490	274.217
Topo	4955346.659	768797.972	274.101
Topo	4955346.686	768798.669	274.067
Topo	4955346.934	768799.591	274.024
Topo	4955347.263	768800.630	273.809
Topo	4955347.271	768801.259	273.761
Topo	4955347.371	768801.912	273.737
Topo	4955347.490	768802.584	273.704
Topo	4955347.627	768803.220	273.624
Topo	4955348.038	768803.862	273.513
Topo	4955348.472	768804.697	273.364
Topo	4955349.709	768804.845	273.268
Topo	4955350.406	768804.870	273.148
Topo	4955351.072	768804.746	273.143
Topo	4955351.685	768804.448	273.130
Topo	4955352.865	768803.478	273.230
Topo	4955353.296	768802.836	273.279
Topo	4955353.609	768802.146	273.455
Topo	4955353.987	768801.672	273.467
Topo	4955354.656	768800.547	273.525
Topo	4955354.962	768799.919	273.555
Topo	4955355.316	768799.335	273.626
Topo	4955342.889	768789.790	275.948
Topo	4955342.565	768790.393	275.919
Topo	4955341.765	768791.188	275.775
Topo	4955341.125	768791.577	275.697
Topo	4955340.059	768792.330	275.629
Topo	4955339.567	768792.674	275.514
Topo	4955339.077	768792.959	275.490
Topo	4955338.195	768793.714	275.449
Topo	4955337.698	768794.117	275.411
Topo	4955337.330	768794.500	275.426
Topo	4955336.965	768794.899	275.372
Topo	4955336.472	768795.229	275.351
Topo	4955335.547	768795.710	275.234
Topo	4955335.453	768796.662	275.099
Topo	4955335.976	768796.981	275.106
Topo	4955336.676	768796.995	275.136

Topo	4955337.296	768796.908	275.177
Topo	4955337.987	768796.733	275.173
Topo	4955338.749	768796.478	275.164
Topo	4955339.509	768796.241	275.172
Topo	4955341.067	768795.920	275.276
Topo	4955341.843	768795.718	275.252
Topo	4955342.529	768795.527	275.289
Topo	4955343.285	768795.290	275.251
Topo	4955343.994	768795.028	275.272
Topo	4955344.695	768794.786	275.199
Topo	4955345.493	768794.580	275.234
Topo	4955346.393	768794.286	275.226
Topo	4955347.197	768794.048	275.248
Topo	4955347.988	768793.926	275.158
Topo	4955348.825	768793.835	275.178
Topo	4955349.599	768793.748	275.169
Topo	4955350.379	768793.743	275.091
Topo	4955351.006	768793.939	275.082
Topo	4955351.660	768793.999	274.991
Topo	4955353.196	768794.107	274.857
Topo	4955353.796	768794.446	274.843
Topo	4955354.252	768794.748	274.802
Topo	4955354.622	768795.134	274.782
Topo	4955355.022	768795.553	274.651
Topo	4955355.839	768796.517	274.596
Topo	4955355.810	768797.080	274.597
Topo	4955354.961	768798.453	274.429
Topo	4955354.591	768799.032	274.403
Topo	4955353.934	768799.590	274.353
Topo	4955353.252	768799.983	274.412
Topo	4955352.545	768800.402	274.387
Topo	4955351.921	768800.931	274.292
Topo	4955351.243	768801.528	274.290
Topo	4955350.386	768801.942	274.280
Topo	4955349.444	768802.207	274.212
Topo	4955348.576	768802.537	274.328
Topo	4955347.701	768802.948	274.300
Topo	4955346.935	768803.424	274.322
Topo	4955346.135	768803.966	274.299
Topo	4955344.575	768804.849	274.269
Topo	4955343.328	768805.448	274.248
Topo	4955342.581	768805.743	274.201
Topo	4955342.102	768806.062	274.140
Topo	4955341.590	768806.256	274.104
Topo	4955340.960	768806.552	274.029
Topo	4955340.255	768806.706	273.981
Topo	4955339.608	768806.994	273.948
Topo	4955338.874	768808.844	273.706
Topo	4955338.672	768809.513	273.644
Topo	4955338.229	768810.179	273.627
Topo	4955337.662	768810.571	273.588
Topo	4955337.026	768810.907	273.542
Topo	4955336.334	768811.335	273.474
Topo	4955335.556	768811.667	273.408
Topo	4955333.929	768813.355	273.198
Topo	4955334.359	768813.633	273.143
Topo	4955335.106	768813.760	273.179
Topo	4955335.851	768813.688	273.189
Topo	4955336.647	768813.511	273.205
Topo	4955337.430	768813.371	273.255
Topo	4955339.500	768812.633	273.409

Topo	4955340.086	768812.296	273.470
Topo	4955340.632	768811.855	273.537
Topo	4955341.395	768811.543	273.527
Topo	4955342.079	768811.398	273.540
Topo	4955342.763	768811.393	273.484
Topo	4955343.463	768811.867	273.496
Topo	4955343.851	768812.368	273.444
Topo	4955344.305	768812.769	273.346
Topo	4955344.759	768813.199	273.303
Topo	4955345.013	768813.681	273.195
Topo	4955345.458	768813.910	273.268
Topo	4955345.927	768813.618	273.222
Topo	4955346.631	768813.400	273.193
Topo	4955347.274	768813.098	273.195
Topo	4955347.955	768812.706	273.265
Topo	4955348.648	768812.340	273.260
Topo	4955349.312	768812.009	273.293
Topo	4955350.424	768811.288	273.368
Topo	4955350.953	768810.893	273.360
Topo	4955351.768	768810.604	273.373
Topo	4955352.483	768810.675	273.298
Topo	4955353.184	768810.586	273.298
Topo	4955353.844	768810.237	273.246
Topo	4955354.643	768809.929	273.302
Topo	4955356.067	768809.243	273.222
Topo	4955356.656	768808.647	273.206
Topo	4955357.057	768808.028	273.310
Topo	4955357.530	768807.383	273.293
Topo	4955357.928	768806.746	273.386
Topo	4955358.245	768806.121	273.551
Topo	4955358.740	768805.594	273.627
Topo	4955359.261	768805.133	273.609
Topo	4955359.645	768804.666	273.590
Topo	4955360.269	768804.158	273.582
Topo	4955360.843	768803.731	273.606
Topo	4955361.229	768803.217	273.668
Topo	4955361.576	768802.789	273.686
Topo	4955363.432	768800.289	273.889
Topo	4955363.912	768799.624	273.875
Topo	4955364.803	768798.195	273.840
Topo	4955365.349	768797.422	273.813
Topo	4955365.884	768796.769	273.906
Topo	4955366.378	768796.206	273.942
Topo	4955366.918	768795.651	273.952
Topo	4955367.562	768795.301	273.979
Topo	4955368.584	768795.412	273.928
Topo	4955370.514	768795.977	273.545
Topo	4955371.376	768796.089	273.536
Topo	4955372.056	768800.267	273.193
Topo	4955371.170	768800.754	273.287
Topo	4955370.272	768801.224	273.316
Topo	4955369.436	768801.629	273.330
Topo	4955368.737	768802.151	273.234
Topo	4955367.869	768802.808	273.253
Topo	4955366.913	768803.293	273.312
Topo	4955365.824	768803.662	273.446
Topo	4955364.735	768803.947	273.470
Topo	4955362.615	768804.849	273.462
Topo	4955361.695	768805.430	273.515
Topo	4955360.709	768805.867	273.461
Topo	4955359.633	768806.121	273.494

Topo	4955358.699	768806.404	273.571
Topo	4955357.722	768806.905	273.422
Topo	4955356.632	768807.474	273.369
Topo	4955355.542	768807.981	273.399
Topo	4955354.473	768808.491	273.484
Topo	4955353.413	768808.948	273.486
Topo	4955352.363	768809.334	273.438
Topo	4955351.370	768809.742	273.529
Topo	4955350.370	768810.155	273.558
Topo	4955349.393	768810.489	273.455
Topo	4955348.575	768810.955	273.465
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Topo	4955347.351	768812.216	273.330
Topo	4955347.127	768812.895	273.299
Topo	4955347.082	768813.659	273.148
Topo	4955346.909	768814.668	273.104
Topo	4955345.441	768815.752	273.082
Topo	4955344.064	768815.883	273.054
Topo	4955343.251	768815.990	273.085
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Topo	4955340.411	768816.617	272.989
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Topo	4955338.856	768817.072	273.146
Topo	4955338.019	768817.285	273.037
Topo	4955337.129	768817.582	273.036
Topo	4955336.267	768817.976	272.947
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Topo	4955334.645	768818.702	272.852
Topo	4955333.917	768819.100	272.810
Topo	4955333.126	768819.533	272.760
Topo	4955331.688	768820.495	272.609
Topo	4955330.984	768821.022	272.537
Topo	4955330.225	768821.423	272.521
Topo	4955328.589	768821.559	272.505
Topo	4955327.661	768821.510	272.444
Topo	4955327.104	768821.534	272.482
Topo	4955326.996	768822.035	272.381
Topo	4955326.981	768822.964	272.245
Topo	4955327.201	768823.776	272.223
Topo	4955327.874	768824.129	272.217
Topo	4955328.574	768824.312	272.203
Topo	4955329.162	768824.399	272.228
Topo	4955329.883	768824.314	272.315
Topo	4955330.636	768824.116	272.311
Topo	4955332.032	768823.107	272.412
Topo	4955332.928	768822.897	272.416
Topo	4955333.683	768823.066	272.420
Topo	4955334.557	768823.000	272.396
Topo	4955335.299	768822.540	272.510
Topo	4955336.926	768821.847	272.470
Topo	4955338.633	768821.289	272.584
Topo	4955339.292	768821.095	272.585
Topo	4955340.209	768821.006	272.601
Topo	4955340.907	768820.845	272.607
Topo	4955341.661	768820.479	272.640
Topo	4955342.572	768820.204	272.537
Topo	4955343.385	768820.206	272.611
Topo	4955344.607	768819.537	272.568
Topo	4955345.131	768819.077	272.563

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Topo	4955346.953	768818.188	272.683
Topo	4955347.869	768818.057	272.642
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Topo	4955351.820	768816.010	272.645
Topo	4955352.831	768815.635	272.612
Topo	4955354.531	768814.885	272.717
Topo	4955355.329	768814.232	272.834
Topo	4955356.129	768813.717	272.785
Topo	4955357.050	768813.246	272.792
Topo	4955357.939	768812.832	272.775
Topo	4955358.813	768812.239	272.751
Topo	4955359.493	768811.588	272.792
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Topo	4955366.810	768807.304	272.823
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Topo	4955369.609	768806.790	272.583
Topo	4955370.521	768806.567	272.572
Topo	4955371.452	768806.524	272.453
Topo	4955372.335	768806.599	272.475
Topo	4955373.155	768806.753	272.384
Topo	4955373.878	768807.072	272.323
Topo	4955374.784	768807.151	272.401
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Topo	4955377.997	768806.285	272.340
Topo	4955378.916	768806.307	272.267
Topo	4955379.788	768806.474	272.325
Topo	4955380.570	768806.579	272.178
Topo	4955381.434	768806.853	272.222
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Topo	4955383.066	768807.043	272.329
Topo	4955383.732	768807.158	272.396
Topo	4955384.234	768807.605	272.279
Topo	4955384.585	768808.092	272.234
Topo	4955384.546	768808.712	272.240
Topo	4955384.229	768809.271	272.125
Topo	4955383.671	768810.728	272.141
Topo	4955383.487	768811.286	272.147
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Topo	4955382.135	768812.509	272.014
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Topo	4955378.171	768814.757	271.908
Topo	4955377.371	768814.787	271.933
Topo	4955376.871	768814.808	271.872
Topo	4955376.124	768815.174	271.812
Topo	4955375.227	768815.446	271.842

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Topo	4955373.967	768815.643	271.831
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Topo	4955371.905	768816.392	271.895
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Topo	4955359.390	768822.910	271.868
Topo	4955358.652	768822.956	271.910
Topo	4955357.974	768823.486	271.908
Topo	4955357.503	768823.916	271.954
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Topo	4955354.553	768825.588	272.084
Topo	4955353.973	768825.912	272.022
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Topo	4955351.535	768826.408	271.909
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Topo	4955346.231	768822.016	272.506
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Topo	4955344.370	768822.655	272.383
Topo	4955343.890	768822.898	272.383
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Topo	4955344.832	768824.979	272.127
Topo	4955344.565	768825.552	272.060
Topo	4955343.681	768826.205	272.023
Topo	4955342.856	768826.585	272.032
Topo	4955341.335	768826.885	272.067
Topo	4955340.774	768826.865	272.091
Topo	4955340.518	768827.651	272.048
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Topo	4955338.938	768828.087	272.020
Topo	4955338.093	768828.170	272.062
Topo	4955337.066	768828.298	272.073
Topo	4955336.549	768828.620	272.043
Topo	4955335.378	768828.868	271.911
Topo	4955334.124	768828.815	271.951
Topo	4955333.381	768829.313	271.926
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Topo	4955331.967	768828.986	271.947

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Topo	4955330.694	768828.722	271.895
Topo	4955329.718	768828.837	271.899
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Topo	4955328.921	768829.366	271.729
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Topo	4955329.426	768831.875	271.642
Topo	4955329.382	768832.659	271.694
Topo	4955330.054	768833.121	271.669
Topo	4955331.024	768833.296	271.683
Topo	4955331.593	768833.032	271.692
Topo	4955332.204	768833.202	271.709
Topo	4955333.024	768833.269	271.678
Topo	4955333.629	768833.807	271.646
Topo	4955334.171	768833.953	271.602
Topo	4955335.074	768833.919	271.669
Topo	4955335.655	768834.295	271.679
Topo	4955336.996	768834.501	271.703
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Topo	4955338.453	768834.997	271.668
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Topo	4955347.292	768838.547	271.466
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Topo	4955348.471	768839.983	271.346
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Topo	4955349.896	768842.387	271.199
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Topo	4955350.265	768844.034	271.143
Topo	4955350.278	768844.658	271.136
Topo	4955350.511	768845.159	271.162
Topo	4955351.207	768845.158	271.105
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Topo	4955353.357	768844.813	271.056
Topo	4955354.041	768844.820	271.095
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Topo	4955361.639	768846.213	270.986
Topo	4955362.230	768846.325	270.964
Topo	4955362.903	768846.102	270.910
Topo	4955363.753	768845.905	270.905
Topo	4955364.498	768845.776	270.952
Topo	4955365.330	768845.592	270.946
Topo	4955366.892	768845.446	270.909
Topo	4955367.708	768845.436	270.953
Topo	4955368.539	768845.425	270.984
Topo	4955369.271	768845.594	270.920
Topo	4955369.863	768845.652	270.951

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Topo	4955378.363	768852.166	270.720
Topo	4955378.697	768852.661	270.737
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Topo	4955381.090	768852.257	270.727
Topo	4955382.001	768852.242	270.673
Topo	4955383.551	768852.000	270.837
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Topo	4955385.901	768852.083	270.573
Topo	4955386.228	768852.564	270.518
Topo	4955386.499	768853.757	270.412
Topo	4955386.400	768854.473	270.492
Topo	4955386.719	768855.151	270.364
Topo	4955387.313	768856.762	270.423
Topo	4955387.443	768857.656	270.506
Topo	4955387.562	768858.446	270.622
Topo	4955387.975	768859.137	270.651
Topo	4955389.100	768860.313	270.520
Topo	4955389.670	768861.234	270.606
Topo	4955389.959	768861.940	270.762
Topo	4955390.237	768862.777	270.767
Topo	4955390.372	768863.477	270.757
Topo	4955390.927	768863.980	270.695
Topo	4955391.843	768864.683	270.630
Topo	4955392.841	768865.240	270.739
Topo	4955393.759	768865.985	270.723
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Topo	4955395.046	768869.018	270.788
Topo	4955395.480	768870.120	270.911
Topo	4955395.910	768871.154	271.018
Topo	4955396.064	768872.190	271.007
Topo	4955396.273	768873.156	271.131
Topo	4955396.138	768874.227	271.110
Topo	4955395.511	768875.079	271.140
Topo	4955392.444	768876.073	271.059
Topo	4955390.318	768876.310	271.000
Topo	4955389.306	768876.500	271.086
Topo	4955387.295	768876.717	271.044
Topo	4955386.306	768876.728	271.091
Topo	4955385.352	768876.830	271.043
Topo	4955383.399	768877.103	271.007
Topo	4955381.676	768877.552	270.861
Topo	4955380.849	768878.534	270.762
Topo	4955380.073	768878.786	270.776
Topo	4955379.153	768878.651	270.680
Topo	4955377.115	768878.044	270.723
Topo	4955376.145	768877.986	270.790
Topo	4955374.097	768877.970	270.803
Topo	4955367.826	768879.322	270.782
Topo	4955367.051	768879.737	270.886
Topo	4955366.267	768880.018	270.856
Topo	4955365.465	768880.462	270.806
Topo	4955364.602	768881.017	270.863
Topo	4955362.984	768882.059	271.106

Topo	4955362.328	768882.463	271.112
Topo	4955361.837	768882.880	271.191
Topo	4955361.346	768883.361	271.193
Topo	4955360.771	768883.182	271.210
Topo	4955361.345	768883.593	271.239
Topo	4955361.473	768884.505	271.225
Topo	4955361.296	768884.993	271.285
Topo	4955360.900	768884.180	271.255
Topo	4955360.852	768883.437	271.227
Topo	4955360.755	768882.757	271.194
Topo	4955361.169	768881.425	271.020
Topo	4955360.730	768879.896	270.786
Topo	4955360.266	768879.271	270.642
Topo	4955359.523	768877.661	270.679
Topo	4955359.431	768876.785	270.612
Topo	4955359.372	768875.868	270.647
Topo	4955359.480	768874.108	270.740
Topo	4955359.253	768872.910	270.724
Topo	4955359.351	768872.107	270.741
Topo	4955359.478	768871.335	270.677
Topo	4955359.198	768870.865	270.539
Topo	4955358.271	768869.492	270.457
Topo	4955357.285	768868.198	270.461
Topo	4955356.442	768866.727	270.491
Topo	4955356.465	768865.926	270.580
Topo	4955355.756	768864.907	270.708
Topo	4955355.223	768865.290	270.699
Topo	4955355.408	768865.811	270.588
Topo	4955355.566	768866.535	270.522
Topo	4955355.839	768867.691	270.458
Topo	4955355.737	768868.392	270.434
Topo	4955355.832	768869.133	270.363
Topo	4955355.717	768869.798	270.350
Topo	4955355.835	768870.866	270.383
Topo	4955356.123	768871.884	270.393
Topo	4955356.274	768872.488	270.410
Topo	4955356.271	768873.016	270.401
Topo	4955356.570	768874.039	270.596
Topo	4955356.732	768874.698	270.607
Topo	4955356.954	768875.436	270.605
Topo	4955357.156	768876.259	270.535
Topo	4955357.423	768877.024	270.588
Topo	4955358.053	768878.340	270.726
Topo	4955358.121	768879.129	270.671
Topo	4955358.273	768879.977	270.666
Topo	4955358.560	768880.922	270.799
Topo	4955358.692	768881.611	271.095
Topo	4955358.982	768882.431	271.128
Topo	4955359.292	768883.474	271.223
Topo	4955359.417	768884.509	271.172
Topo	4955358.924	768885.475	271.199
Topo	4955358.093	768886.025	271.142
Topo	4955357.237	768886.235	271.183
Topo	4955355.302	768886.600	271.143
Topo	4955354.335	768887.041	271.154
Topo	4955352.224	768887.812	271.068
Topo	4955351.102	768888.113	271.116
Topo	4955350.006	768888.319	271.106
Topo	4955348.918	768888.478	271.067
Topo	4955346.855	768888.766	271.102
Topo	4955345.902	768889.040	271.086

