Special Report 14

Quaternary Geology and Dispersal Patterns, Winagami Region, Alberta

Alberta Energy and Utilities Board
Alberta Geological Survey

Published as Alberta Geological Survey Special Report 14

Quaternary Geology and Dispersal Patterns
Winagami Region, Alberta

by

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A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILMENT FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

DEPARTMENT OF EARTH AND ATMOSPHERIC SCIENCES

University of Alberta

EDMONTON, ALBERTA

Spring 2000

ABSTRACT

The Quaternary geology of the Winagami study area is consistent with at least one Late Wisconsinan glacial advance of the Laurentide Ice Sheet. Glacial sediments of possible earlier advances are present, but their chronostratigraphic relationship is speculative. Surficial deposits are associated with ice advance and stagnation, deglaciation and post-glacial processes. Till, glaciolacustrine silt, clay and diamict blanket the majority of the region. Sediments of glaciofluvial, aeolian, colluvial, alluvial and organic origin are widespread, but of limited areal extent.

Distribution of the surface units and ice directional landforms indicates that the Laurentide Ice Sheet varied in thickness and thermal basal regimes during the Late Wisconsinan advance. The dominant ice flow direction was south to southwest and corresponds with the main advance of the ice sheet when ice thickness was at a maximum. The southeasterly ice flow direction was topographically controlled and corresponded with thinner ice lobes marginal to the ice sheet, during the initial stages of ice advance and deglaciation. The Laurentide Ice Sheet was primarily warm-based, with localised regions of cold-based ice.

The stratigraphy of the Winagami region is complex due to the irregularity of drift thickness and bedrock topography. Drift thickness varies from a veneer on topographic highs to over 150 m within the paleochannels. At least six infilled paleochannels of variable depth are present within the study area, although their exact geometry remains unknown. Stratigraphic correlation of the units within these channels is problematic due to the lack of samples and radiometric ages.

Dispersal patterns based on granulometry, lithology, geochemistry and diamond indicator minerals (DIMs) are of limited use in defining dispersal trends due to sample distribution and concentration. Till matrices display homogeneity within three metres of the till – substrate contact, indicating rapid rates of substrate debris entrainment and dilution within the till column. Terminal grade of the entrained material determines the preservation rate of anomalous material within the till column, and can be used to determine glacial transportation distances. In the study area, low and high terminal grades of the underlying bedrock units and the DIMs, respectively, in conjunction with the position of anomalous samples within the till column, indicate debris entrainment within the ice was rapid and the distance of transport was short. Most anomalous samples appear to have come from sources within a few kilometres distance. In the Puskwaskau region, the sources are even closer, likely within one kilometre. Dispersal patterns or trends can be a significant tool in exploration in the Winagami area, provided that they are analysed in conjunction with bedrock topography, drift thickness and glacial history.

ACKNOWLEDGEMENTS

The author wishes to thank several people and organisations for their help and funding of this thesis. Thank you to Mark Fenton and John Pawlowicz at the Alberta Geological Survey for initially proposing the thesis topic and for financial and logistical support. Special thanks to Robin Wyllie for computer support, field assistance and critically reviewing and editing this thesis. Thank you to D. Toop of Prairie Farm Rehabilitation Administration (PFRA) for geological information along the Little Smoky River. The writer is indebted to the willing support received from field assistants J. Sharon and L. Leslie during the 1993 and 1994 field seasons**.** Thanks to the "Quat Clan", J. Bond, D. Rokosh, T. Little, H. Blyth for helpful criticism and suggestions on the thesis and associated field trips. Thanks also go to K. Pearson of Geological Drilling Co. of Edmonton for providing excellent drill cores, Bob for allowing access to the Puskwaskau fire tower, B. Garrett of the Geological Survey of Canada for providing a till standard to use in the geochemical analyses, and to D. Smith for helping out with truck problems and land survey information. At last, but definitely not the least, thanks to my supervisor Dr. Nat Rutter for his wisdom and infinite patience concerning this thesis and its completion. This research was also supported by grants and funding from the Canada-Alberta Partnership on Minerals (MDA), the Canadian Circumpolar Institute, NSERC and the University of Alberta.

DEDICATION

This thesis is dedicated to Robin;
my children Tanner, Cassandra and Ceilidh;
and the rest of our extended families.

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1.0 INTRODUCTION

The discovery of diamondiferous kimberlites in northern Alberta near Buffalo Head Hills and the Birch Mountains sparked renewed interest in the surficial geology and Quaternary stratigraphy of northern Alberta. Diamond exploration methods are dependent on reliable information concerning the location of buried paleochannels and the way in which paleochannels affect ice flow and diamond indicator mineral dispersal patterns, information that is lacking in much of northern Alberta. Information pertaining to ice flow directions and drift thickness is also vital to other mineral, hydrological and aggregate exploration in Alberta. In response, the federal and provincial government conducted research through the Mineral Development Agreement (MDA) to provide the data needed by industry.

The Winagami region, the focus of this thesis, contains the Mountain Lake Kimberlite and was one of several areas defined by the MDA and industry for geological study (Figure 1.1). The region is situated near the eastern limit of the Cordilleran Ice Sheet and within the Late Wisconsinan western limit of the Laurentide Ice Sheet. The presence of a known kimberlite source makes the Winagami area ideal for dispersal analysis. Evidence of earlier ice advances, if present, are restricted to infilled paleochannels and their tributaries, although their exact position and geometry of the channels are uncertain. Possible multiple tills and gravel units in the paleochannels, documented from well logs, have not been correlated geochronologically or chronostratigraphically at a regional scale. As a result, the stratigraphy of the area with respect to glacial movement and Quaternary history is poorly known.

1.1 OBJECTIVES

This thesis has three main objectives. The first objective is to provide information on the style of glaciation in the western half of the Winagami

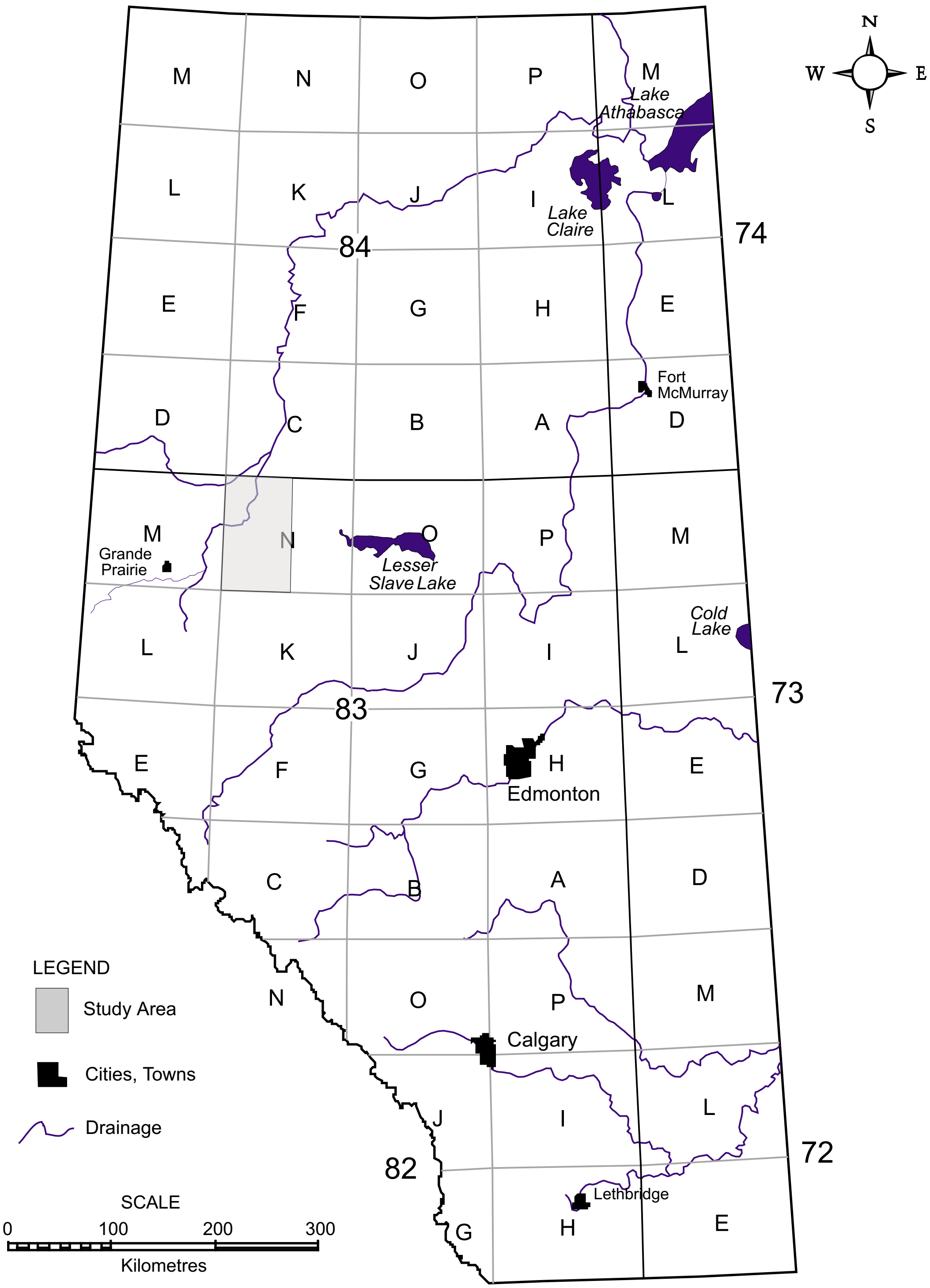


FIGURE 1.1 Location of Study Area

1:250,000 scale National Topographic System (NTS) map sheet 83N (Figure 1.1), its effect on dispersal patterns of diamond indicator minerals and geochemical elements, and the significance of these patterns to metallic mineral and diamond exploration in Alberta.

The second objective is to provide information on the regional distribution and composition of the surficial and subsurface sediments within the study area. Six maps at a scale of 1:100,000 were compiled to show the surficial geology, bedrock topography and the drift thickness of the area.

The third objective is to relate the surficial and subsurface data to the regional stratigraphy and history of the Laurentide Ice Sheet during the Quaternary. Three cross-sections and a composite stratigraphic column were constructed to show the generalized Quaternary geology of the region.

1.2 LOCATION, ACCESS AND PHYSIOGRAPHY

The study area is located in the western half of the 1:250,000 scale Winagami map sheet (NTS 83N) about 50 km east of Grande Prairie and approximately 270 km northwest of Edmonton (Figure 1.1). Fahler, Valleyview and Girouxville are the largest towns in the region (Figure 1.2). Smaller communities and hamlets are located primarily near major highways and railways. Access to the region is restricted mainly to highways, township roads, railway lines, seismic cut-lines, and, to a lesser extent, rivers. Two small airports located at Eaglesham and south of Valleyview service the region.

The study area lies in the Interior Plains of Canada, within the Alberta Plateau and Peace River Lowland physiographic zones (Klassen, 1989). Rolling uplands, undulating river basins and deeply entrenched river valleys characterise the region. Elevations vary from 326 metres above sea level (a.s.l.) along the Peace River to a maximum of 902 m a.s.l at the apex of the “Puskwaskau Hills” (Figures 1.3 and 1.4).

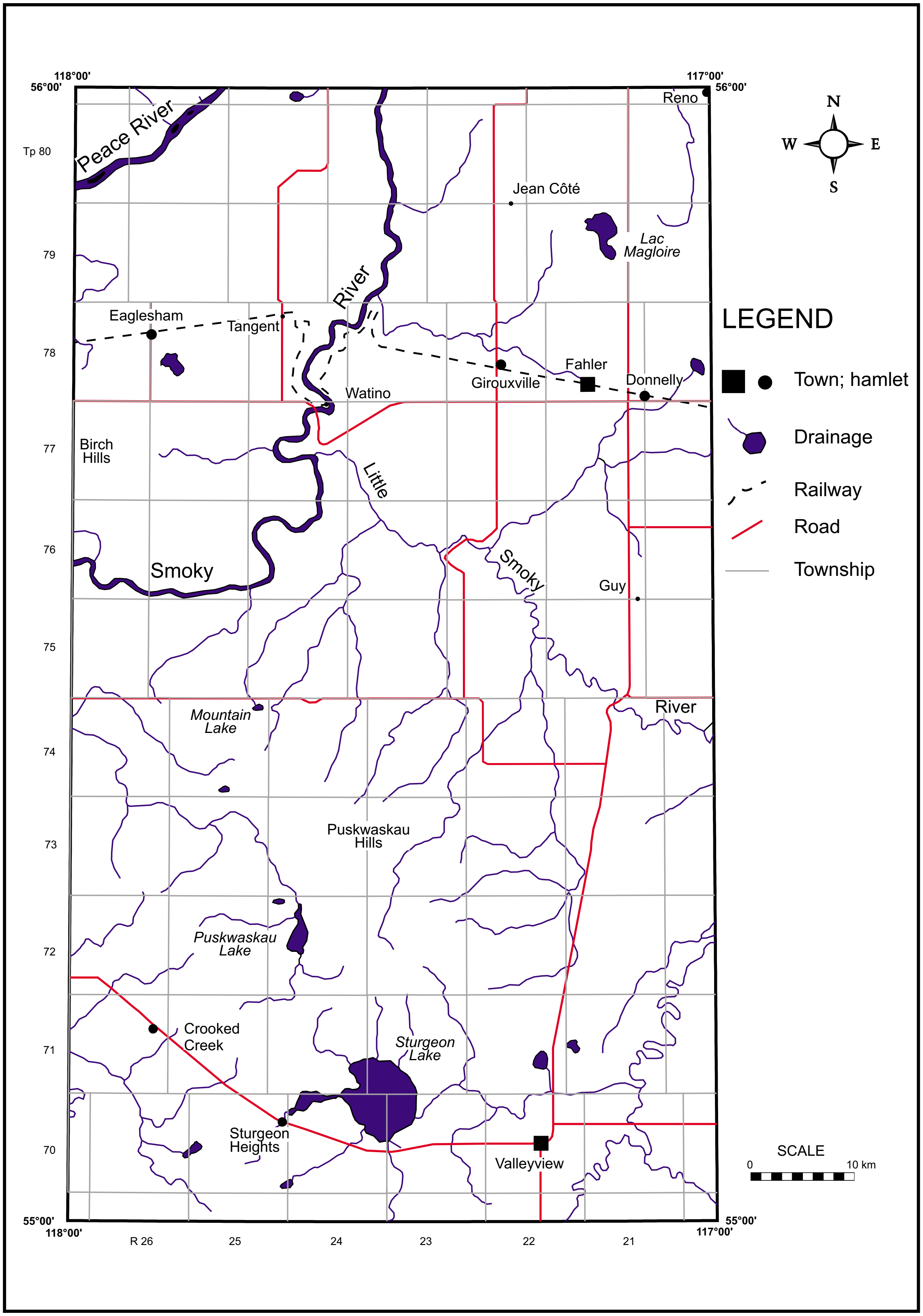


FIGURE 1.2 Detailed Location Map of Study Area

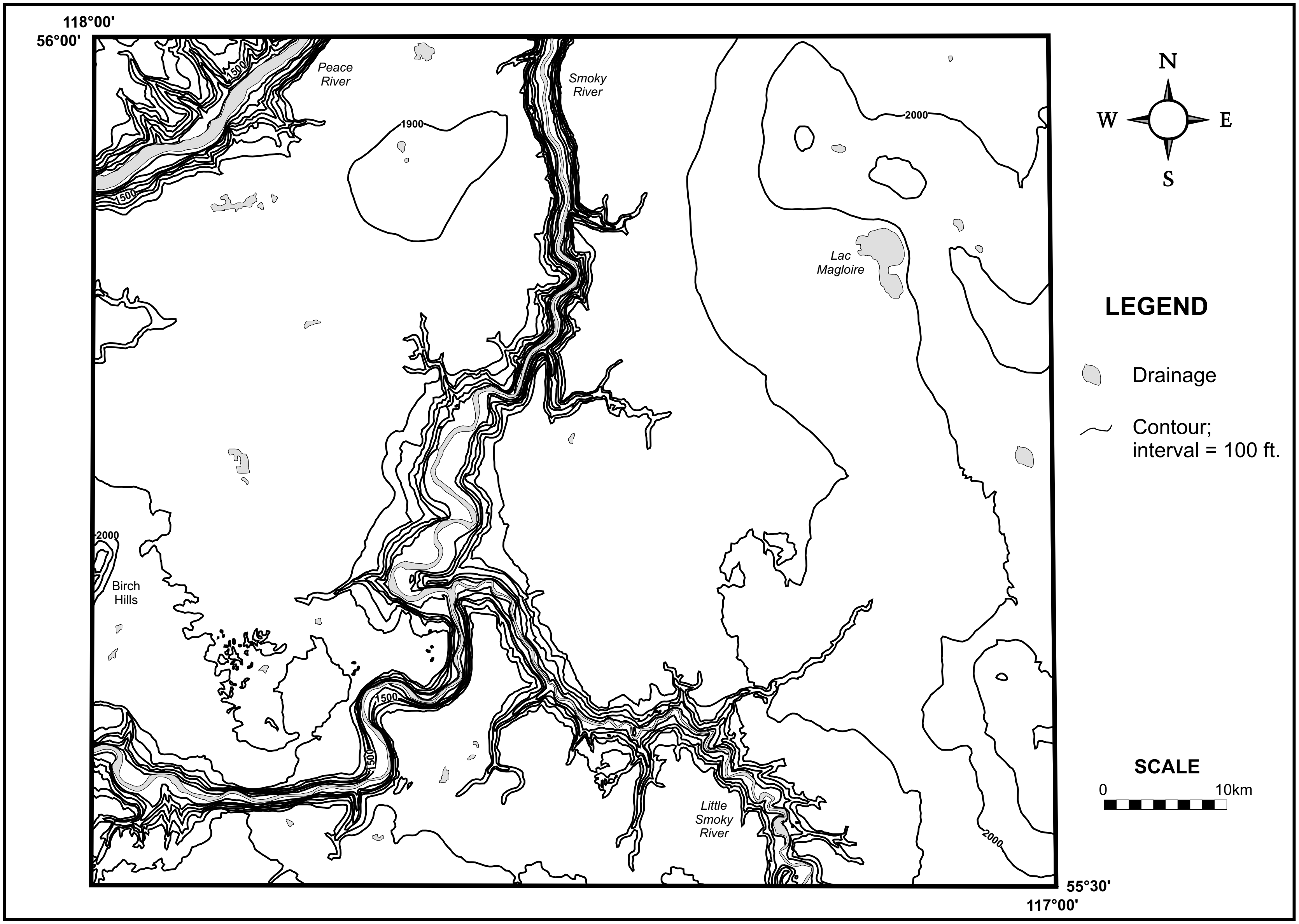


FIGURE 1.3 Topography of the Northern Half of the Study Area

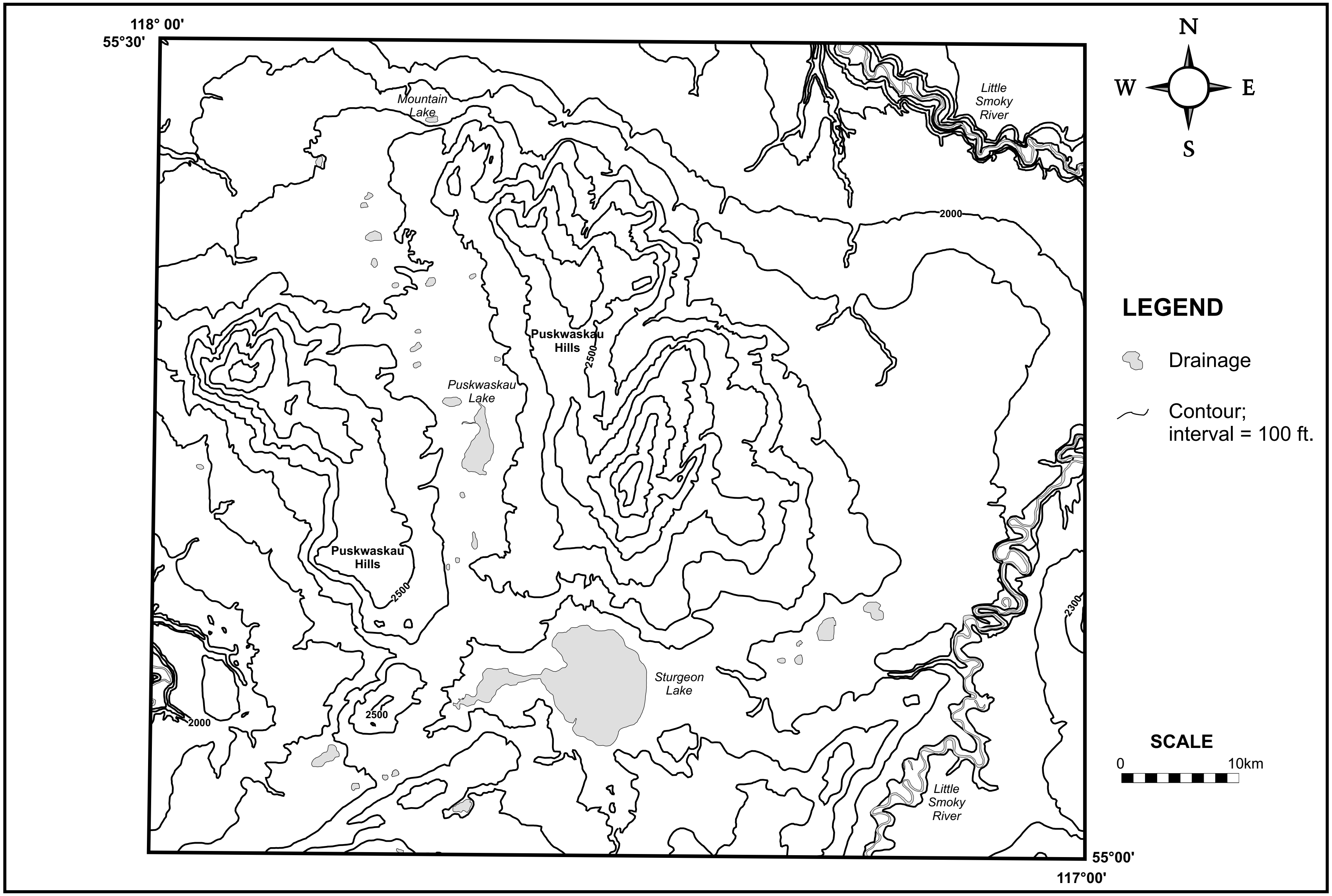


FIGURE 1.4 Topography of the Southern Half of the Study Area

The northern portion of the study area is gently rolling to flat, with the exception of the Birch Hills (90 m) and a small rise in elevation southeast of Fahler (60 m). The Birch Hills form the eastern remnant edge of a north-facing cuesta that extends westward into the Grande Prairie area (Henderson, 1959). South of Smoky River, the land rises over 305 m to form two parallel ridges trending northwest-southeast (informally named herein as the Puskwaskau Hills). Relief in the southern region is extreme, ranging from hummocks less than 2 m in height, to bedrock ridges and hills over 90 m.

Three major rivers drain the region, the Peace, Smoky and Little Smoky (Figure 1.2). The largest river is the Peace, which crosses the northwestern corner of the Winagami sheet, occupying a valley over 420 m in depth and an average of 5 km wide. The depth of the Smoky River's valley decreases from 210 m, near its confluence with the Peace River, to approximately 180 m as it enters the Grande Prairie map sheet area. Valley width is variable, ranging from three km in the north to 6.5 km at Watino. The Little Smoky River valley is 150 m deep and 3 km wide at its confluence with the Smoky River. Southeast of Valleyview, the Little Smoky River valley shallows to less than 30 m and averages 2 to 2.5 km in width. Numerous creeks and streams drain the remaining regions. Extensive slumping characterises all river, creek and stream banks. Paired and unpaired alluvial terraces are common along the larger rivers.

There are three major lakes in the region, Sturgeon Lake, Puskwaskau Lake and Lac Magloire (Figure 1.2). The largest of the lakes, Sturgeon Lake, is approximately 100 km^2 in area and forms the drainage basin for the region south of the Puskwaskau Hills. Puskwaskau Lake is approximately 10 km^2 in size, shallow and accessible primarily during the winter by snow machines or in the spring to fall by helicopter. Lac Magloire is one of several ephemeral lakes. Similar in size to Puskwaskau Lake, it is shallow, with a maximum depth of less than two metres. Numerous small lakes, including Mountain Lake, are found in the trench between the two ridges of the Puskwaskau Hills. Ponding after spring run-off and rain is common throughout the region in low-lying areas. Extensive swamps, bogs, sedge marshes and muskegs are most common in the western half of the study area.

1.3 PREVIOUS WORK

Early Quaternary geology research conducted by various federal and provincial government agencies and universities has focussed on the Laurentide Ice Sheet and its relationship with the Cordilleran Ice Sheet in northern Alberta (Gravenor and Kupsch, 1959; Gravenor and Bayrock, 1961; Westgate *et al.,* 1971, 1972; St. Onge, 1972; Matthews, 1980; Fenton, 1984; Klassen, 1989; Liverman, 1989; Catto *et al.*, 1996). Within the Winagami region, most of the studies were conducted as precursors to or as part of land development projects. As a result, the data collected pertained mainly to pedology (Wyatt, 1935; Odynsky and Newton, 1950; Odynsky *et al.*, 1956), forestry, geomorphology, hydrocarbons, groundwater (Borneuf, 1980; Groundwater Protection Branch, 1992; D. Toop, Prairie Farm Rehabilitation Administration, *pers. comm.*, 1995) and aggregates. Chronological studies involving mid-Wisconsinan and post-glacial deposits have also been conducted in the Winagami region, primarily at Watino (Lowden and Blake, 1970; Westgate *et al.,* 1971, 1972; Jackson and Pawson, 1984; Burns, 1986; Liverman *et al.,* 1989; L. Halsey, University of Alberta, *pers. comm.,* 1996). Private companies and government agencies have conducted regional data compilations and exploration programs for aggregate (Edwards and Scafe, 1994), precious metals (Olson *et al.,* 1994) and kimberlites (Dufresne *et al.*, 1996; Fenton *et al.*, 1996; Eccles *et al.*, 1996; Leckie *et al.,* 1997; Eccles, 1998; Pawlowicz *et al.,* 1998) within the region.

Detailed surficial geology, stratigraphy and Quaternary history of the Winagami region was first studied by Henderson (1959). Henderson interpreted three invasions of Laurentide Ice into the region based on the presence of three till "sheets". These three tills were named "Lower Till", "Middle Till" and "Upper Till". The oldest till was exposed at only one locality (Peavine Creek, 27-76-22W5) and was called the “Lower Till”. This “Lower Till” was much stonier than the upper tills and yellow-brown to brownish grey in colour. The “Middle Till” was laterally extensive, brown in colour, had blocky fractures and contained pebbles and cobbles of Canadian Shield provenance. Reworked portions of the “Middle Till” were identified by silt and sand lenses of glaciofluvial or lacustrine origin and surface boulder lags. The “Upper Till” was distinguished by its low pebble content, a clay-rich matrix, and its limited distribution north and east of the Fish Creek Moraine, a poorly defined ridge near the community of New Fish Creek. This “Upper Till” was deposited, according to Henderson (1959), in a re-advance of Late Wisconsinan ice, whose margin was marked by the Fish Creek Moraine (Henderson, 1959). Many of Henderson’s observations were based on limited exposures, resulting in generalised descriptions and distributions of the till units, and associated sediments.