Topo	4955344.796	768889.287	271.085
Topo	4955343.707	768889.632	271.000
Topo	4955342.638	768889.917	271.074
Topo	4955340.479	768890.528	270.948
Topo	4955339.291	768890.534	270.952
Topo	4955338.298	768890.063	270.974
Topo	4955337.646	768889.270	270.974
Topo	4955337.167	768888.400	271.092
Topo	4955336.835	768887.539	271.119
Topo	4955336.589	768886.638	271.219
Topo	4955336.389	768885.752	271.184
Topo	4955336.293	768884.821	271.216
Topo	4955335.871	768883.169	271.039
Topo	4955335.777	768882.557	270.991
Topo	4955335.706	768881.887	270.952
Topo	4955335.705	768880.752	270.690
Topo	4955335.957	768879.757	270.472
Topo	4955342.755	768849.411	271.102
Topo	4955342.896	768850.104	271.132
Topo	4955341.931	768850.788	271.114
Topo	4955341.407	768850.754	271.128
Topo	4955340.930	768851.014	271.082
Topo	4955340.414	768851.102	271.120
Topo	4955339.934	768851.433	271.061
Topo	4955339.034	768851.984	270.959
Topo	4955338.391	768852.004	271.022
Topo	4955337.787	768852.246	270.966
Topo	4955337.266	768852.244	270.890
Topo	4955336.703	768852.440	270.897
Topo	4955335.948	768852.496	270.953
Topo	4955333.592	768850.143	271.047
Topo	4955333.641	768849.602	271.052
Topo	4955332.762	768847.096	271.112
Topo	4955333.006	768846.564	271.121
Topo	4955332.931	768846.055	271.114
Topo	4955332.986	768845.512	271.218
Topo	4955332.794	768844.850	271.172
Topo	4955332.539	768843.642	271.203
Topo	4955332.273	768840.399	271.278
Topo	4955332.535	768839.739	271.341
Topo	4955332.964	768838.479	271.366
Topo	4955333.047	768837.785	271.383
Topo	4955332.975	768837.086	271.425
Topo	4955332.921	768836.370	271.516
Topo	4955333.049	768835.607	271.575
Topo	4955332.939	768834.921	271.625
Topo	4955332.735	768834.227	271.639
Topo	4955332.622	768833.666	271.698
Topo	4955331.078	768832.555	271.767
Topo	4955330.543	768832.725	271.703
Topo	4955329.910	768832.547	271.701
Topo	4955329.375	768832.412	271.689
Topo	4955328.652	768825.907	272.111
Topo	4955329.371	768825.494	272.186
Topo	4955330.534	768824.312	272.345
Topo	4955332.022	768818.477	272.675
Topo	4955333.444	768811.797	273.260
Topo	4955332.973	768811.245	273.339
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Topo	4955344.491	768787.459	276.113
Topo	4955349.501	768789.384	277.145

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Topo	4955341.470	768790.256	275.932
Topo	4955341.862	768790.617	275.897
Topo	4955342.383	768792.135	275.706
Topo	4955342.382	768792.881	275.677
Topo	4955342.137	768794.356	275.445
Topo	4955341.636	768795.299	275.418
Topo	4955340.718	768798.296	275.016
Topo	4955340.117	768801.339	274.628
Topo	4955342.217	768807.783	273.939
Topo	4955342.856	768807.830	273.969
Topo	4955343.604	768807.674	273.930
Topo	4955344.926	768807.695	273.954
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Topo	4955350.695	768822.538	272.272
Topo	4955350.608	768823.571	272.171
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Topo	4955350.936	768824.921	271.982
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Topo	4955356.518	768824.741	271.920
Topo	4955357.140	768824.733	271.912
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Topo	4955358.293	768824.709	271.814
Topo	4955359.048	768824.422	271.839
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Topo	4955358.570	768820.870	272.090
Topo	4955357.754	768820.543	272.181
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Topo	4955354.128	768819.825	272.277
Topo	4955353.632	768818.763	272.397
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Topo	4955354.166	768817.182	272.409
Topo	4955354.444	768816.704	272.465
Topo	4955354.885	768815.949	272.502
Topo	4955354.917	768815.257	272.601
Topo	4955355.515	768814.109	272.740
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Topo	4955358.111	768812.804	272.660
Topo	4955358.688	768812.486	272.656
Topo	4955359.334	768812.563	272.641
Topo	4955359.886	768812.614	272.718
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Topo	4955363.692	768815.363	272.283
Topo	4955364.361	768815.554	272.236
Topo	4955365.193	768815.498	272.179
Topo	4955366.241	768815.455	272.175
Topo	4955368.067	768814.915	272.131
Topo	4955368.842	768814.732	272.090
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Topo	4955374.267	768808.722	272.182
Topo	4955375.612	768807.581	272.315
Topo	4955377.565	768805.481	272.444
Topo	4955379.012	768805.495	272.376

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Topo	4955380.469	768805.586	272.337
Topo	4955382.609	768805.960	272.319
Topo	4955383.954	768807.489	272.218
Topo	4955384.503	768808.110	272.288
Topo	4955384.586	768808.650	272.253
Topo	4955382.415	768810.284	272.145
Topo	4955381.760	768810.580	272.112
Topo	4955381.212	768810.807	272.065
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Topo	4955377.518	768815.744	272.063
Topo	4955377.334	768815.141	271.945
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Topo	4955375.150	768812.613	272.022
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Topo	4955374.472	768811.353	272.091
Topo	4955374.359	768810.831	272.122
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Topo	4955372.973	768811.224	272.177
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Topo	4955371.574	768811.524	272.208
Topo	4955371.059	768811.653	272.197
Topo	4955370.502	768812.057	272.179
Topo	4955369.875	768812.282	272.212
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Topo	4955365.553	768814.963	272.279
Topo	4955364.949	768815.079	272.278
Topo	4955364.385	768815.037	272.346
Topo	4955363.782	768815.409	272.316
Topo	4955363.128	768815.537	272.352
Topo	4955362.386	768815.763	272.307
Topo	4955361.717	768815.954	272.325
Topo	4955360.515	768816.369	272.466
Topo	4955359.759	768816.611	272.420
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Topo	4955357.573	768817.307	272.471
Topo	4955357.026	768817.514	272.465
Topo	4955356.533	768817.923	272.411
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Topo	4955353.163	768820.502	272.390
Topo	4955352.721	768821.418	272.238
Topo	4955352.313	768821.991	272.229
Topo	4955351.949	768822.448	272.225

Topo	4955351.424	768822.808	272.211
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Topo	4955350.125	768823.387	272.222
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Topo	4955344.183	768825.049	272.176
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Topo	4955342.426	768827.151	272.028
Topo	4955342.089	768827.542	272.061
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Topo	4955339.109	768831.806	271.864
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Topo	4955328.784	768837.761	271.331
Topo	4955327.471	768837.598	271.371
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Topo	4955323.521	768837.909	271.430
Topo	4955322.990	768837.673	271.482
Topo	4955322.414	768837.518	271.458
Topo	4955321.638	768836.241	271.526
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Topo	4955325.476	768834.405	271.489
Topo	4955325.646	768835.288	271.547
Topo	4955325.854	768835.808	271.560
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Topo	4955332.613	768836.498	271.413

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Topo	4955335.415	768846.340	271.106
Topo	4955335.813	768846.783	271.146
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Topo	4955343.282	768844.897	271.238
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Topo	4955344.562	768844.501	271.303
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Topo	4955346.420	768833.514	271.565
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Topo	4955352.838	768841.301	271.139

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Topo	4955356.532	768841.218	271.098
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Topo	4955359.463	768837.288	271.314
Topo	4955359.874	768835.737	271.346
Topo	4955359.932	768834.713	271.394
Topo	4955359.952	768833.791	271.503
Topo	4955359.965	768832.827	271.501
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Topo	4955360.069	768831.080	271.726
Topo	4955359.449	768830.351	271.687
Topo	4955358.616	768829.761	271.783
Topo	4955357.781	768828.961	271.692
Topo	4955357.032	768828.431	271.704
Topo	4955356.311	768827.454	271.743
Topo	4955355.916	768826.618	271.898
Topo	4955355.430	768826.002	271.957
Topo	4955354.870	768825.181	272.023
Topo	4955355.871	768823.862	272.143
Topo	4955356.543	768823.356	272.122
Topo	4955358.007	768822.351	272.032
Topo	4955359.363	768821.460	271.988
Topo	4955360.171	768821.076	271.937
Topo	4955361.041	768820.798	271.901
Topo	4955362.049	768820.826	271.897
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Topo	4955364.645	768822.530	271.781
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Topo	4955365.669	768824.200	271.627
Topo	4955365.924	768825.212	271.626
Topo	4955366.118	768826.208	271.596
Topo	4955366.231	768827.083	271.574
Topo	4955366.574	768828.083	271.515
Topo	4955366.821	768828.942	271.551
Topo	4955366.996	768829.873	271.430
Topo	4955367.022	768830.880	271.533
Topo	4955367.013	768831.560	271.622
Topo	4955366.980	768833.430	271.386
Topo	4955367.086	768834.444	271.508
Topo	4955366.997	768835.339	271.449
Topo	4955367.046	768836.378	271.404
Topo	4955367.297	768837.376	271.342
Topo	4955367.500	768838.904	271.235
Topo	4955367.853	768839.824	271.125
Topo	4955368.185	768840.509	271.146
Topo	4955368.791	768840.830	271.115
Topo	4955370.209	768839.978	271.298
Topo	4955370.912	768839.367	271.349
Topo	4955371.589	768838.852	271.380
Topo	4955373.256	768837.908	271.191
Topo	4955373.654	768836.785	271.243
Topo	4955373.452	768835.747	271.217
Topo	4955373.301	768834.921	271.197

Topo	4955373.210	768834.136	271.246
Topo	4955372.950	768833.499	271.364
Topo	4955372.675	768832.779	271.338
Topo	4955371.710	768831.246	271.363
Topo	4955371.204	768830.556	271.441
Topo	4955370.599	768830.006	271.401
Topo	4955369.977	768828.961	271.380
Topo	4955369.697	768828.018	271.479
Topo	4955369.289	768827.075	271.471
Topo	4955368.723	768824.955	271.584
Topo	4955368.750	768823.876	271.574
Topo	4955368.775	768822.962	271.661
Topo	4955368.951	768822.032	271.640
Topo	4955368.720	768821.044	271.697
Topo	4955368.472	768820.228	271.732
Topo	4955368.165	768819.247	271.850
Topo	4955367.825	768818.430	271.903
Topo	4955367.898	768817.824	271.892
Topo	4955367.868	768817.122	272.001
Topo	4955368.400	768816.141	271.994
Topo	4955369.280	768815.647	272.106
Topo	4955370.326	768815.326	272.007
Topo	4955371.439	768815.485	272.031
Topo	4955372.498	768815.640	271.966
Topo	4955373.370	768815.704	271.896
Topo	4955374.421	768815.759	271.884
Topo	4955375.199	768816.125	271.916
Topo	4955375.903	768816.924	271.850
Topo	4955376.405	768817.868	271.778
Topo	4955377.378	768818.665	271.890
Topo	4955377.871	768819.073	271.887
Topo	4955378.460	768819.711	271.800
Topo	4955378.740	768820.240	271.698
Topo	4955379.140	768820.894	271.597
Topo	4955379.750	768821.671	271.557
Topo	4955380.333	768822.440	271.548
Topo	4955380.958	768823.186	271.547
Topo	4955381.912	768824.070	271.592
Topo	4955382.427	768824.457	271.559
Topo	4955382.964	768824.991	271.496
Topo	4955383.452	768825.174	271.520
Topo	4955384.037	768825.666	271.497
Topo	4955383.650	768826.279	271.468
Topo	4955383.296	768827.023	271.403
Topo	4955383.084	768827.656	271.416
Topo	4955383.001	768828.569	271.333
Topo	4955382.952	768829.541	271.357
Topo	4955382.711	768830.331	271.329
Topo	4955382.941	768831.741	271.255
Topo	4955382.998	768832.281	271.253
Topo	4955382.983	768832.843	271.237
Topo	4955383.154	768834.418	271.184
Topo	4955392.124	768827.385	271.382
Topo	4955392.426	768825.630	271.487
Topo	4955392.356	768825.116	271.473
Topo	4955392.501	768823.822	271.567
Topo	4955392.527	768823.123	271.533
Topo	4955392.522	768822.260	271.610
Topo	4955392.420	768821.042	271.707
Topo	4955392.511	768820.392	271.712
Topo	4955392.486	768819.640	271.716

Topo	4955392.407	768818.850	271.753
Topo	4955392.474	768818.074	271.808
Topo	4955392.541	768816.621	271.924
Topo	4955392.412	768815.817	271.915
Topo	4955392.792	768812.318	272.155
Topo	4955392.886	768811.177	272.172
Topo	4955392.949	768810.560	272.220
Topo	4955392.780	768809.832	272.209
Topo	4955392.549	768809.106	272.212
Topo	4955392.412	768808.445	272.307
Topo	4955391.772	768806.928	272.337
Topo	4955391.545	768806.121	272.316
Topo	4955394.091	768803.632	272.555
Topo	4955395.032	768802.875	272.570
Topo	4955396.148	768801.938	272.653
Topo	4955396.848	768801.486	272.647
Topo	4955397.577	768801.124	272.647
Topo	4955399.149	768799.183	272.885
Topo	4955399.871	768797.970	273.063
Topo	4955399.940	768797.357	273.165
Topo	4955397.884	768796.509	273.061
Topo	4955397.000	768796.506	273.036
Topo	4955396.180	768796.408	272.972
Topo	4955395.311	768796.474	272.981
Topo	4955394.430	768796.712	272.971
Topo	4955393.503	768796.765	272.872
Topo	4955391.706	768796.938	272.858
Topo	4955390.691	768796.868	272.699
Topo	4955389.633	768796.752	272.677
Topo	4955388.604	768796.878	272.602
Topo	4955386.570	768797.729	272.606
Topo	4955385.707	768798.295	272.615
Topo	4955384.851	768799.025	272.587
Topo	4955384.022	768799.671	272.674
Topo	4955383.157	768800.205	272.596
Topo	4955382.284	768800.482	272.636
Topo	4955380.321	768800.452	272.680
Topo	4955378.768	768799.727	272.810
Topo	4955378.010	768799.258	272.871
Topo	4955377.450	768798.866	272.982
Topo	4955376.815	768798.728	273.018
Topo	4955375.381	768798.868	272.985
Topo	4955374.001	768799.580	273.005
Topo	4955373.608	768800.256	272.987
Topo	4955373.131	768800.769	273.017
Topo	4955372.638	768801.765	273.012
Topo	4955371.984	768803.824	272.902
Topo	4955370.690	768807.860	272.514
Topo	4955369.493	768807.196	272.660
Topo	4955367.613	768805.071	273.037
Topo	4955367.002	768804.594	273.119
Topo	4955366.159	768804.053	273.226
Topo	4955365.260	768803.292	273.440
Topo	4955364.746	768802.873	273.475
Topo	4955364.424	768802.218	273.544
Topo	4955363.449	768801.285	273.829
Topo	4955362.975	768800.983	273.850
Topo	4955362.423	768800.789	273.896
Topo	4955361.980	768800.486	273.960
Topo	4955361.284	768800.383	273.961
Topo	4955360.743	768800.000	274.049

Topo	4955360.255	768799.790	274.069
Topo	4955359.760	768799.393	274.145
Topo	4955359.193	768799.176	274.178
Topo	4955358.647	768798.617	274.246
Topo	4955357.570	768797.701	274.380
Topo	4955357.265	768797.097	274.420
Topo	4955356.569	768796.781	274.473
Topo	4955355.968	768796.995	274.587
Topo	4955355.327	768797.021	274.641
Topo	4955353.938	768797.227	274.606
Topo	4955353.095	768797.549	274.678
Topo	4955352.237	768798.027	274.757
Topo	4955351.319	768798.281	274.761
Topo	4955349.585	768798.436	274.850
Topo	4955348.886	768798.182	274.901
Topo	4955347.246	768797.705	274.915
Topo	4955347.711	768797.019	274.979
Topo	4955349.043	768795.768	274.976
Topo	4955350.753	768794.713	275.070
Topo	4955351.459	768794.209	275.012
Topo	4955352.828	768793.561	275.041
Topo	4955354.133	768794.311	274.912
Topo	4955354.829	768794.829	274.820
Topo	4955357.146	768796.009	274.526
Topo	4955358.030	768795.895	274.508
Topo	4955361.260	768795.622	274.301
Topo	4955362.370	768795.611	274.279
Topo	4955363.110	768795.635	274.279
Topo	4955363.879	768795.522	274.161
Topo	4955364.482	768795.457	274.198
Topo	4955365.512	768795.408	274.201
Topo	4955367.029	768795.138	274.123
Topo	4955367.705	768795.270	274.072
Topo	4955369.626	768795.137	273.894
Topo	4955371.247	768794.853	273.845
Topo	4955371.994	768794.810	273.730
Topo	4955372.620	768794.936	273.711
Topo	4955373.425	768794.918	273.663
Topo	4955374.157	768795.094	273.628
Topo	4955374.942	768795.087	273.510
Topo	4955375.762	768794.995	273.432
Topo	4955376.679	768794.852	273.453
Topo	4955377.550	768794.763	273.324
Topo	4955378.288	768794.743	273.326
Topo	4955378.823	768795.290	273.307
Topo	4955378.414	768796.162	273.138
Topo	4955377.589	768796.793	273.161
Topo	4955376.695	768797.297	273.100
Topo	4955375.795	768797.866	273.084
Topo	4955375.085	768798.460	273.087
Topo	4955374.580	768798.980	273.067
Topo	4955374.037	768799.250	273.032
Topo	4955373.202	768799.860	273.025
Topo	4955372.239	768800.497	273.149
Topo	4955370.382	768801.509	273.201
Topo	4955369.652	768801.793	273.257
Topo	4955368.491	768802.357	273.165
Topo	4955367.392	768802.682	273.221
Topo	4955366.452	768802.351	273.358
Topo	4955365.539	768801.756	273.568
Topo	4955364.775	768801.533	273.670

Topo	4955364.186	768801.608	273.705
Topo	4955363.116	768800.904	273.809
Topo	4955362.421	768800.403	273.904
Topo	4955361.660	768800.133	273.990
Topo	4955359.874	768799.936	274.108
Topo	4955358.884	768799.981	274.029
Topo	4955357.840	768800.157	274.067
Topo	4955356.763	768800.277	274.080
Topo	4955353.879	768800.105	274.401
Topo	4955353.756	768800.615	274.351
Topo	4955353.400	768801.781	274.146
Topo	4955353.546	768802.640	274.036
Topo	4955353.742	768803.330	273.978
Topo	4955353.882	768804.120	273.789
Topo	4955354.340	768805.667	273.663
Topo	4955354.883	768806.421	273.586
Topo	4955355.246	768807.303	273.423
Topo	4955354.957	768808.391	273.413
Topo	4955354.057	768808.978	273.397
Topo	4955353.115	768809.303	273.455
Topo	4955352.186	768809.383	273.427
Topo	4955351.264	768809.519	273.535
Topo	4955350.913	768809.127	273.581
Topo	4955350.782	768808.073	273.653
Topo	4955350.688	768806.962	273.744
Topo	4955350.387	768806.278	273.779
Topo	4955349.920	768805.554	273.885
Topo	4955348.638	768803.353	274.221
Topo	4955347.950	768802.844	274.375
Topo	4955346.891	768803.060	274.387
Topo	4955346.338	768803.743	274.307
Topo	4955345.968	768804.471	274.306
Topo	4955345.737	768805.258	274.144
Topo	4955345.525	768806.114	274.019
Topo	4955345.302	768806.861	273.998
Topo	4955345.266	768807.378	273.920
Topo	4955344.897	768808.015	273.884
Topo	4955344.459	768808.573	273.884
Topo	4955343.935	768809.059	273.885
Topo	4955343.549	768809.473	273.806
Topo	4955342.980	768809.655	273.699
Topo	4955342.778	768810.366	273.673
Topo	4955342.735	768811.016	273.624
Topo	4955342.578	768811.523	273.511
Topo	4955341.372	768811.230	273.652
Topo	4955340.974	768810.493	273.705
Topo	4955340.305	768809.795	273.650
Topo	4955339.410	768809.113	273.819
Topo	4955338.601	768808.279	273.826
Topo	4955337.935	768807.361	273.934
Topo	4955337.291	768806.587	273.973
Topo	4955336.493	768805.932	274.071
Topo	4955335.625	768805.127	274.068
Topo	4955334.905	768804.378	274.299
Topo	4955334.016	768803.921	274.273
Topo	4955332.960	768803.688	274.210
Topo	4955332.055	768803.624	274.216
Topo	4955331.207	768803.768	274.144
Topo	4955330.296	768803.962	274.069
Topo	4955329.168	768803.783	274.001
Topo	4955329.078	768802.224	274.168

Topo	4955341.557	768798.978	274.352
Topo	4955342.121	768798.574	274.361
Topo	4955342.873	768797.888	274.392
Topo	4955343.319	768797.120	274.473
Topo	4955344.396	768795.635	274.646
Topo	4955344.964	768794.880	274.621
Topo	4955345.499	768794.174	274.682
Topo	4955333.897	768803.375	273.612
Topo	4955333.246	768803.989	273.377
Topo	4955332.681	768805.454	273.310
Topo	4955332.590	768806.174	273.155
Topo	4955332.268	768807.068	273.000
Topo	4955332.087	768807.787	272.908
Topo	4955332.358	768809.384	272.790
Topo	4955332.299	768810.058	272.737
Topo	4955332.100	768810.685	272.611
Topo	4955331.613	768811.015	272.529
Topo	4955327.788	768809.358	272.682
Topo	4955327.167	768809.218	272.628
Topo	4955326.541	768808.873	272.617
Topo	4955325.350	768808.170	272.628
Topo	4955324.568	768807.884	272.677
Topo	4955323.822	768807.697	272.638
Topo	4955322.847	768807.080	272.673
Topo	4955323.314	768805.732	272.884
Topo	4955322.235	768803.830	273.046
Topo	4955322.803	768800.981	273.402
Topo	4955323.632	768799.598	273.431
Topo	4955324.216	768799.384	273.566
Topo	4955327.047	768798.165	273.688
Topo	4955327.598	768798.291	273.728
Topo	4955328.259	768798.588	273.767
Topo	4955329.544	768799.085	273.836
Topo	4955331.257	768800.818	273.714
Topo	4955330.259	768803.110	273.397
Topo	4955329.513	768803.116	273.327
Topo	4955329.065	768801.325	273.503
Topo	4955328.331	768801.112	273.472
Topo	4955327.648	768801.171	273.444
Topo	4955326.810	768800.955	273.426
Topo	4955325.964	768800.578	273.383
Topo	4955324.526	768799.933	273.488
Topo	4955323.230	768799.449	273.464
Topo	4955320.431	768798.682	273.231
Topo	4955320.909	768798.381	273.306
Topo	4955321.643	768798.531	273.334
Topo	4955323.583	768798.217	273.558
Topo	4955324.120	768798.051	273.630
Topo	4955324.848	768798.316	273.629
Topo	4955342.109	768786.385	276.448
Topo	4955341.730	768785.743	276.466
Topo	4955341.303	768784.473	276.474
Topo	4955340.427	768783.238	276.616
Topo	4955342.128	768786.166	276.476
Topo	4955344.084	768787.378	276.190
Topo	4955344.579	768787.681	276.200
Topo	4955348.337	768789.701	275.743
Topo	4955350.927	768791.039	275.470
Topo	4955351.405	768791.197	275.441
Topo	4955352.378	768791.917	275.285
Topo	4955353.093	768792.364	275.280