Henderson (1959) also proposed deglaciation sequences for each ice retreat in the area using glacial lake phases in relation to topography. The earliest deglaciation phase described, occurred during the Early Wisconsinan when the ice margin lay at the northern edge of the Puskwaskau Hills. Glacial Lake Puskwaskau I occupied a large depression southwest of the study area and Glacial Lake Valleyview I occupied the drainage basin around Valleyview. The two lakes were joined via a spillway at the margin of the ice front, draining to the northeast. As the ice margin retreated north-eastwards, the Fahler basin was exposed and promptly infilled with glacial meltwater creating Glacial Lake Fahler I, which drained eastwards via Lesser Slave Lake. Glacial Lake Fahler I, effectively covered most of the region north and east of Puskwaskau Hills. After the re-advance of the Laurentide Ice Sheet during the Late Wisconsinan, the ice margin again sat proximal to the northern rim of the Puskwaskau Hills. As before, a spillway linked Glacial Lake Puskwaskau II and a much smaller Glacial Lake Valleyview II, which was situated north of New Fish Creek.

Evidence of advances of the Laurentide and the Cordilleran Ice Sheets prior to the Late Wisconsinan are poorly documented in the literature due to the rarity of good natural exposures, drill core samples and drill logs. Most authors agree that the majority of the Quaternary deposits in the Winagami area appear to have been deposited prior to or during the later stages of glaciation by the Laurentide Ice Sheet. In addition, many of the surficial deposits are attributed to deglacial and post-glacial processes. Research conducted by Liverman (1989) west of the study area, indicate that during the Late Wisconsinan, the Grande Prairie area was covered solely by the Laurentide Ice Sheet.

1.3.1 Investigation of Watino Stratigraphy

The majority of research-oriented studies conducted since 1970, within and proximal to the Winagami region, focussed on the timing of glaciation and deglaciation (Reimchen, 1968; Lowden and Blake, 1970; Westgate *et al.*, 1971, 1972; Lichti-Federovich, 1975; Churcher and Wilson, 1979; Fenton, 1984; Fox *et al.,* 1987; Halsey *et al.*, 1987; Halsey, 1989; Klassen, 1989; Liverman, 1989; Liverman *et al.*, 1989). Unfortunately, the majority of this work has focussed on one particular area, Watino.

Timing for the start of the Late Wisconsinan advance of the Laurentide Ice Sheet is based on the Watino sections, which contain one of the few known time-stratigraphic marker horizons in the region, the Watino Nonglacial Interval (Table 1.1). Radiocarbon analysis on material collected from the Watino Nonglacial Interval have yielded ^{14}C dates between 43 ka and 27 ka (Westgate *et al.*, 1971, 1972; Lichti-Federovich, 1975; Fenton, 1984; Klassen, 1989; Liverman, 1989; Liverman *et al.*, 1989). The lowermost portion of the Watino composite section is comprised of the Shaftesbury Formation of Cretaceous age, unconformably overlain by pre-glacial gravels (Fenton, 1984; Liverman *et al.*, 1989). Vertebrate fossils collected from the gravel by Reimchen (1968) were given a Mid-Wisconsinan age based on the radiocarbon dates of the overlying units. However, Churcher and Wilson (1979) claimed that the fauna was more representative of the Sangamon and thus the upper contact of the gravel was an unconformity. Liverman *et al.* (1989) suggested that the gravel formed a conformable sequence with the overlying

TABLE 1.1

Winagami Study Area Radiometric ^{14}C Dates

Location	Lab #	Sample type	^{14}C Age	Source
Watino	GSC-1020	wood from massive fine grained sediments	43,500 ±620	Westgate *et al*. (1971, 1972)
Watino	GX-1207	wood from massive fine grained sediments	>38,000	Westgate *et al*. (1971, 1972)
Watino	I-2516	wood from massive fine grained sediments	35,500 +2300 -1800	Westgate *et al*. (1971, 1972)
Watino	I-2615	wood from massive fine grained sediments	35,500 +3300 -2300	Westgate *et al*. (1971, 1972)
Watino	I-2616	wood from massive fine grained sediments	34,900 +3000 -2000	Westgate *et al*. (1971, 1972)
Watino	I-4878	wood or peat from massive fine grained sediments	27,400 ±850	Westgate *et al*. (1971, 1972)
Watino	AECV-414C	wood from pre-glacial gravel	>40,170	Liverman *et al*. (1989)
Watino	AECV-415C	wood from pre-glacial sand	36,220 ±2520	Liverman *et al*. (1989)
Watino	AECV-416C	wood from pre-glacial sand	31,530 ±1440	Liverman *et al*. (1989)
Watino	GSC-2895	bone from terrace	10,200 ±100	Jackson and Pawson (1984)
Watino	GSC-2902	bone in terrace	10,200 ±100	Jackson and Pawson (1984)
Watino	S-2614	wapiti antler from 50 m terrace	9075 ±305	Burns (1986)
Watino	AECV-272C	wapiti rib	9920 ±220	Catto *et al*. (1996)
Dollar Lake	GSC-1998	organic mud	10,200 ±110	Jackson and Pawson (1984)

units and interpreted the sequence as an abandoned channel that was later reoccupied. Alluvial sediments exposed stratigraphically above the pre-glacial gravel, contain peaty silts and clays yielding pollen, plant macrofossils, molluscs, insect remains and ostracodes representative of a climate slightly cooler than or similar to the present (Westgate *et al.*, 1971, 1972; Lichti-Federovich, 1975). No evidence of glacial activity prior to the Late Wisconsinan has been documented in the Watino section (Liverman *et al.*, 1989; Catto *et al.,* 1996). The uppermost units in the section contain glaciofluvial sands and gravel of Late Wisconsinan age or younger and are interpreted to represent the early stages of incision of the present Smoky River valley subsequent to glaciation.

1.3.2 Deglaciation History

The deglaciation history of northwestern and central Alberta has been described primarily as a sequence of glacial lakes formed when meltwater was dammed by the Laurentide Ice Sheet during deglaciation (Henderson, 1959; St-Onge, 1972; Matthews, 1980; Liverman, 1989). St.-Onge (1972) proposed a sequence of events for the latest episode of deglaciation using ice frontal positions and glacial lake phases. Deglaciation and the creation of pro-glacial lakes in the study area corresponds to the latest stage of deglaciation in north-central Alberta, Phases 5 and 6 of St.-Onge (1972). During Phase 5, Glacial Lake Iosegun III occupied the depression in the lower southeast corner of the study area, laying proximal to the ice margin. As deglaciation progressed, the ice margin moved further to the northeast, uncovering the Fahler basin and opened a new meltwater corridor along the Lesser Slave area (Phase 6). As a result, Glacial Lake Fahler I, which extended from Fahler to Edmonton, was created. By St.-Onge's Phase 7, the ice margin was far east of the study area and all pro-glacial lakes in the region had drained. St.-Onge's (1972) Glacial Lake Iosegun III and Glacial Lake Fahler I are likely correlative to Henderson's (1959) Glacial Lake Valleyview I and Glacial Lake Fahler I.

Mandryk (1996) suggests that based on ^{14}C dates and an ice-melting rate of 20 cm per year, the onset of deglaciation in the study region was ca. 14 ka. Between 13 and 12 ky B.P., pro-glacial lakes and early to later stages of stagnating ice covered the region. Large glacial lakes and the majority of stagnant ice were gone from the area ca. 11 ka.

Supra-till dates, documented from the Watino sections, based on bone and antler fragments found in terraces (Jackson and Pawson, 1984; Burns, 1986) and from organic mud found in Dollar Lake (Jackson and Pawson, 1984), place deglaciation as early as ca. 10 ka (Table 1.1). Current research on basal peat ^{14}C dates from numerous fens and bogs proximal to the study area range between 8 to 6 ky B.P. (L. Halsey, University of Alberta, *pers. comm.*, 1995). In addition, research conducted on the Grande Prairie dune field west of the study area suggests that two periods of aeolian sedimentation occurred, both of which are post-glacial (Halsey, 1989). The first period of aeolian sedimentation followed deglaciation. The second occurred sometime after 4030 ± 180 yrs. B.P. (AECV-627), possibly due to reactivation resulting from a fire.

2.0 BEDROCK AND STRUCTURAL GEOLOGY

Knowledge of the underlying bedrock and structural geology is important in stratigraphic and dispersal studies involving glacial sediments. The type of bedrock, its degree of consolidation and its areal distribution all affect ice flow behaviour at the base of an ice sheet. In addition, these factors determine the type and composition of the glacial sediments later deposited. Structural weaknesses within the bedrock and subsurface units are exploited by actively moving ice, leaving evidence that may be later used to determine basal ice behaviour. In addition, regional bedrock and subsurface structures may provide conduits for metallic and precious minerals or kimberlites. These exploration targets are usually small and isolated. As a result, material in glacial sediments from these point sources commonly form well-defined dispersal trains that provide information on the distance material has travelled within the ice.

2.1 BEDROCK GEOLOGY

The study area lies in the Western Canadian Sedimentary basin within the southern flank of the Peace River Arch (PRA). The basement underlying the PRA is comprised of two terranes, the Buffalo Head (BHT) and the Chinchaga (Figure 2.1), which collectively form the Buffalo Head Craton (Ross *et al.*, 1991, 1998). The Buffalo Head Craton was accreted to the western edge of the Churchill Structural Province (Rae Subprovince) approximately 1.8 to 2.4 billion years ago (Ga). Basement rocks are not exposed in the study area. However, the basement is related to the type of diamond indicator minerals (DIMs) that may be present in kimberlites emplaced during the Cretaceous.

Overlying the basement in the Winagami region is a thick sequence of Phanerozoic rocks comprised mainly of Devonian to Mississippian carbonates and salts at depth and Cretaceous sandstones and shales near surface (Glass, 1990).

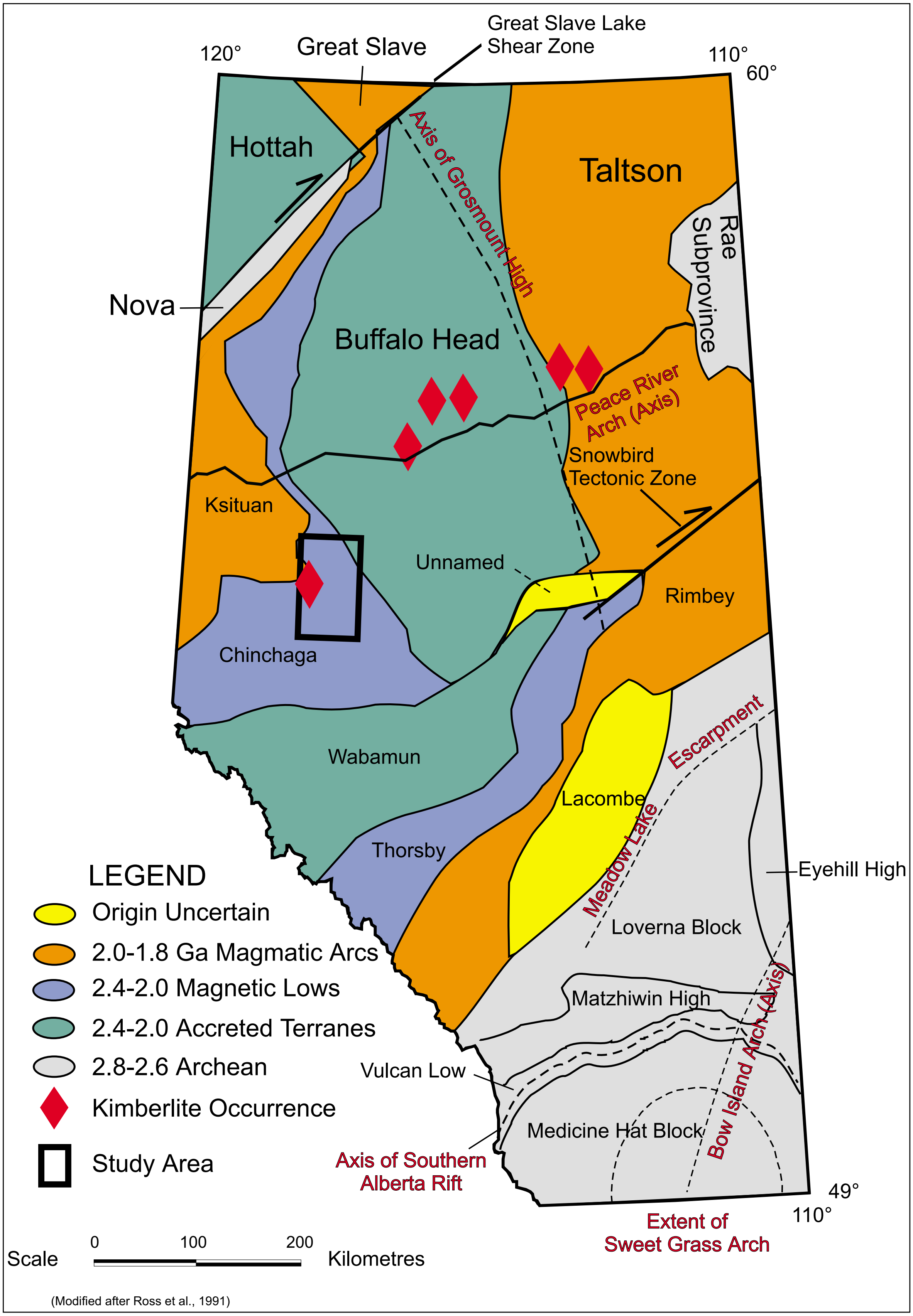


FIGURE 2.1 Basement Geology of Alberta

Bedrock exposure within the study area is limited primarily to river and stream cuts and topographic highs. The upper units found in the thesis area are listed in Table 2.1 and shown on Figure 2.2.

TABLE 2.1

Generalised Stratigraphy

SYSTEM	GROUP	FORMATION	AGE* (MA)	DOMINANT LITHOLOGY
UPPER CRETACEOUS		Wapiti	70 to 80	Sandstone, minor coal seams and conglomerate lenses
	Smoky	Puskwaskau	75 to 86	Shale, silty-shale and ironstone, First White Specks
		Bad Heart	86 to 88	Sandstone
		Kaskapau	88 to 92	Shale, silty-shale and ironstone, Second White Specks
		Dunvegan	92 to 95	Sandstone and siltstone
	Fort St. John	Shaftesbury	95 to 98	Shale, bentonites, Fish Scale Fm.

*Ages approximated from Green *et al.* (1970), Glass (1990), Dufresne *et al.* (1996) and Leckie *et al.* (1997).

The Shaftesbury Formation, Early to Late Cretaceous in age (Albian to Cenomanian) is the oldest unit exposed in the study area. Part of the Fort St. John Group, the Shaftesbury Formation is divided into three members, Westgate, Fish Scale and Belle Fourche. The lowermost member, Westgate, comprises dark grey,

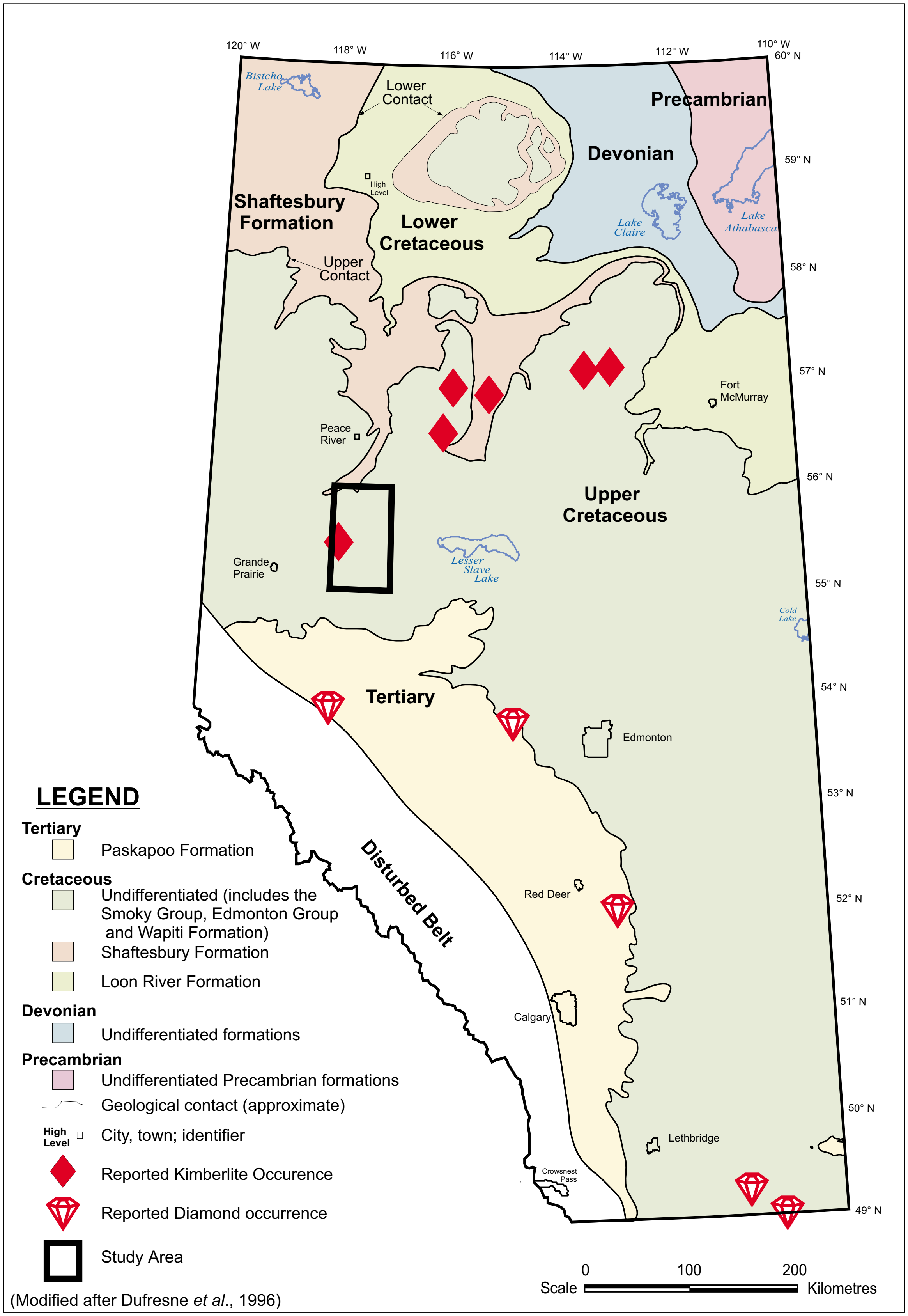


FIGURE 2.2 Generalised Geology of Alberta

marine shale with thin interbeds of silt, sand and bentonite. Ironstone concretions may be present (Green, 1972; Glass, 1990). The Fish Scale Member, a significant geophysical marker horizon, contains fish-scale bearing, friable, dark grey, marine shale. Nodules and thin beds of concretionary ironstone and bentonite partings may be present (Green, 1972; Glass, 1990). The youngest member, Belle Fourche, comprises massive, but highly bioturbated grey marine shale (Mossop and Shetson, 1994). The entire Shaftesbury Formation is fossiliferous, containing ammonites such as *Neogastroplites, Irenicoceras, Beattonoceras*, *Posidonia nahwisi*, and *Holcolepis* (Glass, 1990). The upper contact of the Shaftesbury Formation is conformable with the overlying Dunvegan Formation except at Watino, where the contact is marked by a depositional hiatus. Exposures of the Shaftesbury Formation are limited to river cuts along the Peace and the Smoky rivers in the northern portion of the study area. The presence of bentonites of variable thickness, distribution and composition, especially within and near the Fish Scales horizon across much of Alberta, are used as evidence of extensive volcanism during deposition of the Shaftesbury Formation (Leckie *et al*., 1992; Bloch *et al*., 1993).

The Dunvegan Formation of Late Cretaceous age (Cenomanian), comprises a grey, fine-grained, felspathic sandstone with thin beds of shale, shelly limestone and coal deposited in a deltaic to shallow-marine environment (Glass, 1990). Shales of the Kaskapau Formation conformably and transitionally overlie the Dunvegan Formation. Fossils include shallow-water molluscs along with numerous conifers**,** cycads and ferns. This unit is exposed in valleys along the Peace River, and the northern segment of the Smoky River.

The Late Cretaceous (Cenomanian to Campanian) Smoky Group, comprises three formations, the Kaskapau, Bad Heart and Puskwaskau, all of which are marine in origin. The oldest formation, the Kaskapau, contains dark-grey, fissile, carbonaceous shale with thin concretionary ironstone beds. Fossil assemblages in the Kaskapau Formation include *Inoceramus sp.*, *Inoceramus (Mytiloides) labiatus*, *Dunveganoceras*, *Watinoceras*, *Scaphites s.l.* (Glass, 1990). Exposures are restricted primarily to valleys occupied by the Smoky and the Little Smoky rivers and their tributaries.

The Bad Heart Formation contains medium- to coarse-grained marine, quartzose and ferruginous oolitic sandstones, mudstones, chert bands and numerous marine fossils, including *Scaphites, Inoceramus stantoni* and *Pinna* (Glass, 1990). The Bad Heart Formation forms a thin line of outcrop south of Watino, extending through Fahler. It is conformable with both the Puskwaskau Formation and the underlying Kaskapau Formation, pinching out towards the east. Exposures are found along smaller creek and stream valleys in the northern half of the study area. There is strong evidence of volcanism associated within the depositional time span of the Bad Heart Formation in the vicinity of the PRA (Auston, 1998; Carlson *et al.*, 1998). The recently discovered Buffalo Head Hills kimberlites intrude Kaskapau shale, yielding emplacement ages of 86 to 88 Ma (Auston, 1998; Carlson *et al.*, 1998).

The Puskwaskau Formation, the youngest unit of the Smoky Group, comprises thinly bedded, dark grey, fossiliferous marine shale. The unit forms an east-west trending belt south of Watino. Recessive in outcrop, the Puskwaskau Formation is thickest in the Smoky River area. The Puskwaskau Formation is conformably overlain by the Wapiti Formation. Notable fossil assemblages include *Inoceramus, Scaphites s.l.,* and *Baculites* (Glass, 1990). Exposure is restricted to the Smoky and the Little Smoky River valleys.

The Late Cretaceous (Campanian to Maastrichtian) Wapiti Formation is the youngest of the bedrock units. It forms a wide belt that covers the study area south of the confluence of the Smoky and Little Smoky rivers. Thinly bedded to massive, medium- to coarse-grained, calcareous, felspathic, clayey, fresh-water sandstone comprises most of this unit. Bentonitic mudstone and bentonite, with scattered clay beds and coal seams may be present (Glass, 1990). Exposures are found along the Smoky and Little Smoky rivers, and some of the larger streams. The Mountain Lake Kimberlite, located at the northwestern tip of the Puskwaskau Hills, intrudes the Wapiti Formation sediments, yielding an emplacement age of 75 Ma (Leckie *et al.,* 1997).

2.2 STRUCTURAL GEOLOGY

The study area is situated proximal to and overlies many structural and tectonic features in northwestern Alberta (Figure 2.3), including the Peace River Arch (PRA) and the Peace River Embayment (PRE). Several of these features may have provided pathways for kimberlite pipe emplacement and/or contributed to significant erosion of pre-existing sediments during the Cretaceous and Tertiary.

During the mid-Cretaceous and Early Tertiary, compressive deformation occurred as a result of the Laramide Orogeny that eventually led to the formation of the Rocky Mountains. In Alberta, the PRA is a region where the younger Phanerozoic rocks have undergone periodic vertical and, possibly, compressive deformation prior to and into the Tertiary (Cant, 1988; O'Connell *et al.*, 1990; Dufresne *et al.*, 1995, 1996). This pattern of long-lived, periodic uplift and subsidence has imposed a structural control on the deposition patterns of the Phanerozoic strata in northern Alberta and resulted in a rectilinear pattern of faults. The PRE is represented by a series of linked grabens produced during extension, km-scale subsidence and significant displacements along fault systems associated with the PRA. Uplift and tectonism associated with the PRA and PRE likely contributed to increased erosion and incision of the existing topography by various fluvial systems, in particular, the depositional hiatus above the Shaftesbury Formation at Watino.

The Phanerozoic rocks beneath the study area lie along and proximal to the axis of the PRA, PRE and their associated basement faults, including the Belloy, South Peace River and Normandville faults (Dufresne *et al.*, 1996). These and other

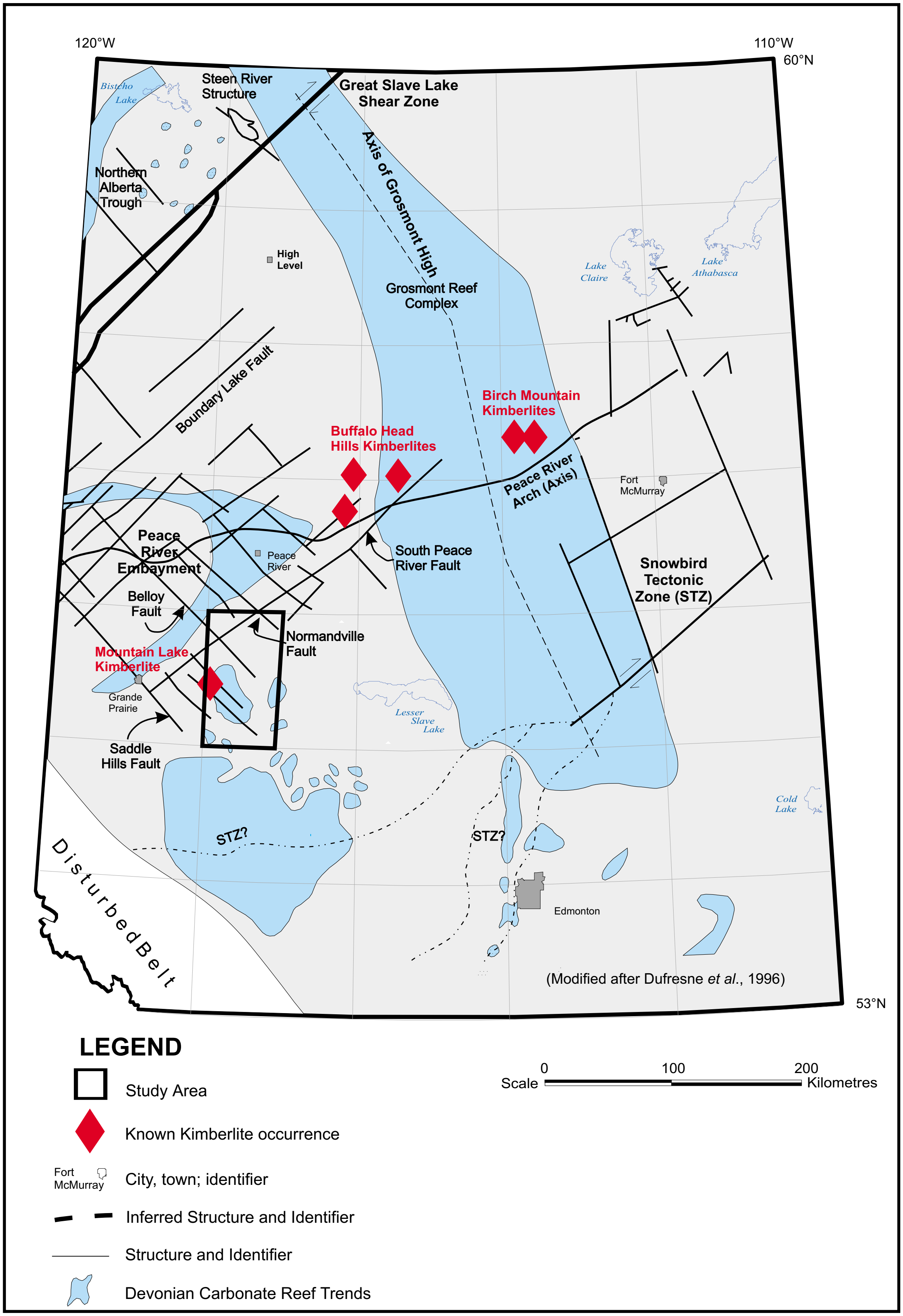


FIGURE 2.3 Structural Geology of Northern Alberta

smaller faults may have controlled the emplacement of the Mountain Lake, Buffalo Head Hills and Birch Mountain kimberlites, known point sources of DIMs (Dufresne *et al.*, 1996; Leckie *et al.*, 1997). The Belloy Fault, in particular, is adjacent to the Mountain Lake Kimberlite lying within the trench between the Puskwaskau Hills.

3.0 FIELD AND LABORATORY METHODS

Several techniques were employed to determine the surficial geology, bedrock topography, stratigraphy, and glacial history of the region: (1) literature research, including airphoto, water-well and geophysical log interpretation; (2) geological mapping, drilling and sampling; and (3) granulometric, lithological, geochemical and diamond indicator mineral (DIM) laboratory analyses.

3.1 PRELIMINARY RESEARCH

Preliminary research, involving airphoto (scale 1:63,360), water-well and petroleum log interpretations, was completed prior to field work in order to delineate map units, landforms and section/sample locations. Map units were defined based on morphology, tone and drainage.

3.2 GEOLOGICAL MAPPING, DRILLING AND SAMPLING

The study area was mapped, drilled and sampled during the 1993, 1994 and 1995 field seasons. A total of 169 stratigraphic sections and 17 boreholes were described and sampled (Figure 3.1; Appendices 1, 2 and 3). Field work was restricted to reasonably accessible areas due to time and manpower constraints. Access in the region was accomplished by truck, canoe and foot traverse.

Section samples were collected from the "C" soil horizon to avoid past pedogenic alteration of sediments that would most greatly affect the geochemistry and granulometry of the sediments. Minimum sampling depth was 0.5 m. Two hundred forty-five samples, 3 to 5 kg in mass, were collected from the stratigraphic sections (Appendices 1 and 2). The majority of samples were from diamictons of probable glacial origin and gravel; however, representative samples of bedrock, glaciolacustrine, glaciofluvial and aeolian deposits were also collected for comparison (Appendices 1 and 2). Where possible, each unit was represented by

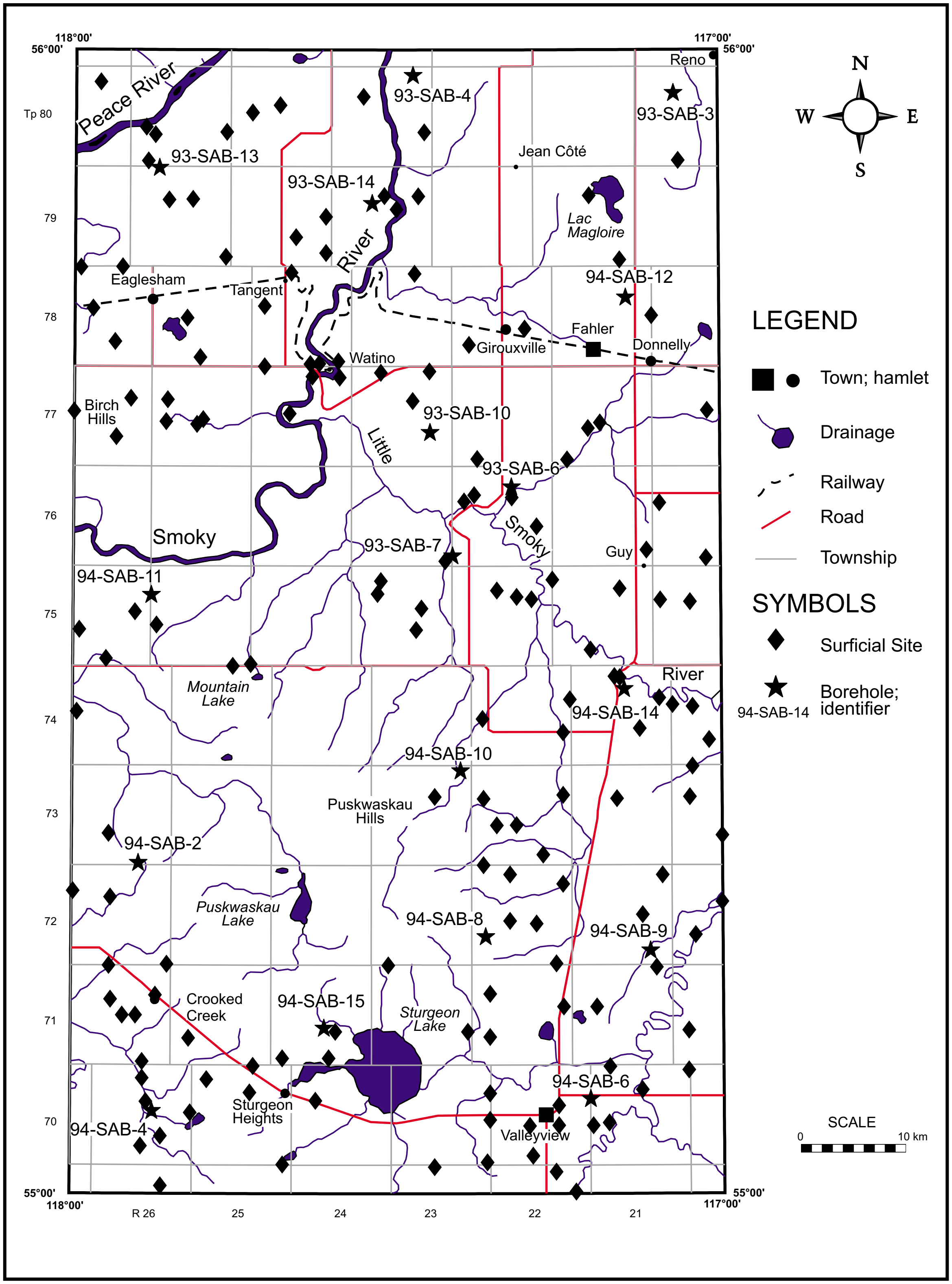


FIGURE 3.1 Surface Sample and Borehole Locations

a minimum of one sample. Large sections with thick diamicton units were sampled at minimum intervals of 1.5 m to obtain information on vertical variations.

Seventeen hollow-stem auger cores were drilled by Canadian Geological Drilling Limited of Edmonton (Plate 3.1; Appendices 1 and 3). Maximum core length was 45 m, with a diameter of 7.5 cm. The cores were initially described and photographed in the field to ensure that a permanent record of core material would be available in the event that the original core was misplaced or damaged during shipping or storage (Plate 3.2). Sampling and more detailed description of the cores was conducted after the field season in the Alberta Geological Survey (AGS) core labs (Appendix 3). A total of 97, 1 kg samples from various units were collected from eleven of the cores (93-SAB-06, 93-SAB-13, 94-SAB-02, 94-SAB-04, 94-SAB-08, 94-SAB-09, 94-SAB-10, 94-SAB-11, 94-SAB-12, 94-SAB-14 and 94-SAB-15) for use in various analyses (Appendices 1 and 2). The majority of the samples collected from the cores represented diamicton; however, as with the section samples, bedrock, sand, silt and clay were also sampled. Thick diamicton units within the cores were sampled at 1.5 m intervals to provide information on vertical variations within stratigraphic units and their relationship to the underlying bedrock and post-depositional processes.

Of the 342 samples, 180 (plus 9 duplicates) were analysed for matrix lithology. Two hundred six samples (8 duplicates) were analysed for matrix granulometry. Due to financial constraints, only 211 sample matrices were geochemically analysed, 15 of which were duplicates and 5 were GSC standards. An additional 15, 25 kg bulk, samples were collected from six sections (94-SB-14, 94-SB-35, 94-SB-38, 94-SB-39, 94-SB-52 and 94-SB-76) and eight boreholes (93-SAB-13, 93-SAB-06, 94-SAB-04, 94-SAB-09, 94-SAB-11, 94-SAB-12, 94-SAB-14 and 94-SAB-15) for DIM processing, picking and microprobing. The samples collected for DIMs are part of an on-going, regional, Northern Alberta study conducted by the AGS.

PLATE 3.1 - Auger drill rig set-up.

PLATE 3.2 - Core description set-up.

3.3 LABORATORY ANALYSES

Samples from stratigraphic sections and cores were analysed by various methods to determine their granulometric, lithologic and geochemical characteristics. Granulometry and lithology analyses were completed at the University of Alberta. Geochemical analyses were conducted by Barringer Laboratories. The Saskatchewan Research Council (SRC), AGS and University of Alberta Microprobe Laboratory conducted the DIM processing, picking and microprobing, respectively.

3.3.1 Granulometric Analyses

There were 189 samples, 50 grams in mass, prepared and analysed using combined hydrometer and sieving techniques according to modified American Society for Testing and Materials (1964) methods (Broster, 1982; Balzer, 1992). The samples were analysed for per cent (%) sand, silt and clay, mean grain size and sorting (Appendix 4). Results were used to characterise the surficial units and to determine vertical and lateral lithologic and stratigraphic variations within the units.

Three modifications to the ASTM techniques were used in this study. The first modification was that an older version of Calgon® water softener was used as the dispersing agent instead of hexametaphosphate because it was cheaper. The newer Calgon® product containing blue flecks produces inconsistent results in the hydrometer technique and was therefore not used.

The second modification related to reading times. The first hydrometer reading was taken at the 15 minute mark and an additional reading was added at the 12 hour mark. Studies conducted by Broster (1982) suggested that readings taken earlier than the 15 minute mark (sand fraction) were unreliable and difficult to reproduce in subsequent tests. Broster (1982) also recommended that the 12 hour reading more clearly helped to define the silt-clay boundary.

The third modification included running hydrometer tests in sets of eight, according to the modified ASTM methods described above. Duplicate runs were performed on nine samples to determine the precision of the technique. Residue from the hydrometer tests were dried, weighed and subsequently sieved into separate grain sizes using stainless steel sieves and an automatic vertical shaker. The silt and clay fractions were collected in the pan at the base of the sieve stack. Coarser material in each sieve was weighed. The cumulative weight of all material in the sieves was compared to the original dried sample weight to determine what percentage of material may have been lost during shaking and weighing. The coarse sand to granule fractions were collected into vials for use in the lithology analysis.

Data were plotted as scatter graphs using Excel®, version 5.0 to determine cumulative percentages. These cumulative percentages were then plotted against grain size diameters in phi units (ϕ) using a graph designed by Balzer (1992). Statistical parameters for grain size determined from the curves include sand, silt and clay percentages, graphic mean (M_Z), and inclusive graphic standard deviation (σ_I) (cf., Folk, 1974).

Sand, silt and clay percentages were read directly from the curve on the Balzer (1992) graph using the ϕ divisions -1.0 to 4.0, 4.0 to 8.0, and +8.0, respectively. These percentages represent the components of the matrix and do not take into consideration any portion of the sample that is larger than the -1.0 ϕ size fraction (e.g., granules, pebbles and cobbles). The 8.0 ϕ value was used as the silt-clay boundary marker instead of the 9.0 ϕ value due to personal preference (Balzer, 1992). A 9.0 ϕ value does not significantly change the silt or clay content of the matrix.

Statistical parameters were used to determine correlations between samples in individual units and between borehole logs and natural exposures. The statistical parameters were determined using formulae supplied by Folk (1974). Graphic mean, a value based on three points of the curve, is the best graphic measure for determining the overall average grain size of a sample. It is given by the formula:

$$M_z = \frac{(\phi16 + \phi50 + \phi84)}{3}$$

The inclusive graphic standard deviation includes 90% of the curve in its measure and is the best estimate of grain sorting for the samples (Folk, 1974). It is given by the formula:

$$\sigma_I = - \frac{(\phi84 - \phi16)}{4} + \frac{(\phi95 - \phi5)}{6.6}$$

According to Folk (1974), sorting values theoretically range from 0.00 ϕ to infinity, where the lower the value, the better the sorting. In glacial areas, most sediments tend to be poorly sorted, with values normally 4.0 ϕ or greater. Better sorting suggests reworking by fluvial processes or the incorporation of material that was originally better sorted (e.g., fluvial sands and gravels).

3.3.2 Lithological Analyses

Lithological analyses were conducted at the University of Alberta to determine the provenance of the material comprising the samples, the type of diamicton and, ultimately, ice flow directions. In addition, lithological compositions of the samples may be useful in characterising surficial and stratigraphic units. Lithological identification of the coarse sand to pebble fractions of the samples was determined visually using binocular microscopy. Lithological analyses are normally performed on clasts in the pebble size fraction, where each sample consists of a minimum of 50 pebbles. Samples from natural sections and boreholes described in the Winagami study area rarely contain enough pebbles within a small enough area to produce statistically viable results. As a result, the granule to coarse sand fractions of the samples was used. One hundred eighty nine samples were taken from the residue remaining in the sieving portion of the granulometric analyses.

One hundred and fifty granule to coarse sand grains from each sample were described using a binocular microscope. Values were normalised to 100 and rounded to the nearest per cent. Grains were divided into 12 visually identifiable lithological groups: quartz, carbonate, igneous and metamorphic, quartzite, sandstone, volcanic, coal, siltstone and shale, pyrite, ironstone, gypsum, and, “others”. Lithologies represented by less than one per cent were denoted as trace. The lithological groups used represent both proximal and distal bedrock sources. Carbonate, igneous, metamorphic and volcanic clasts and quartzite are distal rock types originating from either the Canadian Shield or the Cordillera. Defining Canadian Shield versus Cordilleran sources is difficult in the grain size used for this study. However, visual classification of boulders, cobbles and larger pebbles during field work suggest that the majority of carbonate, igneous, metamorphic and volcanic clasts are similar to rocks found in the Canadian Shield. Shale, siltstone, sandstone, coal and ironstone groups are proximal in origin and represent local bedrock units. Pyrite and “gypsum” were included as distinct groups because they provide specific information about post-depositional changes in the units and provenance. “Gypsum” commonly occurs in fractures during post-depositional weathering by hydrological processes. Pyrite is common in the Shaftesbury Formation, which is rich is sulphidic oozes and contains abundant pyritised fossils.

3.3.3 Geochemical Analyses

Geochemical analyses were performed on 211 samples using Induced Neutron Activation Analysis (INAA) and Total Atomic Absorption Spectrometry (AA). These geochemical analyses were conducted to provide data on lateral and vertical dispersal trends and variations within glacial sediments. In addition, the geochemical data supplements the existing AGS and GSC geochemical databases. Preliminary preparation of the samples was performed at the University of Alberta. The samples were disagreggated using a rubber mallet and stainless steel knife. Samples were dry-sieved using stainless steel sieves to obtain the <0.063 mm fraction (silt and clay) needed for the analyses.

The samples were collected from sections and boreholes, and included diamicton, glaciolacustrine silt/clay, bedrock, and a Geological Survey of Canada

(GSC) standard. Fifteen duplicate samples and five samples of the GSC standard were run to determine analytical precision and data quality. The elements analysed in the INAA and AAS procedures were chosen by AGS to match their database with that of the GSC.

Base metal contents (Ag, Cd, Cu, Co, Fe, Li, Mn, Mo, Ni, Pb, V, Zn) were determined using AAS by Barringer Laboratories Ltd. of Edmonton (Table 3.1; Appendix 6A). Base metals were extracted out of 30 gram samples using hot, dilute HNO_3 and analyzed with a spectrometer.

Thirty-four geochemical elements (Ag, Au, As, Ba, Br, Cd, Ce, Co, Cr, Cs, Eu, Fe, Hf, Ir, La, Lu, Mo, Na, Ni, Rb, Sb, Sc, Se, Sm, Sn, Ta, Tb, Te, Th, U, W, Yb, Zn, Zr) were analysed via INAA by Barringer Laboratories Alberta Ltd. of Edmonton (Table 3.1). A 30-gram sample of the sediment was encapsulated, irradiated and then measured in a multi-element mode for gold and the other elements. Mercury was added by cold vapour techniques to keep temperatures under 25^{o}C during irradiation.

Data obtained from both techniques were plotted using Excel®5 to determine geochemical variations in the boreholes due to sample type, depth and proximity to bedrock. Data from surficial samples were plotted using Surfer®6 to determine areal dispersion patterns.

3.3.4 Diamond Indicator Mineral Analyses

Fifteen 25-kg bulk diamicton samples were collected for DIM analyses by the author and AGS personnel. Nine samples were collected from eight cores (93-SAB-06, 93-SAB-13, 94-SAB-04, 94-SAB-09, 94-SAB-11, 94-SAB-12, 94-SAB-14, 94-SAB-15) and six from sections (93-SB-38, 93-SB-39, 93-SB-52, 94-SB-14, 94-SB-35, 94-SB-76). The samples were sent to the Saskatchewan Research Council (SRC) for heavy mineral processing. Potential DIM grains were picked by personnel at the AGS and sent to the University of Alberta for microprobing.

TABLE 3.1

Geochemical Elements: Symbols and Names

Element Symbol	Element Name	Element Symbol	Element Name
Ag	Silver	Na	Sodium
Au	Gold	Ni	Nickel
As	Arsenic	Pb	Lead
Ba	Barium	Rb	Rubidium
Br	Bromine	Sb	Antimony
Cd	Cadmium	Sc	Scandium
Ce	Cerium	Se	Selenium
Co	Cobalt	Sm	Samarium
Cr	Chromium	Sn	Tin
Cs	Cesium	Ta	Tantalum
Cu	Copper	Tb	Terbium
Eu	Europium	Te	Tellurium
Fe	Iron	Th	Thorium
Hf	Hafnium	U	Uranium
Ir	Iridium	V	Vanadium
La	Lanthanum	W	Tungsten
Li	Lithium	Yb	Ytterbium
Lu	Lutetium	Zn	Zinc
Mn	Manganese	Zr	Zirconium
Mo	Molybdenum		

4.0 LABORATORY RESULTS

Three major types of analyses were performed on samples collected from the Winagami study area, including granulometry, lithology and geochemistry (Appendices 4, 5 and 6). The majority of samples analysed were obtained from diamictons; however, selected samples from bedrock, glaciolacustrine and aeolian units were also analysed for comparison. In addition, diamond indicator mineral (DIM) analyses were performed on samples selected by the Alberta Geological Survey (AGS) as part of a regional DIM study.

4.1 GRANULOMETRIC ANALYSES

Granulometric analyses were performed on the samples using a combined ASTM hydrometer and sieving technique (Balzer, 1992). Sand, silt and clay percentages in the matrix of the samples and their statistical parameters were determined using data obtained from a specially constructed chart (Balzer, 1992) and formulae designed by Folk (1974) (Appendix 4).

In general, the matrix composition of diamicton samples collected from sections and boreholes were variable, ranging from loamy to clay-rich. The majority of surface samples were loamy with a variable proportion of sand (Appendix 4). In comparison, diamicton samples taken from the cores were also mainly loamy. Diamicton samples taken near surface, proximal to the Wapiti Formation, and near aeolian or river sediments, contained high sand percentages within their matrices. Borehole 94-SAB-15, located adjacent to Young's Point Provincial Park was unique in that the majority of diamicton samples collected from the core had silty matrices. The matrices of samples collected from glaciolacustrine sediments were composed of mainly silt and clay of varying proportions.

Statistical parameters of the samples exhibit moderate to little statistical variation (Appendix 4). The graphic mean of the diamicton surface samples ranged from 5.43 to 29.02 phi (ϕ) with the majority of diamicton sample values ranging between 6 and 10 ϕ. These values indicate that most diamicton samples collected within the Winagami area have matrices composed primarily of silt and clay. Samples with graphic means below 6 ϕ were restricted to bedrock samples composed of sandstones and aeolian dune sand samples. Samples taken from diamicton in the boreholes show a smaller range of values for the graphic mean. All values for borehole diamicton samples range from 7 to 10 ϕ, with the majority between 7 and 8.5 ϕ.

Inclusive Graphic Standard Deviation, a measure of sorting, indicates that the majority of samples are poorly- to very poorly-sorted (values greater than 4.0 ϕ). Sorting in the diamicton samples range from moderate (e.g., 2.34 ϕ in sample 93-SB-51) to extremely poor (e.g., 19.26 ϕ in sample 94-SB-02). The majority of diamicton samples collected from both the surface and the borehole cores had sorting values between 3.00 and 6.50 ϕ (moderate to very poor), values typical of tills (Table 4.1; Folk, 1974). Samples representing bedrock, aeolian sands and glaciolacustrine sediments are well- to moderately-sorted (values less than 3.00 ϕ).

4.2 LITHOLOGICIAL ANALYSIS

The amount of local material (i.e., shales, siltstones, sandstones and ironstone) versus distal material (i.e., igneous, metamorphic, carbonate, volcanic, quartzite) in the samples, particularly the diamictons, is an indication of: (a) mode of transport, (b) distance of transport, and, (c) environment of deposition (Table 4.1). For simplicity, the use of the term clast within this section will refer to the resistant granule to coarse sand-sized fraction of the sample, unless stated otherwise. During transport, minerals have minimum grain-sizes (terminal grades) to which they can be physically reduced (Dreimanis and Vagners, 1971). Accordingly, grain size is reduced as distance of transport increases; however, minerals are not reduced indefinitely. The mineralogy of Canadian Shield and Cordilleran rock types and of local sandstones should be preserved in coarser grain-sizes such as granules and sand because of higher terminal grade of quartz

TABLE 4.1

General Characteristics of Specific Till Types

Till Type	Characteristics*
Supraglacial and Flow tills	- moderately to poorly sorted; moderate to poor pebble fabric - reworked by fluvial activity; sorted sediments may be present - massive to weakly stratified; may have crude horizontal layering - poorly compacted; matrix supported - lower contact usually gradational - pebbles mainly non-local; sub-angular; striated clasts are rare
Englacial melt-out till**	- moderately to poorly sorted; weak to moderately strong pebble fabric - may be reworked; small amounts of sorted sediments may be present as lenses (often faulted or deformed) - stratified; moderately compact; matrix supported - lower contact gradational - pebbles mainly local but abundant non-local material; sub-angular to sub-rounded; some facetting; striation common
Basal melt-out till**	- very poorly sorted; strong pebble fabric - some reworking; may contain horizontal sand lenses - compact; massive; matrix supported - lower contact sharp and planar - pebbles mainly local; sub-angular to sub-rounded; some facetting; striation common
Basal till (indeterminate origin)	- very poorly sorted; strong pebble fabric - some reworking; may contain rare sand or silt lenses - compact; massive; matrix supported - lower contact sharp and planar or gradational - pebbles mainly local; sub-angular to sub-rounded; some facetting; striation common - underlying substrate may be compressively deformed, eroded and incorporated as matrix or clasts
Lodgement till	- poorly sorted; moderate to strong pebble fabric - rare reworking - highly compact; massive; matrix to clast-supported - lower contact sharp and planar (erosional) - pebbles local; sub-angular to sub-rounded; bullet shaped; facetting on pebble tops; striated - underlying sediments often deformed
Deformation till	- sorting dependent on underlying substrate - compact; massive; matrix to clast-supported - lower contact sharp or gradational into glaciotectonic deformations - clasts and matrix are local in composition; angular to sub-angular; may contain rip-up clasts of underlying substrate - glacio-dynamic structures like folds, shear planes, etc.

*Compiled from Dreimanis (1976), Lawson (1981), Dreimanis and Lundqvist (1984), Catto *et al.* (1996).
**Englacial and basal denote stratigraphic position of the till, not genetic origin.

and feldspar. Ideally, the concentration of clasts with a proximal provenance should increase with till unit depth while distal material content decreases. Areally, clasts with a distal and occasionally proximal provenance may form dispersion patterns that can be used to define ice movement direction and distance of transport.

Quartz, carbonates, gypsum and Canadian Shield-type igneous and metamorphic rocks are the dominant lithological groups, with minor amounts of quartzite, sandstone, volcanic rocks, coal, shale, siltstone, pyrite, and ironstone (Appendix 5). Igneous and metamorphic rocks given a Canadian Shield origin include the granitoids, schists and gneisses. However, shield-like rocks with a Cordilleran origin may be present in pre-glacial and non-glacial fluvial deposits in the region.

Quartz constitutes the bulk of the coarse sand fraction in the samples, ranging from 25 to 79% in the diamictons, with an average of approximately 60%. Diamicton samples with anomalously low percentages (93-SB-08a, 93-SB-51, 94-SB-50c, 94-SB-79, 94-SAB-02/3.35, 94-SAB-15/18.75 and 94-SAB-15/19.20) were restricted to silty and clayey diamicton (Appendices 2 and 5). Samples comprised of bedrock, silt or clay also contained low amounts of quartz grains.

The carbonate group collectively includes limestone, dolostone and calcareous flakes and concretions. Carbonate content is highly variable in the samples, ranging from 1 % to 92 % in the diamictons (Appendix 5). High values appear to be associated with samples likely deposited in or near a glaciolacustrine environment (e.g., waterlain diamicton, silt and clay). Samples collected from borehole cores with thick diamicton sequences show a significant decrease in carbonate content with depth within the first 5 to 15 m. Carbonate content in the diamicton samples below 15 m tends to remain constant at 5 % or less.

Gypsum crystals are found in the waterlain diamictons and in the weathered portions of the other diamictons to a depth of approximately 15 metres. The crystals vary in shape and clarity from dirty massive blades to clear flakes and blades. When present, gypsum may constitute greater than 80 % of the granule to coarse sand fraction (e.g., 93-SB-07a). The majority of unweathered diamicton samples contain negligible amounts of gypsum (Appendix 5).

The igneous and metamorphic group represents lithologies with a probable Canadian Shield provenance. Most of the diamictons contain approximately 15 to 30 % Canadian Shield type lithologies in their granule to coarse sand fraction (Appendix 5). The presence of distal lithologies in the samples is characteristic of long distances of travel, a feature common to tills (Dreimanis, 1976). Samples with very low amounts of Canadian Shield type clasts are restricted to glaciolacustrine sediments and bedrock. Samples collected from three boreholes (93-SAB-06, 93-SAB-13 and 94-SAB-09) had slightly increasing amounts of Canadian Shield type lithologies with depth (Appendix 5). These three boreholes did not intersect bedrock during drilling. Sudden decreases of up to 19 % in Shield-type lithologies are seen immediately above bedrock, where the diamicton in borehole cores 94-SAB-02, 94-SAB-10, 94-SAB-11 and 94-SAB-15 grade into or abruptly overlie bedrock (Appendices 2 and 5). This decreasing trend would be expected in samples representative of basal till (Table 4.1).

The remaining 7 to 10% of the granule to coarse sand fraction composition of the samples comprises coal, shale/siltstone, pyrite, ironstone, quartzite, sandstone, volcanic rocks and “other” rocks. Individually, these groups vary from trace amounts to 100 % of the clasts in the samples (Appendix 5). Samples collected proximal to the Wapiti Formation (sandstone), particularly in the southern half of the study area, where bedrock is near surface, contain the highest amounts of coal, siltstone and shale. Coal clasts are characteristically larger in size and more abundant proximal to bedrock (e.g., 94-SAB-08/5.33). Although siltstone and shale comprise a significant amount of the local bedrock, they rarely constitute more than 10 % of the lithological composition of the granule to coarse sand fraction. The few diamicton samples with higher values were collected from locations proximal to bedrock (94-SB-11b, 94-SB-29e, 94-SB-58, 94-SB-91b). The high percentage of these local lithologies in the diamicton samples collected adjacent to bedrock suggest that these samples are subglacial in origin and may represent basal melt-out, deformation or lodgement tills (Table 4.1; Dreimanis, 1971; Dreimanis and Lundqvist, 1984).