Topo	4955354.620	768792.965	275.051
Topo	4955355.379	768793.380	275.053
Topo	4955356.132	768793.566	274.973
Topo	4955357.792	768794.078	274.785
Topo	4955359.779	768794.322	274.619
Topo	4955361.383	768794.343	274.565
Topo	4955361.959	768793.767	274.509
Topo	4955362.157	768793.207	274.555
Topo	4955362.983	768790.832	274.526
Topo	4955364.074	768789.837	274.480
Topo	4955367.195	768789.051	274.281
Topo	4955367.793	768788.869	274.270
Topo	4955372.315	768790.865	273.752
Topo	4955372.460	768791.392	272.767
Topo	4955373.175	768792.528	272.618
Topo	4955377.329	768792.790	271.972
Topo	4955376.438	768788.048	271.934
Topo	4955342.446	768786.645	276.405
cowpath	4955336.094	768778.172	277.724
cowpath	4955336.491	768779.650	277.501
cowpath	4955337.346	768781.140	277.213
cowpath	4955338.557	768782.546	277.008
cowpath	4955339.808	768783.685	276.852
cowpath	4955341.089	768785.046	276.667
cowpath	4955343.074	768786.626	276.431
cowpath	4955345.415	768788.105	276.193
cowpath	4955347.253	768789.405	276.014
cowpath	4955349.531	768790.654	275.762
cowpath	4955352.540	768791.803	275.496
cowpath	4955355.332	768792.964	275.194
cowpath	4955359.071	768793.575	274.950
cowpath	4955362.539	768794.480	274.652
cowpath	4955365.436	768794.579	274.484
cowpath	4955369.299	768794.291	274.172
cowpath	4955373.220	768794.201	273.898
cowpath	4955376.520	768793.917	273.622
cowpath	4955379.771	768793.801	273.454
cowpath	4955384.912	768794.231	273.383
cowpath	4955361.228	768789.588	274.868
cowpath	4955358.532	768789.765	275.085
cowpath	4955355.075	768788.964	275.411
cowpath	4955352.559	768787.796	275.620
cowpath	4955350.701	768787.010	275.794
cowpath	4955348.767	768785.919	275.978
cowpath	4955346.828	768784.950	276.177
cowpath	4955344.894	768783.594	276.448
cowpath	4955342.921	768781.869	276.702
cowpath	4955341.176	768780.173	277.065
cowpath	4955339.667	768778.480	277.390
cowpath	4955338.844	768776.541	277.651
cowpath	4955338.751	768779.751	277.142
cowpath	4955340.424	768781.834	276.839
cowpath	4955342.544	768783.957	276.553
cowpath	4955346.020	768786.399	276.172
cowpath	4955349.580	768788.452	275.780
cowpath	4955354.861	768790.679	275.300
cowpath	4955359.663	768791.606	274.921
cowpath	4955365.883	768791.508	274.452
cowpath	4955372.024	768790.718	273.978
cowpath	4955377.694	768790.599	273.546
fencepost	4955356.251	768795.294	274.918

fencepost	4955356.668	768789.238	275.200
fencepost	4955336.599	768781.833	277.361
fencepost	4955341.991	768786.756	276.528
Route 102 edge	4955334.087	768899.359	271.862
Route 102 edge	4955347.310	768893.365	271.811
Route 102 edge	4955365.506	768886.654	271.877
Route 102 edge	4955384.773	768881.290	271.889
Route 102 edge	4955404.682	768877.391	271.904
Drainage Gully	4955335.625	768782.849	277.408
Drainage Gully	4955333.648	768781.463	278.399
Drainage Gully	4955331.862	768780.565	279.153
Drainage Gully	4955330.653	768778.836	280.110
Drainage Gully	4955329.765	768776.939	281.346
Drainage Gully	4955327.711	768774.982	282.802
Drainage Gully	4955332.169	768778.616	279.873
Drainage Gully	4955333.159	768779.338	279.136
Drainage Gully	4955333.410	768778.075	279.065
Drainage Gully	4955332.582	768777.455	280.068
Drainage Gully	4955334.568	768777.566	278.324
Drainage Gully	4955335.033	768779.327	277.924
Drainage Gully	4955335.870	768780.843	277.728
Drainage Gully	4955336.744	768781.216	277.341
Drainage Gully	4955335.619	768778.360	277.451
Drainage Gully	4955336.844	768778.053	277.408
Drainage Gully	4955338.536	768777.328	277.408
Drainage Gully	4955339.794	768777.069	278.186
Drainage Gully	4955339.211	768775.451	278.331
Drainage Gully	4955338.485	768775.633	277.677
Drainage Gully	4955336.225	768776.304	277.739
Drainage Gully	4955335.377	768776.417	277.978
Drainage Gully	4955334.725	768776.540	278.344
Drainage Gully	4955348.925	768784.627	276.050
Drainage Gully	4955350.318	768783.522	276.159
Drainage Gully	4955351.915	768783.241	276.477
Drainage Gully	4955353.097	768782.433	276.975
Drainage Gully	4955354.063	768785.110	276.409
Drainage Gully	4955353.140	768786.707	275.646
Drainage Gully	4955354.382	768788.053	275.438
Drainage Gully	4955355.350	768787.024	275.685
Drainage Gully	4955356.265	768788.122	275.285
Drainage Gully	4955356.832	768787.113	275.525
Drainage Gully	4955357.202	768788.116	275.225
Drainage Gully	4955345.159	768782.467	276.635
Drainage Gully	4955343.286	768781.066	276.950
Drainage Gully	4955345.427	768781.302	276.997
Drainage Gully	4955346.038	768780.338	277.619
Drainage Gully	4955344.034	768779.523	277.858
Drainage Gully	4955340.655	768779.773	277.192
Drainage Gully	4955341.524	768778.811	277.930
Drainage Gully	4955343.276	768777.542	278.767
Drainage Gully	4955344.515	768775.107	280.545
Drainage Gully	4955345.230	768773.040	282.216
Drainage Gully	4955346.623	768769.931	284.687
Drainage Gully	4955347.319	768767.648	286.238
Drainage Gully	4955338.500	768773.661	278.508
Drainage Gully	4955337.912	768773.837	277.993
Drainage Gully	4955335.539	768775.284	277.987
Drainage Gully	4955334.713	768775.328	278.227
Drainage Gully	4955333.526	768775.554	279.015
Drainage Gully	4955332.281	768775.867	280.043
Drainage Gully	4955331.095	768776.141	281.158

Drainage Gully	4955329.993	768774.856	281.658
Drainage Gully	4955331.290	768773.595	280.791
Drainage Gully	4955332.356	768772.679	279.749
Drainage Gully	4955333.067	768773.939	279.275
Drainage Gully	4955333.972	768773.167	278.617
Drainage Gully	4955336.230	768770.570	278.649
Drainage Gully	4955336.693	768770.273	279.027
Drainage Gully	4955337.304	768769.851	279.156
Drainage Gully	4955336.345	768768.617	279.293
Drainage Gully	4955335.699	768769.811	279.017
Drainage Gully	4955335.093	768769.928	278.854
Drainage Gully	4955333.097	768771.529	278.853
Drainage Gully	4955332.127	768772.214	279.486
Drainage Gully	4955330.805	768772.379	280.551
Drainage Gully	4955329.301	768772.948	281.701
Drainage Gully	4955327.665	768774.578	282.931
Drainage Gully	4955326.264	768774.516	283.468
Drainage Gully	4955327.574	768772.998	282.985
Drainage Gully	4955329.124	768772.048	281.610
Drainage Gully	4955329.778	768770.980	280.697
Drainage Gully	4955330.317	768770.310	279.941
Drainage Gully	4955330.872	768769.766	279.509
Drainage Gully	4955333.226	768767.900	279.417
Drainage Gully	4955334.196	768767.481	279.577
Drainage Gully	4955335.113	768767.003	279.605
Drainage Gully	4955338.147	768772.778	278.624
Drainage Gully	4955337.524	768773.082	278.136
Drainage Gully	4955336.042	768773.760	278.160
Drainage Gully	4955333.505	768766.135	280.030
Drainage Gully	4955333.199	768766.597	279.940
Drainage Gully	4955332.851	768766.883	279.617
Drainage Gully	4955330.487	768768.148	279.736
Drainage Gully	4955329.472	768769.243	280.096
Drainage Gully	4955328.026	768770.153	281.402
Drainage Gully	4955326.397	768771.307	282.722
Drainage Gully	4955325.352	768772.460	284.242
Drainage Gully	4955325.417	768773.903	283.856
Drainage Gully	4955323.109	768772.943	285.264
Drainage Gully	4955323.883	768771.555	285.351
Drainage Gully	4955324.618	768770.366	284.230
Drainage Gully	4955325.494	768769.203	282.826
Drainage Gully	4955327.190	768768.677	281.303
Drainage Gully	4955328.059	768767.840	280.659
Drainage Gully	4955328.719	768767.127	280.218
Drainage Gully	4955330.963	768765.565	279.942
Drainage Gully	4955331.638	768764.897	280.197
Drainage Gully	4955332.056	768764.489	280.398
Drainage Gully	4955330.982	768763.349	280.599
Drainage Gully	4955330.399	768763.668	280.381
Drainage Gully	4955328.532	768764.615	280.429
Drainage Gully	4955327.788	768765.651	280.526
Drainage Gully	4955326.942	768766.430	281.020
Drainage Gully	4955325.938	768767.130	281.446
Drainage Gully	4955323.929	768768.113	283.403
Drainage Gully	4955322.344	768769.500	285.349
Drainage Gully	4955321.681	768771.810	287.573
Drainage Gully	4955320.571	768771.405	287.961
Drainage Gully	4955317.078	768771.224	289.291
Drainage Gully	4955315.559	768771.013	289.641
Drainage Gully	4955314.355	768770.958	290.182
Drainage Gully	4955319.820	768770.310	287.984

Drainage Gully	4955320.859	768768.651	285.564
Drainage Gully	4955322.073	768767.249	283.852
Drainage Gully	4955324.194	768766.142	282.425
Drainage Gully	4955325.345	768765.330	281.337
Drainage Gully	4955326.030	768764.275	281.039
Drainage Gully	4955327.106	768763.724	280.780
Drainage Gully	4955329.101	768761.919	280.753
Drainage Gully	4955329.459	768761.561	280.957
Drainage Gully	4955328.279	768760.358	281.207
Drainage Gully	4955327.831	768760.504	281.067
Drainage Gully	4955325.727	768761.643	281.160
Drainage Gully	4955324.954	768762.071	281.478
Drainage Gully	4955323.884	768762.735	281.775
Drainage Gully	4955322.051	768764.103	282.662
Drainage Gully	4955320.980	768765.635	284.138
Drainage Gully	4955319.631	768767.562	285.481
Drainage Gully	4955318.332	768769.151	287.437
Drainage Gully	4955316.748	768769.316	288.157
Drainage Gully	4955315.358	768768.431	288.514
Drainage Gully	4955315.398	768769.927	289.413
Drainage Gully	4955316.866	768767.684	287.138
Drainage Gully	4955318.446	768766.489	285.665
Drainage Gully	4955319.756	768764.737	284.165
Drainage Gully	4955320.959	768763.529	283.036
Drainage Gully	4955321.907	768762.098	282.310
Drainage Gully	4955322.509	768761.956	282.027
Drainage Gully	4955323.494	768760.969	282.092
Drainage Gully	4955323.858	768760.542	281.638
Drainage Gully	4955325.707	768759.075	281.412
Drainage Gully	4955326.051	768758.607	281.587
Drainage Gully	4955326.097	768758.509	281.775
Drainage Gully	4955326.445	768757.887	282.033
Drainage Gully	4955334.550	768776.274	278.448
Drainage Gully	4955336.214	768769.120	279.292
Drainage Gully	4955341.562	768787.583	276.465
Drainage Gully	4955341.560	768787.576	272.198
Drainage Gully	4955341.551	768787.587	272.200
Drainage Gully	4955341.558	768787.580	276.461
Drainage Gully	4955324.868	768756.353	282.463
Drainage Gully	4955324.411	768756.639	282.078
Drainage Gully	4955321.677	768758.918	282.230
Drainage Gully	4955321.016	768759.104	282.620
Drainage Gully	4955319.958	768760.080	282.710
Drainage Gully	4955319.180	768761.013	283.174
Drainage Gully	4955317.525	768762.801	284.627
Drainage Gully	4955314.994	768764.826	287.099
Drainage Gully	4955314.240	768767.212	288.859
Drainage Gully	4955310.844	768769.273	291.770
Drainage Gully	4955307.945	768767.847	292.362
Drainage Gully	4955306.281	768766.840	292.464
Drainage Gully	4955312.950	768767.534	289.743
Drainage Gully	4955314.997	768764.170	286.576
Drainage Gully	4955316.160	768762.350	285.219
Drainage Gully	4955317.813	768759.895	283.441
Drainage Gully	4955318.770	768759.339	282.851
Drainage Gully	4955319.376	768758.337	282.922
Drainage Gully	4955320.001	768757.523	283.067
Drainage Gully	4955320.696	768756.963	282.632
Drainage Gully	4955323.078	768755.389	282.604
Drainage Gully	4955323.471	768754.792	282.981
Drainage Gully	4955322.247	768753.406	283.304

Drainage Gully	4955321.810	768753.630	283.190
Drainage Gully	4955319.819	768755.698	283.104
Drainage Gully	4955318.717	768756.319	283.471
Drainage Gully	4955317.128	768757.293	283.228
Drainage Gully	4955315.719	768575.803	283.927
Drainage Gully	4955313.407	768758.349	285.465
Drainage Gully	4955310.946	768761.052	288.342
Drainage Gully	4955308.011	768764.376	290.846
Drainage Gully	4955302.850	768764.957	292.491
Drainage Gully	4955304.465	768763.443	291.188
Drainage Gully	4955308.653	768762.076	289.700
Drainage Gully	4955306.151	768761.593	289.526
Drainage Gully	4955307.220	768760.206	288.610
Drainage Gully	4955309.114	768760.896	289.040
Drainage Gully	4955304.204	768760.325	290.915
Drainage Gully	4955302.614	768756.983	290.512
Drainage Gully	4955303.411	768754.790	290.361
Drainage Gully	4955305.639	768753.301	288.909
Drainage Gully	4955305.443	768755.678	289.059
Drainage Gully	4955305.275	768757.515	289.302
Drainage Gully	4955307.102	768760.240	288.639
Drainage Gully	4955310.444	768760.539	288.436
Drainage Gully	4955308.534	768757.243	287.138
Drainage Gully	4955306.933	768756.057	287.987
Drainage Gully	4955307.863	768754.361	287.605
Drainage Gully	4955309.842	768754.055	287.053
Drainage Gully	4955309.995	768756.036	286.223
Drainage Gully	4955310.886	768757.867	286.454
Drainage Gully	4955312.123	768758.906	286.746
Drainage Gully	4955313.703	768758.439	285.223
Drainage Gully	4955312.394	768756.719	285.104
Drainage Gully	4955311.231	768754.149	285.893
Drainage Gully	4955312.285	768752.804	286.201
Drainage Gully	4955313.304	768755.349	284.274
Drainage Gully	4955314.479	768755.591	283.761
Drainage Gully	4955313.618	768757.516	285.036
Drainage Gully	4955315.550	768757.308	283.894
Drainage Gully	4955316.575	768755.339	284.164
Drainage Gully	4955317.097	768754.605	284.163
Drainage Gully	4955317.875	768753.688	284.094
Drainage Gully	4955316.690	768752.103	284.603
Drainage Gully	4955315.285	768752.742	284.846
Drainage Gully	4955314.115	768753.308	285.200
Drainage Gully	4955312.107	768752.604	286.489
Drainage Gully	4955313.154	768750.654	285.792
Drainage Gully	4955314.552	768749.335	285.605
Drainage Gully	4955314.922	768748.653	285.336
Drainage Gully	4955316.007	768750.592	284.618
Drainage Gully	4955317.832	768752.978	283.883
Drainage Gully	4955343.038	768773.359	281.324
Drainage Gully	4955336.215	768769.113	279.292
Drainage Gully	4955345.157	768769.318	284.598
Drainage Gully	4955347.223	768767.514	286.259
Drainage Gully	4955347.755	768764.447	287.511
Drainage Gully	4955348.545	768762.013	288.949
Drainage Gully	4955349.594	768760.284	289.599
Drainage Gully	4955343.553	768758.751	289.506
Drainage Gully	4955340.646	768755.233	289.872
Drainage Gully	4955338.142	768757.027	286.966
Drainage Gully	4955336.238	768757.416	285.669
Drainage Gully	4955340.294	768760.280	287.006

Drainage Gully	4955342.530	768762.412	286.703
Drainage Gully	4955345.280	768763.743	286.765
Drainage Gully	4955343.437	768765.890	284.463
Drainage Gully	4955341.747	768767.196	282.775
Drainage Gully	4955339.999	768765.163	283.466
Drainage Gully	4955339.339	768762.763	285.160
Drainage Gully	4955337.274	768762.001	284.290
Drainage Gully	4955335.151	768759.758	283.987
Drainage Gully	4955333.520	768760.876	282.175
Drainage Gully	4955332.722	768762.368	281.119
Drainage Gully	4955331.891	768763.148	280.555
Drainage Gully	4955334.104	768765.791	279.980
Drainage Gully	4955336.749	768764.428	282.288
Drainage Gully	4955339.155	768765.010	283.032
Drainage Gully	4955337.985	768766.172	281.358
Drainage Gully	4955336.595	768766.836	280.238
Drainage Gully	4955335.614	768767.433	279.457
Drainage Gully	4955337.375	768768.872	279.336
Drainage Gully	4955339.948	768767.630	281.426
Drainage Gully	4955342.672	768765.960	283.963
Drainage Gully	4955342.216	768767.840	282.887
Drainage Gully	4955340.125	768767.803	281.514
Drainage Gully	4955337.885	768770.164	279.086
Drainage Gully	4955329.102	768759.613	280.976
Drainage Gully	4955327.852	768759.134	281.239
Drainage Gully	4955326.344	768757.852	282.079
Drainage Gully	4955326.880	768757.712	281.830
Drainage Gully	4955327.184	768755.381	282.079
Drainage Gully	4955328.055	768754.301	282.531
Drainage Gully	4955327.444	768752.579	283.622
Drainage Gully	4955327.866	768750.634	284.978
Drainage Gully	4955330.377	768749.092	286.734
Drainage Gully	4955332.188	768746.657	289.650
Drainage Gully	4955333.447	768745.963	290.725
Drainage Gully	4955334.099	768747.925	289.932
Drainage Gully	4955333.539	768749.156	289.789
Drainage Gully	4955334.785	768749.437	289.197
Drainage Gully	4955333.580	768752.171	286.382
Drainage Gully	4955331.583	768751.446	286.260
Drainage Gully	4955332.011	768754.441	284.569
Drainage Gully	4955329.980	768752.787	284.255
Drainage Gully	4955329.673	768755.213	282.825
Drainage Gully	4955334.542	768776.266	278.432
Drainage Gully	4955336.212	768769.113	279.287
Drainage Gully	4955341.552	768787.583	276.459
Drainage Gully	4955329.379	768760.045	280.983
Drainage Gully	4955331.862	768758.365	282.814
Drainage Gully	4955331.598	768756.903	283.348
Drainage Gully	4955330.197	768757.694	282.243
Drainage Gully	4955330.012	768760.684	280.969
Drainage Gully	4955327.447	768765.168	280.764
Drainage Gully	4955330.627	768762.654	280.711
Drainage Gully	4955313.305	768751.631	286.181
Drainage Gully	4955311.049	768751.311	287.620
Drainage Gully	4955308.843	768751.649	289.304
Drainage Gully	4955306.974	768751.594	289.338
Drainage Gully	4955304.492	768751.156	290.935
Drainage Gully	4955301.988	768751.546	292.035
Drainage Gully	4955299.144	768752.269	293.098
Drainage Gully	4955302.142	768754.687	291.962
Drainage Gully	4955302.642	768753.118	291.460

Drainage Gully	4955301.720	768757.008	292.551
Drainage Gully	4955297.034	768753.950	293.205
Drainage Gully	4955297.959	768756.623	293.321
Drainage Gully	4955295.787	768751.918	293.682
Drainage Gully	4955295.504	768755.097	293.691
Drainage Gully	4955296.820	768757.474	293.504
Drainage Gully	4955293.848	768750.407	293.551
Drainage Gully	4955294.367	768748.772	293.708
Drainage Gully	4955296.148	768749.898	292.863
Drainage Gully	4955295.928	768747.933	293.276
Drainage Gully	4955297.936	768746.942	292.614
Drainage Gully	4955299.064	768749.208	291.834
Drainage Gully	4955300.539	768746.888	291.813
Drainage Gully	4955301.051	768749.131	291.102
Drainage Gully	4955303.429	768746.923	290.445
Drainage Gully	4955303.613	768748.939	289.926
Drainage Gully	4955305.407	768747.275	289.670
Drainage Gully	4955305.697	768749.522	289.041
Drainage Gully	4955308.102	768747.858	288.272
Drainage Gully	4955308.113	768749.497	288.202
Drainage Gully	4955310.999	768748.564	286.902
Drainage Gully	4955310.264	768746.945	287.317
Drainage Gully	4955313.451	768747.485	286.279
Drainage Gully	4955312.202	768745.490	289.067
Drainage Gully	4955310.406	768745.945	287.448
Drainage Gully	4955310.174	768743.271	288.498
Drainage Gully	4955308.620	768743.778	288.312
Drainage Gully	4955306.254	768742.378	289.212
Drainage Gully	4955306.834	768739.950	289.630
Drainage Gully	4955305.117	768738.576	290.037
Drainage Gully	4955303.051	768740.211	290.498
Drainage Gully	4955300.719	768742.171	291.213
Drainage Gully	4955301.095	768744.443	291.372
Drainage Gully	4955316.491	768750.259	284.703
Drainage Gully	4955315.420	768748.535	285.355
Drainage Gully	4955314.409	768747.393	285.835
Drainage Gully	4955313.422	768745.709	286.245
Drainage Gully	4955312.176	768743.660	286.889
Drainage Gully	4955310.413	768741.271	287.588
Drainage Gully	4955312.105	768739.915	287.392
Drainage Gully	4955314.378	768738.212	287.602
Drainage Gully	4955308.490	768739.082	288.349
Drainage Gully	4955310.009	768737.527	288.177
Drainage Gully	4955312.721	768735.752	288.192
Drainage Gully	4955311.312	768733.850	288.673
Drainage Gully	4955308.907	768735.368	288.768
Drainage Gully	4955306.698	768737.024	289.046
Drainage Gully	4955304.846	768735.080	289.418
Drainage Gully	4955306.630	768733.453	289.323
Drainage Gully	4955309.657	768731.449	289.065
Drainage Gully	4955307.345	768729.137	289.769
Drainage Gully	4955304.885	768731.034	289.818
Drainage Gully	4955302.466	768733.404	290.287
Drainage Gully	4955300.998	768730.454	290.813
Drainage Gully	4955302.959	768728.109	290.140
Drainage Gully	4955305.382	768726.449	290.493
Drainage Gully	4955302.795	768723.909	291.015
Drainage Gully	4955301.136	768725.470	290.678
Drainage Gully	4955299.971	768726.587	291.228
Drainage Gully	4955298.531	768727.578	291.516
Drainage Gully	4955296.630	768724.629	292.100

Drainage Gully	4955298.049	768723.467	291.786
Drainage Gully	4955298.798	768722.716	291.449
Drainage Gully	4955300.615	768721.495	291.713
Drainage Gully	4955298.604	768718.784	292.593
Drainage Gully	4955296.460	768720.302	292.158
Drainage Gully	4955294.640	768722.186	292.668
Drainage Gully	4955292.669	768719.299	293.149
Drainage Gully	4955293.735	768718.493	292.721
Drainage Gully	4955295.868	768717.430	292.873
Drainage Gully	4955296.698	768716.564	293.056
Drainage Gully	4955295.353	768714.541	293.888
Drainage Gully	4955293.550	768715.626	293.635
Drainage Gully	4955291.737	768717.123	293.207
Drainage Gully	4955289.767	768715.392	293.823
Drainage Gully	4955291.798	768713.927	294.277
Drainage Gully	4955295.214	768713.310	294.151
Drainage Gully	4955294.866	768712.278	294.409
Drainage Gully	4955293.501	768713.400	294.343
Drainage Gully	4955295.586	768712.596	294.571
Drainage Gully	4955294.582	768711.959	294.766
Drainage Gully	4955293.442	768713.055	294.651
Drainage Gully	4955292.712	768711.906	294.873
Drainage Gully	4955292.012	768711.669	294.742
Drainage Gully	4955290.169	768712.439	294.702
Drainage Gully	4955288.611	768713.977	294.257
Drainage Gully	4955285.104	768713.522	294.813
Drainage Gully	4955287.832	768711.276	294.825
Drainage Gully	4955290.360	768710.356	295.119
Drainage Gully	4955291.683	768709.437	295.064
Drainage Gully	4955293.793	768709.963	295.074
Drainage Gully	4955296.409	768710.520	295.065
Drainage Gully	4955292.717	768708.560	295.301
Drainage Gully	4955290.615	768707.809	295.405
Drainage Gully	4955288.301	768708.801	295.229
Drainage Gully	4955285.439	768710.549	295.062
Drainage Gully	4955283.303	768712.609	295.049
Drainage Gully	4955280.145	768713.075	295.321
Drainage Gully	4955281.451	768710.563	295.357
Drainage Gully	4955282.881	768708.568	295.449
Drainage Gully	4955284.867	768707.753	295.479
Drainage Gully	4955278.036	768708.600	295.660
Drainage Gully	4955278.298	768712.878	295.443
Drainage Gully	4955278.798	768714.915	295.431
Drainage Gully	4955278.738	768719.536	295.235
Drainage Gully	4955281.269	768726.169	294.850
Drainage Gully	4955284.940	768734.369	294.635
Drainage Gully	4955288.976	768741.473	294.139
Drainage Gully	4955290.448	768743.578	294.024
Drainage Gully	4955290.765	768745.804	294.035
Drainage Gully	4955292.782	768749.022	293.878
Drainage Gully	4955293.232	768746.789	293.862
Drainage Gully	4955294.814	768747.019	293.660
Drainage Gully	4955294.633	768745.788	293.180
Drainage Gully	4955292.231	768744.699	293.443
Drainage Gully	4955292.277	768742.769	293.433
Drainage Gully	4955293.502	768741.974	293.455
Drainage Gully	4955294.411	768744.123	292.994
Drainage Gully	4955296.811	768745.295	292.673
Drainage Gully	4955296.586	768742.882	292.503
Drainage Gully	4955296.145	768741.584	292.902
Drainage Gully	4955294.186	768739.517	293.202

Drainage Gully	4955292.534	768736.224	293.433
Drainage Gully	4955291.166	768733.598	293.586
Drainage Gully	4955288.660	768727.572	293.985
Drainage Gully	4955284.635	768721.286	294.474
Drainage Gully	4955284.892	768717.518	294.825
Drainage Gully	4955286.025	768715.028	294.744
Drainage Gully	4955288.295	768714.766	294.575
Drainage Gully	4955290.754	768717.267	293.845
Drainage Gully	4955289.247	768719.678	294.063
Drainage Gully	4955289.396	768723.059	293.845
Drainage Gully	4955293.090	768721.224	293.197
Drainage Gully	4955292.524	768726.105	293.262
Drainage Gully	4955293.754	768730.222	292.960
Drainage Gully	4955293.677	768733.701	292.896
Drainage Gully	4955294.922	768736.495	292.895
Drainage Gully	4955296.455	768738.875	292.540
Drainage Gully	4955297.728	768741.156	292.472
Drainage Gully	4955299.019	768742.691	291.752
Drainage Gully	4955300.948	768740.955	291.131
Drainage Gully	4955299.597	768738.501	291.572
Drainage Gully	4955296.734	768737.384	292.279
Drainage Gully	4955295.771	768734.580	292.451
Drainage Gully	4955296.982	768731.329	292.177
Drainage Gully	4955299.666	768730.751	291.544
Drainage Gully	4955299.648	768733.218	291.411
Drainage Gully	4955299.957	768736.238	291.458
Drainage Gully	4955301.336	768738.132	290.946
Drainage Gully	4955302.459	768739.935	290.812
Drainage Gully	4955303.412	768739.445	290.438
Drainage Gully	4955304.414	768738.050	290.168
Drainage Gully	4955303.804	768736.900	290.376
Drainage Gully	4955302.247	768735.566	290.833
Drainage Gully	4955300.455	768736.081	291.236
Drainage Gully	4955299.014	768733.167	291.551
Drainage Gully	4955300.385	768731.871	291.285
Drainage Gully	4955300.503	768733.741	291.147
Drainage Gully	4955301.897	768733.120	290.598
Drainage Gully	4955317.635	768748.584	284.833
Drainage Gully	4955318.614	768745.983	285.622
Drainage Gully	4955316.021	768744.327	286.110
Drainage Gully	4955317.070	768743.031	286.327
Drainage Gully	4955315.245	768739.473	287.140
Drainage Gully	4955313.319	768740.166	287.175
Drainage Gully	4955324.196	768753.948	283.531
Drainage Gully	4955324.153	768752.422	283.445
Drainage Gully	4955325.560	768753.885	282.651
Drainage Gully	4955322.668	768751.976	284.267
Drainage Gully	4955323.509	768751.589	283.702
Drainage Gully	4955326.353	768749.080	285.517
Drainage Gully	4955326.647	768747.070	283.779
Drainage Gully	4955327.257	768740.776	291.168
Drainage Gully	4955328.359	768738.529	292.401
Drainage Gully	4955324.917	768740.639	290.118
Drainage Gully	4955324.384	768743.763	288.322
Drainage Gully	4955321.677	768742.788	287.832
Drainage Gully	4955320.324	768742.698	287.183
Drainage Gully	4955322.971	768747.310	285.633
Drainage Gully	4955324.897	768747.913	285.915
Drainage Gully	4955320.533	768746.676	285.950
Drainage Gully	4955319.192	768745.805	286.242
Drainage Gully	4955319.684	768744.401	286.866

Drainage Gully	4955320.255	768743.671	286.815
Drainage Gully	4955317.882	768742.664	287.054
Drainage Gully	4955318.702	768741.803	287.312
Drainage Gully	4955320.542	768741.358	288.318
Drainage Gully	4955322.939	768738.816	290.375
Drainage Gully	4955323.528	768736.764	292.185
Drainage Gully	4955319.253	768736.874	290.724
Drainage Gully	4955317.754	768737.344	289.603
Drainage Gully	4955315.628	768738.322	287.986
Drainage Gully	4955312.473	768734.903	288.608
Drainage Gully	4955314.086	768733.863	289.872
Drainage Gully	4955315.674	768732.857	290.941
Drainage Gully	4955316.998	768731.511	292.988
Drainage Gully	4955314.302	768729.525	293.042
Drainage Gully	4955311.429	768726.250	292.948
Drainage Gully	4955310.108	768726.277	291.824
Drainage Gully	4955309.306	768725.655	291.233
Drainage Gully	4955309.704	768728.016	290.678
Drainage Gully	4955308.463	768727.713	290.487
Drainage Gully	4955308.420	768728.844	289.956
Drainage Gully	4955307.265	768727.856	290.132
Drainage Gully	4955306.338	768724.837	291.295
Drainage Gully	4955306.709	768724.128	291.410
Drainage Gully	4955304.357	768722.286	291.763
Drainage Gully	4955302.515	768722.439	291.689
Drainage Gully	4955327.492	768765.176	280.831
Drainage Gully	4955330.665	768762.663	280.785
Drainage Gully	4955300.969	768720.423	292.424
Drainage Gully	4955303.591	768720.115	292.183
Drainage Gully	4955301.360	768718.279	292.737
Drainage Gully	4955299.457	768718.857	292.866
Drainage Gully	4955297.625	768716.679	293.466
Drainage Gully	4955298.646	768715.544	293.330
Drainage Gully	4955299.452	768714.831	290.380
Drainage Gully	4955298.805	768712.535	293.856
Drainage Gully	4955297.470	768713.414	294.133
Drainage Gully	4955295.815	768714.017	294.217
Drainage Gully	4955296.728	768711.694	294.674
Drainage Gully	4955298.528	768711.512	294.323
Drainage Gully	4955297.636	768709.842	295.175
Drainage Gully	4955296.828	768711.126	294.835
Drainage Gully	4955289.815	768716.630	293.927
Drainage Gully	4955296.814	768710.615	294.950
Drainage Gully	4955288.131	768688.489	297.351
Drainage Gully	4955327.502	768765.178	280.879
Drainage Gully	4955330.682	768762.668	280.832
Drainage Gully	4955327.811	768734.020	294.229
Drainage Gully	4955325.843	768731.961	294.128
Drainage Gully	4955322.145	768728.417	294.582
Drainage Gully	4955317.683	768725.446	294.754
Drainage Gully	4955315.468	768723.281	294.765
Drainage Gully	4955311.313	768719.498	294.664
Drainage Gully	4955308.611	768717.426	295.009
Drainage Gully	4955306.179	768715.617	294.980
Drainage Gully	4955303.968	768713.515	295.260
Drainage Gully	4955303.525	768711.595	295.292
Drainage Gully	4955302.870	768708.224	295.317
Drainage Gully	4955301.776	768708.872	294.452
Drainage Gully	4955300.984	768708.135	295.357
Drainage Gully	4955300.358	768710.350	294.203
Drainage Gully	4955299.632	768713.025	293.723

Drainage Gully	4955298.003	768707.032	295.589
Drainage Gully	4955301.504	768703.322	295.927
Drainage Gully	4955297.849	768702.822	296.033
Drainage Gully	4955295.313	768700.191	296.376
Drainage Gully	4955290.634	768703.047	296.086
Drainage Gully	4955293.079	768706.539	295.505
Drainage Gully	4955286.323	768705.238	295.728
Drainage Gully	4955295.315	768752.826	293.572
Drainage Gully	4955296.261	768757.310	293.470
Drainage Gully	4955297.665	768760.217	293.396
Drainage Gully	4955297.294	768767.255	293.418
Trench Corner	4955341.282	768790.792	276.105
Trench Corner	4955341.936	768792.311	275.921
Trench Corner	4955339.791	768793.232	275.779
Trench Corner	4955341.647	768804.107	274.600
Trench Corner	4955341.647	768806.041	274.380
Trench Corner	4955340.292	768805.995	274.332
Trench Corner	4955337.820	768793.805	275.671
Trench Corner	4955330.157	768796.407	275.035
Trench Corner	4955329.328	768794.754	275.166
Trench Corner	4955339.939	768790.717	276.072
Trench Stake	4955339.939	768793.417	275.754
Trench Stake	4955340.467	768795.801	275.492
Trench Stake	4955341.004	768798.300	275.306
Trench Stake	4955340.417	768800.972	274.894
Trench Stake	4955341.711	768803.235	274.671
Trench Stake	4955341.878	768805.447	274.447
Trench Stake	4955329.339	768794.599	275.142
Trench Stake	4955331.031	768793.835	275.371
Trench Stake	4955333.114	768792.986	275.595
Trench Stake	4955335.819	768791.863	275.884
Trench Stake	4955337.938	768791.204	276.078
Trench Stake	4955340.923	768790.501	276.142
Grid Point-stem (Section 1, Grid 1)	4955339.873	768793.432	276.090
Grid Point-stem (Section 5/6, Grid 1)	4955340.993	768798.257	276.059
Grid Point-stem (Section 6/7, top of Grid 2)	4955340.900	768799.295	275.087
Grid Point-stem (Section 11, Grid 2)	4955341.729	768804.100	275.009
Grid Point-top (Section 1, Grid 1)	4955329.452	768794.624	276.061
Grid Point-top (Section 12, Grid 1)	4955340.684	768790.606	276.146

Bristol alluvial fan

Point Description	Northing	Easting	Elevation
Bench 1	4888916.385	656322.809	190.042
Bench2	4888922.904	656366.684	190.269
Bench 3	4888629.614	656318.956	188.441
Rt. 116 - edge	4888996.610	656314.576	191.005
Rt. 116 - edge	4888992.844	656314.813	191.014
Rt. 116 - edge	4888988.245	656315.068	190.994
Rt. 116 - edge	4888983.969	656315.337	190.968
Rt. 116 - edge	4888979.880	656315.648	190.931
Rt. 116 - edge	4888975.607	656315.900	190.916
Rt. 116 - edge	4888971.456	656316.208	190.854
Rt. 116 - edge	4888966.935	656316.454	190.858

Rt. 116 - edge	4888962.204	656316.837	190.848
Rt. 116 - edge	4888958.149	656317.169	190.809
Rt. 116 - edge	4888953.955	656317.346	190.758
Rt. 116 - edge	4888949.877	656317.558	190.731
Rt. 116 - edge	4888945.993	656317.859	190.668
Rt. 116 - edge	4888942.255	656318.070	190.589
Rt. 116 - edge	4888938.220	656318.300	190.528
Rt. 116 - edge	4888934.116	656318.519	190.478
Rt. 116 - edge	4888929.989	656318.838	190.432
Rt. 116 - edge	4888925.746	656319.274	190.364
Rt. 116 - edge	4888921.897	656319.634	190.266
Rt. 116 - edge	4888910.287	656320.414	190.187
Rt. 116 - edge	4888898.920	656320.759	190.034
Rt. 116 - edge	4888866.759	656322.665	189.428
Rt. 116 - edge	4888854.970	656323.406	189.238
Rt. 116 - edge	4888842.793	656324.163	189.076
Rt. 116 - edge	4888830.601	656324.981	188.943
Rt. 116 - edge	4888818.757	656325.692	188.850
Topo	4888817.954	656333.218	187.493
Topo	4888809.569	656335.245	187.415
Topo	4888821.221	656334.383	187.598
Topo	4888832.550	656333.680	188.079
Topo	4888844.450	656333.063	188.412
Topo	4888857.087	656332.593	188.795
Topo	4888869.328	656332.124	189.191
Topo	4888881.602	656331.483	189.531
Topo	4888893.851	656331.011	189.777
Topo	4888906.196	656330.691	189.939
Topo	4888918.223	656330.413	189.967
Topo	4888930.353	656329.829	189.963
Topo	4888942.938	656329.242	190.079
Topo	4888955.332	656328.699	190.123
Topo	4888968.125	656327.985	190.291
Topo	4888980.315	656328.490	190.450
Topo	4888992.227	656327.753	190.644
Topo	4888991.242	656338.907	190.679
Topo	4888978.792	656339.430	190.319
Topo	4888965.980	656339.539	190.202
Topo	4888953.407	656340.138	190.085
Topo	4888941.169	656340.851	189.947
Topo	4888929.095	656341.898	189.705
Topo	4888916.486	656342.771	189.674
Topo	4888903.687	656344.018	189.524
Topo	4888891.003	656345.003	189.233
Topo	4888878.509	656345.806	189.052
Topo	4888866.024	656346.281	188.870
Topo	4888853.737	656346.952	188.734
Topo	4888841.084	656347.680	188.513
Topo	4888827.947	656348.581	187.889
Topo	4888814.386	656348.679	187.633
Topo	4888802.389	656349.209	187.430
Topo	4888801.749	656357.909	187.461
Topo	4888810.242	656358.295	188.900
Topo	4888818.173	656358.413	188.956
Topo	4888826.181	656358.447	188.812
Topo	4888833.802	656358.272	188.546
Topo	4888841.337	656358.300	188.981
Topo	4888849.730	656347.610	188.668
Topo	4888858.460	656347.181	188.748
Topo	4888867.412	656347.060	188.852
Topo	4888875.676	656346.874	188.946