Pyrite is present in both framboidal and crystalline forms. Pyrite appears to be restricted primarily to core samples collected below the weathered zone. It is, however, present in trace amounts in some surface diamicton samples. Concentrations of pyrite up to 3 % are present in core samples from boreholes drilled north and east of the Puskwaskau Hills (93-SAB-06, 93-SAB-13, 94-SAB-09, 94-SAB-10, 94-SAB-11 and 94-SAB-15). High concentrations of pyrite are not restricted to a particular depth within the borehole cores. Samples with pyrite concentrations of 2 % or more are found as shallow as 1.52 m in 94-SAB-11 to depths of 41.76 m in 93-SAB-06 (Appendix 5).

Ironstone clasts are prevalent in samples collected from sections and borehole cores in regions underlain by the Wapiti Formation. The concentration of ironstone clasts within the samples range from 0 to 25 %, with the majority of samples between 1 to 4 % (Appendix 5). Higher concentrations of ironstone clasts are found in samples collected from sections near Mountain Lake (93-SB-43), Sturgeon Lake (94-SB-05), Puskwaskau Hills (94-SB-07), New Fish Creek (94-SB-77), Crooked Creek (94-SB-29) and Valleyview (94-SB-46 and 94-SB-58). All of the boreholes drilled over the Wapiti Formation contain higher concentrations of ironstone clasts in diamicton samples collected from the upper half of the cores, with one exception, 94-SAB-02. Ironstone clasts in core samples collected from borehole 94-SAB-02 show increases in ironstone concentration down core.

Quartzite, sandstone, and volcanic clasts in samples collected from surface sections and borehole cores comprise maximums of 6%, 7% and 3% of the granule to coarse sand fraction, respectively (Appendix 5). Most of the diamicton samples contain 3% or less of these groups. Quartzite clast concentration is highest in samples collected from sections along stream or river cuts (93-52, 93-11, 93-05 and 94-91) and the upper 12 to 15 m of core from boreholes (93-SAB-06, 94-SAB-09, 94-SAB-10 and 94-SAB-15). Only samples collected from borehole 93-SAB-13, increased in quartzite clast content with depth. Sandstone clast concentration is also highest in samples collected from sections along stream or river cuts (93-05, 93-06, 93-11, 93-42, 93-52 and 93-53) and the upper 15 m of core from boreholes (93-SAB-06, 94-SAB-02 and 94-SAB-08). Samples collected from boreholes 94-SAB-10 and 94-SAB-15 contain high concentrations of sandstone in the core until directly above the bedrock contact. Volcanic clasts are present in low concentrations, generally less than 2%, in samples collected from sections and cores. This lithological group does not appear to be confined to a specific area or depth.

4.3 GEOCHEMICAL ANALYSES

Atomic Absorption Spectrometry (AA) and Induced Neutron Activation Analysis (INAA) were conducted on samples representing various surficial units and on multiple samples of the same diamicton units within selected boreholes. The accuracy of the geochemical data is uncertain since no reference data were available for the standards used. Precision measurements for the elements were obtained using duplicate samples of selected sediments and multiple samples of a GSC standard (Tables 4.2 and 4.3).

Duplicates and standards produced precision values ranging from 0 to 50 % compared to the mean (error value). The highest error values occur in samples near the detection limits. Errors in diamicton samples can be significant. An anomalous value in a sample but not its duplicate (e.g., gold) is easily detected and can be attributed to contamination. However, since such errors cannot be identified in the samples with only one duplicate, other anomalous values in specific elements should be viewed with caution.

Background limits for geochemical elements were defined as the 50th percentile for both the AA and the INAA data using the spreadsheet program Excel®5 (Tables 4.4 and 4.5). Samples analysed in 1993 were collected over the northern half of the study area, which is underlain primarily by shales of the Smoky Group and older units. Samples analysed in 1994 were collected over the southern half of the area, which is underlain by sandstones of the Wapiti Formation. To minimise biases that may result from differences in the local bedrock and analytical technique from year to year, two separate background values were calculated for 1993 and 1994. Samples with geochemical concentrations of background plus two standard deviations are considered anomalous (Tables 4.4, 4.5, 4.6 and 4.7).

TABLE 4.2

Precision measurements of AA using a GSC standard.

Element	Detection Limit	Average	Standard Deviation	Error %
Zn	2 ppm	77.6	5.6	7.22
Cu	2 ppm	24.0	1.0	4.17
Pb	2 ppm	12.6	1.1	8.73
Ni	2 ppm	29.0	1.2	4.14
Co	2 ppm	9.0	0.7	7.78
Ag	0.2 ppm	0.2	0.1	50.0
Mn	5 ppm	441.2	22.8	5.17
Cd	0.2 ppm	0.2	0	0
Fe	0.02 %	2.80	0.10	3.57
Mo	2 ppm	4.8	1.1	22.92
V	5 ppm	136.0	7.0	5.17

4.3.1 Surface Samples

The signatures of the geochemical elements in diamicton samples collected from surface sections are highly variable, both within and between sections. A comparison of the geochemical element concentrations within the surface samples and local bedrock statistical means (Table 4.8) yields some interesting results.

TABLE 4.3

Precision measurements of INAA using a GSC standard.

Element	Detection Limit	Average	Standard Deviation	Error %
Au	2 ppb	2	1	50
Sb	0.1 ppm	1.0	0	0
As	0.5 ppm	8.1	0.2	2.4
Ba	50 ppm	648	15	2.3
Br	0.5 ppm	3.1	0.1	3.2
Ce	5 ppm	53	4	7.5
Cs	0.5 ppm	3.7	0.1	2.7
Cr	20 ppm	70	7	10
Co	5 ppm	12	1	8.3
Hf	1 ppm	4	1	25
Fe	0.2 %	2.6	0.1	3.8
La	2 ppm	30	1	3.3
Lu	0.2 ppm	0.2	0	0
Mo	1 ppm	1	0	0
Ni	10 ppm	36	12	33.3
Rb	5 ppm	90	6	6.6
Sm	0.1 ppm	4.9	0.1	2
Sc	0.2 ppm	10	1	10
Ag	2 ppm	1	0	0
Na	0.02 %	0.90	0.09	10
Ta	0.5 ppm	0.8	0.1	12.5
Tb	0.5 ppm	0.6	0.0	0
W	1 ppm	1	0.0	0
U	0.2 ppm	3.9	0.1	2.6
Yb	1 ppm	2	0	0

TABLE 4.4

AA 1993 Background Values of Overburden

Element	Background	Standard Deviation	Anomalous Limit
Zn	103 ppm	11.14	125.27
Cu	33 ppm	4.16	41.33
Pb	16 ppm	1.79	19.57
Ni	32 ppm	3.92	39.85
Co	10 ppm	1.66	13.32
Ag	0.2 ppm	0.11	0.43
Mn	240 ppm	71.05	382.11
Cd	0.2 ppm	0.09	0.39
Fe	3%	0.3	3.6
Mo	5 ppm	0.96	6.93
V	164 ppm	16.58	197.15

The AA geochemical signatures of samples collected in 1993 show a reduction in concentration of most elements compared to shale of the Smoky Group (Second White Specks unit). However, the surficial values are very similar to shale of the Shaftesbury Formation, which is generally exposed north of the study area. Surface samples analysed in 1994 have elevated geochemical element concentrations compared to the underlying Wapiti Formation.

Samples analysed by INAA also show differences in element concentration compared to the underlying bedrock. The 1993 surface samples show similar geochemical affinities with the bedrock as seen in the AA analysis. Although the values are more variable, they correspond well with the geochemical signatures of the Shaftesbury Formation shales. The 1994 surface samples have geochemical element signatures similar to the Wapiti Formation, with some exceptions. The surface samples tend to show reduced concentrations of As, Mo and U compared to the bedrock and concentration increases in Cr, Hf, Ba, Co, Ni, Rb, Ag, Na and Zr.

TABLE 4.5

AA 1994 Background Values of Overburden

Element	Background	Standard Deviation	Anomalous Limit
Zn	105 ppm	9.46	123.92
Cu	34 ppm	3.53	41.05
Pb	16 ppm	2	20
Ni	40 ppm	7.85	55.71
Co	17 ppm	3.16	23.32
Ag	0.2 ppm	0.09	0.39
Mn	363 ppm	100.48	563.96
Cd	0.2 ppm	0.11	0.41
Fe	3.1 %	0.27	3.64
Mo	5 ppm	1.17	7.35
V	190 ppm	22.36	234.72
Li	27 ppm	5.76	38.52

Areal distributions of geochemical anomalous values are described in this study in four main groupings: Rare Earths; base metals and polymetallics; precious metals and associated tracers; and, others. The majority of surface samples contain geochemical element concentrations at or below background values (Appendices 6A and 6B). Many of the anomalous values are coincidental and can be pinpointed to individual samples.

Anomalous and elevated values related to the Rare Earths (Ce, Eu, La, Lu, Sc, Sm, Tb and Yb) are concentrated in samples collected from the southern half of the study area (Appendix 7A). There are five samples which consistently show anomalous or elevated concentrations of Rare Earths: 93-32, 93-39, 93-44, 93-55 and 94-40. Samples 93-39, 93-44 and 94-40 were collected from areas of thin overburden overlying the Wapiti Formation.

TABLE 4.6

INAA 1993 Background Values of Overburden

Element	Background	Standard Deviation	Anomalous Limit
Au	2 ppb	1.59	6.17
Sb	1.1 ppm	0.15	1.41
As	14 ppm	2.64	19.28
Ba	930 ppm	99.75	1129.5
Br	2.3 ppm	0.85	3.99
Ce	66 ppm	7.13	80.26
Cs	5.7 ppm	0.9	7.5
Cr	96 ppm	12.03	120.06
Co	13 ppm	2.33	17.67
Eu	1 ppm	0.36	1.71
Hf	6 ppm	1.67	9.34
Fe	3.2 %	0.37	3.94
La	37 ppm	4.6	46.2
Lu	0.2 ppm	0.1	0.41
Mo	1 ppm	0.57	2.14
Ni	41 ppm	10.62	62.23
Rb	110 ppm	15.01	140.01
Sm	6.1 ppm	0.74	7.59
Sc	13 ppm	1.61	16.21
Ag	1 ppm	0.45	1.9
Na	0.55 %	0.11	0.78
Ta	1.1 ppm	0.15	1.4
Tb	0.5 ppm	0.17	1.13
Th	12 ppm	1.37	14.73
W	1 ppm	0.37	1.75
U	4.2 ppm	0.75	5.7
Yb	3 ppm	0.63	4.26
Zn	110 ppm	35.41	180.82
Zr	270 ppm	119.88	509.75

TABLE 4.7

INAA 1994 Background Values of Overburden

Element	Background	Standard Deviation	Anomalous Limit
Au	2 ppb	1.47	4.95
Sb	1.2 ppm	0.16	1.53
As	12 ppm	2	16
Ba	955 ppm	105.17	1165.3
Br	2.45 ppm	1.11	4.66
Ce	69 ppm	8.41	85.83
Cs	5.85 ppm	0.93	7.71
Cr	96 ppm	13.24	122.47
Co	15 ppm	3.18	21.36
Eu	1 ppm	0.12	1.24
Hf	6 ppm	1.04	8.08
Fe	3.4 %	0.32	4.04
La	35 ppm	4.66	44.32
Lu	0.2 ppm	0.05	0.3
Mo	1 ppm	0.31	1.62
Ni	36.5 ppm	13.81	64.11
Rb	93 ppm	13.62	120.2
Sm	5.8 ppm	0.83	7.47
Sc	12.5 ppm	1.32	15.13
Ag	2 ppm	0.39	2.79
Na	0.62 %	0.17	0.96
Ta	1 ppm	0.18	1.35
Tb	0.8 ppm	0.19	1.17
Th	11 ppm	0.97	12.93
W	1 ppm	0.23	1.47
U	3.3 ppm	0.61	4.52
Yb	2 ppm	0.56	3.11
Zn	118.1 ppm	27.04	154.09
Zr	200 ppm	116.57	433.14

TABLE 4.8

Geochemical Data of Selected Bedrock Units - Statistical Means

Element	Analysis Used	Formation/Unit				
		Fish Scale		Westgate	2-WS	Wapiti
		Bone Bed	Shale	Shale	Shale	Sandstone
Au	INA	2	3	2	6	2
As	INA	26.5	16	13	52	17
Sb	INA	1.05	1.1	0.6	6.6	1.2
Te	INA	5	5	5	NA	5
Ag	INA/AA	0.2	0.2	0.2	1.1	0.2
Cu	AA	30	27	23	61	24
Pb	AA	7	16	18	17	15
Zn	INA/AA	390	93	94.5	191	108
Cd	INA/AA	3.6	0.25	0.25	3.8	0.6
Co	INA/AA	12	7	7	17	10
Ni	INA/AA	35	25	27	100	25
V	AA	51	132	118	344	115
Mo	INA/AA	15	8	2	40	6
Ba	INA	1600	865	695	850	830
Cr	INA	59	78.5	87	97	74
Sn	INA	50	50	50	50	50
W	INA	0.5	0.5	0.5	0.5	0.5
Se	INA	2.5	2.5	2.5	11	2.5
Fe	INA/AA	3.8	3.2	3.3	4.21	3.2
Mn	AA	472	81	93.5	159	143
Na	INA	0.255	0.33	0.355	0.29	0.32
Ir	INA	2.5	2.5	2.5	2.5	2.5
Br	INA	1.1	5.05	3.4	14	2.5
Rb	INA	22.5	95	105	91	72
Th	INA	12.5	11	12	11	11
U	INA	113.5	6.2	4.05	23	5.3
Ce	INA	270	63	75.5	87	68
Cs	INA	1.4	6.5	7	5	4
Eu	INA	7.3	0.5	1	1.9	1
Hf	INA	2	3	5	5	4
La	INA	160	36	40	47	37
Lu	INA	0.1	0.1	0.3	0.6	0.3
Sm	INA	30.65	4.35	5.3	6.8	5.3
Sc	INA	17.5	11	13	11	11
Ta	INA	0.25	0.9	1.1	0.25	0.7
Tb	INA	6.15	0.5	0.7	1.2	0.6
Yb	INA	15	1	2	3.8	2
Zr	INA	100	100	100	NA	100

Data acquired from M. Dufresne, APEX Geoscience Ltd.

Anomalous and elevated concentrations of base metals and polymetallics (Cd, Co, Cu, Fe, Mn, Mo, Ni, Pb, Sb, W and Zn) are common in samples collected from three main areas: Guy, Valleyview to just west of Crooked Creek, and, the northwest edge of the Puskwaskau Hills. The distribution of the anomalous samples within these three regions appears random, although several samples show coincidental elevated values (Appendix 7A). Anomalous values of one element, Mo, are restricted to a west to east trending belt between Townships 74 and 77. This belt overlies the contact area between the Wapiti Formation (south) and the older Smoky Group formations (north).

Geochemical element concentrations of precious metals and their tracers (Au, Ag and As) display seemingly random distributions within the study area (Appendix 7A). However, there are three areas where samples display elevated precious metal concentrations: Valleyview area, northwest edge of the Puskwaskau Hills, and around sample 93-22. Surface samples with anomalous Au concentrations were collected proximal to streams, rivers or bedrock. Many of these samples also show elevated or anomalous As concentrations. Anomalous Ag concentrations are more random, but usually show elevated concentrations in regions where the bedrock is near surface.

The remaining geochemical elements display anomalous or elevated concentrations in surface samples collected primarily in the southern half of the study area, especially around Valleyview and northwest of the Puskwaskau Hills (Appendix 7A). Samples containing high concentrations of Na are clustered around Valleyview, an area containing soils belonging to the Solonetzic Order (Odynsky *et al.,* 1956).

4.3.2 Borehole Samples

The geochemistry of samples from eight boreholes (93-SAB-06, 93-SAB-13, 94-SAB-02, 94-SAB-08, 94-SAB-09, 94-SAB-10, 94-SAB-11 and 94-SAB-15) were analysed to determine vertical variations (Appendices 6A and B). Vertically, most geochemical elements in the boreholes show little variation in the diamictons with depths below the water table (Appendix 7B). Greatest variability in geochemical values is found in the upper 25 m of the core, with the extreme variations in the upper 5 to 6 m. Geochemical changes in the cores are abrupt and occur adjacent to and within water-saturated zones and bedrock (Figure 4.1a,b; Appendices 2, 6A, 6B and 7B). Samples collected from these highly variable zones included diamictons and glaciolacustrine sediments. These diamictons are laminated, highly weathered, fractured and/or contain interbedded silt and sand lenses and laminae, features common to supraglacial and some englacial melt-out tills (Table 4.1; Lawson, 1981; Dreimanis and Lundqvist, 1984).

Diamicton samples collected from core below 25 m have relatively constant geochemical values for the majority of the elements (Figure 4.1a). Changes in geochemical signatures with depth are not apparent until approximately three metres above bedrock (Figure 4.1b). Strong geochemical trends mimicking the bedrock geochemical signature are not apparent until 0.5 m above the diamicton – bedrock contact (Appendices 6A, 6B and 7B). This sharp change in composition between the bedrock and the basal diamicton samples over such a short vertical distance (Figure 4.1b) may represent deformation till (Table 4.1; Dreimanis and Lundqvist, 1984).

The transition from diamicton to bedrock displays distinct changes in INAA and AA geochemical element trends that vary depending upon the underlying bedrock lithology. Diamicton samples collected proximal to the Wapiti sandstone from two of the boreholes (94-SAB-02 and 94-SAB-08), display an increase in Sc and Na, and a decrease in Cu, Sb and Cs contents as the bedrock contact is approached (Appendices 6A, 6B and 7B). Other possible trends that may be linked to the Wapiti sandstone are increases in Zn, Zr and As, and decreases in Ba, La, Li and Mo concentrations in the basal diamicton samples.

Diamicton samples collected proximal to siltstone of the Kaskapau Formation (Smoky Group) from borehole cores 94-SAB-10 and 94-SAB-11 show increases in Ni, Cu , Sc, Co and Cr, and decreases in Pb, U, Tb, As and Br as the bedrock insert

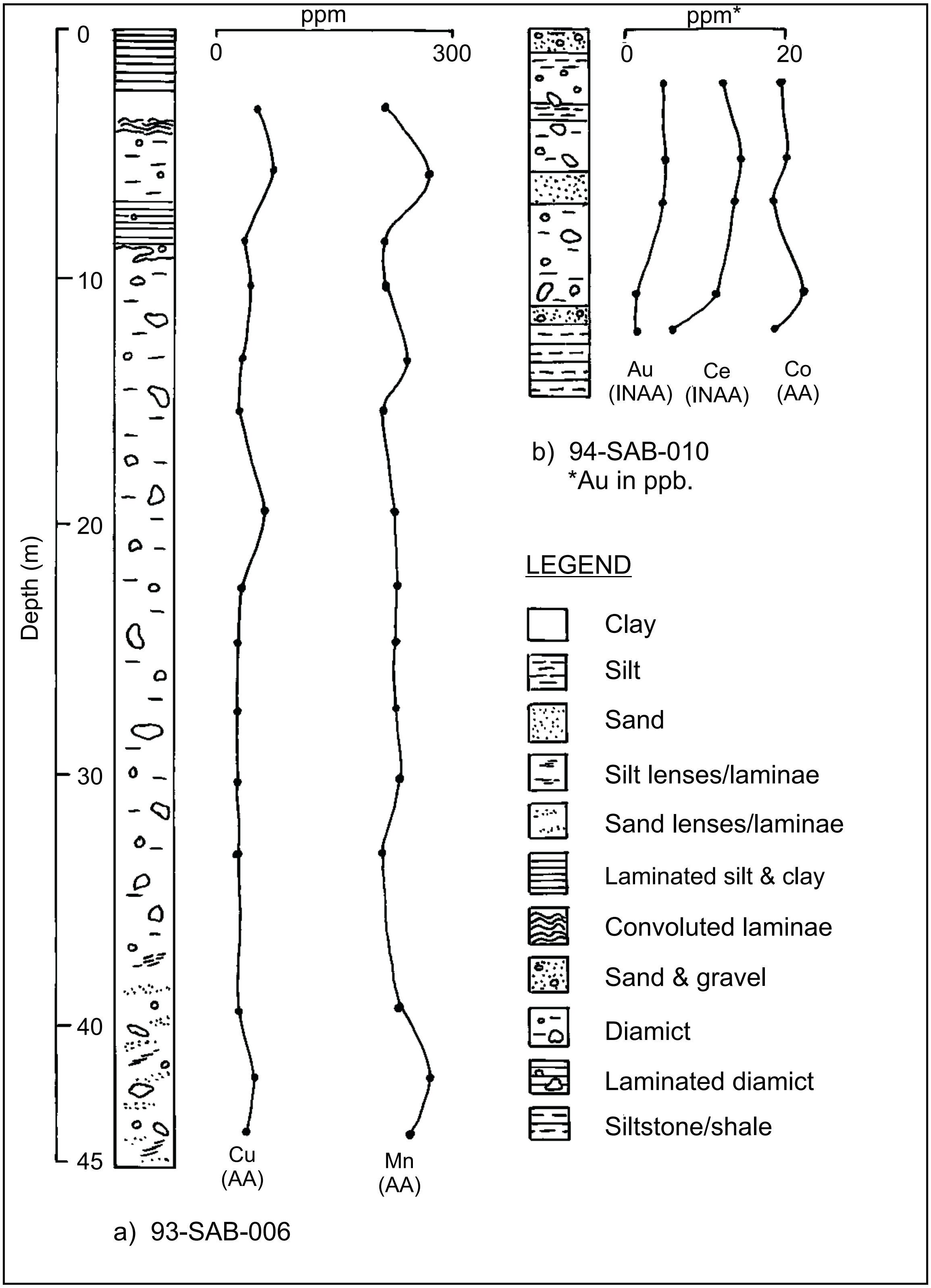


FIGURE 4.1 Vertical profiles of selected borehole geochemistry.

contact is approached (Appendices 6A, 6B and 7B). The depth at which the geochemical signature of the diamictons within the two boreholes started to mimic the bedrock is variable. Diamicton samples in 94-SAB-10 mimicked bedrock after 6.8 m in depth, whereas till samples in 94-SAB-11 displayed similarities to bedrock after 13.7 m. In addition, other geochemical trends were apparent in the diamicton to bedrock contact zones of each individual borehole, but not between them.

Borehole 94-SAB-15 intersected bedrock comprised of silty shale from the Wapiti Formation. Geochemical trends from this borehole are based on only one sample and are therefore not well defined. However, the diamicton to bedrock transition appears to be reflected by increases in Ni, Cu, Pb, Mo, U, Rb, Sc, Na, Co, Ba and Br and decreases in Li, Mn, V, Sm, Ta, La, Hf, Ce and Sb (Appendices 6A, 6B and 7B). These geochemical trends are not apparent in the core until after 16.7 m in depth.

4.4 DIAMOND INDICATOR MINERAL ANALYSIS

The regional coverage in terms of the number of surface and borehole samples analysed for diamond indicator minerals (DIMs) is sparse. Eight surface samples (7 diamicton, 1 sand and gravel) and 11 borehole samples (from 9 boreholes) were collected by the author and other personnel of the AGS and submitted for DIM analysis (Appendix 6C). The diamicton samples collected from the sections and the borehole cores are believed to be glacial in origin and thus tills.

Of the eight surface samples, five contained DIMs, including chromites, eclogitic garnets and kimberlitic garnets (Figure 4.2). The sand and gravel sample collected from the pre-glacial fluvial gravels at the base of the Watino section contained eight DIM indicators, namely one eclogitic garnet and seven chromites. The four anomalous diamicton samples, namely 94-SB-14, 94-SB-35, 94-SB-39 and 94-SB-76, were collected from sections located in the southern half of the study area along the eastern and southern edges of the Puskwaskau Hills and the

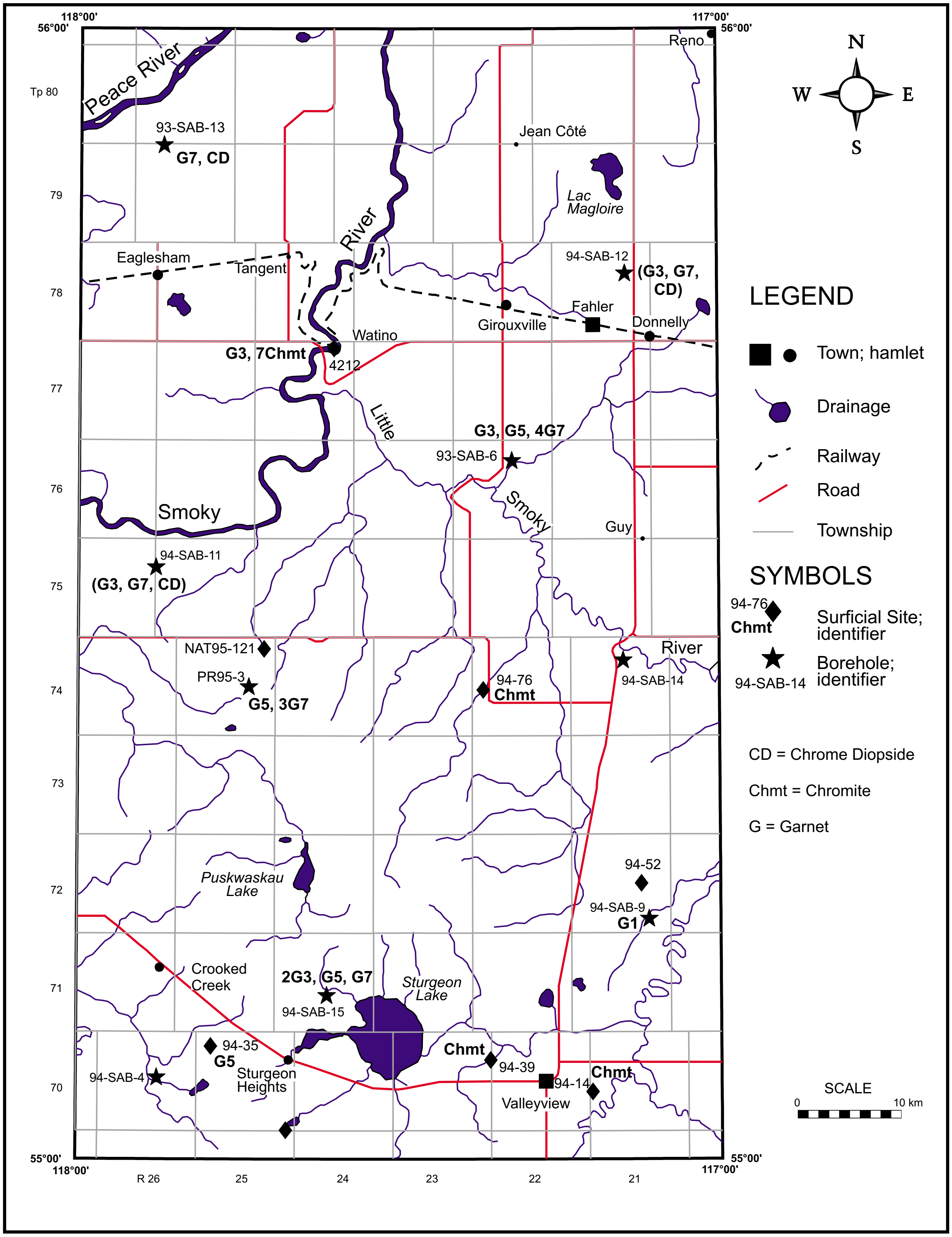


FIGURE 4.2 DIM Sample Locations and Results

western flank of the Little Smoky River (Figure 4.2). The surface sample collected by the AGS (NAT95-121) proximal to the Mountain Lake kimberlite yielded no DIMs.