Topo	4888885.086	656346.902	189.031
Topo	4888894.003	656346.813	189.167
Topo	4888902.796	656346.815	189.333
Topo	4888911.253	656346.563	189.463
Topo	4888919.601	656346.418	189.654
Topo	4888928.674	656346.119	189.738
Topo	4888937.321	656346.013	189.947
Topo	4888945.335	656346.071	190.046
Topo	4888953.499	656346.277	190.125
Topo	4888962.831	656346.294	190.185
Topo	4888971.080	656346.333	190.310
Topo	4888979.138	656345.978	190.363
Topo	4888987.131	656344.839	190.545
Topo	4888987.782	656352.332	190.532
Topo	4888979.956	656352.995	190.416
Topo	4888971.628	656353.351	190.335
Topo	4888962.831	656353.951	190.250
Topo	4888954.237	656354.734	190.192
Topo	4888945.775	656355.333	190.124
Topo	4888937.315	656356.232	190.046
Topo	4888929.022	656356.891	189.826
Topo	4888924.222	656356.711	189.904
Topo	4888915.663	656357.661	189.951
Topo	4888916.784	656357.369	189.882
Topo	4888896.575	656357.657	189.846
Topo	4888887.419	656357.632	189.762
Topo	4888887.295	656358.031	189.591
Topo	4888870.043	656358.303	189.467
Topo	4888861.812	656358.801	189.370
Topo	4888851.684	656359.608	189.184
Topo	4888843.466	656359.527	189.026
Topo	4888837.855	656359.488	188.900
Topo	4888833.565	656360.426	188.489
Topo	4888828.561	656360.907	188.871
Topo	4888819.387	656361.973	189.229
Topo	4888808.297	656361.684	189.118
Topo	4888795.311	656359.597	188.531
Topo	4888789.985	656363.936	189.126
Topo	4888800.897	656363.567	189.322
Topo	4888810.122	656363.499	189.380
Topo	4888818.064	656363.164	189.423
Topo	4888825.951	656362.795	189.158
Topo	4888831.745	656362.639	188.858
Topo	4888836.367	656362.084	188.597
Topo	4888840.268	656361.709	188.971
Topo	4888848.600	656362.643	189.260
Topo	4888860.482	656363.254	189.588
Topo	4888868.248	656363.037	189.772
Topo	4888875.576	656363.186	189.941
Topo	4888885.011	656363.201	190.074
Topo	4888895.918	656364.077	190.155
Topo	4888903.207	656363.607	190.181
Topo	4888908.728	656363.364	190.225
Topo	4888915.843	656362.821	190.183
Topo	4888921.101	656362.358	190.154
Topo	4888926.894	656361.849	190.087
Topo	4888934.146	656362.289	190.013
Topo	4888941.992	656361.887	190.242
Topo	4888953.038	656361.733	190.293
Topo	4888963.305	656361.387	190.338
Topo	4888975.574	656361.495	190.360

Topo	4888984.017	656361.587	190.316
Topo	4888987.526	656367.926	190.339
Topo	4888979.253	656368.535	190.379
Topo	4888967.949	656368.957	190.319
Topo	4888958.799	656369.012	190.292
Topo	4888950.412	656369.429	190.270
Topo	4888943.416	656369.105	190.285
Topo	4888937.797	656369.360	190.274
Topo	4888931.076	656369.075	190.273
Topo	4888924.906	656369.956	190.347
Topo	4888920.191	656370.052	190.395
Topo	4888913.456	656370.324	190.396
Topo	4888907.764	656370.210	190.380
Topo	4888900.613	656370.398	190.364
Topo	4888892.558	656369.950	190.255
Topo	4888885.306	656370.137	190.259
Topo	4888876.005	656369.973	190.165
Topo	4888868.676	656370.464	189.937
Topo	4888858.492	656370.222	189.563
Topo	4888849.775	656370.595	189.291
Topo	4888843.319	656371.057	189.000
Topo	4888838.784	656371.696	189.171
Topo	4888831.993	656371.579	189.372
Topo	4888823.266	656371.348	189.686
Topo	4888814.568	656370.867	189.904
Topo	4888805.197	656370.662	189.895
Topo	4888795.284	656370.891	189.885
Topo	4888794.539	656375.964	189.992
Topo	4888801.838	656376.328	189.994
Topo	4888811.153	656376.422	189.971
Topo	4888819.596	656376.474	189.882
Topo	4888829.762	656376.841	189.686
Topo	4888839.496	656376.726	189.413
Topo	4888845.790	656376.750	189.391
Topo	4888850.962	656376.623	189.249
Topo	4888856.985	656376.918	189.542
Topo	4888861.753	656377.008	189.693
Topo	4888866.392	656377.330	189.905
Topo	4888872.904	656377.443	190.252
Topo	4888878.876	656377.630	190.486
Topo	4888884.657	656377.506	190.520
Topo	4888889.425	656377.273	190.548
Topo	4888894.748	656377.174	190.576
Topo	4888899.819	656377.623	190.640
Topo	4888905.382	656377.595	190.661
Topo	4888911.378	656377.661	190.653
Topo	4888916.219	656377.514	190.659
Topo	4888921.530	656377.129	190.626
Topo	4888926.085	656377.317	190.559
Topo	4888933.190	656377.564	190.497
Topo	4888938.684	656377.413	190.512
Topo	4888944.688	656377.252	190.462
Topo	4888950.895	656376.783	190.419
Topo	4888957.533	656376.531	190.406
Topo	4888966.909	656376.518	190.471
Topo	4888975.048	656376.467	190.524
Topo	4888987.787	656375.762	190.454
Topo	4888987.766	656381.614	190.460
Topo	4888978.075	656382.429	190.499
Topo	4888971.511	656382.999	190.485
Topo	4888963.795	656383.409	190.453

Topo	4888957.444	656383.852	190.448
Topo	4888952.054	656383.787	190.463
Topo	4888945.820	656383.716	190.533
Topo	4888938.821	656384.330	190.632
Topo	4888932.479	656383.753	190.628
Topo	4888926.035	656383.582	190.731
Topo	4888921.253	656383.992	190.829
Topo	4888915.776	656383.624	190.874
Topo	4888910.893	656383.114	190.875
Topo	4888906.111	656382.960	190.881
Topo	4888901.270	656382.327	190.886
Topo	4888895.331	656382.567	190.860
Topo	4888889.264	656383.357	190.911
Topo	4888883.495	656383.772	190.908
Topo	4888876.876	656385.711	190.678
Topo	4888869.190	656386.949	190.155
Topo	4888861.406	656386.796	189.863
Topo	4888854.163	656386.733	189.619
Topo	4888843.899	656387.275	189.888
Topo	4888831.633	656388.095	190.096
Topo	4888817.258	656389.535	190.200
Topo	4888809.229	656394.601	190.304
Topo	4888819.596	656395.301	190.452
Topo	4888831.152	656396.813	190.507
Topo	4888843.180	656398.259	190.547
Topo	4888852.489	656399.397	190.478
Topo	4888859.889	656399.141	190.026
Topo	4888865.705	656398.912	190.287
Topo	4888871.085	656398.880	190.566
Topo	4888876.104	656398.758	190.966
Topo	4888882.259	656395.945	191.288
Topo	4888888.208	656394.056	191.429
Topo	4888893.893	656392.996	191.407
Topo	4888899.792	656391.635	191.324
Topo	4888905.066	656391.266	191.317
Topo	4888911.457	656391.168	191.338
Topo	4888917.609	656391.350	191.295
Topo	4888927.007	656390.835	191.084
Topo	4888934.875	656390.575	190.916
Topo	4888942.386	656390.623	190.893
Topo	4888932.668	656390.318	190.674
Topo	4888963.232	656390.589	190.577
Topo	4888973.630	656390.324	190.628
Topo	4888985.420	656390.434	190.581
Topo	4888985.925	656395.168	190.612
Topo	4888978.631	656396.005	190.694
Topo	4888971.260	656396.569	190.723
Topo	4888969.011	656397.005	190.737
Topo	4888957.669	656396.917	190.762
Topo	4888949.880	656396.905	190.910
Topo	4888941.634	656397.246	191.237
Topo	4888933.996	656397.307	191.355
Topo	4888928.190	656397.254	191.476
Topo	4888922.053	656398.483	191.682
Topo	4888917.569	656398.496	191.794
Topo	4888912.231	656398.559	191.828
Topo	4888906.966	656398.342	191.788
Topo	4888900.222	656398.884	191.885
Topo	4888894.321	656399.462	191.911
Topo	4888888.233	656399.963	191.764
Topo	4888881.621	656400.249	191.410

Topo	4888873.754	656400.562	190.795
Topo	4888867.249	656401.015	190.365
Topo	4888863.136	656401.872	190.149
Topo	4888855.287	656403.671	190.754
Topo	4888836.142	656401.804	190.727
Topo	4888835.833	656406.042	191.153
Topo	4888844.092	656408.083	191.346
Topo	4888852.850	656409.471	191.323
Topo	4888858.453	656409.517	191.225
Topo	4888861.257	656407.458	190.296
Topo	4888863.775	656405.233	190.335
Topo	4888868.635	656405.285	190.461
Topo	4888874.024	656405.282	190.791
Topo	4888880.510	656405.360	191.462
Topo	4888886.173	656405.813	191.861
Topo	4888891.460	656405.361	192.181
Topo	4888899.080	656404.636	192.228
Topo	4888906.545	656404.683	192.129
Topo	4888913.858	656404.720	192.157
Topo	4888919.764	656404.858	192.173
Topo	4888924.437	656404.484	192.045
Topo	4888930.163	656403.902	191.908
Topo	4888938.067	656404.960	191.697
Topo	4888945.741	656404.898	191.401
Topo	4888953.948	656404.582	191.084
Topo	4888962.064	656404.216	190.893
Topo	4888971.954	656403.604	190.813
Topo	4888986.314	656402.437	190.722
Topo	4888989.758	656405.049	190.896
Topo	4888980.644	656406.120	190.892
Topo	4888970.870	656407.594	190.889
Topo	4888961.036	656408.724	191.111
Topo	4888948.787	656408.742	191.493
Topo	4888938.542	656409.251	191.948
Topo	4888931.098	656409.898	192.485
Topo	4888924.497	656410.956	192.605
Topo	4888918.863	656411.728	192.682
Topo	4888912.945	656412.798	192.967
Topo	4888904.912	656413.514	193.130
Topo	4888899.561	656413.705	193.260
Topo	4888895.019	656413.034	192.806
Topo	4888888.143	656411.686	192.333
Topo	4888882.135	656410.224	191.551
Topo	4888874.843	656410.064	191.121
Topo	4888868.188	656409.762	190.978
Topo	4888863.717	656409.812	191.094
Topo	4888864.830	656414.455	191.759
Topo	4888868.602	656416.601	192.314
Topo	4888878.515	656414.730	192.018
Topo	4888881.727	656418.601	192.884
Topo	4888888.344	656415.356	192.582
Topo	4888894.802	656417.039	193.459
Topo	4888900.880	656418.377	193.785
Topo	4888909.139	656417.984	193.653
Topo	4888918.945	656418.197	193.370
Topo	4888925.626	656415.206	193.132
Topo	4888932.653	656414.108	193.097
Topo	4888932.759	656419.949	193.880
Topo	4888925.169	656422.599	193.877
Topo	4888920.505	656425.400	194.479
Topo	4888916.136	656427.649	194.578

Access Road	4888925.971	656402.882	191.904
Access Road	4888924.803	656388.069	190.921
Access Road	4888923.706	656375.417	190.556
Access Road	4888921.945	656357.477	189.987
Access Road	4888921.077	656343.259	189.744
Access Road	4888919.746	656327.675	189.965
Topo	4888924.527	656368.468	190.456
Topo	4888924.560	656368.504	190.461
Topo	4888924.574	656368.572	190.442
Topo	4888924.571	656368.590	190.440
Topo	4888924.810	656368.552	190.447
Topo	4888924.475	656371.028	190.563
Topo	4888924.086	656373.367	190.637
Topo	4888924.355	656376.998	190.700
Topo	4888924.448	656380.006	190.843
Topo	4888924.838	656384.599	190.914
Topo	4888924.849	656384.612	190.912
Topo	4888924.851	656384.582	190.917
Topo	4888924.808	656384.642	190.927
Topo	4888925.020	656385.054	190.944
Topo	4888925.144	656385.736	190.966
Topo	4888925.184	656386.589	191.013
Topo	4888925.203	656388.341	191.109
Topo	4888925.224	656390.155	191.169
Topo	4888925.357	656391.205	191.307
Topo	4888925.304	656395.577	191.613
Topo	4888925.210	656396.611	191.691
Topo	4888925.094	656397.643	191.740
Topo	4888924.660	656399.825	191.898
Topo	4888924.085	656400.816	192.071
Topo	4888923.406	656401.576	192.114
Topo	4888922.666	656402.202	192.200
Topo	4888921.862	656402.720	192.204
Topo	4888920.057	656403.006	192.253
Topo	4888919.151	656403.076	192.257
Topo	4888918.354	656403.127	192.310
Topo	4888917.533	656403.218	192.347
Topo	4888916.712	656403.416	192.307
Topo	4888915.824	656403.408	192.325
Topo	4888914.959	656403.412	192.301
Topo	4888914.040	656403.554	192.309
Topo	4888913.120	656403.416	192.239
Topo	4888911.330	656402.784	192.264
Topo	4888910.544	656402.220	192.162
Topo	4888909.797	656401.624	192.185
Topo	4888908.950	656401.364	192.186
Topo	4888908.022	656401.158	192.203
Topo	4888907.038	656400.920	192.138
Topo	4888906.109	656400.601	192.130
Topo	4888905.229	656400.274	192.082
Topo	4888904.341	656400.055	192.078
Topo	4888903.324	656399.923	192.126
Topo	4888902.416	656399.634	192.052
Topo	4888900.599	656399.187	192.069
Topo	4888899.768	656398.990	191.990
Topo	4888898.959	656398.754	191.997
Topo	4888898.069	656398.630	192.003
Topo	4888897.204	656398.567	191.999
Topo	4888895.375	656398.780	192.024
Topo	4888894.463	656398.960	192.007
Topo	4888892.995	656399.768	192.098

Topo	4888892.511	656400.211	192.140
Topo	4888892.597	656400.821	192.096
Topo	4888892.983	656401.277	192.191
Topo	4888893.804	656401.439	192.247
Topo	4888894.419	656401.511	192.250
Topo	4888895.083	656401.777	192.219
Topo	4888896.058	656401.806	192.242
Topo	4888896.975	656401.711	192.322
Topo	4888898.712	656402.139	192.210
Topo	4888899.258	656402.194	192.243
Topo	4888899.948	656402.205	192.246
Topo	4888900.832	656402.103	192.285
Topo	4888901.603	656402.180	192.290
Topo	4888902.378	656402.259	192.293
Topo	4888903.289	656402.213	192.286
Topo	4888904.222	656402.431	192.231
Topo	4888906.056	656402.792	192.346
Topo	4888906.887	656403.100	192.277
Topo	4888907.807	656403.438	192.256
Topo	4888908.760	656403.631	192.289
Topo	4888909.802	656403.819	192.204
Topo	4888910.852	656403.869	192.267
Topo	4888912.912	656404.061	192.292
Topo	4888916.086	656404.924	192.370
Topo	4888914.119	656405.551	192.329
Topo	4888911.845	656405.542	192.286
Topo	4888911.099	656405.501	192.237
Topo	4888910.709	656405.515	192.277
Topo	4888909.218	656405.851	192.245
Topo	4888908.122	656405.980	192.293
Topo	4888906.383	656406.196	192.304
Topo	4888906.189	656406.156	192.326
Topo	4888905.907	656406.186	192.290
Topo	4888904.779	656406.392	192.256
Topo	4888904.152	656406.438	192.267
Topo	4888903.622	656406.373	192.292
Topo	4888902.325	656406.586	192.412
Topo	4888900.980	656406.767	192.457
Topo	4888900.224	656406.836	192.449
Topo	4888898.241	656406.635	192.422
Topo	4888897.369	656406.658	192.382
Topo	4888896.738	656406.735	192.470
Topo	4888896.222	656406.787	192.435
Topo	4888895.651	656406.864	192.472
Topo	4888895.202	656406.888	192.500
Topo	4888894.750	656407.008	192.462
Topo	4888893.599	656407.311	192.366
Topo	4888892.991	656407.225	192.339
Topo	4888892.464	656407.191	192.267
Topo	4888891.824	656407.171	192.211
Topo	4888891.125	656407.313	192.227
Topo	4888904.633	656399.698	192.111
Topo	4888904.631	656399.690	192.111
Topo	4888904.638	656399.693	192.116
Topo	4888904.637	656399.696	192.123
Topo	4888904.644	656399.697	192.115
Topo	4888904.702	656399.811	192.120
Topo	4888904.704	656399.842	192.124
Topo	4888904.708	656399.879	192.141
Topo	4888904.871	656399.970	192.138
Topo	4888904.928	656400.045	192.155

Topo	4888904.901	656400.107	192.138
Topo	4888904.872	656400.117	192.138
Topo	4888904.869	656400.122	192.139
Topo	4888904.874	656400.114	192.141
Topo	4888904.867	656400.100	192.134
Topo	4888904.868	656400.091	192.134
Topo	4888904.877	656400.091	192.133
Topo	4888904.909	656400.105	192.132
Topo	4888904.915	656400.107	192.134
Topo	4888904.910	656400.099	192.130
Topo	4888904.915	656400.108	192.133
Topo	4888905.034	656400.219	192.154
Topo	4888905.137	656400.809	192.212
Topo	4888905.860	656402.088	192.282
Topo	4888906.302	656402.617	192.295
Topo	4888907.058	656403.716	192.285
Topo	4888907.420	656404.835	192.318
Topo	4888907.745	656405.338	192.330
Topo	4888908.127	656407.024	192.388
Topo	4888908.205	656407.864	192.520
Topo	4888908.293	656408.256	192.564
Topo	4888908.469	656408.645	192.594
Topo	4888908.730	656409.126	192.756
Topo	4888908.954	656409.777	192.791
Topo	4888908.976	656410.354	192.946
Topo	4888908.959	656410.842	193.073
Topo	4888907.157	656400.373	192.143
Topo	4888907.159	656400.373	192.150
Topo	4888907.157	656400.372	192.141
Topo	4888907.147	656400.385	192.148
Topo	4888907.147	656400.531	192.155
Topo	4888907.056	656401.085	192.170
Topo	4888923.541	656421.664	193.869
Topo	4888904.680	656427.347	195.093
Topo	4888917.477	656422.329	194.176
Topo	4888910.918	656422.538	194.376
Topo	4888903.805	656423.120	194.725
Topo	4888897.306	656421.890	194.132
Topo	4888888.941	656422.393	194.234
Topo	4888882.542	656421.333	193.774
Topo	4888895.301	656428.702	195.129
Topo	4888901.453	656429.314	195.306
Topo	4888907.581	656429.409	195.110
Topo	4888914.573	656429.191	194.777
Topo	4888921.243	656428.854	195.444
Topo	4888921.490	656433.256	197.000
Topo	4888917.436	656434.353	196.322
Topo	4888910.308	656434.744	195.806
Topo	4888904.462	656433.483	196.492
Topo	4888899.692	656432.761	195.677
Topo	4888896.135	656432.364	196.212
Topo	4888897.636	656435.909	197.226
Topo	4888901.111	656436.229	195.981
Topo	4888905.071	656436.412	197.171
Topo	4888910.016	656437.011	196.554
Topo	4888914.409	656438.648	197.535
Topo	4888909.954	656440.368	197.823
Topo	4888905.789	656440.554	198.026
Topo	4888902.819	656439.807	197.216
Topo	4888900.258	656439.786	197.036
Topo	4888897.789	656438.982	198.307

Topo	4888897.589	656442.491	199.873
Topo	4888901.301	656443.065	198.367
Topo	4888904.678	656443.182	198.437
Topo	4888907.444	656443.028	199.196
Topo	4888906.691	656446.917	201.218
Topo	4888902.913	656446.949	200.549
Topo	4888898.676	656446.306	200.532
Topo	4888895.910	656445.916	201.407
Topo	4888901.402	656457.016	205.916
Hillslope	4888921.243	656428.854	195.444
Hillslope	4888921.490	656433.256	197.000
Hillslope	4888917.436	656434.353	196.322
Hillslope	4888896.135	656432.364	196.212
Hillslope	4888897.636	656435.909	197.226
Hillslope	4888914.409	656438.648	197.535
Hillslope	4888909.954	656440.368	197.823
Hillslope	4888897.789	656438.982	198.307
Hillslope	4888897.589	656442.491	199.873
Hillslope	4888906.691	656446.917	201.218
Hillslope	4888902.913	656446.949	200.549
Hillslope	4888898.676	656446.306	200.532
Hillslope	4888895.910	656445.916	201.407
Hillslope	4888901.402	656457.016	205.916
Trench Corner	4888916.090	656414.390	192.980
Trench Corner	4888900.850	656415.030	193.460
Trench Corner	4888900.680	656400.640	191.960
Trench Corner	4888902.690	656400.840	191.940
Trench Corner	4888902.910	656412.910	193.110
Trench Corner	4888915.700	656412.380	192.810
Trench Stake - top	4888913.820	656414.550	193.020
Trench Stake - top	4888912.580	656414.630	193.000
Trench Stake - top	4888910.920	656414.630	193.210
Trench Stake - top	4888909.190	656414.650	193.180
Trench Stake - top	4888907.830	656414.730	193.210
Trench Stake - top	4888906.260	656414.990	193.320
Trench Stake - top	4888904.360	656415.050	193.330
Trench Stake - top	4888902.150	656415.150	193.430
Trench Stake - top	4888900.520	656413.190	192.950
Trench Stake - stem	4888900.440	656411.860	192.900
Trench Stake - stem	4888900.490	656410.210	192.690
Trench Stake - stem	4888900.120	656408.610	192.510
Trench Stake - stem	4888900.270	656406.220	192.280
Trench Stake - stem	4888900.330	656404.210	192.190
Trench Stake - stem	4888900.310	656402.490	192.170
Trench Stake - stem	4888900.480	656401.420	192.040
Grid Point:1,11stem	4888900.540	656402.230	191.990
Grid Point:0,9 stem	4888900.340	656404.210	193.040
Grid Point:0,0 stem	4888900.540	656413.170	193.070
Grid Point:0,11 top	4888902.790	656415.060	193.610
Grid Point:0,0 top	4888913.800	656414.550	193.710