Samples collected from six, possibly seven, of the nine boreholes yielded kimberlitic and eclogitic garnets and one chrome diopside (Appendix 6C). The diamicton samples collected from boreholes 94-SAB-11 and 94-SAB-12 by the AGS were apparently mislabeled sometime after collection. As a result, the DIMs yielded by the two samples were combined by the AGS. It is unknown, which borehole actually yielded the kimberlitic garnet, eclogitic garnet and chrome diopside.

The remaining five boreholes that yielded DIMs (93-SAB-6, 93-SAB-13, 94-SAB-9, 94-SAB-15 and PR95-3) are located at least 30 km apart. The lower diamicton sample collected from borehole 93-SAB-13 yielded a kimberlitic garnet and a chrome diopside. A borehole located along Peavine Creek, approximately 47 km southeast of borehole 93-SAB-13, yielded DIMs in both the upper and lower diamicton samples (Appendix 6C). The uppermost sample contained a single eclogitic garnet. In comparison, the lower diamicton sample yielded four kimberlitic garnets and one eclogitic garnet. A diamicton sample from borehole 94-SAB-9, located along the western flank of the Little Smoky River yielded a single kimberlitic garnet (Appendix 6C).

The last two boreholes yielding DIMs, 94-SAB-15 and PR95-3, are situated along the southern and the northern edge, respectively, of the Puskwaskau Hills. The basal diamicton sample collected from 94-SAB-15 yielded three eclogitic garnets and a single kimberlitic garnet (Appendix 6C). Borehole PR95-3, located approximately 3.5 km south of the Mountain Lake kimberlite, yielded DIMs in the upper and basal diamicton samples (Appendix 6C). The upper diamicton sample yielded two kimberlitic garnets. The basal diamicton sample yielded one kimberlitic garnet and one eclogitic garnet.

5.0 SURFICIAL GEOLOGY

The surficial geology of the western half of the Winagami map area comprises sediments of glacial and post-glacial origin (Maps 1 and 2). These sediments are divided into eight readily identifiable units based on genetic origin, including organic (Op), alluvial (A), colluvial (Cv), aeolian (AE), glaciolacustrine (GL), glaciofluvial (GF) and morainal deposits (M), and bedrock (R). The symbols and genetic classifications used are based on the system currently in use by the Geological Survey of Canada. Thickness, relief and morphology characteristics, herein denoted by modifiers, divide the main units into sub-units that are more useful in field identification and mapping. Unit modifiers include: d (dunes); f (fluted); h (hummocky); m (rolling); p (plain); pd (prairie doughnuts); t (terrace); and x (complex, mixture of features). Areas where the main unit is covered, often discontinuously, by a veneer of a second unit are indicated by a slash (/). In such a case, the first identifier represents the veneer and the second identifier represents the underlying unit. As with most surficial maps, unit and sub-unit boundaries are approximate due to natural variation during deposition and on-going post-glacial processes.

5.1 ORGANIC DEPOSITS (Op)

Organic deposits (Op) occur as swamps, fens and peat bogs of variable extent and depth. Organic deposits are found primarily in shallow basins and poorly drained areas characterised by high water tables (Maps 1 and 2). Dense vegetation, including various grasses and forbs, alder (*Alnus crispa*) and black spruce (*Picea mariana*) accompany many organic deposits. Deposits are often several square kilometres in extent, particularly near the Puskwaskau Hills and southeast of Valleyview (Map 2). Smaller patches of organic deposits are scattered throughout the study area. The thickness of the organic deposits are uncertain;

however, soil probing of a selected few deposits indicate that these units can exceed several metres in depth.

5.2 ALLUVIAL DEPOSITS (A)

Alluvial deposits (Ap, At) contain moderately to well-sorted sand and gravel, silt and clay. The unit is represented primarily by channel fill, bars, floodplains (Ap) and terraces (At) within the present day river valleys (Plate 5.1). The thickness of alluvial deposits in the study area varies from remnant overbank deposits a few metres thick to floodplains over tens of metres thick in the Peace, Little Smoky and Smoky river valleys (Plate 5.2). A major source of sediment for the larger rivers and creeks is obtained from slumped material along the valley sides.

Remnant floodplain and overbank deposits have been noted along the upper flanks of valley walls of the Peace and Smoky rivers (Maps 1 and 2). A large splay feature comprised of fine to medium sand along the south rim of the Peace River valley is an excellent example of one overbank deposit. Most remnant floodplain features are not readily noticeable on airphotos due to dense vegetative cover.

Up to six generations of terraces (paired and unpaired) appear along the Peace, Smoky and Little Smoky rivers (Plates 5.1 and 5.3; Maps 1 and 2). Old terraces along the Smoky and Little Smoky rivers are mined for aggregates for use in local building projects. Younger terraces are used as pasture, cropland, campgrounds and community playgrounds (Plate 5.1).

5.3 COLLUVIAL DEPOSITS (Cv)

Colluvium (Cv) is comprised of a variety of slumped material, including till, clay, silt, sand, gravel and bedrock. These slumps form the gently undulating slopes of the major rivers and streams (Plate 5.4; Maps 1 and 2). In areas of large-scale slumping (the Peace and Smoky rivers), valley sides are flanked by large

PLATE 5.1 - Floodplains, terraces and bars along the Smoky River, near Watino.

PLATE 5.2 - Section showing Smoky River floodplain sediments.

PLATE 5.3 - Multiple terraces along the Little Smoky River.

PLATE 5.4 - Slump blocks along the Little Smoky River.

scalloped hummocks and ridges. Adjacent to the valleys, hummocks and ridges up to 5 m in relief resulting from slumping are visible 500 m beyond the valley rim. Colluvium thickness is dependent on the size of the drainage valley and the underlying sediment. Slump blocks range from boulder-sized to over 15 m in height.

Some sections along the major rivers (e.g., Watino section) contain sediment gravity flow structures, such as flow noses, convoluted laminae and detachment surfaces with slickensides (Plate 5.5). Blocks of material are bounded by listric normal faults (Plate 5.6) resulting from loss-of-support (e.g., 93-SB-67, 94-SB-01). Reverse faulting has been noted, suggesting that some material may have experienced compression by glacial overriding prior to slumping. A majority of the sections exposed along the rivers are slumped blocks which came from higher stratigraphic positions. In many cases, the stratigraphic order of units within the slumped blocks has been preserved.

Colluvium is actively forming along all rivers and streams due to surface runoff, poor drainage and structural weaknesses in the underlying sediment. Slumping has required extensive remedial engineering of valley walls and highways. During 1993-1994 a new segment of highway 49 near Watino was constructed in order to bypass stretches of the original highway prone to slumping. Slumping in the new section was observed during and soon after the bypass was completed.

5.4 AEOLIAN DEPOSITS (AE)

Aeolian deposits are composed primarily of moderately to well-sorted sand and silt. They form parabolic, irregular and linear dunes, hummocks and ridges. These deposits are usually covered by forest vegetation and grasses. Organic deposits commonly infill the intervening depressions. The thickness of Unit AE ranges from a veneer (less than 2 m) in the southeast to a thick blanket (greater than 10 m) in the west (Map 1). Aeolian deposits are divided into two sub-units: forested dunes (AEd); and, transitional dunes with ice stagnation sediments (AEh).

PLATE 5.5 - Dewatering structures, convolution and slumping near Watino.

PLATE 5.6 - Listric normal faulting in section 94-SB-01.

5.4.1 Sub-unit AEd

Densely forested, large-scale (up to 10 m) parabolic and irregular dunes and hummocks form areally extensive fields south of the Smoky River (Plate 5.7; Map 1). The sands become interbedded with and overlie glaciolacustrine fine silts and clays southeast of Watino. Southwest of Watino, the dunes are larger, forming densely vegetated ridges surrounded by swamps and bogs. Sub-unit AEd may be a continuation of the Grande Prairie dune fields described by Liverman (1989), Halsey (1989) and Halsey *et al.* (1990).

5.4.2 Sub-unit AEh

A transitional zone of dunes and glaciolacustrine with stagnation deposits (AEh) lies east of the major dune field (Map 1). The zone trends north-south along the Smoky River. Similar in composition to unit AEd, this area contains large-scale ridges and hummocks up to 3 m in height and 1 km in length. Fine silts and clays drape over most of the ridges and hummocks in this region, particularly in the eastern portions. Fine sand, silt and clay, massive to thinly laminated, comprises the majority of the material in the transitional zone. Loss of support features, such as normal micro-faulting are preserved in ridge cross-sections (Plate 5.8).

5.5 GLACIOLACUSTRINE DEPOSITS (GL)

Deposits of glaciolacustrine origin are composed of laminated to massive units of silt and clay, with minor amounts of sand, diamict and dropstones. Thickness varies from less than 2 m in ridged, fluted and hummocky areas to over 10 m in the flatter regions (Maps 1 and 2). Low relief hummocks, ridges, flutes and slump scars typify the surface morphology. Relief is generally less than two metres, but may reach five metres in the hummocky regions. Glaciolacustrine deposits are

PLATE 5.7 - Forested dune field (Aed) near Watino.

PLATE 5.8 - Micro-faulting due to loss of support..

divided into two sub-units based on morphology, drainage, and sedimentological characteristics: subdued, flat to fluted (GLpf); and variable, flat to hummocky (GLx).

5.5.1 Sub-unit GLpf

Sub-unit GLpf is predominantly flat in appearance with swaths of ridges and flutes, up to 3 m in height, and shallow grooves. Massive to laminated silt and clay infill low-lying regions and drape over till ridges and flutes. Patches of organic deposits are widespread in the poorly drained regions. Relict drainage patterns mimic masked flutes and ridges, indicating general ice flow directions. East and south of the Smoky River, sub-unit GLpf forms a veneer over thick morainal units. The unit thickens to the northeast, forming a blanket over much of the region north of Fahler (Maps 1 and 2).

5.5.2 Sub-unit GLx

Sub-unit GLx contains surficial variations in morphology and drainage that are too localised to differentiate at a map scale of 1:100,000. This sub-unit ranges from flat areas with low-relief ridges to large (greater than 3 m high) hummocks. Compositionally, the unit is dominated by silt and clay with minor fine sand and till. The unit is massive to laminated in the flatter regions. Convolution of the laminae have been noted in some of the ridges.

Hummocky regions contain till mounds draped by laminated or convoluted bands of silt, clay and fine sands of variable thickness. Well to poorly-drained areas with local surface ponding and organic deposits occur throughout the region. Sub-unit GLx is found mainly in the northern half of the study area between the Peace and Smoky rivers (Map 1), and in the northeastern portion of Map 1. A large exposure of unit GLx is found in the southeastern corner of Map 2 along the Little Smoky River. Unit thickness is variable, ranging from a veneer over morainal sediments at higher elevations to a thick blanket north of Eaglesham and Fahler (Map 1).

5.6 GLACIOFLUVIAL DEPOSITS (GF)

Glaciofluvial deposits are divided into two distinct map sub-units based on depositional environment and morphology: outwash and meltwater channels (GFp); and, ice-contact landforms (GFx). Pre-glacial fluvial deposits modified by ice-contact are included in sub-unit GFx.

5.6.1 Sub-unit GFp

Moderately sorted glaciofluvial deposits, composed of sand, silt and minor amounts of clay infill the meltwater channels (Maps 1 and 2). Meltwater channel deposit thicknesses vary and may exceed 30 m. Most channels are broad and shallow with poorly preserved sides.

Four distinct channels occur in the map area and are represented by a curvilinear arrow on the Maps 1 and 2. The first channel curves around the north and eastern edges of the Birch Hills (Map 1) and is infilled by sand and silt. Several terrace-like ridges along the edges of the Birch Hills may indicate the original western channel side (Plate 5.9). The lack of evidence for the eastern wall suggests that the channel lay marginal to the ice front.

The second channel, situated east of Valleyview (Map 2), is currently occupied by the Little Smoky River. Its western and eastern edges are marked by a series of parallel strand lines and terraces (Plate 5.10). The eastern edge of the channel lies just outside of the study area. Much of the central portion of the channel is obscured by organic, fluvial and glaciolacustrine deposits. Exposures through the strand lines are difficult to obtain since the majority of the strand lines lie on private property. The origin of the strand lines has been attributed to pro-

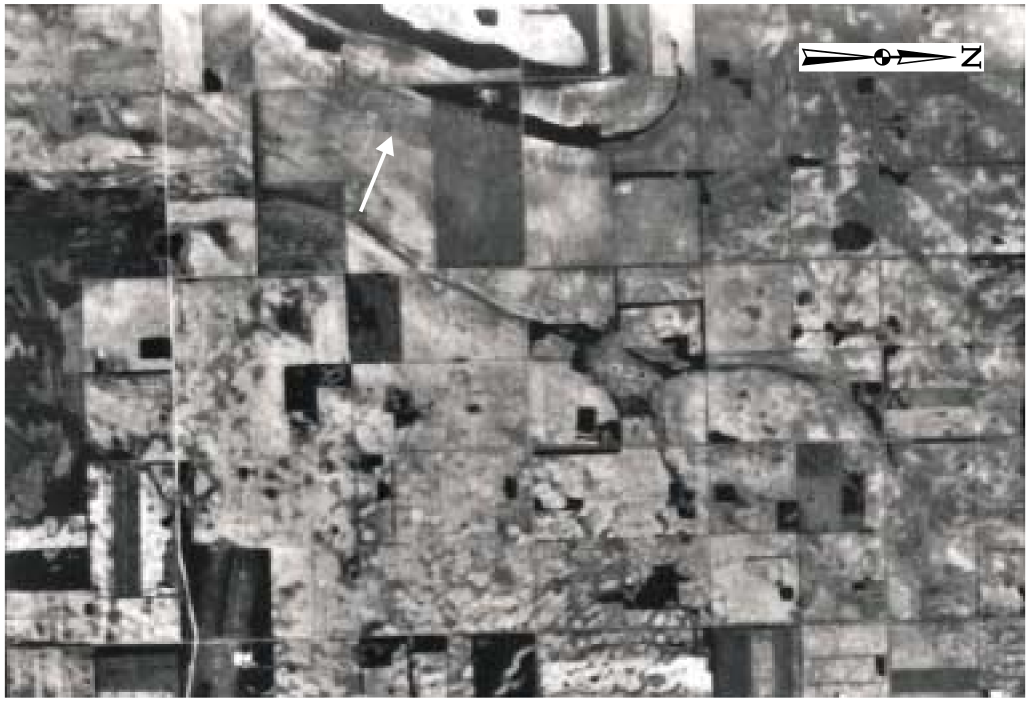


PLATE 5.9 - Terraces of remnant meltwater channel along the eastern flank of the Birch Hills.

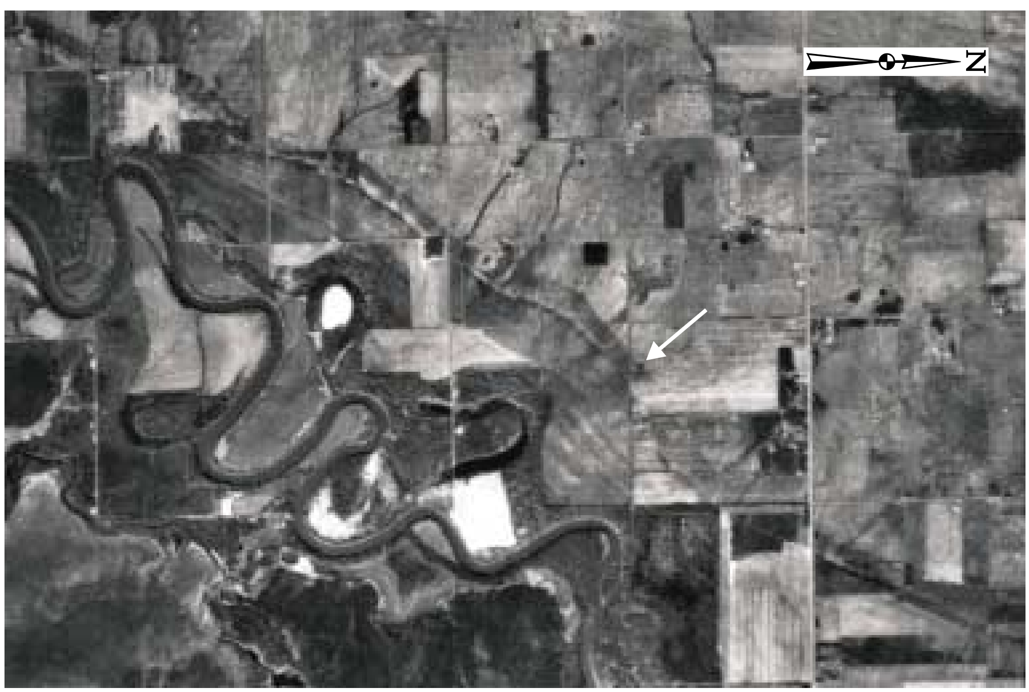


PLATE 5.10 - Strandlines and terraces along the western flank of the Little Smoky River.

glacial ponding in the channels during later the early stages of deglaciation (Henderson, 1959; St.-Onge, 1972).

The third channel follows the northeastern edge of the Puskwaskau Hills (Map 2) and ends in a large splay of glaciofluvial sediments around New Fish Creek. The channel is very shallow at its northwestern tip where the bedrock is near surface, and appears to deepen towards the southeast. The western edge of the channel has cut into the side of the Puskwaskau Hills, forming a well-defined rim. The lack of evidence supporting an eastern edge suggests that the channel was likely ice marginal. At New Fish Creek, a large sandy ridge marks the southeastern edge of the channel (Plate 5.11). This ridge has previously been interpreted as the Fish Creek Moraine, an end moraine marking the ice marginal position during the Late Wisconsinan (Henderson, 1959). The "moraine" comprises moderately to well-sorted medium to fine sand and appears to be more representative of an esker or kame complex.

The fourth channel is situated in the southwestern corner of Map 2 and is currently occupied by the Simonette River. This channel is poorly preserved and discriminating sediments deposited by the present river and those from glacial sources is difficult. Extensive slumping and poor access has prevented the detailed study of the sections along the river.

5.6.2 Sub-unit GFx

Ice-contact deposits are composed primarily of gravel with minor amounts of sand, silt, clay and diamict. Cobble and boulder lags on the surface are common. Unit thickness is variable, often exceeding several metres. These sediments have been deposited at the margin of, within or under glacial ice. Most of the deposits appear to have been reworked by post-glacial processes.

Streamlined ridges, hummocks, and kames of low relief typify these deposits. Kames and hummocks are common north of Watino, west of the Smoky River (Map 1). Ridges are situated adjacent to meltwater channels and in the transitional zones between aeolian and glaciolacustrine deposits (Maps 1 and 2). Several of the ridges are used as local sources of aggregate.

Included in unit GFx is an area in the southwestern corner of the map region (Map 2), where near-surface pre-glacial gravels have been subglacially modified into low relief linear ridges (22-70-26W5). A discontinuous veneer of till drapes the ridges and infills the flanks of the “ridged” gravels (Plate 5.12).

5.7 MORAINAL DEPOSITS (M)

Diamicton comprises much of the southern half of the study area (Map 2). In addition, small patches and veneers of glaciolacustrine, aeolian, alluvial and organic deposits are present. Diamicton thickness ranges from a veneer on topographic highs to over 43 m. Morainal deposits can be subdivided into three sub-units based on morphology, drainage and sedimentological properties: mixed (Mx), hummocky and kettled (Mh), and prairie doughnuts (Mpd).

The majority of the diamictons in the study area are interpreted as glacial in origin based on several properties. These diamictons have a bimodal grain size distribution, consisting of a finer grained matrix and striated and faceted clasts in the pebble to boulder size range; features common to tills (Table 4.1; Dreimanis and Vagners, 1971; Dreimanis, 1976; Lawson, 1981; Dreimanis and Lundqvist, 1984). The lithological composition of the diamictons includes material of Canadian Shield provenance, indicating long distances of transport by glacial ice, and local material (Appendices 2, 3 and 5). Diamicton samples collected from natural exposures are oxidised and often contain lenses and fine laminae of fine sand and silt (Appendices 2 and 3), indicating reworking by pedogenic and fluvial processes. The presence of laminae and lenses in the diamictons are common in tills with a supraglacial or englacial origin and in some mass flow deposits (Table 4.1; Dreimanis, 1976; Dreimanis and Lundqvist, 1984; Lawson, 1984). In addition, the diamictons are commonly laminated at the top, grading into massive units with depth (Appendices 2 and 3). Lamination in diamictons are found in tills deposited by melt-out in the

PLATE 5.11 - Sandy ridge (”moraine”) at New Fish Creek.

PLATE 5.12 - Bouldery till draping ridged nonglacial gravels..

supraglacial zones of ice (Table 4.1). The gradation of the laminated to massive diamicton may represent deposition by melt-out in the supraglacial to englacial zone within the ice.

5.7.1 Sub-unit Mx

Sub-unit Mx contains numerous types of streamlined and stagnation glacial depositional features too areally restricted to subdivide. Flutes, ridges, drumlins, drumlinoids, hummocks, kettles and flat plains typify the region. Topographic relief of the ridges and hummocks may exceed five metres (Plate 5.13). Drainage is irregular and often intermittent. Unit thickness is variable, ranging from less than 2 m on the Puskwaskau Hills, the Birch Hills and the Valleyview hill to over 43 m in buried paleochannels (e.g. High Prairie, Tangent, and Bezanson channels). Low-relief drumlins and drumlinoid ridges indicate ice movement directions to the southwest, south and southeast (Maps 1 and 2).

The upper 15 m of the unit comprises brownish-grey to brown, supraglacial, melt-out and englacial melt-out tills (Table 4.1). Silty-clayey to loamy in texture, the tills have a granule to pebble-sized clast content of 15% or less (Plate 5.14). Fine sand with rare silt lenses and laminae may be present in the supraglacial till. Fractures infilled by gypsum crystals with blades up to five cm in length are common. Supraglacial till in depressions and high water table areas contains higher amounts of gypsum crystallization and have undergone more advanced oxidization and weathering. The clasts are sub-rounded, highly weathered and very friable. Lithologically, they are dominated by a mixture of Canadian Shield (granitoids, schists and gneisses), Devonian carbonates and to a lesser extent, local material (shales and sandstones).

PLATE 5.13 - Fluted and ridged moraine (Mx).

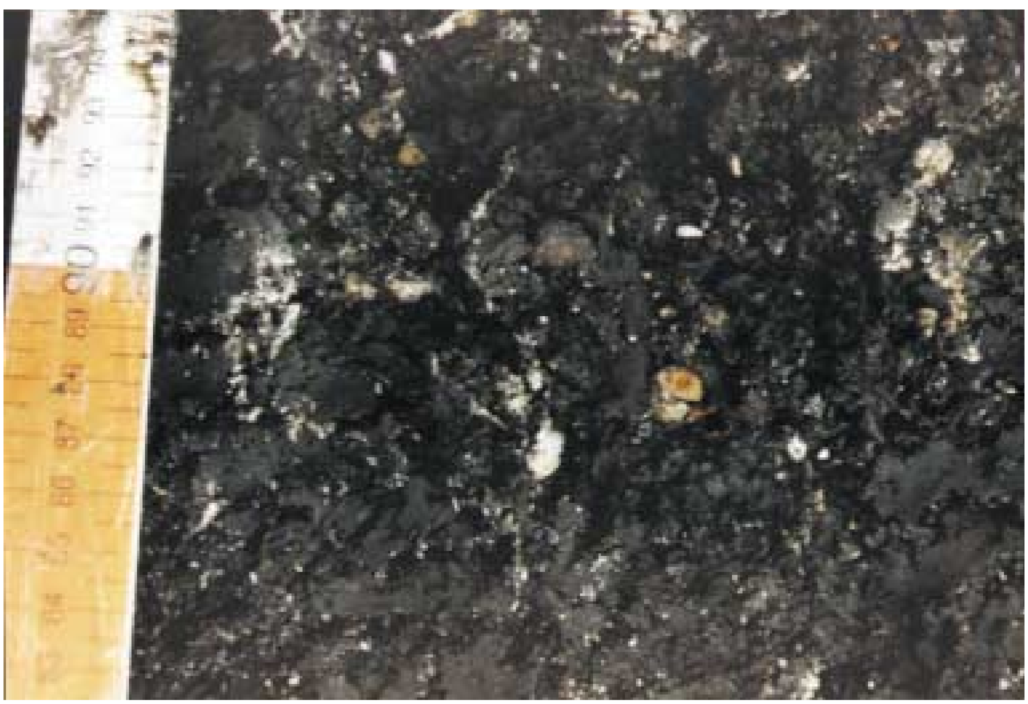


PLATE 5.14 - Weathered diamict with gypsum mineralisation.

5.7.2 Sub-unit Mh

Sub-unit Mh contains the typical hummocky terrain associated with ice stagnation. Hummocks are irregular in shape and form a basket of eggs topography (Plate 5.15). Topographic relief of the hummocks may exceed 10 m. Depressions (kettles) usually contain water during the spring and summer. Numerous swamps, fens, bogs, ponds and lakes are common in most low-lying regions. This sub-unit is restricted primarily to the trench between the Puskwaskau Hills and a local high east of the Little Smoky River near Provincial Highway 2A (Maps 1 and 2).

Lower relief regions are used for agriculture, while the higher relief areas are restricted to pasture or forestry. This unit contains primarily supraglacial and melt-out tills similar in composition, texture, colour and lithology to sub-unit Mx.

5.7.3 Sub-unit Mpd

The last sub-unit, Mpd, is similar to Mh, but the shape of the hummocks is distinctive and the areal extent of organics is more localised. The hummocks look like doughnuts on airphotos and miniature volcanoes on the ground (Plate 5.16). Roughly circular, the mounds have relatively steep sides and circular depressions on the top. These depressions are often filled with water or vegetation. Mounds can exceed 10 m in height and 500 m in diameter.

Sub-unit Mpd comprises mainly massive englacial melt-out till and small patches of supraglacial till (Table 4.1). Compositionally, Mpd is similar to subunits Mx and Mh; however, the granules and pebbles are less weathered. Finer sediments, primarily laminated to massive silts and clays drape the mounds, thickening towards the central depression. These finer sediments are also found in depressions and poorly drained regions around the mounds. These finer sediments have been attributed to glaciolacustrine processes in the past (Henderson, 1959). However, these sediments are similar to those deposited from

PLATE 5.15 - Hummocky moraine (Mh).

PLATE 5.16 - Till moraine with “Prairie Doughnut” features (Mpd).

surface run-off and sediment settling within ponds, a process witnessed many times in the study area.

5.8 BEDROCK (R)

Only one bedrock exposure is large enough to qualify as a map unit at 1:100,000 scale (Map 2). The exposure is a small hill located approximately 15 km northeast of New Fish Creek (29-73-20W5). A road cut through the exposure reveals bedding planes inconsistent with the local bedrock pattern. The bedding planes within the exposure have an apparent dip of approximately 9° to the east (Plate 5.17). Faults, bedding flexure and orientation measurements (224/19 to 333/07) support thrusting from the northwest or west. The hill is comprised of bedrock similar to the Kaskapau Formation exposed along the Little Smoky River.