Hancock alluvial fan

Point Description	Northing	Easting	Elevation
Bench 1	4867098.725	673297.394	283.490
Bench 2	4867074.962	673309.138	283.666
Bench 3	4867103.274	673271.250	283.055
Topo	4867118.915	673325.195	283.897
Topo	4867090.692	673271.492	282.728
Topo	4867088.611	673285.010	282.824

Topo	4867094.945	673287.508	282.605
Topo	4867100.798	673290.340	282.293
Topo	4867105.125	673292.669	282.284
Topo	4867111.763	673294.831	282.577
Topo	4867120.382	673296.977	282.644
Topo	4867130.539	673299.147	282.641
Topo	4867142.476	673300.809	282.119
Topo	4867150.999	673300.535	282.125
Topo	4867158.662	673300.222	282.276
Topo	4867165.278	673299.951	282.210
Topo	4867165.342	673305.561	282.122
Topo	4867159.427	673306.189	282.259
Topo	4867153.269	673306.626	282.116
Topo	4867147.073	673306.882	282.162
Topo	4867141.438	673306.468	282.433
Topo	4867134.964	673305.753	282.716
Topo	4867127.303	673304.969	282.772
Topo	4867120.482	673303.931	282.748
Topo	4867114.711	673300.403	282.798
Topo	4867109.973	673297.312	282.657
Topo	4867103.822	673293.729	282.297
Topo	4867098.247	673290.985	282.432
Topo	4867090.241	673288.131	282.634
Topo	4867087.461	673288.016	282.684
Topo	4867085.825	673293.663	282.742
Topo	4867091.227	673295.929	282.594
Topo	4867095.917	673298.102	282.582
Topo	4867100.450	673300.901	282.593
Topo	4867104.873	673304.089	282.845
Topo	4867108.644	673307.033	282.959
Topo	4867114.823	673310.300	283.010
Topo	4867119.115	673312.449	283.033
Topo	4867125.372	673314.561	283.031
Topo	4867131.033	673316.191	283.118
Topo	4867138.047	673317.847	283.072
Topo	4867143.670	673319.562	283.006
Topo	4867150.673	673320.199	282.811
Topo	4867156.920	673319.666	282.685
Topo	4867163.258	673319.181	282.723
Topo	4867169.628	673318.415	282.554
Topo	4867170.386	673323.363	282.858
Topo	4867164.076	673324.171	282.937
Topo	4867158.898	673324.644	282.866
Topo	4867152.717	673324.936	283.095
Topo	4867144.117	673323.971	283.110
Topo	4867138.288	673322.552	283.306
Topo	4867130.654	673320.324	283.190
Topo	4867122.432	673318.602	283.192
Topo	4867113.955	673316.121	283.309
Topo	4867106.015	673312.528	283.129
Topo	4867101.546	673308.919	283.024
Topo	4867095.772	673305.988	282.839
Topo	4867088.846	673303.882	282.642
Topo	4867083.730	673302.190	282.626
Topo	4867083.098	673307.591	282.732
Topo	4867087.917	673310.188	282.675
Topo	4867088.101	673310.269	282.688
Topo	4867094.604	673313.922	283.013
Topo	4867099.243	673316.726	283.200
Topo	4867104.396	673319.000	283.353
Topo	4867109.830	673321.265	283.551

Topo	4867115.262	673322.694	283.642
Topo	4867119.769	673324.106	283.878
Topo	4867123.107	673326.625	284.458
Topo	4867132.300	673327.450	283.840
Topo	4867138.446	673326.955	283.457
Topo	4867143.476	673327.227	283.314
Topo	4867149.309	673327.929	283.170
Topo	4867154.820	673327.939	283.175
Topo	4867160.322	673327.453	282.925
Topo	4867166.900	673326.869	283.085
Topo	4867166.234	673331.076	283.079
Topo	4867162.021	673331.399	282.968
Topo	4867155.126	673332.000	283.249
Topo	4867148.408	673332.545	283.400
Topo	4867140.298	673332.591	283.750
Topo	4867129.126	673332.009	284.112
Topo	4867123.026	673331.104	284.243
Topo	4867116.134	673330.283	284.286
Topo	4867110.249	673329.326	284.126
Topo	4867104.412	673327.259	283.860
Topo	4867100.016	673324.587	283.606
Topo	4867095.608	673320.747	283.354
Topo	4867090.297	673318.474	283.042
Topo	4867084.480	673316.735	282.946
Topo	4867082.744	673316.154	282.896
Topo	4867080.081	673322.828	283.172
Topo	4867087.505	673326.167	283.270
Topo	4867096.229	673328.861	283.645
Topo	4867104.074	673331.215	284.201
Topo	4867109.807	673334.329	284.547
Topo	4867116.831	673336.682	284.738
Topo	4867122.897	673339.130	284.851
Topo	4867130.242	673340.381	284.670
Topo	4867136.609	673340.923	284.535
Topo	4867155.879	673342.886	283.586
Topo	4867166.390	673344.696	283.526
Topo	4867167.292	673352.000	283.746
Topo	4867148.135	673351.953	284.762
Topo	4867140.710	673352.526	285.458
Topo	4867133.115	673353.119	285.958
Topo	4867125.120	673352.299	286.093
Topo	4867117.762	673350.795	286.078
Topo	4867112.780	673345.954	285.528
Topo	4867108.255	673341.727	285.126
Topo	4867103.663	673339.194	284.822
Topo	4867096.457	673336.391	284.278
Topo	4867091.633	673332.832	283.681
Topo	4867087.431	673329.044	283.390
Topo	4867080.966	673325.688	283.262
Topo	4867078.693	673332.420	283.631
Topo	4867085.036	673337.165	284.033
Topo	4867090.584	673341.706	284.435
Topo	4867094.830	673346.077	285.066
Topo	4867101.185	673350.285	285.555
Topo	4867106.362	673353.744	286.045
Topo	4867111.026	673356.246	286.613
Topo	4867116.859	673359.353	287.083
Topo	4867123.583	673360.813	287.198
Topo	4867130.543	673361.314	286.928
Topo	4867138.232	673359.757	286.242
Topo	4867145.951	673358.660	285.427

Topo	4867152.823	673354.476	284.826
Topo	4867171.535	673357.922	284.199
Topo	4867156.906	673364.321	284.744
Topo	4867151.657	673364.621	285.337
Topo	4867148.904	673362.614	285.364
Topo	4867141.488	673364.085	286.235
Topo	4867136.880	673363.202	286.565
Topo	4867134.377	673364.873	286.963
Topo	4867129.347	673365.232	287.448
Topo	4867124.223	673365.114	287.808
Topo	4867120.285	673364.783	288.058
Topo	4867117.952	673361.360	287.394
Topo	4867114.862	673364.376	287.632
Topo	4867109.180	673363.913	287.362
Topo	4867104.490	673361.698	286.847
Topo	4867101.045	673358.184	286.280
Topo	4867098.009	673356.267	286.061
Topo	4867094.208	673354.970	285.781
Topo	4867091.847	673352.079	285.413
Topo	4867088.583	673349.053	285.110
Topo	4867094.002	673349.002	285.183
Topo	4867088.567	673345.079	284.701
Topo	4867085.831	673342.241	284.443
Topo	4867082.802	673341.417	284.299
Topo	4867108.016	673367.327	287.795
Topo	4867114.883	673367.506	287.995
Topo	4867109.494	673370.969	288.383
Topo	4867117.438	673373.064	288.959
Topo	4867111.969	673377.195	289.341
Topo	4867118.144	673376.319	289.439
Topo	4867115.985	673379.982	289.725
Topo	4867113.108	673380.877	289.832
Topo	4867119.067	673383.660	290.360
Topo	4867115.824	673385.406	290.377
Topo	4867120.403	673388.438	291.208
Topo	4867117.813	673390.259	290.945
Topo	4867120.694	673391.627	290.940
Topo	4867122.472	673394.515	291.726
Topo	4867118.870	673394.672	292.327
Topo	4867120.336	673400.039	293.633
Topo	4867129.025	673399.641	294.013
Topo	4867087.500	673253.066	282.373
Topo	4867103.302	673256.964	282.339
Topo	4867121.138	673257.356	282.048
Topo	4867137.657	673260.557	282.105
Topo	4867153.016	673153.016	282.381
Topo	4867169.241	673169.241	282.556
Topo	4867184.619	673184.619	282.885
Topo	4867178.667	673178.667	282.799
Topo	4867172.330	673172.330	282.717
Topo	4867164.570	673164.570	282.779
Topo	4867156.544	673156.544	282.737
Topo	4867144.387	673227.182	282.320
Topo	4867135.741	673221.143	282.482
Topo	4867125.711	673213.204	282.371
Topo	4867112.757	673206.350	282.256
Topo	4867090.691	673271.490	282.738
Topo	4867118.916	673325.203	283.897
Trench Corner	4867119.828	673360.708	288.149
Trench Corner	4867119.742	673362.491	288.438
Trench Corner	4867131.423	673363.306	288.184

Trench Corner	4867131.478	673362.037	287.969
Trench Corner	4867126.027	673361.349	288.184
Trench Corner	4867127.146	673346.522	286.595
Trench Corner	4867125.870	673346.405	286.525
Trench Corner	4867124.348	673361.277	288.188
Extra Pit Corner	4867119.191	673305.772	283.660
Extra Pit Corner	4867116.840	673304.687	283.617
Extra Pit Corner	4867114.269	673309.310	283.827
Extra Pit Corner	4867116.270	673310.468	283.790
Trench Stake - top	4867119.775	673362.649	288.448
Trench Stake - top	4867122.048	673362.881	288.577
Trench Stake - top	4867124.228	673363.126	288.503
Trench Stake - top	4867126.649	673363.379	288.504
Trench Stake - top	4867129.177	673363.422	288.232
Trench Stake - top	4867131.340	673363.421	288.154
Trench Stake - stem	4867125.699	673346.741	286.501
Trench Stake - stem	4867125.359	673350.046	286.820
Trench Stake - stem	4867125.085	673352.303	287.148
Trench Stake - stem	4867125.007	676654.796	287.309
Trench Stake - stem	4867124.589	673357.215	287.674
Trench Stake - stem	4867124.294	673359.270	287.901
Trench Stake - stem	4867124.251	673361.139	288.198
Grid Point:1,11 top	4867120.057	673362.505	288.937
Grid Point: 6/7,1 top	4867125.034	673363.009	288.959
Grid Point: 1/2,1 top	4867130.993	673363.299	288.936
Grid Point: 14/15,2 stem	4867125.631	673347.148	287.454
Grid Point: 7/8,2 stem	4867125.104	673354.198	287.480
Grid Point: 3/4,1 stem	4867124.468	673358.019	288.491
Grid Point: 1,1 stem	4867124.288	673361.073	288.579

Bridgewater Corners alluvial fan

Point Description	Northing	Easting	Elevation
Bench 1	4824032.902	689085.331	335.550
Bench 2	4824068.123	689150.392	324.531
Bench 3	4823982.245	689132.422	327.978
Topo	4823981.867	689131.588	327.866
Topo	4824042.110	689137.686	325.701
Topo	4824042.214	689139.878	325.651
Topo	4824042.353	689141.970	325.650
Topo	4824042.177	689144.322	325.615
Topo	4824042.076	689146.401	325.557
Topo	4824041.965	689148.511	325.547
Topo	4824041.885	689150.673	325.575
Topo	4824041.587	689152.674	325.557
Topo	4824041.568	689155.242	325.541
Topo	4824041.681	689157.796	325.538
Topo	4824042.204	689137.556	325.758
Topo	4824042.310	689135.388	325.776
Topo	4824042.400	689133.260	325.901
Topo	4824042.591	689131.033	326.005
Topo	4824042.650	689128.647	326.110
Topo	4824042.714	689126.170	326.361
Topo	4824042.784	689122.038	326.779
Topo	4824043.649	689119.418	326.831
Topo	4824043.024	689108.596	328.828
Topo	4824043.051	689103.958	329.689

Topo	4824043.259	689100.914	330.331
Topo	4824043.307	689098.355	330.748
Topo	4824043.251	689095.185	331.354
Topo	4824043.216	689093.016	331.706
Topo	4824043.264	689090.945	332.027
Topo	4824043.270	689087.477	332.681
Topo	4824043.074	689083.977	333.208
Topo	4824042.847	689081.758	333.575
Topo	4824042.092	689079.603	333.890
Topo	4824040.862	689077.646	334.143
Topo	4824037.669	689076.081	334.712
Topo	4824035.334	689075.887	334.967
Topo	4824031.838	689076.781	335.394
Topo	4824029.642	689077.917	335.729
Topo	4824027.535	689078.910	336.096
Topo	4824025.573	689079.877	336.249
Topo	4824030.296	689087.233	335.366
Topo	4824029.190	689089.961	335.492
Topo	4824026.969	689090.841	335.750
Topo	4824024.657	689091.325	336.035
Topo	4824022.784	689092.621	336.150
Topo	4824020.065	689093.850	336.448
Topo	4824017.853	689093.239	336.723
Topo	4824014.805	689092.446	336.951
Topo	4824012.759	689092.112	337.101
Topo	4824008.020	689089.785	337.176
Topo	4824008.302	689087.428	337.100
Topo	4824005.948	689085.298	337.187
Topo	4824003.411	689084.147	337.254
Topo	4824000.630	689083.334	337.329
Topo	4823997.613	689082.900	337.427
Topo	4823994.578	689083.007	337.528
Topo	4824033.161	689066.824	335.288
Topo	4824035.033	689064.783	335.385
Topo	4824036.501	689063.177	335.441
Topo	4824041.571	689066.819	334.971
Topo	4824041.833	689069.160	334.642
Topo	4824043.301	689071.059	334.376
Topo	4824045.278	689071.526	334.202
Topo	4824049.463	689070.502	333.907
Topo	4824051.370	689069.754	333.836
Topo	4824053.880	689069.495	333.712
Topo	4824056.547	689070.021	333.598
Topo	4824058.755	689070.542	333.457
Topo	4824064.249	689068.033	333.597
Topo	4824065.282	689065.907	333.666
Topo	4824067.521	689064.409	333.586
Topo	4824069.280	689063.218	333.514
Topo	4824071.924	689061.774	333.489
Topo	4824073.680	689060.516	333.410
Topo	4824075.323	689058.880	333.349
Topo	4824078.717	689054.909	333.643
Topo	4824079.759	689053.050	333.922
Topo	4824080.978	689051.094	334.054
Topo	4824081.680	689048.804	334.442
Topo	4824046.594	689063.610	335.130
Topo	4824042.944	689067.097	334.631
Topo	4824043.481	689070.610	334.223
Topo	4824042.944	689074.861	334.036
Topo	4824043.340	689078.377	333.568
Topo	4823984.639	689127.743	327.589

Topo	4823963.139	689124.442	328.442
Topo	4824029.843	689143.612	325.517
Topo	4824031.885	689143.145	325.453
Topo	4824034.688	689144.000	325.401
Topo	4824037.813	689144.873	325.304
Topo	4824039.745	689145.453	325.393
Topo	4824042.470	689145.796	325.490
Topo	4824046.028	689146.109	325.102
Topo	4824048.146	689146.276	324.863
Topo	4824050.869	689146.062	324.806
Topo	4824054.868	689146.439	324.635
Topo	4824057.151	689146.344	324.628
Topo	4824060.585	689145.705	324.469
Topo	4824062.793	689145.263	324.461
Topo	4824064.773	689144.766	324.385
Topo	4824066.753	689144.027	324.424
Topo	4824068.680	689143.205	324.399
Topo	4824070.645	689142.508	324.460
Topo	4824072.780	689142.250	324.383
Topo	4824076.744	689141.005	324.390
Topo	4824079.239	689139.779	324.428
Topo	4824083.074	689135.024	324.344
Topo	4824084.872	689133.559	324.368
Topo	4824087.052	689132.799	324.255
Topo	4824088.792	689131.670	324.218
Topo	4824090.757	689129.820	324.224
Topo	4824092.640	689127.354	324.191
Topo	4824093.666	689125.447	324.226
Topo	4824096.114	689123.311	324.201
Topo	4824098.311	689121.399	324.274
Topo	4824100.082	689116.459	324.161
Topo	4824100.953	689113.839	324.164
Topo	4824101.746	689110.463	323.998
Topo	4824103.228	689107.606	323.979
Topo	4824103.114	689105.268	323.882
Topo	4824103.199	689102.839	323.780
Topo	4824104.163	689100.456	323.661
Topo	4824103.401	689097.356	323.652
Topo	4824103.085	689099.388	323.755
Topo	4824098.150	689103.644	323.926
Topo	4824096.503	689105.461	324.016
Topo	4824094.836	689106.901	324.095
Topo	4824092.846	689108.421	324.135
Topo	4824091.803	689110.342	324.133
Topo	4824090.019	689111.616	324.223
Topo	4824088.516	689113.077	324.201
Topo	4824086.777	689114.733	324.247
Topo	4824084.593	689117.024	324.290
Topo	4824082.281	689118.248	324.310
Topo	4824079.230	689120.381	324.275
Topo	4824075.699	689122.739	324.366
Topo	4824072.832	689121.968	324.417
Topo	4824072.709	689119.611	324.440
Topo	4824072.620	689116.615	324.457
Topo	4824070.209	689116.484	324.381
Topo	4824067.626	689117.627	324.357
Topo	4824065.384	689118.202	324.360
Topo	4824063.286	689118.346	324.455
Topo	4824059.424	689119.645	324.590
Topo	4824055.506	689125.318	324.912
Topo	4824054.951	689127.282	324.774

Topo	4824053.092	689128.216	324.844
Topo	4824050.678	689128.069	325.124
Topo	4824046.702	689130.957	325.729
Topo	4824046.390	689133.170	325.641
Topo	4824047.541	689135.049	325.461
Topo	4824049.699	689135.716	325.186
Topo	4824051.894	689136.089	324.860
Topo	4824053.963	689135.997	324.794
Topo	4824056.949	689135.216	324.653
Topo	4824058.871	689134.441	324.646
Topo	4824061.677	689133.300	324.527
Topo	4824063.740	689132.667	324.566
Topo	4824065.681	689131.764	324.481
Topo	4824067.529	689130.964	324.409
Topo	4824069.410	689129.992	324.495
Topo	4824071.425	689129.058	324.386
Topo	4824074.285	689128.320	324.407
Topo	4824077.002	689127.670	324.311
Topo	4824079.748	689126.877	324.287
Topo	4824081.886	689125.460	324.250
Topo	4824084.191	689124.040	324.304
Topo	4824086.093	689122.586	324.344
Topo	4824087.836	689120.517	324.237
Topo	4824089.909	689118.956	324.241
Topo	4824091.651	689117.722	324.221
Topo	4824093.265	689116.394	324.273
Topo	4824094.451	689114.667	324.193
Topo	4824095.710	689112.777	324.067
Topo	4824096.542	689110.036	324.091
Topo	4824097.280	689107.964	324.008
Topo	4824097.319	689105.712	323.963
Topo	4824097.099	689103.687	323.978
Topo	4824096.506	689101.553	323.894
Topo	4824096.065	689099.102	323.916
Topo	4824094.990	689096.108	324.009
Topo	4824093.975	689094.302	324.184
Topo	4824092.534	689092.690	324.305
Topo	4824091.140	689090.894	324.444
Topo	4824089.116	689089.623	324.690
Topo	4824084.151	689093.424	325.105
Topo	4824083.687	689095.734	325.027
Topo	4824081.086	689099.221	324.893
Topo	4824079.604	689101.230	324.729
Topo	4824078.224	689103.275	324.654
Topo	4824077.710	689105.452	324.493
Topo	4824076.025	689106.966	324.440
Topo	4824074.148	689108.523	324.327
Topo	4824070.019	689117.374	324.480
Topo	4824068.877	689119.768	324.522
Topo	4824067.334	689121.649	324.517
Topo	4824066.533	689124.131	324.557
Topo	4824065.888	689126.643	324.456
Topo	4824065.619	689129.242	324.461
Topo	4824066.271	689131.844	324.457
Topo	4824065.717	689134.532	324.644
Topo	4824065.091	689137.461	324.627
Topo	4824065.589	689140.242	324.555
Topo	4824066.247	689142.385	324.483
Topo	4824066.704	689144.372	324.428
Topo	4824066.573	689146.490	324.358
Topo	4824065.220	689148.097	324.426

Topo	4824063.815	689150.256	324.523
Topo	4824061.857	689151.717	324.572
Topo	4824059.818	689152.318	324.607
Topo	4824056.805	689151.775	324.543
Topo	4824054.507	689151.656	324.586
Topo	4824051.659	689149.845	324.652
Topo	4824044.393	689146.256	325.461
Topo	4824042.247	689146.352	325.552
Topo	4824040.088	689146.950	325.423
Topo	4824039.732	689151.661	325.375
Topo	4824036.411	689148.399	325.416
Topo	4824036.193	689144.598	325.407
Topo	4824036.045	689142.591	325.445
Topo	4824035.793	689139.276	325.397
Topo	4824035.763	689137.001	325.354
Topo	4824035.579	689134.991	325.506
Topo	4824034.942	689132.616	325.497
Topo	4824033.967	689130.726	325.527
Topo	4824034.219	689128.315	325.871
Topo	4824033.821	689126.226	326.421
Topo	4824036.243	689122.882	327.047
Topo	4824034.556	689124.012	326.921
Topo	4824033.656	689122.084	327.314
Topo	4824031.642	689125.458	326.506
Topo	4824030.856	689127.315	325.954
Topo	4824030.118	689129.642	325.560
Topo	4824029.902	689132.375	325.567
Topo	4824029.304	689134.491	325.465
Topo	4824028.405	689137.816	325.525
Topo	4824027.735	689141.164	325.581
Topo	4824027.189	689143.211	325.623
Topo	4824026.366	689145.385	325.619
Topo	4824024.042	689146.743	325.677
Topo	4824021.545	689146.449	325.738
Topo	4824019.513	689145.559	325.794
Topo	4824019.712	689143.279	325.715
Topo	4824020.358	689140.832	325.729
Topo	4824020.801	689138.378	325.678
Topo	4824021.238	689135.901	325.623
Topo	4824021.075	689133.188	325.553
Topo	4824021.753	689131.153	325.627
Topo	4824022.672	689129.286	325.597
Topo	4824023.867	689127.657	325.720
Topo	4824023.185	689125.761	326.119
Topo	4824020.096	689127.295	325.956
Topo	4824018.961	689129.098	325.697
Topo	4824017.792	689131.341	325.590
Topo	4824017.034	689133.643	325.628
Topo	4824015.971	689135.593	325.687
Topo	4824015.307	689137.835	325.710
Topo	4824014.355	689139.927	325.778
Topo	4824013.647	689142.686	325.873
Topo	4824012.106	689143.970	325.925
Topo	4824037.434	689140.140	325.388
Topo	4824035.211	689138.844	325.422
Topo	4824032.859	689139.014	325.430
Topo	4824030.260	689138.946	325.512
Topo	4824027.414	689138.238	325.515
Topo	4824024.206	689137.030	325.602
Topo	4824022.072	689136.464	325.631
Topo	4824020.072	689135.606	325.583

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Topo	4824015.168	689132.811	325.655
Topo	4824012.100	689135.542	325.832
Topo	4824009.979	689134.547	325.955
Topo	4824003.458	689135.581	326.202
Topo	4824000.783	689135.801	326.285
Topo	4823982.186	689132.362	327.822
Topo	4824030.210	689077.006	335.557
Topo	4824030.585	689074.084	335.388
Topo	4824030.655	689071.415	335.450
Topo	4824030.318	689068.006	335.413
Topo	4824028.699	689066.242	335.490
Topo	4824022.923	689064.232	335.501
Topo	4824016.617	689061.082	335.868
Topo	4824014.495	689060.114	335.948
Topo	4824010.442	689061.197	336.014
Topo	4824008.139	689061.957	336.104
Topo	4824005.921	689062.979	336.216
Topo	4824003.502	689064.032	336.319
Topo	4824000.912	689064.978	336.539
Topo	4823997.277	689066.703	336.783
Topo	4823994.935	689067.723	337.073
Topo	4823989.076	689069.903	337.293
Topo	4823986.920	689071.316	337.555
Topo	4823985.040	689072.503	337.598
Topo	4823982.273	689076.161	338.120
Topo	4823976.604	689076.163	338.475
Topo	4823948.560	689078.697	339.657
Topo	4823946.499	689078.565	339.611
Topo	4823945.094	689080.033	339.487
Topo	4823942.846	689081.949	339.571
Topo	4823940.650	689082.910	339.791
Topo	4823938.464	689083.034	339.771
Topo	4823936.411	689083.036	339.765
Topo	4823934.254	689083.010	339.647
Topo	4823939.654	689083.715	339.758
Topo	4823943.374	689084.615	339.675
Topo	4823945.600	689084.030	339.545
Topo	4823951.182	689079.086	339.712
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Topo	4824026.109	689060.236	335.274
Topo	4824028.978	689060.391	335.250
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Topo	4824042.199	689059.396	335.406
Topo	4824044.397	689059.177	335.485
Topo	4824047.159	689057.978	335.487
Topo	4824048.951	689056.638	335.498
Topo	4824050.429	689055.210	335.487
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Topo	4824053.547	689049.460	335.299
Topo	4824052.625	689046.313	335.281
Topo	4824054.490	689043.226	335.310
Topo	4824057.584	689043.041	335.372
Topo	4824059.794	689043.837	335.345
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Topo	4824058.261	689052.464	334.958

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Topo	4824066.800	689048.585	334.867
Topo	4824068.927	689047.882	334.957
Topo	4824070.965	689046.954	335.062
Topo	4824073.077	689046.422	335.127
Topo	4824075.298	689047.708	334.977
Topo	4824073.768	689049.654	334.832
Topo	4824071.848	689051.224	334.614
Topo	4824069.794	689052.692	334.488
Topo	4824067.576	689054.309	334.427
Topo	4824065.220	689056.118	334.328
Topo	4824062.897	689057.991	334.317
Topo	4824060.485	689059.700	334.448
Topo	4824058.059	689061.436	334.507
Topo	4824055.516	689063.011	334.612
Topo	4824053.043	689064.588	334.699
Topo	4824050.337	689065.903	334.688
Topo	4824047.636	689067.262	334.598
Topo	4824045.037	689068.984	334.506
Topo	4824042.640	689070.954	334.467
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Topo	4824024.974	689092.109	335.953
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Topo	4824021.586	689095.316	336.223
Topo	4824019.522	689095.614	336.302
Topo	4824019.111	689093.526	336.612
Topo	4824017.310	689092.611	336.698
Topo	4824014.005	689090.862	337.051
Topo	4824011.844	689090.876	337.169
Topo	4824009.471	689093.007	337.269
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Topo	4824002.752	689084.484	337.251
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Topo	4823998.433	689075.281	336.979
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Topo	4823993.690	689077.037	337.226
Topo	4823993.501	689079.088	337.383
Topo	4823994.993	689081.661	337.426
Topo	4823997.194	689082.493	337.472
Topo	4823999.681	689082.753	337.406
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Topo	4824004.157	689083.377	337.185
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Topo	4824013.901	689084.384	336.828
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Topo	4824018.078	689082.813	336.662

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Topo	4824013.375	689138.762	325.870
Topo	4824011.202	689138.419	325.959
Topo	4824009.192	689137.193	325.929
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Topo	4823996.267	689132.954	326.807
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Topo	4823986.859	689130.356	327.575
Topo	4823982.628	689129.380	327.800
Topo	4823981.389	689127.203	327.705
Topo	4823978.913	689126.946	327.896
Topo	4823975.844	689127.716	328.078
Topo	4823973.405	689128.047	328.300
Topo	4823971.173	689128.137	328.300
Topo	4823966.812	689128.212	328.375
Topo	4823966.526	689125.926	328.322
Topo	4823964.409	689125.640	328.377
Topo	4823962.313	689126.381	328.421
Topo	4823959.995	689124.256	328.459
Topo	4823956.870	689121.883	328.606
Topo	4823955.197	689120.486	328.734
Topo	4824068.123	689150.392	324.531
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Topo	4823977.262	689133.869	328.356
Topo	4823971.640	689134.443	328.500
Topo	4823965.640	689135.299	328.797
Topo	4823956.022	689136.372	328.742
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Topo	4823938.690	689132.747	329.531
Topo	4823929.135	689128.886	330.260
Topo	4823923.467	689126.805	330.708
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Topo	4823920.863	689118.147	331.628
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Topo	4823924.926	689110.115	332.336
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Topo	4823943.085	689111.405	329.846

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Topo	4823956.210	689113.309	328.718
Topo	4823962.237	689113.620	328.298
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Topo	4823975.598	689111.430	327.630
Topo	4823981.537	689112.824	327.387
Topo	4823987.609	689111.810	327.318
Topo	4823993.341	689111.323	327.260
Topo	4823999.090	689115.660	327.047
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Topo	4823924.340	689120.158	331.358
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Topo	4823928.737	689121.994	330.907
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Topo	4823929.617	689128.664	330.258
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Topo	4823932.924	689113.444	331.112
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Topo	4823933.011	689123.610	330.411
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Topo	4823932.298	689129.569	330.098
Topo	4823934.655	689129.886	329.895
Topo	4823935.116	689126.747	330.022
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Topo	4823938.517	689119.208	330.208
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Topo	4823955.384	689131.461	329.777

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Topo	4823944.003	689110.085	329.782
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Topo	4823943.745	689120.176	329.640
Topo	4823942.953	689123.396	329.664
Topo	4823941.930	689126.662	329.558
Topo	4823941.148	689130.315	329.412
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Topo	4823944.245	689131.764	329.168
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Topo	4823952.576	689115.700	328.991
Topo	4823951.445	689119.355	329.036
Topo	4823950.838	689122.470	329.016
Topo	4823949.534	689126.200	329.104
Topo	4823948.259	689129.845	329.048
Topo	4823946.678	689133.433	329.041
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Topo	4823955.782	689124.004	328.738
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Topo	4823957.967	689129.490	328.622
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Topo	4823967.198	689115.808	328.079
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Topo	4823961.832	689130.687	328.521
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Topo	4823967.906	689122.957	328.286
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Topo	4823976.018	689115.321	327.530
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Topo	4823972.434	689123.703	328.073
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Topo	4823974.724	689131.724	328.397
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Topo	4823981.171	689116.749	327.441
Topo	4823986.107	689115.594	327.236
Topo	4823983.120	689121.650	327.354
Topo	4823977.507	689131.242	328.221
Topo	4823984.829	689125.607	327.495

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Topo	4823988.593	689131.519	327.503
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Topo	4823996.154	689123.594	327.013
Topo	4823997.749	689118.960	327.108
Topo	4824001.548	689121.907	327.036
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Topo	4823995.768	689134.628	326.764
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Topo	4824013.415	689127.472	326.291
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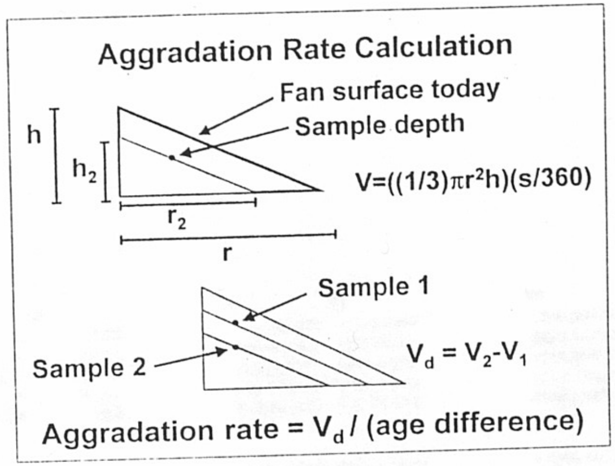
Topo	4824014.439	689131.666	325.797
Topo	4823999.745	689127.646	326.951
Topo	4823961.804	689127.294	328.490
Topo	4823918.624	689109.720	332.997
Topo	4823918.262	689111.672	332.898
Topo	4823917.524	689113.348	332.569
Topo	4823916.460	689115.281	332.062
Topo	4823914.992	689116.888	331.620
Topo	4823913.347	689118.753	331.388
Topo	4823912.217	689114.926	332.679
Topo	4823914.862	689109.125	334.542
Topo	4823914.947	689105.960	335.326
Driveway	4824042.214	689139.878	325.651
Driveway	4824042.353	689141.970	325.650
Driveway	4824042.177	689144.322	325.615
Driveway	4824042.076	689146.401	325.557
Driveway	4824041.965	689148.511	325.547
Driveway	4824041.885	689150.673	325.575
Driveway	4824041.587	689152.674	325.557
Driveway	4824041.568	689155.242	325.541
Driveway	4824041.681	689157.796	325.538
Driveway	4824042.204	689137.556	325.758
Driveway	4824042.310	689135.388	325.776
Driveway	4824042.400	689133.260	325.901
Driveway	4824042.591	689131.033	326.005
Driveway	4824042.650	689128.647	326.110
Driveway	4824042.714	689126.170	326.361
Driveway	4824042.784	689122.038	326.779
Driveway	4824043.649	689119.418	326.831
Driveway	4824043.024	689108.596	328.828
Driveway	4824043.051	689103.958	329.689
Driveway	4824043.259	689100.914	330.331
Driveway	4824043.307	689098.355	330.748
Driveway	4824043.251	689095.185	331.354
Driveway	4824043.216	689093.016	331.706
Driveway	4824043.264	689090.945	332.027
Driveway	4824043.270	689087.477	332.681
Driveway	4824043.074	689083.977	333.208
Driveway	4824042.847	689081.758	333.575
Driveway	4824042.092	689079.603	333.890
Driveway	4824040.862	689077.646	334.143

Driveway	4824037.669	689076.081	334.712
Driveway	4824035.334	689075.887	334.967
Driveway	4824031.838	689076.781	335.394
Driveway	4824029.642	689077.917	335.729
Driveway	4824027.535	689078.910	336.096
Driveway	4824025.573	689079.877	336.249
Stream	4823918.624	689109.720	332.997
Stream	4823918.262	689111.672	332.898
Stream	4823917.524	689113.348	332.569
Stream	4823916.460	689115.281	332.062
Stream	4823914.992	689116.888	331.620
Stream	4823913.347	689118.753	331.388
Stream	4823912.217	689114.926	332.679
Stream	4823914.862	689109.125	334.542
Stream	4823914.947	689105.960	335.326
Test pit #3	4823961.804	689127.294	328.490
Test pit #5	4823999.745	689127.646	326.951
Trench Corner	4823929.805	689125.033	330.742
Trench Corner	4823926.124	689116.338	331.833
Trench Corner	4823929.055	689112.382	331.857
Trench Corner	4823928.215	689111.665	331.980
Trench Corner	4823922.164	689118.524	331.886
Trench Corner	4823923.165	689119.557	331.658
Opposite stem trench section	4823959.311	689127.045	328.847
Opposite stem trench section	4823959.652	689128.079	328.812
Trench Stake	4823929.966	689124.372	330.746
Trench Stake	4823929.205	689122.566	331.091
Trench Stake	4823928.589	689120.922	331.165
Trench Stake	4823927.577	689118.794	331.373
Trench Stake	4823926.661	689117.744	333.286
Trench Stake	4823928.031	689111.532	332.033
Trench Stake	4823926.741	689112.928	332.089
Trench Stake	4823925.510	689114.281	332.154
Trench Stake	4823923.600	689116.363	331.965
Grid Point	4823929.955	689124.455	331.563
Grid Point	4823926.445	689116.71	332.175
Grid Point	4823927.978	689111.545	332.495
Grid Point	4823922.145	689118.086	332.464

APPENDIX C: Aggradation Rate Calculations



***sample is out of stratigraphic order

Eden Mills:

sample #	median age	depth	h1	hs	r1	rs	V1	Vs	Vd	Age diff	Agg rate
53	80	0.66	5.5	4.84	67	58.952497	6460.41917	4401.47432	2058.94484	80	25.7368105
6	490	0.7	4.84	4.8	58.952497	58.4652862	4401.47432	4293.24626	108.228067	410	0.2639709
58	6090	1.36	4.8	4.14	58.4652862	50.4263094	4293.24626	2754.62897	1538.61728	5600	0.27475309 ***
40	9450	1.28	4.14	4.22	50.4263094	51.4007308	2754.62897	2917.42326	-162.79428	3360	-0.0484507 ***
60	9650	1.15	4.22	4.35	51.4007308	52.9841657	2917.42326	3195.43405	-278.01079	200	-1.390054
70	12900	2.15	4.35	3.35	52.9841657	40.8038977	3195.43405	1459.47449	1735.95956	3250	0.5341414
71	13320	2.65	3.35	2.85	40.8038977	34.7137637	1459.47449	898.6626	560.811892	420	1.33526641

EM alternate:

sample #	median age	depth	h1	hs	r1	rs	V1	Vs	Vd	Age diff	Agg rate
53	80	0.66	5.5	4.84	67	58.952497	6460.41917	4401.47432	2058.94484	80	25.7368105
6	490	0.7	4.84	4.8	58.952497	58.4652862	4401.47432	4293.24626	108.228067	410	0.2639709
60	9650	1.15	4.8	4.35	58.4652862	52.9841657	4293.24626	3195.43405	1097.81221	9160	0.11984849
70	12900	2.15	4.35	3.35	52.9841657	40.8038977	3195.43405	1459.47449	1735.95956	3250	0.5341414
71	13320	2.65	3.35	2.85	40.8038977	34.7137637	1459.47449	898.6626	560.811892	420	1.33526641

Bridgewater:

sample #	median age	depth	h1	hs	r1	rs	V1	Vs	Vd	Age diff	Agg rate
31	3650	0.57	2.7	2.13	42.7	33.8095238	1288.15439	637.097812	651.056573	3650	0.17837166
4	4960	0.75	2.13	1.95	33.8095238	30.952381	637.097812	488.844955	148.252857	1310	0.11317012
12	5570	0.9	1.95	1.8	30.952381	28.5714286	488.844955	384.489796	104.355159	610	0.17107403
34	6020	0.95	1.8	1.75	28.5714286	27.7777778	384.489796	353.330761	31.1590346	450	0.0692423
17	6610	1.18	1.75	1.52	27.7777778	24.1269841	353.330761	231.525093	121.805669	590	0.20645029
66	11333	3	1.52	-0.3	24.1269841	-4.7619048	231.525093	-1.7800454	233.305138	4723	0.04939766
10	14203	1.35	-0.3	1.35	-4.7619048	21.4285714	-1.7800454	162.206633	-163.98668	2870	-0.0571382 ***

Maidstone:

sample #	median age	depth	h1	hs	r1	rs	V1	Vs	Vd	Age diff	Agg rate
4	77	0.3	6	5.7	75	71.25	12265.625	10516.2402	1749.38477	77	22.7192827
23	79	0.82	5.7	5.18	71.25	64.75	10516.2402	7892.69301	2623.54723	2	1311.77361
2	81	1.1	5.18	4.9	64.75	61.25	7892.69301	6680.73387	1211.95914	2	605.979569
13	132	1.35	4.9	4.65	61.25	58.125	6680.73387	5709.45679	971.277082	51	19.0446487
52	150	4.2	4.65	1.8	58.125	22.5	5709.45679	331.171875	5378.28491	18	298.793606

Note: only included the samples which were in stratigraphic order

all	150	4.2	6	1.8	75	22.5	12265.625	331.171875	11934.4531	150	79.5630208

Bristol:

sample #	median age	depth	h1	hs	r1	rs	V1	Vs	Vd	Age diff	Agg rate
3	3541	0.3	8	7.7	55	52.9391543	6332.33333	5646.67934	685.653988	3200	0.21426687
46	3900	0.55	7.7	7.45	52.9391543	51.2203506	5646.67934	5114.34203	532.337311	359	1.48283374
10	4370	0.6	7.45	7.4	51.2203506	50.8765899	5114.34203	5012.05825	102.283779	470	0.21762506
35	9330	0.85	7.4	7.15	50.8765899	49.1577862	5012.05825	4521.04757	491.010688	4960	0.09899409
32	9340	0.92	7.15	7.08	49.1577862	48.6765211	4521.04757	4389.55731	131.490252	10	13.1490252
53	9380	2.6	7.08	5.4	48.6765211	37.1261602	4389.55731	1947.61105	2441.94626	40	61.0486566
55	10310	3.45	5.4	4.55	37.1261602	31.2822276	1947.61105	1165.07837	782.532678	930	0.84143299
59	12980	5.2	4.55	2.8	31.2822276	19.2506016	1165.07837	271.515761	893.562612	2670	0.33466765

Note: only included the samples which were in stratigraphic order

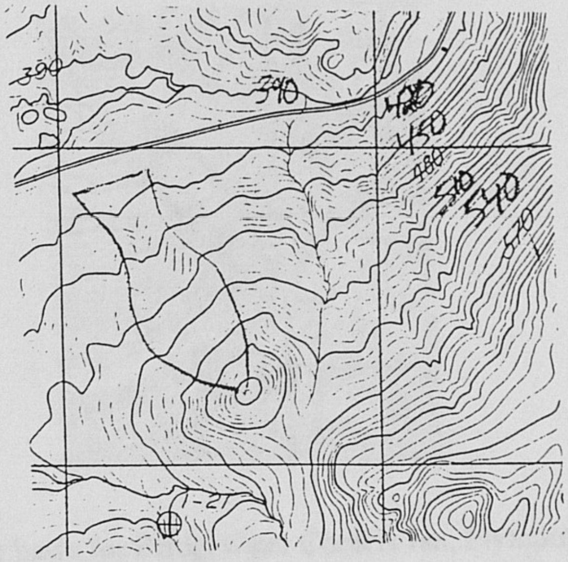
Hancock:

sample #	median age	depth	h1	hs	r1	rs	V1	Vs	Vd	Age diff	Agg rate
39	740	0.6	8	7.4	83.3	7.70833333	14525.4097	115.053834	14410.3559	740	19.4734539
8	2740	1.08	7.4	6.92	7.70833333	7.20833333	115.053834	94.0858297	20.9680042	2000	0.010484
45	5460	1.15	6.92	6.85	7.20833333	7.13541667	94.0858297	91.2594087	2.82642106	2720	0.00103913
31	6900	1.15	6.85	6.85	7.13541667	7.13541667	91.2594087	91.2594087	0	1440	0
22	10030	1.51	6.85	6.49	7.13541667	6.76041667	91.2594087	77.6139929	13.6454158	3130	0.00435956

Note: only included the samples which were in stratigraphic order

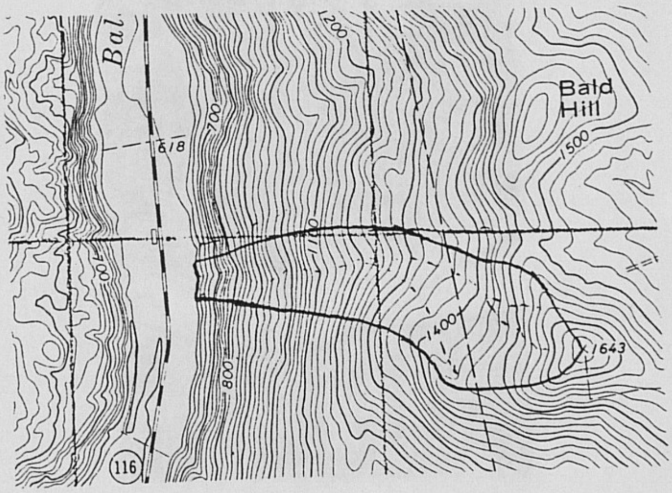
Appendix D: Drainage Basin areas

The drainage basins of the Eden Mills, Bristol, Bridgewater Corners, and Hancock fans were delineated on USGS 1:24,000 topographic maps. The outlined drainage basins were then digitized using standard software to determine the surface area of each drainage basin. The Maidstone drainage gully was surveyed using a Pentax total station, and a topographic map was created from the survey data. The gully was delineated on the generated topographic map, and digitized to determine the surface area of the gully. The following five figures show the delineated drainages for each alluvial fan, as used for the surface area calculations. These drainage basins were only partially investigated in the field, and hence the calculated surface area for each drainage basin should be viewed as a maximum possible value.