Bedrock is close to surface (within 5 m) in the Puskwaskau region, particularly along the northern and eastern flanks of the hills. The top of Birch Hills is draped by a thin veneer of till. Smaller exposures within the study area have revealed small-scale thrusting of bedrock. For example, section 95-SB-06 located along the contact region between sub-units AEd and GFx (17-77-25W5) contains thrusted slabs of oxidised sandstone similar to the bedrock exposed on the Birch Hills (Plate 5.18). The bedrock slabs dip shallowly, with measurements ranging from 17° to 27°. Strike measurements curve from 042° on one end of the exposure to 124° on the other. Bedrock is also exposed in various locations along the Smoky, Little Smoky and Peace rivers and in smaller creek and stream beds, particularly during drier seasons. These exposures are generally small, of limited extent and are often covered, at least partially, by slumped material.

5.9 ICE FLOW INDICATORS

There are few good morphological features that can be used as indicators of ice flow direction in the study area. Interpretation based on the areal distribution

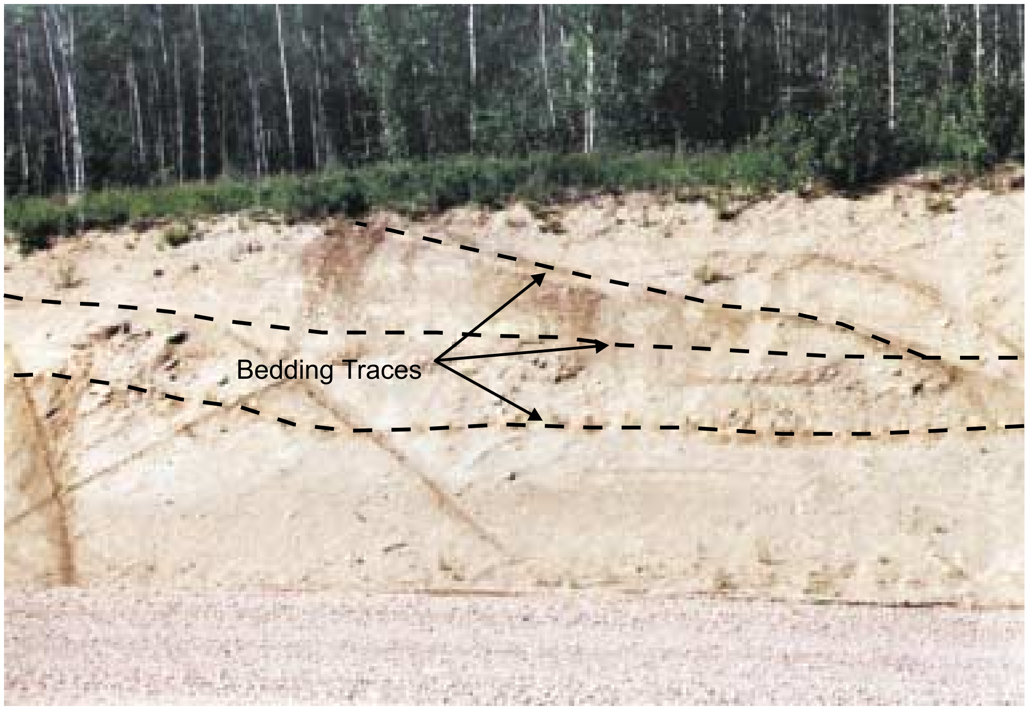


PLATE 5.17 - Glacial thrusting of Kaskapau Fm. (94-SB-67).

PLATE 5.18 - Glacial thrusting of bedrock (95-SB-06).

of flutes, drumlinoid ridges and grooves, suggest two major ice-flow directions, south to southwest and southeast. Both of these directions are attributed to the ice movement during the Late Wisconsinan.

The south to south-westward direction is the stronger, more erosive ice flow movement that originated north to northeast of the Peace River map area. Long low relief ridges, grooves and flutes in the Winagami map area support this interpretation. Linear features crossing over upland areas suggest that during this advance the margin of the Laurentide Ice Sheet was thick enough to override topographic controls.

A second, weaker trend to the southeast flowed around local topographic features and was channeled by them. This second flow pattern appears to have originated northwest or west of the study region. This latter direction may be a result of ice streaming or diversion of smaller lobes off the main ice sheet during later stages of the Late Wisconsinan advance. The lack of cross-cutting relationships between the thicker ice and the thinner, topographically controlled ice appears to support this conclusion.

Bedding plane orientations taken from possible ice-thrusted bedrock exposures found at sections 94-SB-67 and 95-SB-06 also support the southeasterly flow pattern. Both sections are found proximal to major topographic features, namely, the Puskwaskau and Birch hills.

6.0 QUATERNARY STRATIGRAPHY

The stratigraphy of the Winagami region is complicated by the irregularity of the underlying bedrock topography. Although numerous paleochannels and their tributaries underlying the region have been mapped, they are still poorly defined in terms of geometry and orientation. Bedrock topography and the resulting variation in drift thickness affects the Quaternary stratigraphy and glacial history of the Winagami region. Dispersal analyses conducted by industry as part of their exploration programs require detailed information on bedrock topography, drift thickness and glacial history to assess properly the economic viability of their properties.

The generalised stratigraphy of the Winagami region is fairly straightforward, representing a sedimentary sequence deposited during and after the Late Wisconsinan. More complex and likely older stratigraphic sections are present solely within the channels. Unfortunately, a lack of good time-stratigraphic markers outside of the Watino section hinders chronological correlation of these older sections.

6.1 BEDROCK TOPOGRAPHY

Bedrock topography in the Winagami region was compiled using information obtained from oil, gas and water well litho- and geophysical logs, published reports (Henderson, 1959; Borneuf, 1979) and drilling. Six large buried channels and their tributaries occupy the area, including the Shaftesbury (Tokarsky, 1967), Tangent (Henderson, 1959), High Prairie (D. Toop, *pers. comm.*, 1995), Bezanson (Carlson and Hackbarth, 1974; Liverman, 1989), one near Valleyview (herein referred to as the Valleyview channel) and, one near Crooked Creek (herein referred to as the Simonette channel). The complexity of the bedrock topography in the Winagami region is evident on Maps 3 and 4. These channels are believed to be pre-glacial in origin and may be as old as Tertiary in age (Churcher and Wilson, 1979; Edwards and Scafe, 1994).

The largest of the channels, the Shaftesbury, is located north of the Smoky River, and parallels the Peace River (Tokarsky, 1967). The channel thalweg is at an elevation of at least 350 m a.s.l., based on oil and gas well log data provided in Henderson's report (1959). The Peace River appears to have incised a secondary channel sub-parallel to, but to the same depth of the original Shaftesbury Channel (Map 3). Large tributaries, one of which appears to have been the Tangent Channel, fed into this system.

Channel sediments exposed at Watino belong to the Bezanson Channel (Map 3), originally defined by Carlson and Hackbarth (1974) in the Grande Prairie region, southeast of Watino. The depth and orientation of the channel and its tributaries should be viewed as speculative, due to the paucity of data. At Watino, the Smoky River has cut its channel deeper than the original Bezanson Channel. In this location, the channel thalweg lies at approximately 150 m depth (366 m a.s.l.), exposing shales of the Shaftesbury Formation.

The Tangent and High Prairie channels follow the same southeast to northwest trend and may have been a single channel or tributaries to the Bezanson Channel (Maps 3 and 4). The Tangent Channel is defined based solely on gas and oil wells drilled primarily in the 1950s (Henderson, 1959). Lack of a well-defined channel may imply that the Tangent Channel was a tributary to the Bezanson Channel. The course of the High Prairie Channel and its tributaries is speculative. Its extension southeast towards High Prairie has been verified by drilling and field studies conducted during the latter part of 1995 by the Prairie Farm Rehabilitation Administration (PFRA). The High Prairie Channel thalweg lies at approximately 400 m a.s.l. and is only about 125 m in depth (Maps 3 and 4). The base of the High Prairie Channel lies at a higher elevation than the current Bezanson Channel. Since the initial Bezanson Channel base was at an elevation higher than that seen at Watino, the base of the High Prairie channel may represent the Bezanson Channel's pre-glacial depth.

The fourth channel, east of Valleyview, is currently occupied by portions of the Little Smoky River (Map 4). The channel is relatively shallow with a maximum depth of about 75 m. The channel thalweg lies at approximately 530 m a.s.l. Water from the southern half of the Puskwaskau Hills (e.g. Sturgeon Lake region) appears to have drained into the Valleyview Channel in the past. The channel is extremely broad, containing at least two sets of terraces with numerous strand lines. Hydrologic flow is towards the northeast (Borneuf, 1980). The Valleyview Channel's confluence with the High Prairie Channel lies east of the study area.

The Simonette channel lies southwest of the Puskwaskau Hills near Crooked Creek. Infilled primarily by tills and overlain by glaciofluvial sands and gravels, the channel is defined solely through drill logs. The Simonette channel trends in a northwest - southeast direction.

Glacial modification of the channels likely occurred during the initial stages of ice advance as lobes preferentially followed the valleys. Possible effects include widening or infilling of the channel and abrasion of the channel sides. Post-glacial incision of the Peace, Smoky and Little Smoky rivers has modified the bedrock topography by partially incising the sediments infilling the paleochannels or cutting across them.

6.2 DRIFT THICKNESS

Paleochannels, and bedrock ridges and hills contribute to the variability of the drift thickness in the Winagami region (Maps 5 and 6). Information obtained from field work, and oil, gas and water well litho- and geophysical logs were used in conjunction with bedrock topography to construct the drift thickness maps. In regions where data coverage is sparse, the drift thickness is considered as approximate or speculative.

The Puskwaskau Hills, Valleyview, Birch Hills and the area just south of the Smoky River and Little Smoky River confluence, all contain 20 m or less of drift cover (Maps 5 and 6). Local exposures at the top of Birch Hills and near the northwestern edge of the Puskwaskau Hills indicate that bedrock is often within two metres of the surface.

Drift thickness increases away from the sides of the paleochannels, with the thickest portion in the thalwegs (Maps 5 and 6). All of the paleochannels described in the bedrock topography section are or were completely infilled by 80 to 200 m of sediments by the end of the last glaciation. The sediments infilling the Shaftesbury Channel are not well documented in the literature.

At Watino, the Bezanson Channel is currently infilled by fluvial and lacustrine sediments of non-glacial origin, overlain by glaciofluvial gravels and till. Paleocurrent direction appears to have been towards the northeast. Material deposited between the Shaftesbury Formation (92 Ma) and the base of the fluvial, non-glacial gravels (between 63 Ma and 50 ka of age) are missing, representing a minimum time gap of 29 Ma for which no data exist. Elsewhere, the channel is known, from drill holes, to contain two gravel or sand units separated by two diamicts (Borneuf, 1980). It is unknown whether the sand and gravel units are glacial in origin, since no samples of the material were available to the author. In addition, the origin of the overburden material between the sand and gravel units is unknown for similar reasons.

Sediments exposed along the Little Smoky River and information obtained from drill holes indicate that the High Prairie Channel is infilled primarily by glacial sediments, namely tills and glaciofluvial sands and gravels. Drilling by PFRA in 1995 intersected two thick diamict units, both of which appeared to be tills, separated by a thick sand and gravel unit (D. Toop, PFRA, *pers. comm.*, 1995). An additional sand and gravel unit, of unknown origin, was documented at the base of the channel. Samples of the sand and gravel units and the lower “till” were not obtainable by the author for analysis (D. Toop, PFRA, *pers. comm.*, 1995). It is possible that the sand and gravel unit at the base of the High Prairie Channel may be pre-glacial in origin.

The lack of samples from overburden units situated beneath the uppermost till unit is a problem. Exposures of these units are not available along river cuts due to massive slumping. In addition, the depth of these units requires drilling techniques that are not suited for uncontaminated sampling of unconsolidated material. However, the fact that several authors have consistently described multiple sand and gravel units separated by other overburden material in the paleochannels cannot be overlooked. If the lower unit is a till, it may represent an earlier ice advance than the Late Wisconsinan, during which deposited the upper till unit. If the lower unit was deposited by a pre-isotope stage 5 ice advance, the classic Mid- to Late Wisconsinan exposure at Watino may represent an episode of river incision that removed earlier sediments, rather than evidence of non-glaciation.

6.3 UNIT DESCRIPTION AND INTERPRETATION

Many of the units seen in stratigraphic sections have been previously described in the surficial and bedrock sections. Five major units, not including bedrock, have been described for use in stratigraphic sections: pre-glacial sediments (A); glaciofluvial sediments (B); till, supraglacial to basal in origin (C); glaciolacustrine sediments (D); and post-glacial or Recent sediments (E). Many of the units are stratigraphically correlative. Figure 6.1 shows a simplified composite section of the main units listed above. Units within the paleochannels that have been described in the literature, but not verified by the author, have been included on the cross-sections. Sand and gravel units of unknown origin are denoted as AB. In addition, the overburden unit overlying the lowermost sand and gravel unit is denoted as AC.

6.3.1 Unit A

The characteristics of unit A (Figure 6.1) are based primarily on exposures at Watino (Plate 6.1) and in the southwestern corner of the thesis area (Plate 6.2). Unit A comprises pre-glacial sediments of fluvial origin. Moderately sorted gravel (granule to boulder sized) and poor to moderately sorted fine to coarse sand (A-1), constitute the base of the unit and represent channel lag deposits. Laminated

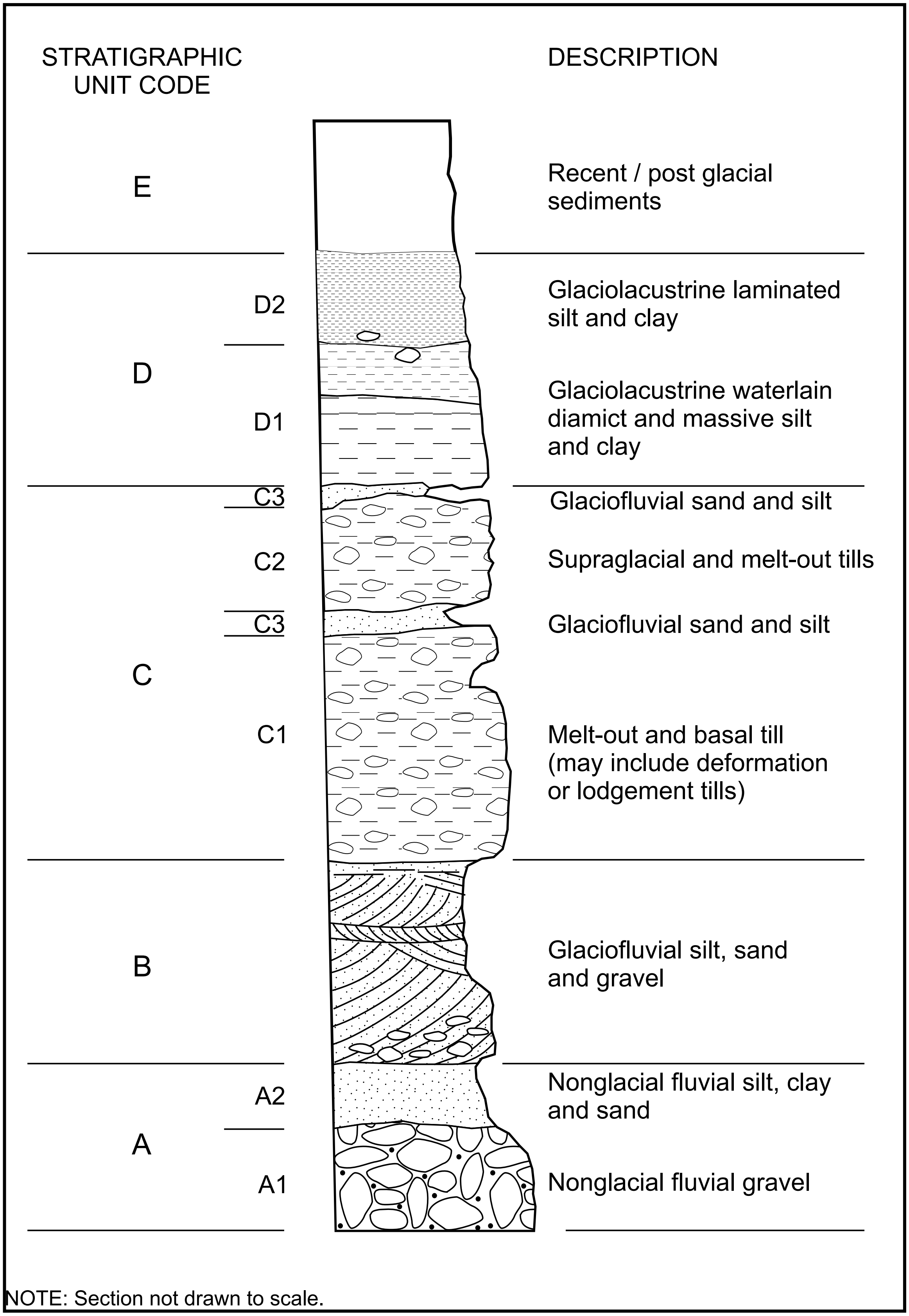


FIGURE 6.1 Composite stratigraphic section of study area.

sands, silts and clays represent floodplain sediments associated with a more mature fluvial system (A-2).

6.3.1.1 Sub-unit A-1

Sub-unit A-1 is composed of interbedded cobble gravel and coarse to medium sand (Figure 6.1). The gravel beds vary in thickness from 0.3 to 2.0 m and are separated by thinner, 0.1 to 0.9 m beds of sand. Contacts between the beds vary from erosional to gradational. Gravel beds are clast-supported with medium- to coarse-sand matrices. Sorting is moderate. Distinctive orange oxidation stains were observed in the gravel and sand of sub-unit A-1 (Plates 6.1 and 6.2). The clasts are sub- to well-rounded and highly weathered. Lithologies are dominantly Cordilleran in origin, consisting primarily of quartzites, sandstones and carbonates.

The gravels of sub-unit A-1 seem to be restricted primarily to paleochannels cut into the underlying bedrock. Information obtained from hydrogeological drilling projects (Borneuf, 1980; D. Toop, PFRA, *pers. comm.*, 1995) indicate that these gravels are present at the base of the Shaftesbury, Bezanson and High Prairie paleochannels. Sub-unit A-1 is also exposed in the southwestern corner of the Winagami sheet (33-70-26W4) as small (up to 3 m high), subglacially modified ridges that may be a remnant of the Simonette channel east of Crooked Creek, or its tributary.

Sub-unit A-1 is believed to have originated as channel fill in old river beds and as terrace deposits. Earlier work by Liverman *et al.* (1989) suggests that the deposit was from a braided river system and is correlated with their unit W-1. Wood detritus and pollen (*Picea* sp. and *Salix* sp.) are present in the gravels (Liverman *et al*., 1989). Large-scale, trough cross-bedding shows a weak paleocurrent direction towards 010° at the Watino section. Thickness is variable and not well documented. At the Watino section, thickness averages 15 m and abruptly overlies ironstone and shales of the Shaftesbury Formation. The upper contact varies from conformable to abrupt.

PLATE 6.1 - Sub-unit A-1 gravel in the Watino section.

PLATE 6.2 - Subglacially modified sub-unit A-1 gravel ridges..

The age of the sediments is questionable. Sediments at the Watino section have been interpreted as Tertiary, Sangamon or Mid-Wisconsinan in age, based on their stratigraphic position, fossil content and lack of glacially derived material. Carbon 14 dates from wood (Table 1.1) in the gravels range from 34,900 ± 3000 to greater than 40,170 yrs BP (Westgate *et al.*, 1971, 1972; Liverman *et al*., 1989). If these dates are correct, the Bezanson Channel had cut to its deepest point prior to or during the last glacial interstade (Mid-Wisconsinan). If sub-unit A-1 at Watino is chronologically correlative with the sand and gravel unit at the base of the High Prairie Channel, it would imply that the area was only glaciated during the late Wisconsinan. However, Churcher and Wilson (1979) suggested that the fossil fauna in the gravels in the region were more representative of the Sangamon. Others have interpreted the gravels to be Tertiary in age, although no incontrovertible evidence for this age was provided (Edwards and Scafe, 1994). The gravels at the base of the Shaftesbury Channel have been interpreted by others as Tertiary in age (Tokarsky, 1967).

6.3.1.2 Sub-unit A-2

The characteristics of sub-unit A-2 are also based on the Watino exposure in the Bezanson Channel (Map 3). Sub-unit A-2 contains finely laminated, very fine sand, silt and clay, with granule-rich lenses (Figure 6.1; Plate 6.3). Strata vary in thickness from 0.1 to 15 cm, with laminae as thin as 1 mm. The lower portion of the unit contains climbing A-type ripples that gradually become planar stratified towards the middle section. The upper section is more massive and contains large (up to 50 cm) dewatering structures. Overlying the sands is a unit approximately two metres thick comprised of planar-laminated, dark grey, silty clay, brown silt and grey-brown, silty sand. Laminae thickness varies from 1 to 190 mm. The sandier portions are cross-laminated to wavy, with climbing B-type ripples (Lindholm, 1987). At Watino, the lower contact with sub-unit A-1 seems abrupt and unconformable. However, Liverman *et al.* (1989) suggest that the contact is actually conformable.

The upper portions of sub-unit A-2 contain well-sorted, very fine sand with black laminae comprised of organic fragments and coal. The unit progresses upwards from A to B-type ripples, climbing A-ripples, sinuous wavy lamination and eventually to planar lamination. Above the ripples lies a massive to finely laminated, dark grey, silty clay. The laminae are commonly deformed, displaying distinct detachment surfaces with slickensides. Above the silty clay is another unit less than five metres thick, of moderately to well-sorted fine to medium sand. The sand is trough cross-bedded with gravel at the base, becoming horizontally laminated up-section and eventually massive at the top. There is no glacially-derived material in the unit.

The age of the lower portion of sub-unit A-2 is questionable. A lack of Canadian Shield material indicates that the unit is pre-glacial. Carbon 14 dates indicate an age ranging from 27 to >40 ka (Westgate *et al.*, 1972; Liverman *et al*., 1989). These dates link the sediments to the Watino Non-glacial Interval of Mid-Wisconsinan age.

The conformable nature of sub-unit A-2 supports continuous sedimentation. However, slumping in the Watino sections has distorted the true stratigraphic sequence of sediments present (Plate 6.4). Sedimentary features such as laminations and ripples support a fluvial origin for sub-unit A-2. Sediments in the lower portion were likely deposited as sand bars and floodplains. The sequence of rippled to planar lamination, and the presence of organics in the upper portions, suggests an environment of decreasing energy, such as a floodplain or oxbow lake. Sub-unit A-2 is correlative with units W-2, 3, 4, 5, 6 and 7 of Liverman *et al*. (1989). Current literature does not document any conclusive evidence of sub-unit A-2 in other paleochannels.

PLATE 6.3 - Mid-Wisconsinan fluvial sediments (sub-unit A-2) in the Watino section.

PLATE 6.4 - Convolution of units due to slumping in the Watino section.

6.3.2 Unit B

Unit B contains a mixture of sediments of glaciofluvial origin, including fine to coarse sand, gravel, diamict and massive to laminated silt and clay (Figure 6.1). Unit B is conformably overlain by unit C, except at Watino where it is overlain by colluvium. The lower contact of unit B at Watino is erosional.

Unit B is well exposed in the Bezanson channel at Watino (Plate 6.5). The glaciofluvial sands and gravels are stratified, displaying trough cross-bedding and ripples representative of braided river systems. The total thickness of unit B at Watino is 5.5 m. The gravels at the base of the unit are clast-supported and moderately to well sorted. Consisting of cobbles and pebbles, the gravels form the basal portions of the unit and are interstratified with beds of normally graded, coarse to medium sands. Contacts between strata are erosional. Unit B comprises material from the Canadian Shield (granites and gneisses) and the local bedrock (coal, shale, sandstone, etc.). Bedding structure and the presence of Canadian Shield-derived material suggest that unit B is representative of a southeasterly advancing Laurentide Ice meltwater deposit. The unit is correlative with unit W-8 described by Liverman *et al*. (1989).

Clays and silts occur in smaller pockets or depressions in areas further south, particularly in the Puskwaskau Hills region. Their existence is known mainly through drilling for geological, landfill and hydrological studies (Groundwater Protection Branch, 1994). The lithological composition of the silts and clays have not been determined and their correlation with advancing Laurentide Ice deposits is therefore tentatively based upon their stratigraphic position (i.e. below the basal till). Ponding due to damming of previous drainage systems by ice margins may have resulted in their deposition.

6.3.3 Unit C

Unit C, comprised of sediments deposited by the Laurentide Ice Sheet, is divided into three sub-units based upon composition and depositional environment (Figure 6.1). The dark grey, lower diamicton is classified as C-1 and is known primarily from drill core (Appendix 3). Brown-grey to brown supraglacial, melt-out and englacial melt-out tills (C-2) as described in chapters 4 and 5 (Table 4.1) and in Appendix 3, overly and grade into C-1. Large laminae and lenses of glaciofluvial sediments found within the melt-out and supraglacial tills are classified as C-3.

6.3.3.1 Sub-unit C-1

Sub-unit C-1 is a dark-grey, massive, very compact and laterally extensive silty-clay diamicton (Plate 6.6). The diamicton is massive, showing little variation in composition or appearance until just above the substrate. Pebble to granule sized clasts comprise approximately 8-12% of the unit. These clasts are generally sub-angular to angular, striated and fresh in appearance. Local bedrock (shales, sandstones, ironstone) and material from the northeast or Canadian Shield regions (granites, volcanics, pink-purple quartzites, carbonates, schists) form the bulk of the clasts. The percentage of local material within the diamicton increases substantially towards the substrate suggesting that the upper diamicton may be a melt-out till that grades into a basal till with increased depth. Framboidal and crystalline pyrite may be present, particularly in the northern half of the study area. Geochemically, the sub-unit is similar to the underlying bedrock within the basal portions, but changes rapidly with decreasing depth and increasing proximity to ground water horizons, and pedogenic processes.

The upper portions of the diamicton show characteristics similar to the englacial melt-out tills of C-2 without the effects of post-depositional modification. The sharp change in geochemistry and the increase in local material and compaction in the diamicton adjacent to the substrate suggest that, at least in some

PLATE 6.5 - Glaciofluvial sand and gravel at Watino (unit B)..

PLATE 6.6 - Dark grey till (sub-unit C-1) at base of borehole 94-SAB-15.

boreholes, the lowermost diamicton portions is basal in origin and may represent deformation till. Some of the boreholes contain a very compact “monolithic diamict” that grades from the melt-out till to the substrate. The matrix and the pebble-sized, rip-up clasts in the “monolithic diamict” are composed entirely of the underlying substrate and may represent deformation till (Table 4.1; Dreimanis, 1976; Lawson, 1981; Dreimanis and Lundqvist, 1984; Sugden and John, 1991).

Diamict in the englacial portions of the unit may contain lenses or laminae of silt, clay or fine to coarse sand indicating glaciofluvial activity during deposition. Lenses range from 6 to 32 cm thick. Based on stratigraphic position, this portion of the diamict is probably an englacial melt-out till. The lower contact varies from abrupt or sharp (e.g., 94-SAB-10), to gradational or deformational (e.g., 94-SAB-02) with the underlying bedrock. The upper contact may be gradational or sharp with C-2, C-3 or D, and is abrupt with alluvial sediments of Unit E.

Sub-unit C-1 was documented at the base of every borehole drilled during this study, indicating that it appears to be present throughout the western half of the Winagami map sheet. The unit thickness varies, ranging from less than 3 m near the Winagami-Peace River map boundary to well over 40 m in the paleochannels. All of the exposures of C-1 appear to be correlative, representing deposition from the most recent Late Wisconsinan ice advance of the Laurentide Ice Sheet in the region.