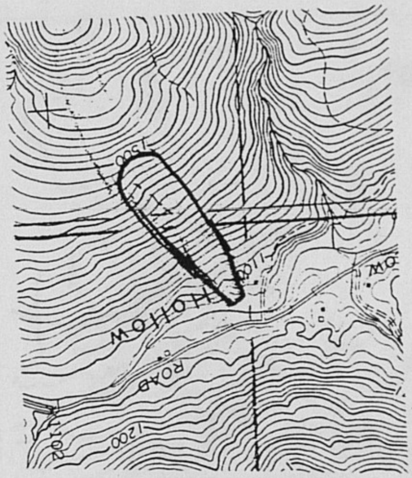
Drainage basin for Eden Mills fan, Albany Quadrangle.

Drainage basin area is 135,000 m^2.



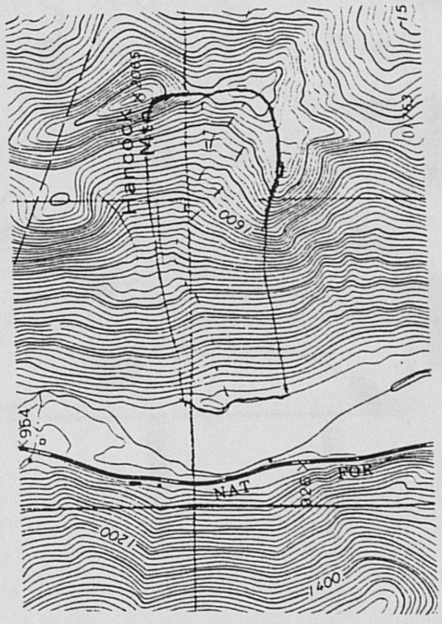
Drainage basin for Bristol fan, Bristol Quadrangle.

Drainage basin area is 249,000 m^2.



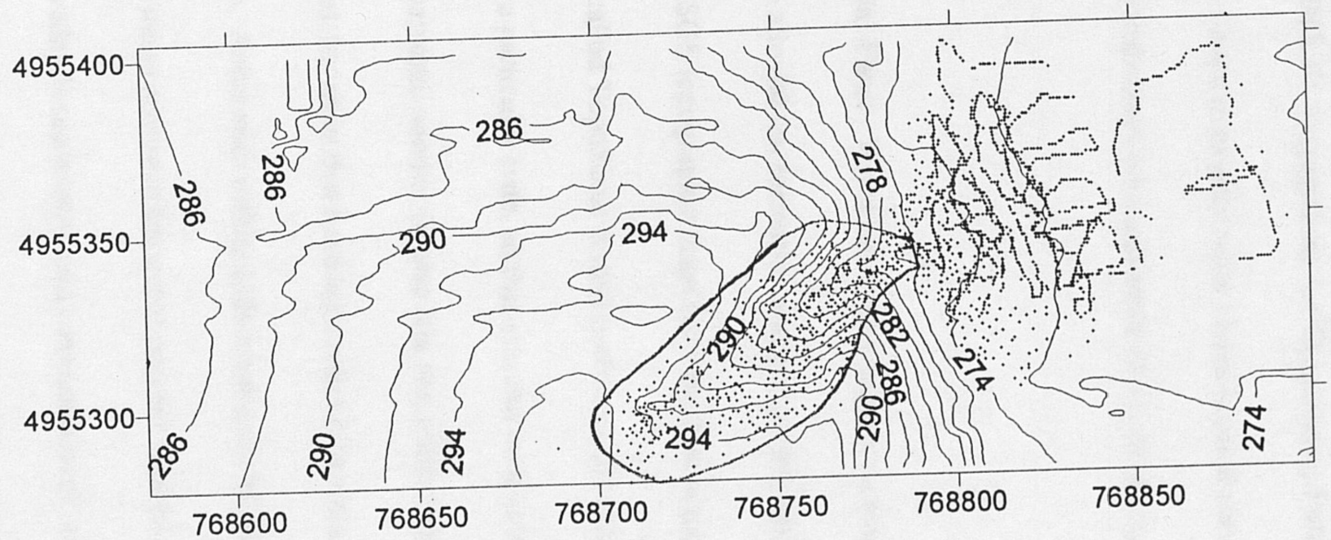
Drainage basin for Bridgewater Corners fan, Plymouth Quadrangle.

Drainage basin area is 41,600 m^2.



Drainage basin for Hancock fan, Hancock Quadrangle.

Drainage basin area is 225,000 m^2.



Topographic map of Maidstone fan and drainage gully. Dots are measured survey points. X and Y axes are in UTM coordinates. Drainage surface area is 2, 800 m2.

APPENDIX E: Suggestions for Organizing Future Work

With this section, I hope to explain what I have learned about the best way to organize this project so that others who undertake this type of study will have some guidelines to follow.

Field Mapping Alluvial Fans. When covering a large area, it is easiest to map out locations conducive to alluvial fan formation and preservation before heading out into the field. The 1:24,000 USGS topographic maps have the best resolution for doing this. A commercial program called TopoScout is also useful; it puts together all the USGS topographic maps for a particular state, so that you can look at them on a computer screen and scroll from one map onto another (it also lets you zoom in and out). On the topographic maps, look for areas that have high relief hillslopes abutting wide, flat valleys (Figure AE.1). Areas with rolling hills are not useful for finding alluvial fans because there are too many sediment traps that prevent alluvial fans from forming. Alternatively, if the valley is too narrow and contains a river, all of the eroded sediment from the hillslopes will go directly into the river and be washed downstream (Figure AE.2).

Look for areas on the topographic maps that are not too heavily forested. For a quick, drive-by type of reconnaissance (necessary for covering large areas in a short amount of time), alluvial fans hidden by forest coverage will not be visible. Also, the likelihood that the backhoe would be able to trench a forested alluvial fan is very slim. Once you have identified good fan producing/preserving areas on the topographic maps, circle those same areas on the State Gazetteer maps for reference while in the field (the Gazetteer is more portable in the field than a bunch of topographic maps). For example, you can see where I circled potential fan areas on the maps in Appendix A.

It takes a while to train your eye to spot alluvial fans in the field, so I would suggest driving around to look at some previously mapped alluvial fans in order to get a better idea of what they look like in the field. The best time of the year to see alluvial fans in the landscape is in the winter (the snow cover accentuates the fan shape) and in the early spring before the vegetation grows back. The worst time of the year for viewing alluvial fans is in late summer. The dense, bushy vegetation that has grown in by July and August makes it difficult to see the natural landscape shape. Also, fans that are in or behind corn fields are completely obscured by August when the corn is at its highest.

Once you are out in the field mapping the locations of alluvial fans, my suggestion would be to document each fan you find as follows. Develop a coding system and assign each fan a code. The code that worked best for me was to use A1 through A9, then B1 through B9, and so on. Mark the location of the fan on the Gazetteer map, and write the code next to that position. Also write the code in the upper, outside corner of the Gazetteer page – this allows you to flip through the Gazetteer pages later and easily see which fans are located on that page. In a separate field notebook, write the fan code, Gazetteer page number, a description of the location (so that you can easily find the fan again), and a description of the fan setting/characteristics/condition. Also document any information you may have about the landowners: for example, there may be a sign if the property is a farm or business, or a name on the mailbox.

Take a photograph of each fan you identify, and write the roll number and exposure number in your field notes. Keep track of which roll is which by affixing a label to the film canister with the year and roll number (i.e. 2001-5 for roll number 5 taken during 2001). As soon as the film is developed, write the fan code on the back of each photo and store the photos in an album. Don't put this off – it is easy to forget what a particular fan looks like when you are mapping 30 or 40 of them.

In some instances there may be confusion about whether a particular landform is actually an alluvial fan. For example, colluvial wedges may resemble fans. Also, in locations where there are two incising streams on either side of a rolling hill, the eroded hill may take on a fan shape. I found that it was safest to assume a landscape feature was an alluvial fan if it had an identifiable drainage channel or gully that was positioned at the apex of the fan. For example, some fan-shaped features that I examined had an apex that abutted a flat hillslope with no evidence of a channel or gully. I assumed such landforms to be erosional (i.e. a hill that has been eroded from the sides), rather than depositional features of the landscape, and therefore not alluvial fans.

In studies where alluvial fans with ages spanning the Holocene are desired, another thing to consider during reconnaissance is the potential age of each fan. Older fans will have well-developed, deeply incised feeder channels. An alluvial fan that has a feeder channel that is not deeply incised is likely to be entirely historic deposition. Similarly, alluvial fans that are located on river terraces are constrained by the age of that terrace. So alluvial fans that are situated on the modern floodplain, or on lower terraces, are likely to be very young and possibly historic in age (the Maidstone fan is an example of this). Alluvial fans on higher terraces are more likely to have an older basal age.

Landowner permission. While you are doing field reconnaissance, you will want to get a closer look at the fans, and will talk to some landowners to get permission to walk around their property. At that point, you will need to give them a brief background on your project. You may also want to ask them if the property has ever been disturbed (i.e. dug up) and ask them for their name and phone so you can contact them in the future. However, I would *very strongly* recommend *against* saying anything about trenching at this point. I found that at the mere mention of a backhoe trenching anything, people would naturally get a bit defensive, turning what would have been a 5 minute discussion into a 30 minute discussion about why it was necessary to trench and getting into the details of my project. This wastes valuable field time on a fan that you might not end up using anyway. Instead, I would recommend holding off any discussion about backhoes or trenching until you have made a final decision about which fans you want to trench.

After you have completed your field mapping/reconnaissance, sit down with a state map and all of your fan photos and descriptions. Choose the fans that would be best to trench based on their location and condition. Several months before you plan to do the fieldwork, contact the landowners of the fans you are interested in trenching. If possible, it is best to go back to the field site and talk with the landowner in person, so they can see exactly where on their property you are interested in trenching. However, this may not be feasible if the landowner does not permanently reside on the property (a common occurrence in Vermont and New York). In such situations it may be difficult to find out the landowner's name, address or phone number. The best place to start to look for this type of information is the local town office. The town office should have property tax maps that list the name and address of each property owner (this information is public domain).

This time around, when you talk to the landowners, you will need to get into the details of the project and explain why you want to trench their property. Justifiably, most people are wary of having their property dug up for any reason. My only advice is just to be patient and don't pressure anyone into doing anything they don't want to. Remember that if some stranger wanted to dig up your yard, you'd probably be pretty suspicious and defensive about it too. If you are understanding about that, maybe they will be more likely to grant permission (at the very least they will think better of you as a person). Be prepared for a lot of rejection, and to have to re-visit some landowners many times to talk to them more about the project.

Although I did not do this myself, I have wondered whether having references would have helped with getting permission from landowners. I think having references from other people who have had their property trenched for UVM Geology projects might go a long way (but only if those people are willing to say good things about having their property trenched).

Another thing to consider is having some sort of legal document that addresses liability issues. For example, several landowners expressed to me their concern about being liable if I was hurt while on their property, and in one case, I was denied permission to trench for that exact reason. It may also be useful to have some sort of legal, written statement from the landowner that you have permission to trench (which I did not do) to protect yourself from financial liability if a landowner felt that you dug up too much of their property. However, having a lot of legal papers could make landowners more suspicious and weary of having you on their property.

Planning the field season. I setup my field season over the summer months, allowing mid May to mid June for logistical planning, and ten weeks from Mid June through August for solid field work. Having the field season arranged as such resulted in a lot of scrambling around to get things done at the last minute and a lower number of fans being trenched in the end. The reality of this type of work is that the logistics must be done on an ongoing basis. Because of the difficulty of getting landowner permission, it is very likely that you will be continually re-evaluating which fans you can trench and talking to more landowners as you are denied permission from trenching other fans. Because of the way I had set up my field season, I often found myself in a position where I had a hired field hand but nothing to trench (because no one had granted permission), requiring me to do last-minute reconnaissance on weekends to find more fans and talk to more landowners so that the money spent on a field assistant was not being wasted. Having ten solid field weeks in a row also led to both my field assistant and myself being continually overworked and burnt-out.

As an alternative, I would suggest arranging the field season as several on/off weeks. Trenching and field work would be done during "on" weeks, and logistics would be taken care of during the "off" weeks. For example, consider a cycle of 2.5 weeks "on" and 1.5 weeks "off." The "on" weeks allow enough time to survey each fan surface before trenching, and to do the trenching and logging work. The "off" weeks provide the time to arrange for a backhoe and a place to stay at the next field site, contact other landowners, take care of any office work that needs to be done (such as downloading survey data), and do further reconnaissance if necessary. Hire your field assistant only for the "on" weeks. That way, you will be only paying for their time spent in the field, and the assistant has a week off every third week, preventing burn-out for someone not used to intensive field work.

Field Assistants. I had one main field assistant for this project, who was paid for ten weeks of work during the trenching and logging of three of the alluvial fans. When hiring a field assistant, I would suggest using an informal work contract that lays out your expectations for their involvement, the worst-case scenario of what the field work will be like, and a strong statement that your work has first priority over any independent research the field assistant may want to do. Have the contract signed by yourself, the field assistant, and the advisor so that each person knows what is expected of them and the others.

I strongly believe that when hiring someone for intensive field work, you need to let them know what they are in for, assuming that they have never been exposed to this type of work before. The good people will not be scared off by this tactic, and the people who are scared off probably would have been miserable in the field anyway. Then when problems arise, you know it is not because your assistant was surprised by an unexpected working environment.

When choosing a field assistant for alluvial fan trenching, it would be ideal to have someone with a coursework background in geomorphology, hydrology, sedimentology/stratigraphy, and soils. However, if you have to choose only one of those disciplines, I would suggest hiring someone who has had some geomorphology or sedimentology/stratigraphy coursework. Since the bulk of this project is figuring out depositional sequences, it is essential to have had some prior exposure to sedimentary landform evolution.

Planning for the Backhoe and Trenching. Finding a backhoe to dig your trenches in the summer will be a bit difficult. This is the busiest season for backhoe owners, and they will not want to spend their time on a small job when they could be making more money on digging a house foundation. Since digging two trenches is a fairly small job, it is likely that no backhoe operator will reserve a spot for you more than a week in advance.

I found that the best way to find a backhoe operator to dig the trenches is to ask the landowner if they could recommend someone. This is actually a good way to build trust with the landowner, because then they can give you the name of someone they know, rather than worry about you bringing in an unknown operator who might ruin their property. If the landowner doesn't know who to recommend, or if the person they recommended is too busy, try asking at the local general store. Usually, the landowner or store owner will give you the names of people who are more likely to be interested in doing a good job on a small project. Also, some of the locally-recommended backhoe operators are less expensive (but not always, so don't count on it).

Expect to pay a lot for the hired backhoe. During my field season, the average price of hiring a backhoe in Vermont was $70 to $80 per hour. When you arrange for the backhoe, you will need to tell them approximately how long it will take them to do the job. For my trenches, it took about 2 hours to dig the trenches, and about 3 to 4 hours to do the deeper digging and then fill the trenches in (depending on how interesting the deeper sediments are). You will need to outline where the trenches are to be dug with stakes or flags before the backhoe arrives. Make sure you know the approximate dimensions of the trench in English units in case the backhoe operator asks. Also, don't be afraid to tell them to stop periodically so you can get into the trench and make sure it looks right.

Both the landowner and the hired backhoe will want to know how long you will have the trenches open. I would suggest ten working days for the trenching and logging. Going back to the 2.5 weeks "on" and 1.5 weeks "off" scenario, I would suggest using the half-week for surveying the fan surface and staking out where the trenches are to be dug. The next 2 weeks (10 work days) would be reserved for the trench work. Note that these time estimates are for working full time (8-10 hours/day) and leaving the weekends free, which I found I needed to take care of ongoing logistical problems. Considering the extra time built in for logistics with the on/off plan, the free weekends might not be necessary, but it's always good to have the extra time to put towards any unpredicted problems that might arise.

I logged one fan during the fall semester, on which I worked part-time while teaching and taking classes. This fan took me four weeks to trench and log, with an average time input of 4 to 5 hours per day, and 4 or 5 workdays per week.

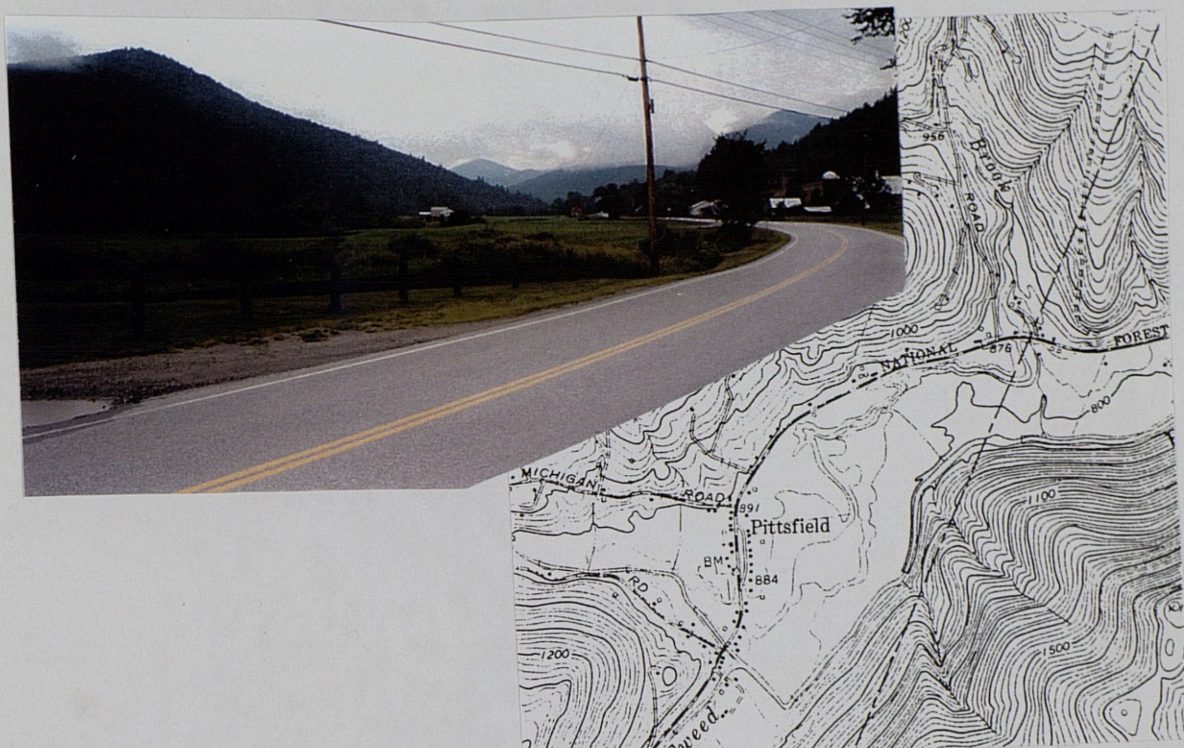


Figure AE.1. Example of an area likely to preserve alluvial fans, White River Valley, Vermont.

Figure AE.2. Example of fan sediments deposited into a stream.