6.3.3.2 Sub-unit C-2

Sub-unit C-2 is a greyish-brown to brown, englacial to supraglacial till, as defined in chapters 4 and 5 (Table 4.1; Plate 6.7). Compositionally, the till varies from loamy to clayey-silty, but may locally contain higher proportions of clay, silt or sand. Sandier facies are common at higher elevations, particularly in the Puskwaskau region, where bedrock is near surface. The sub-unit varies from massive to stratified and may show convolution in the stratified portions. Pebble to granule sized clasts comprise approximately 15% of the unit and are weathered, soft, friable and sub- to well-rounded. Lithologically, the clasts contain local (shales, siltstones, sandstones) and Canadian Shield (granites, schists, gneisses, volcanics, carbonates) material. In the southwestern corner of the Winagami map area, sub-unit C-2 may contain Cordilleran type lithologies (carbonates, quartzites, cherts), particularly where pre-glacial gravels are near surface. Laminae and lenses of silt and sand are common. Large vertical, oxidised fractures can be found to depths of 22 m. The fractures are usually orange-brown to brown in colour and contain gypsum crystals with blades up to 4 cm in length.

Sub-unit C-2 conformably overlies the dark-grey till of sub-unit C-1 in most regions. The lower contact is usually gradational or inter-laminated to interbedded with 10 to 30 cm beds. The upper contact of sub-unit C-1 varies from gradational to abrupt, but is conformable with unit D (when present). Sub-unit C-2 varies in thickness from 1.5 m to over 16.5 m. Alteration by groundwater and pedogenic processes is visible in exposed sections. C-2 is attributed to the same ice depositional event as C-1.

6.3.3.3 Sub-unit C-3

Sub-unit C-3 contains glaciofluvial sand and gravel deposited primarily within the englacial portion of the till column of C-1 and C-2. However, meltwater beneath, within, atop and proximal to the ice all contributed to sub-unit C-3. The unit is generally thin (less than 2 m) and discontinuous in occurrence. Sub-unit C-3 may occur as lenses or distinct beds or laminae of variable thickness and extent (e.g., 93-SAB-03, 94-SAB-10, 94-SAB-04, 94-SAB-06, 94-SAB-11). This sub-unit lies stratigraphically between sub-units C-1 and C-2 in the Shaftesbury and High Prairie channels. Sub-unit C-3 may appear at the surface in the meltwater channels (units GFx and GFp on Maps 1 and 2).

6.3.4 Unit D

Unit D comprises sediments deposited in pro-glacial lakes situated proximal to the ice margin (Plate 6.8). The unit is divided into two sub-units (Figure 6.1): diamict (D-1); and, massive to laminated silts and clays (D-2).

6.3.4.1 Sub-unit D-1

Sub-unit D-1 comprises a laminated to massive, silty-clay diamict, greyish-brown in colour. Abundant granules of calcareous concretions and local dropstones comprise approximately 2-3% of the unit. The lower and upper contacts are abrupt to gradational with units C and E, respectively. Sub-unit D-1 is local in extent and found primarily northeast of the Little Smoky River in the Winagami map area. Thickness varies from approximately 1 to 4 m. This unit appears to have been deposited as ice-rafted debris or as debris flows from proximal Laurentide Ice.

6.3.4.2 Sub-unit D-2

Sub-unit D-2 contains massive to rhythmically laminated glaciolacustrine silts and clays (Plate 6.8). Laminae are 1 to 30 mm thick and may be convoluted. Dropstones (variable lithologies) and carbonate concretions comprise less than 1% of the unit. Thicker silt bands are commonly water-saturated. The lower contact is conformable, but abrupt with unit C and gradational with sub-unit D-1. The upper contact is conformable with the present soil horizons or is abrupt with the post-glacial alluvial and aeolian sediments of unit E. Sub-unit D-2 varies in thickness from 2 to 30 m.

Sub-unit D-1 is laterally extensive in the northern portions of the study area, particularly west and northwest of Fahler (Map 1 and 2). The unit is thickest south of the Peace and Smoky rivers and north of the Puskwaskau Hills region (Map 1). The sediments of sub-unit D-1 were deposited during the early stages of

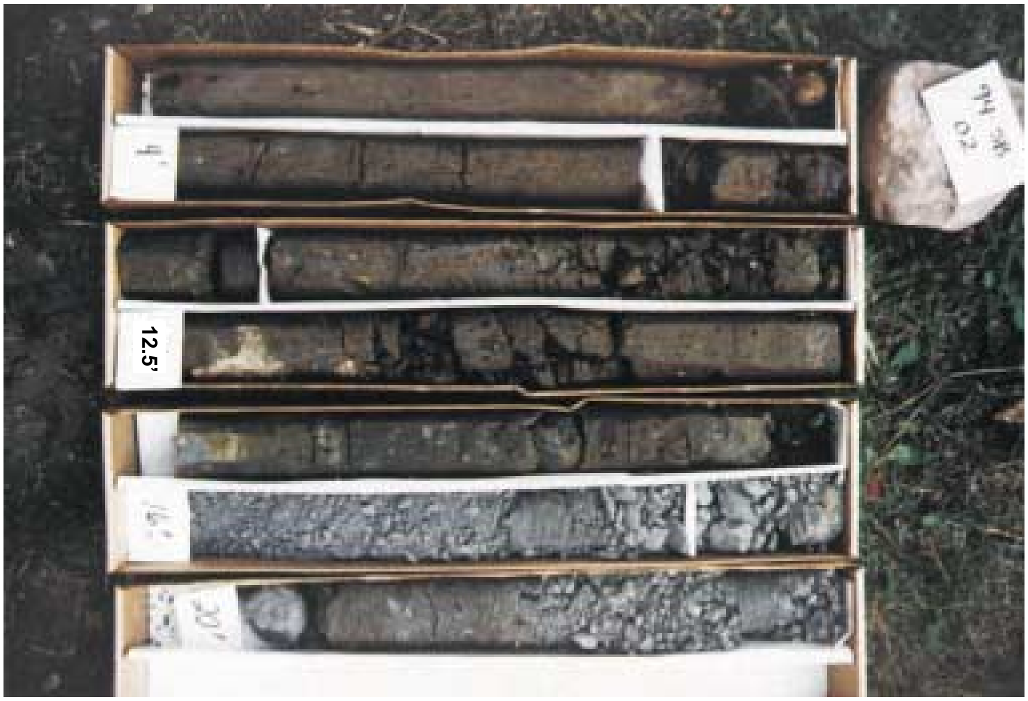


PLATE 6.7 - Oxidized supraglacial and meltout tills (sub-units C2 and C3) in borehole 94-SAB-02.

PLATE 6.8 - Laminated and massive glaciolacustrine sediments (unit D) overlying meltout till at the Peavine section.

Late Wisconsinan deglaciation as drainage systems in the region were dammed by the ice. Post-glacial modification of glaciolacustrine sediments around Watino produced the dune fields currently seen there (units AEd and AEh on Map 1).

6.3.5 Unit E

Unit E contains all sediments deposited post-glacially (Figure 6.1), including organic, alluvial, colluvial and aeolian deposits (units Op, Ap, At, Cv, AEd and AEh on Maps 1 and 2). The lower contact of these units is variable, ranging from abrupt and conformable (Op, AEd and AEh) to erosional (Ap, At and Cv). Unit E, with the exception of Op, AEd and AEh, is restricted to regions adjacent to present day rivers and creeks, forming floodplain, channel and slumped deposits associated with the incision of the rivers and creeks.

Organic deposits are not restricted to specific units, but rather result from topographic depressions and poor drainage. As a result, Op may overlie any unit. The aeolian sediments of Unit E conformably overlie Unit D, the source of the material of the dunes, in the west-central portion of the study area near Watino.

6.4 CROSS-SECTION CORRELATIONS

To better understand the regional stratigraphy of the Winagami area and its relationship to the Laurentide Ice Sheet during the Quaternary, three north to south cross-sections are presented (Figure 6.2). The cross-sections have been simplified to better show the changes in the major units from A to E, and the underlying bedrock topography. Bedrock topography and drift thickness for the cross-sections were obtained from maps 3 to 6.

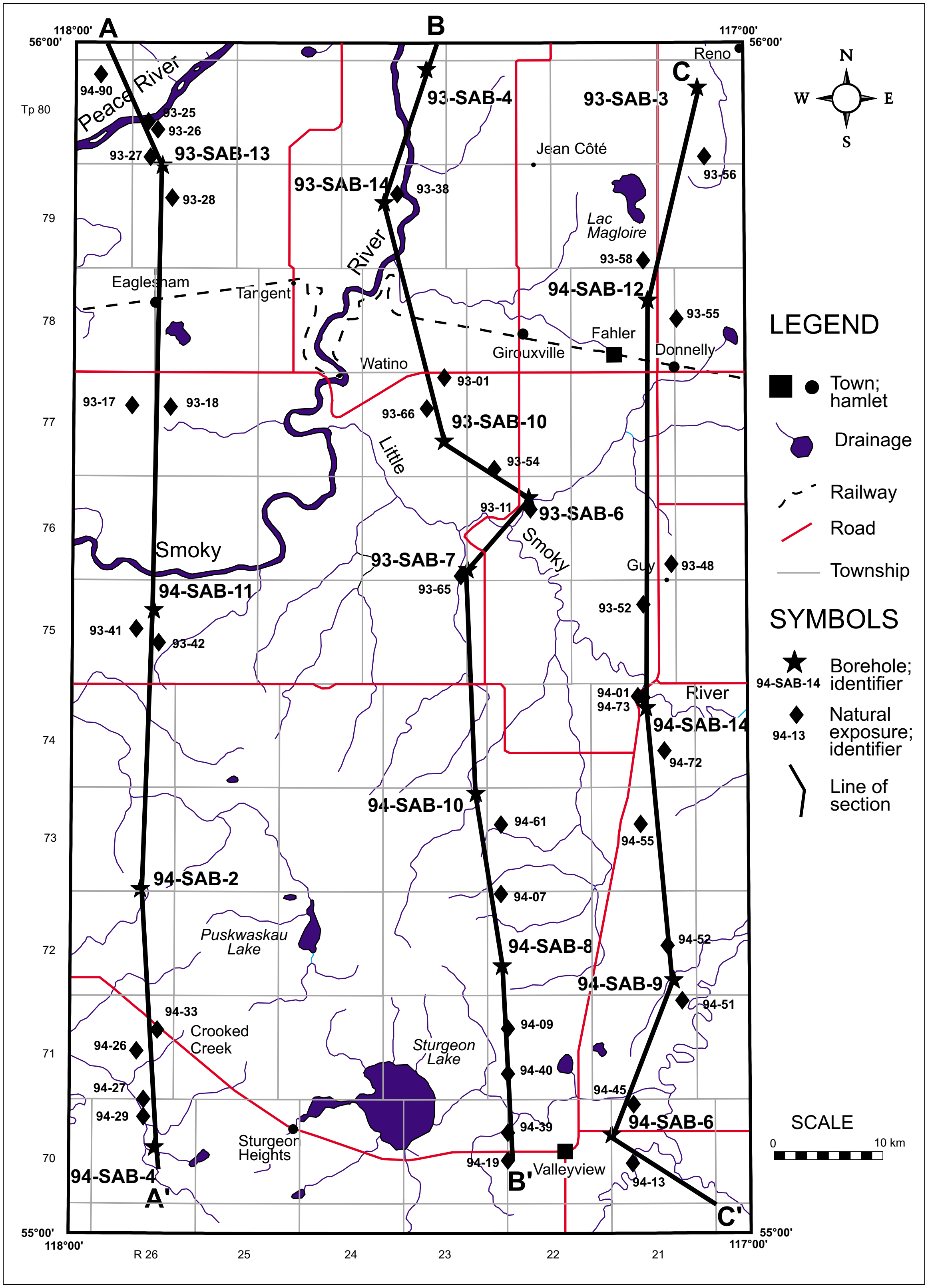


FIGURE 6.2 Location of Cross-sections.

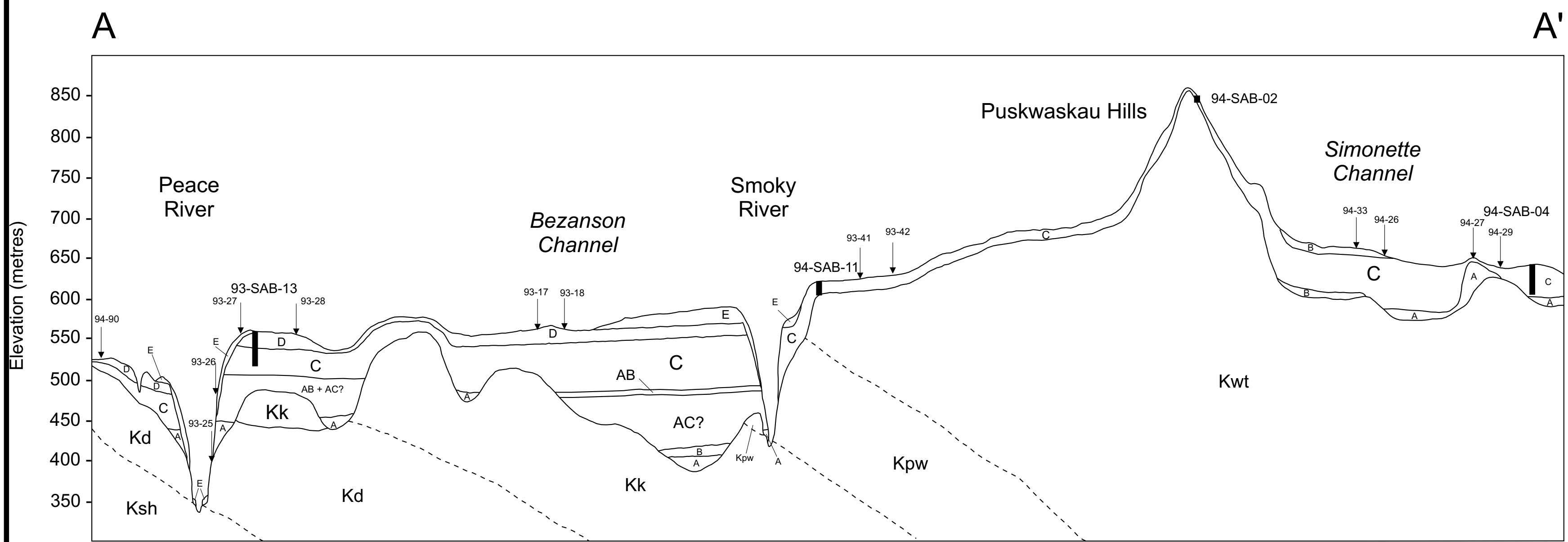
6.4.1 Cross-section A - A'

Cross-section A-A' extends along the western side of the Winagami map area, crossing over the Peace and Smoky rivers, and the westernmost ridge of the Puskwaskau Hills (Figures 6.2 and 6.3). Three paleochannels are represented in the cross-section: the Shaftesbury; Bezanson; and, the Simonette.

The Shaftesbury and Bezanson channels in the northern half of the cross-section are infilled by largely unknown sediment types. However, based on the Watino section and limited borehole information from drilling and hydrological reports, the channels likely contain unit A at the base. Several hundred metres of material of unknown origin (AB and/or AC) overlies the basal unit. The material within the "unknown" zone in the channels likely comprises several units of pre-Wisconsinan age.

The upper 45 m of the material in these channels comprises sub-unit C-1 at the base grading into sub-unit C-2, which contains interbeds of sub-unit C-3. Collectively unit C forms a thick blanket north of the Smoky River, thinning considerably along the northern flank of the Puskwaskau Hills. South of the Puskwaskau Hills, unit C thickens and infills the Simonette channel near Crooked Creek. This upper C-1 to C-3 collection of sub-units are representative of the most recent Late Wisconsinan ice advance of the Laurentide Ice Sheet.

North of the Smoky River, a thick sequence of glaciolacustrine sediments of unit D-2 overlies the tills of unit C. Thickness varies from about 3 to 17 m, with the thickest portion between the Peace and Smoky rivers. The glaciolacustrine sediments were deposited in pro-glacial lakes situated along the retreating ice margins of the Laurentide Ice Sheet. Unit E, comprising colluvial and alluvial deposits, flank the major river channels. Unit E also comprises sediments of aeolian and/or organic origin, both of which form blankets of variable extent and thickness. Aeolian sediments (mainly sand and silt) overlie glaciolacustrine sediments north of the Smoky River. Organic deposits are found wherever high water tables and depressions coincide.



LEGEND

Ksh = Shaftesbury Fm.
Kd = Dunvegan Fm.
Kk = Kaskapau Fm.
Kpw = Puskwaskau Fm.
Kwt = Wapiti Fm.

93-SAB-13 - Borehole; identifier (length indicates depth of borehole)
94-29 - Natural exposure; identifier
A - Preglacial fluvial sediments
B - Glaciofluvial sediments
C - Till and interstratified glaciofluvial sediments
D - Glaciolacustrine sediments
E - Aeolian, colluvial, alluvial and/or organic sediments

FIGURE 6.3 Cross-section A-A'.

6.4.2 Cross-section B - B'

Cross-section B-B' extends from northeast of the Smoky River (93-SAB-04), to the southeast of Sturgeon Lake (Figures 6.2 and 6.4). The cross-section cuts across the Smoky and Little Smoky rivers and the High Prairie Channel.

The oldest units along the cross-section are sub-unit A-1 gravels at the base of the High Prairie Channel (D. Toop, PFRA, *pers. comm.*, 1995) and sub-unit A-2 laminated silts and clays in shallow depressions in the Puskwaskau Hills (Groundwater Protection Branch, 1992). A combination of unit C with possible unit B overlies the pre-glacial fluvial sediments.

Unit C (sub-units C-1, C-2 and C-3 combined) forms a blanket varying in thickness from 3 m over bedrock in the Puskwaskau Hills to greater than 100 m within the High Prairie Channel. In the High Prairie Channel, two units of C, separated by unit B, overlies the basal gravels of unit A. The two till units may represent two glacial advances of Late Wisconsinan age. Alternatively, the lower unit C may represent an advance that predates the Late Wisconsinan. Unfortunately, samples of unit C and B were not available for detailed analysis. The thickness of unit C along the northeastern flank of the Puskwaskau Hills is highly variable, thinning to a veneer at the apex of the hills. Southeast of the hills, unit C thickens considerably, infilling the large depression west of Valleyview.

Glaciolacustrine sediments of unit D conformably overlie unit C, until just south of borehole 93-SAB-07 (Figure 6.4) where it abuts against a broad meltwater channel infilled with unit C-3 along the northeastern edge of the Puskwaskau Hills. The meltwater channel marks the southern edge of the pro-glacial lake that occupied the northern half of the study area. The thickness of unit D is variable, but is considerably thicker west of the Smoky River (Figures 6.2 and 6.3). North of the Smoky River, near boreholes 93-SAB-10 and 93-SAB-06, sub-unit D-2 grades vertically into the waterlain diamict of sub-unit D-1, and conformably overlies the uppermost till (C-2) of unit C. The localised nature of sub-unit D-1 suggests that the

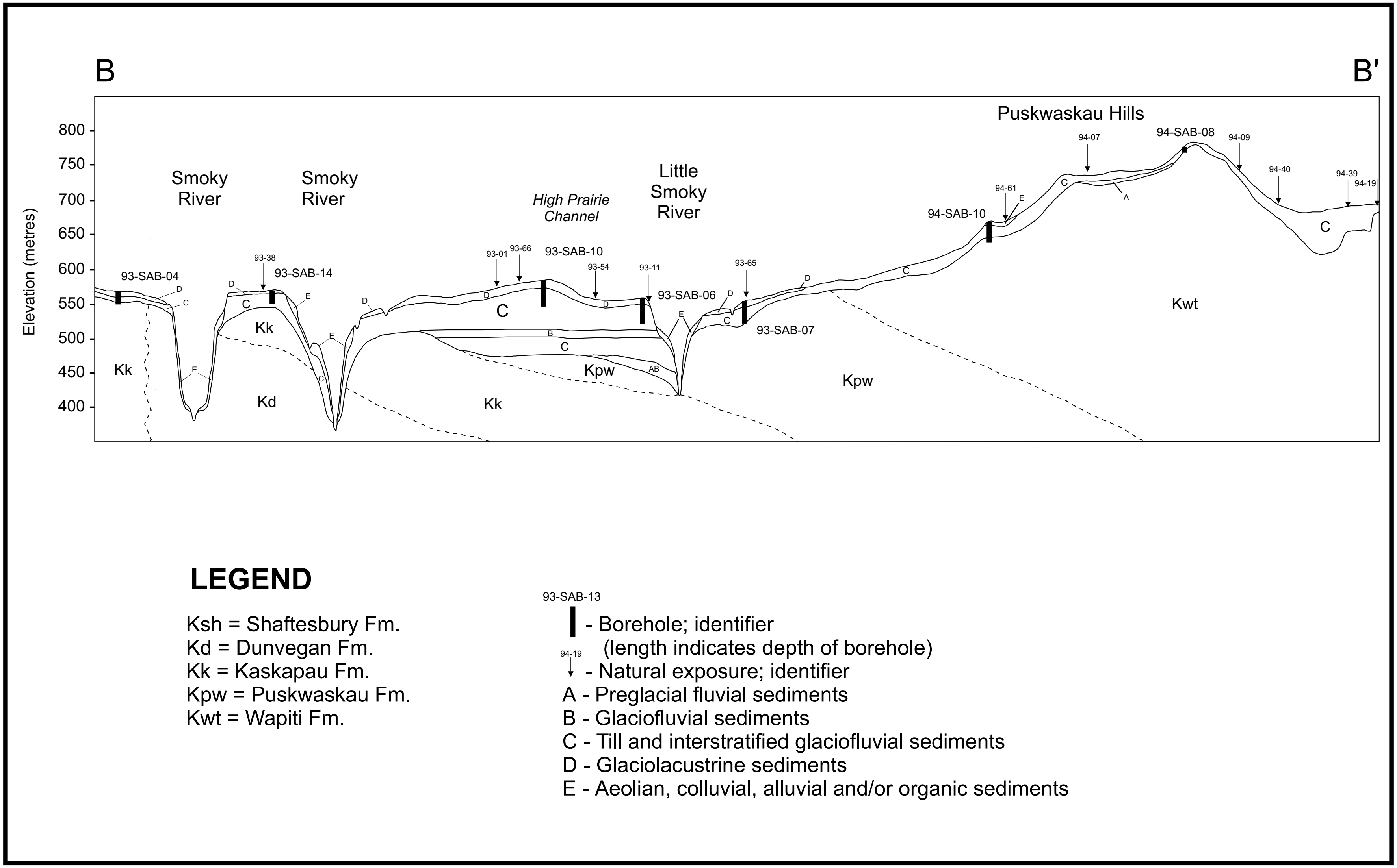


FIGURE 6.4 Cross-section B-B'.

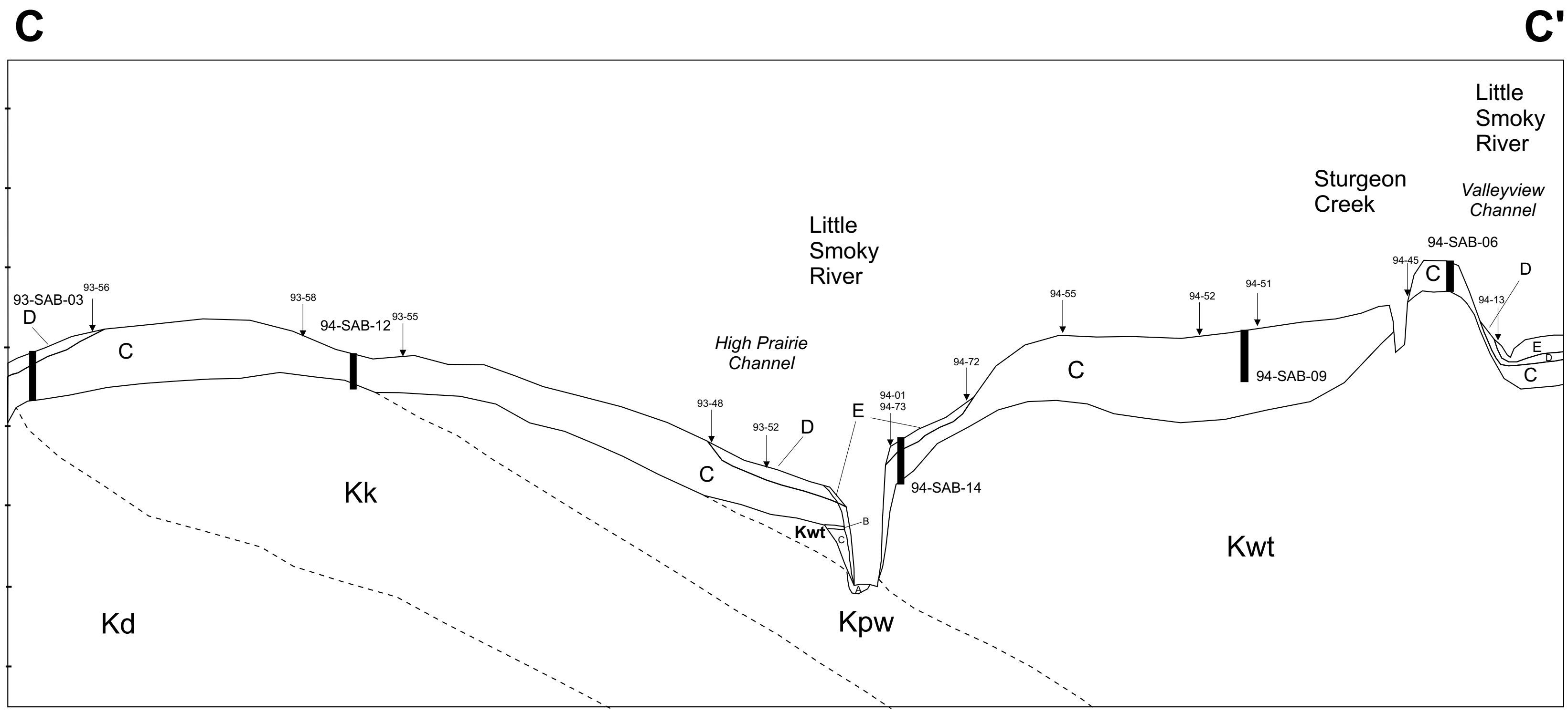
ice margin was stationary during the development of the proglacial lake in the region and was likely situated just southwest of Fahler.

Along cross-section B-B’, unit E comprises mainly alluvial deposits formed during incision of the Smoky River and smaller streams (e.g. borehole 94-SAB-10). The alluvial sediments comprise mainly fine sand and silt, with variable amounts of gravel and coarser sand from remnant floodplains and terraces. Sediments of colluvial and organic origin are also part of unit E along cross-section B-B’. As with cross-section A-A’, these sediments flank all rivers and streams and infill depressions.

6.4.3 Cross-section C - C'

Cross-section C-C' is the simplest, stratigraphically, of the cross-sections, extending along the eastern side of the Winagami map area, crossing over the Little Smoky River and ending southeast of Valleyview (Figures 6.2 and 6.5). In general, the thickness of the Quaternary sediments has remained relatively consistent compared to the other cross-sections. The underlying bedrock topography indicates the presence of two major channels, the High Prairie and the Valleyview. Both channels are believed to contain basal gravels (units A or B) overlain by tills (unit C). However, basal gravels in the Valleyview Channel have not been confirmed.

Along the C-C' cross-section, unit C forms the bulk of the Quaternary sediments in the region, often overlying the bedrock. Within the High Prairie Channel, two C units, divided by a unit B, have been confirmed by drilling by the PFRA along the northern flank of the current Little Smoky River (D. Toop, PFRA, *pers. comm.*, 1995). The southern flank of the Little Smoky River contains little evidence of the High Prairie Channel. The age of the lowermost unit C within the channel is unknown. The uppermost unit C in the channel was deposited by the Laurentide Ice Sheet during the Late Wisconsinan and is correlative with the uppermost unit C throughout the Winagami region. Unit C thickness varies from 21 m near borehole 94-SAB-14 to greater than 75 m within the paleochannels.



LEGEND

Ksh = Shaftesbury Fm.
Kd = Dunvegan Fm.
Kk = Kaskapau Fm.
Kpw = Puskwaskau Fm.
Kwt = Wapiti Fm.

93-SAB-13 - Borehole; identifier (length indicates depth of borehole)
94-13 - Natural exposure; identifier
A - Preglacial fluvial sediments
B - Glaciofluvial sediments
C - Till and interstratified glaciofluvial sediments
D - Glaciolacustrine sediments
E - Aeolian, colluvial, alluvial and/or organic sediments

FIGURE 6.5 Cross-section C-C'.

Unit D is found in localised regions, primarily around Reno (93-SB-03) and southeast of Valleyview (94-SAB-06). In both regions, unit D is quite thin, generally less than two metres. Near Valleyview, glaciolacustrine silts and clays show distinct rhythmic lamination and infill part of the local meltwater channel. This channel, originally a paleochannel and later a meltwater one, is currently occupied by the Little Smoky River, which is depositing alluvium (unit E) over the glaciofluvial and glaciolacustrine sediments in the channel (Figure 6.5). Strand lines and terraces along the western edge of the Little Smoky River represent the edge of a meltwater channel and pro-glacial lake that occupied this depression during the early stages of deglaciation.

Unit E also occurs in the Little Smoky River as floodplain and terrace deposits comprised of sands, silts and gravels. Thicker deposits of unit E (greater than two metres) are present on the southern flank of the Little Smoky River at borehole 94-SAB-14 (Figure 6.5). Comprised of sand and gravel, this part of unit E formed an old terrace or floodplain of the river during its initial incision. Colluvial sediments are also part of unit E along cross-section C-C’, flanking the northern portion of the Little Smoky River valley.

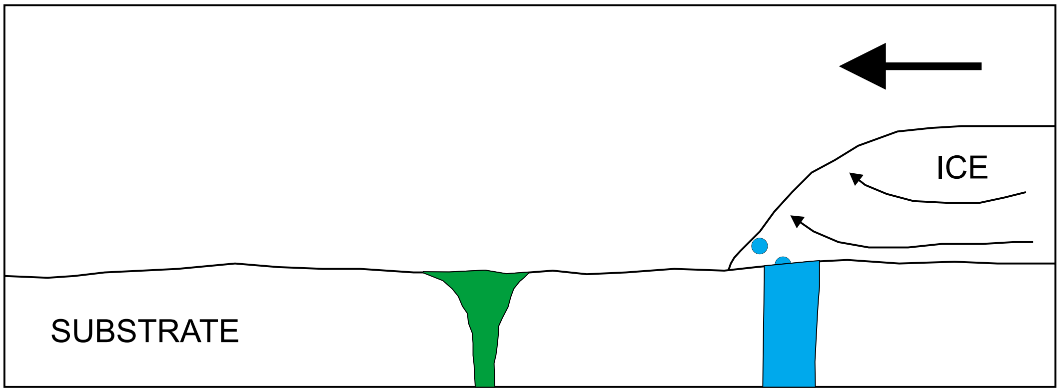
7.0 DISPERSAL PATTERNS

In glacial geology, dispersal patterns of granulometric parameters, lithology and geochemistry are used to determine the direction, mode and distance of glacial transport. Vertical variations in these patterns are useful in correlating or comparing similar units between boreholes and sections. Differences in dispersal patterns may be attributed to groundwater, proximity to bedrock, differing depositional environments within the ice, and soil forming processes. Areal variations within a specific unit are useful in determining the direction and distance of transport by either the ice or water.

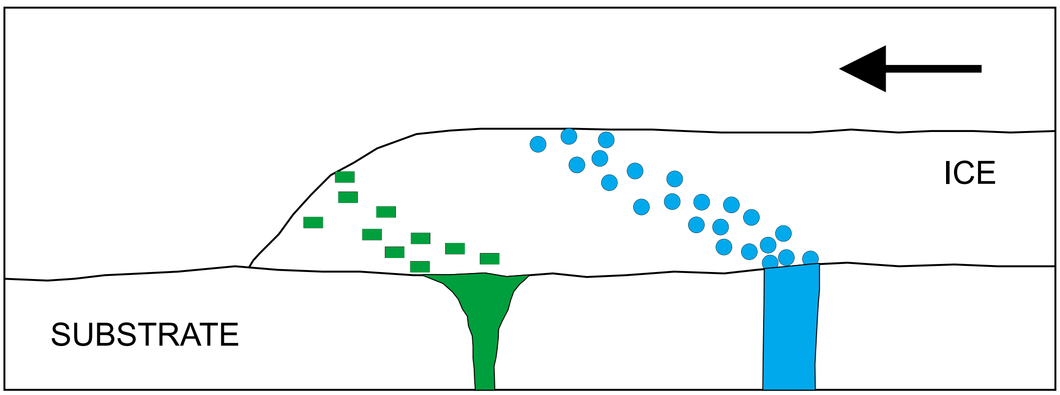
There are several basic principles vital to the interpretation of glacial dispersal patterns. First, when glacial ice overrides a particular unit (i.e., a kimberlite), it will incorporate material from that unit through one of two methods (Dreimanis and Vagners, 1971; Shilts, 1976; DiLabio, 1990; Sudgen and John, 1991; Klassen, 1997; McClenaghan *et al*., 1997). If warm-based, the ice will scour, scrape and erode the unit, incorporating the eroded material into the base of the ice. Alternatively, cold-based ice may freeze to the source and pluck off portions of the material into the base of the ice as it flows forward. In both cases, basal ice flow patterns are towards the snout and move upwards (Figure 7.1a). As the ice continues to flow over the source, material previously incorporated in the basal portions of the ice move upwards through the ice column (Figure 7.1b). When the ice eventually melts, the material from the furthest (distal) source will be stratigraphically higher in the sediment column (Figure 7.1c).

7.1 DISPERSAL PATTERN TYPES

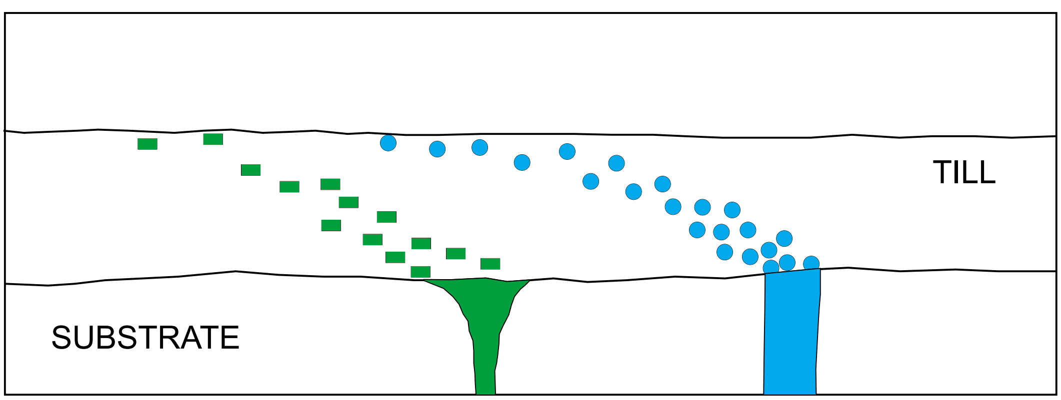
Dispersal patterns and their relevance to ice flow movement and exploration in Canada was originally described by W.W. Shilts (1976). According to him, well-defined dispersal trains are finger- or ribbon-shaped. Variations in their morphology



A. Ice flow pattern at the snout of active glacier.



B. Source material entrainment and dispersal within the ice.



C. Dispersal pattern of source material in the till after deposition.

FIGURE 7.1 - Entrainment and dispersal patterns of material from source points.

are attributed to changes in ice-flow direction, physiographic influences or multiple ice-flow events. Dispersal trains, classified according to shape and concentration (Table 7.1) could be used in conjunction with ice flow directions to define follow-up exploration programs designed to pinpoint potential targets.

Types 3A, B and C (Table 7.1) are well-defined dispersal patterns with nearby sources (Shilts, 1976). Anomalous values associated with the Type 3 patterns are usually considered high priority for exploration. Types 2A, B and C have indeterminate sources, and are considered moderate priority for exploration. Types 1A, B and C have the lowest priority for exploration. The latter types are poorly defined, small and difficult to interpret.

The three-type classification scheme works best for geochemical data although dispersal patterns based on clasts and granulometric parameters can also be used if there are distinct substrate units in the vicinity. However, dispersal patterns based on regional groups defined by lithology or granulometry cannot be properly classified according to Table 7.1. In addition, regional lithologic and granulometric groups may be diluted by multiple sources, forming dispersal patterns with multiple apparent ice-flow directions.

7.2 GRANULOMETRIC PATTERNS

Granulometric dispersal patterns are not well-defined in the Winagami area. Many of the samples are relatively homogenous in terms of their silt, clay and sand proportions. The high proportion of silt and clay in the matrix of the till samples is expected, since most of the subcropping bedrock in the northern half of the thesis area is comprised of shales and siltstones. Ice flow indicators in the region suggest a southerly to southwesterly flow direction. In addition, the siltstones and shales of the local bedrock are highly susceptible to disaggregation by glacial attrition due to their fissile and soft nature. Basic glacial ice flow principles indicate that sediments

TABLE 7.1

Dispersal Anomaly Classification*

CONCENTRATION	
1	Anomalies consisting of one or two adjacent samples with values just above the regional background.
2	Anomalies covering several square kilometres with values ranging from just above background to four times background.
3	Anomalies comprising one or two adjacent samples whose values are five or more times background.

AREAL SHAPE	
A	Amoeboid, irregular or isotropic.
B	Strongly elongated in the direction of glacial movement.
C	Strongly elongated in the direction of bedrock strike.

deposited in down-ice locations would consist mainly of grain sizes typical of the subsurface material found up-ice (Sudgen and John, 1991). As a result, till samples collected over the Wapiti Formation, which is primarily composed of sandstone, still contain higher proportions of silt and clay in their matrices than sand. An increase of sand in the till is usually only apparent within the lower few metres above the till – bedrock contact and immediately down-ice of the Wapiti Formation and Smoky Group subsurface bedrock contact.

The loamy texture and higher sand content in the matrices of surface and borehole core samples can be attributed to several other processes. Erosion of sedimentary, igneous and metamorphic clasts by glacial attrition will reduce the material to specific grain sizes, “terminal grade” (Dreimanis and Vagners, 1971). As an example, ice will reduce the quartz in rocks to sand and other minerals such as mica to silt or clay. Therefore, an abundance of clasts from lithological groups high in quartz content will invariably increase the sand-sized grain content of the samples. In addition, samples collected proximal to the underlying Wapiti Formation may have incorporated a significant amount of sandstone. A third possible process for increased sand content within sample matrices is pro- and post-glacial reworking by melting ice, precipitation, rivers and wind. Post-glacial reworking by water and wind will remove finer material (winnowing), leaving coarser grain-size fractions behind. This process is evidenced by cobble and pebble-rich lags situated on mounds and hills and by the accumulation of fines in depressions. However, post-glacial reworking is limited to samples collected above the water table, which, in this region, appears to be at a maximum depth of about 15 m. A fourth possible source of increased sand content in the samples is attributed to the disaggregation of gypsum crystals in the tills during sample preparation. Post-glacial weathering of the sediments resulting from soil formation, exposure to the elements and higher groundwater levels may permit the formation of gypsum crystals in oxidised fractures within the upper 15 m of the sediments. The preparation method of till and diamict samples for granulometric analyses requires that the samples be disaggregated to a suitable grain-size. Although care was taken not to pulverise larger clasts within the samples, it is difficult to avoid disaggregating the smaller crystals.

As expected, statistical analysis of the data indicates that the majority of the till and diamict samples collected from the area were poorly to very poorly sorted. In both the surface and core samples, the sorting measurements are typical of those found in tills elsewhere in Canada (Liverman, 1989; Balzer, 1992). Till samples with lower sorting values can be attributed to the incorporation of previously well-sorted material (e.g., fluvial sediments or bedrock) from the underlying substrate or to their proximity to glaciofluvial processes during deposition. For example, sorting within a till or diamict sample may increase if the sample was within the depositional range of englacial and supraglacial sediments, a range which often experiences glaciofluvial reworking. Glaciofluvial deposits in the form of silt, sand and gravel lenses, laminae, pockets, layers are common down to depths of 20 m within some sections and cores. Basal till samples collected proximal to the substrate generally contain high proportions of the material comprising the substrate. If the substrate is composed of well-sorted material, such as siltstone, sandstone, shale, clay, silt or sand, the basal till will also be better sorted. Basal till samples collected from borehole cores 94-SAB-11 and 94-SAB-15 are excellent examples of this type of sorting (Appendix 4).

7.3 LITHOLOGICAL DISPERSAL PATTERNS

Few of the lithological groups used in this study form distinct patterns or trends. However, the sample lithology does indicate where the surficial and stratigraphic units show the most variability or similarity between and within individual units.

Quartz, being a dominant mineral component of most rock types in the region, comprises the highest proportion of the lithological groups in matrices of the samples. Although abundant, quartz is not a good indicator for provenance in this area. The weathering and attrition of sedimentary, igneous and metamorphic clasts in the till produces elevated quartz values. Samples located near the dune fields, rivers and bedrock (Wapiti Formation) characteristically contain higher amounts of quartz than those located elsewhere.

Carbonates, primarily limestone and dolomite, have two potential provenances. The first source of carbonates is located up-ice of the Winagami area in the northeastern corner of the province in the Wood Buffalo National Park area. A second source of carbonates is from pre-glacial river gravels located in paleochannels and surficial deposits throughout northern Alberta. The original sources of these gravel deposits are from the Cordillera. Since carbonate material incorporated by glacial ice could have come from either source, carbonates are not useful for determining ice movement in this area. Samples collected with high percentages of carbonate in their matrices were diamicts, silts and clays, material likely deposited in pro- to post-glacial lake environments. These samples contain the second form of carbonates, precipitated flakes and concretions. Carbonates dissolve readily in cold water and were likely present in pro- and post-glacial lakes. As water levels in the lakes decreased by evaporation or drainage through meltwater channels, in conjunction with a warming climate, lake water temperatures increased resulting in carbonate precipitation.

Gypsum, in the form of selenite, is a post-secondary deposition resulting from weathering processes. Anhdyrite, the dehydrated version of gypsum, is present in the local bedrock of the region and in northeastern Alberta (Mossop and Shetsen, 1984). Glacial ice could have incorporated anhydrite in its sediments from anhydrite-rich substrates or rock fragments. Leaching and oxidisation of the upper few metres of the surficial units in the Winagami area by groundwater permitted the hydration of anhydrite and subsequent deposition of gypsum flakes, blades and rosettes in fractures.

Igneous and metamorphic rocks of the Canadian Shield are present in the northeastern corner of the province. Till samples collected from sections and borehole cores in the Winagami area contain high proportions of Canadian Shield-type lithologies. Considering the distance of the Winagami area from the bedrock source of these lithologies, the concentration of the lithological group should increase in samples deposited within the englacial to supraglacial zones. However, a slight increase in concentration is noted in the boreholes with increasing depth until immediately above the bedrock contact. This apparent increase may be a result of reduced aggregation of material during transport or, more likely, a function of terminal grade. Material that has travelled further within glacial ice will have undergone more disaggregation than material in the basal to lower englacial zones. As a result, rock fragments such as granite are more likely to have been reduced to quartz grains and the micas to silt or clay in samples collected from the upper portions of the cores and from sections. Therefore, the amount of igneous and metamorphic type clasts in the englacial to supraglacial zones will appear to be lower, while quartz values will be elevated.

Coal is found in the Wapiti Formation underlying the southern half of the thesis area. Due to its friable nature, coal will be quickly disaggregated by the ice. As a result, its presence in a sample collected from sections or borehole cores indicates proximity to the Wapiti Formation. This information can be used to estimate overburden thickness in regions where drilling was terminated prior to bedrock intersection.

Shale and siltstone is present in the local bedrock throughout the Winagami area. Easily disaggregated, these two lithological groups comprise only a small percentage of the clasts within the samples and rarely exceed 10 % of the granule to coarse sand fraction composition. Larger shale clasts have been noted in core within units near the bedrock interface (Appendix 3). The friable nature of the shale and siltstone resulted in some of the clasts being inadvertently crushed during sample preparation and by glacial attrition prior to deposition. As a result, till matrices were enriched in the silt and clay sized fraction instead of the granule to coarse sand sized fraction used in the lithological analysis.

Sulphides occur in exposures of the Shaftesbury Formation as yellowish oozes and as replacement minerals in fossils. In addition, the First and Second White Specks units of the Smoky Group, which underlies the northern half of the thesis area, are known to contain elevated sulphur levels and pyrite in the shales (M. Dufresne, *pers. comm*., 1998). Pyrite was likely already in a crystalline to framboidal state prior to its erosion and subsequent incorporation by glacial ice.

Ironstone occurs as concretions and ledges in the Wapiti Formation and as a ledge overlying the Shaftesbury Formation at Watino. Most of the samples containing ironstone clasts were collected from sediments underlain by the Wapiti Formation. Although ironstone is local in source, it is not present in all portions of the Wapiti Formation. Reduced concentrations of ironstone clasts in core samples collected from the lower half of the boreholes may be a result of dilution by the more prevalent siltstone, shale and sandstone units of the underlying substrate.

Quartzite and sandstone clasts are present in low proportions throughout the area. However, quartzite and sandstone content is higher in samples collected along river and stream cuts. Many of the gravel deposits associated with the rivers in the region contain abundant quartzite and sandstone pebbles, cobbles and boulders of pre-glacial, Cordilleran origin. Glacial ice overriding these deposits will have incorporated some of the material and deposited it in till proximal to its source.

The Athabasca Sandstone is found northeast of the Winagami area. Distinctive in colour (pink to purple), granules to coarse sand clasts from the Athabasca Sandstone are present in some till samples and have been visually noted as pebbles and cobbles in sections and borehole cores. The presence of pink to purple clasts is a good indicator of ice flow movement of the Laurentide Ice Sheet to the south and southwest during the Late Wisconsinan.

The remaining lithological group, volcanic rocks, appears to be of little use in determining provenance. Volcanic units are present in many bedrock formations of northern Alberta, British Columbia and the Northwest Territories. In addition, the grain size used in the lithological study is too small to properly identify the type of volcanic rock or its source.

7.4 GEOCHEMICAL DISPERSAL PATTERNS

Areal and vertical geochemical dispersal patterns are useful in determining provenance, ice flow directions and glacial behaviour. However, the usefulness of dispersal patterns depends greatly on the sampling methodology used. The majority of samples collected in the Winagami area are clustered along roads, rivers, streams, creeks, parks and villages/hamlets, resulting in wide gaps with no data coverage in less accessible regions. The clustering pattern and data gaps are a result of time and financial constraints that prevented a grid-sampling program and detailed sample analysis. The wide-spaced boreholes also prevented the correlation of dispersal patterns of units at depth. As a result, the areal dispersal patterns described in this study represent anomalous regions.

Till sample types, supraglacial, flow, melt-out, basal, lodgement and deformation, were described in earlier chapters and in Table 4.1. Flow and supraglacial tills contain high proportions of distally derived lithologies such as granites, quartzites, volcanics, and are generally more yellow, orange and brown in colour. These tills are generally loamy, blocky and friable. In addition, the clasts (all grain sizes) are weathered and fractures within the till commonly are oxidized and infilled by gypsum crystals. These tills typically comprise the upper few metres of the overburden above the water table.

Basal till, including lodgement and deformation, defined mainly on drill core samples, are dark grey to almost black in colour. Highly compact, these tills contain mainly clasts of the underlying bedrock or substrate. The clasts are typically very fresh in appearance. Weathering related to groundwater may be present in the form of an oxidized layer along the till – substrate interface. The lower contact with the substrate may be abrupt, gradational or deformational.

All other till samples were defined as melt-out (supraglacial, englacial or basal) or basal (indeterminate origin). Placement within the englacial category is also based on stratigraphic position of the sample within the depositional column.

7.4.1 Areal Dispersal Patterns

Most geochemical elements form ill-defined dispersal patterns (Type 1) in the supraglacial and flow tills, with values barely above background. On a regional scale, background concentrations of geochemical elements in the tills show similarities to the underlying bedrock type, particularly in the southern half of the area, where the Wapiti Formation is near surface. Background geochemical element concentrations in the northern half of the study area are more representative of shale belonging to the Shaftesbury Formation, which lies further north, than the shales of the underlying Smoky Group.

Samples north of Township 75 seem geochemically homogenous, with element concentrations at or below background (Appendix 7A). Due to the paucity of data between the samples, it is uncertain whether anomalous samples are part of regional trends or are isolated occurrences.

Anomalous and elevated concentrations of Rare Earths north of Township 75 are restricted to two samples, 93-SB-32 (near Peace River) and 93-SB-55 (near Donnelly), located 42 km apart (Appendices 6B and 7A). Sample 93-SB-32 also contains anomalous concentrations of Au and As. Anomalous and elevated concentrations of base metals in this region are random in their distribution. The majority of elevated to anomalous samples are located close to local drainage systems (Appendix 7A). It is possible that the elevated concentrations of base metals in these samples are due to post-glacial hydrological processes. One till sample, collected at 93-SB-38, contains coincidental base metal, Au and As anomalies. However, it too lies adjacent to a major drainage system, the Smoky River. This sample may have been reworked during post-glacial incision of the river, resulting in hydrologically induced enrichment of base and precious metals.

South of Township 76, the concentrations of geochemical elements in the till are often elevated or anomalous, but rarely show distinct trends or dispersal patterns. The abundance of samples containing elevated to anomalous concentrations seems related to the proximity of the samples to bedrock or to major drainage systems. There are five major localities where anomalous samples are clustered: (1) Crooked Creek, (2) Valleyview, (3) north to northeast of Sturgeon Lake, (4) northwestern edge of the Puskwaskau Hills, and (5) along the Little Smoky River (Appendix 7A). These regions do not define dispersal patterns useful for determining ice direction movement. However, they do indicate regions where detailed sampling may be employed to define actual dispersal trends.

There are four samples in the Crooked Creek area containing coincidental anomalies, namely 94-SB-21, 94-SB-23, 94-SB-26 and 94-SB-30. All of these samples display elevated base and precious metals, and Rare Earth concentrations in the till. The samples were collected from and down-ice of sites where the Wapiti Formation is near-surface. It is likely that these samples may be representing the composition of the underlying Wapiti Formation.

Anomalous samples around Valleyview are situated on and immediately west of the bedrock hill that flanks the town of Valleyview. As with the Crooked Creek area, the anomalous sample sites are proximal and likely related to bedrock of the Wapiti Formation. The high amounts of Na in samples south and southwest of Valleyview are related to the pedogenic processes that formed the Solonetzic soils in the region (Appendix 7A).

The anomalous sample areas north of Sturgeon Lake and along the northwestern edge of the Puskwaskau Hills contain thin overburden cover (Appendix 7A). Bedrock of the Wapiti Formation is locally exposed in these regions. Samples displaying coincidental anomalies of base and precious metals, Rare Earths and other geochemical elements are common, namely 93-SB-39, 93-SB-41, 93-SB-42, 93-SB-44, 94-SB-40 and 94-SB-91. In these two main regions, the anomalous concentrations are likely representing the Wapiti Formation. However, kimberlitic or related intrusives that may exist within the Puskwaskau Hills may have also influenced the geochemical signature of the tills.

Anomalous samples collected from sites along the Little Smoky River have two possible sources, both of which may have influenced the geochemical signatures of the tills. Although these anomalous sample sites are underlain by the

Wapiti Formation, they have also been subjected to post-glacial reworking by hydrological processes related to the incision of the Little Smoky River. As a result, any geochemical element that is mobile in oxidised fluvial environments (for example, Fe, Ni, Zn and U) may be concentrated in the surface till samples.

In conclusion, the majority of geochemical elements define anomalous regions characterised by a few coincidental anomalous samples. Anomalous concentrations seem to be related to the proximity of the local bedrock, in particular the Wapiti Formation, or to post-glacial hydrological and pedogenic processes. Unfortunately, the dispersal patterns do not provide much information on local or regional ice flow directions. In addition, these patterns do not characterise distinct units that could be used to determine till facies.

7.4.2 Vertical Dispersal Patterns

Vertical dispersal patterns cannot be discerned between laterally continuous stratigraphic units due to the distances between boreholes. However, vertical trends within individual boreholes show some similarities of certain units that may be useful in stratigraphic correlations.

In general, the greatest variability in the geochemical element concentrations of till occur within the upper 15 to 25 m of deep boreholes (Figure 4.1a; Appendix 7B). The water table in these regions is generally located up to 15 m in depth; however, it may be closer to the surface where overburden cover is thin. In addition, the upper portions of the boreholes contain supraglacial and melt-out tills that are commonly stratified with thin, water-saturated laminae of silt or sand. The till and diamict in this zone is often fractured and oxidised, containing gyspum crystals and weathered granules and pebbles. Many geochemical elements display sharp and distinct abundance spikes in the samples collected from the upper zone, particularly within the stratified units. These spikes are related to oxidised water reacting with the reduced environment in the till. Geochemical elements, such as Cr, Cs, Fe, Ni, Rb, Sc, U and Zn are consistently higher in concentration in the stratified till and diamict zones compared to the underlying more massive melt-out till.

Tills found below the water table display homogenous geochemical patterns that do not vary significantly until 0.5 to 3 m above the bedrock contact. In general, till does not start to mimic the geochemical signatures of the bedrock until the last 3 m above the contact (Figure 4.1b). The change of the geochemical signature of the till to that of the bedrock is almost indiscernible until 0.5 m above the contact, at which point the change is significant (Appendix 7B).

The homogeneity of the lower tills within and between the boreholes in terms of their geochemical composition suggests that the tills are likely correlative and laterally continuous. This implies that the tills were deposited by the latest advance of the Laurentide Ice Sheet during the Late Wisconsinan.

The rapid dilution of the geochemical signature of the bedrock into the till matrix is an important consideration in delineating dispersal trends and determining drift thickness. If the signature of the bedrock is known, samples of till taken at the base of boreholes that display a sudden change in till signature may be used to determine the proximity of the bedrock. In terms of geochemical dispersion, the rapid dilution of the bedrock into the till is problematic, particularly in thick till units. The bedrock in the Winagami area is composed of soft and friable shales, siltstones and sandstones, and is thus highly susceptible to glacial attrition. It is therefore not surprising, that till matrices in the area are homogenous and are comprised mainly of silts and clays. The rapid dilution of bedrock into the till matrix may be important to other dispersal techniques, including clast lithology and DIM studies that are dependent on the underlying bedrock type. If the dilution rate of the geochemical signature of bedrock into the till is representative of how quickly the ice incorporates material of the substrate, the presence of bedrock material in the till indicates the proximity of the substrate source. In the Winagami area, that would imply that the presence of substrate material in the lower englacial to basal till likely reflects a point source only a few hundred metres away.

7.5 DIM DISTRIBUTION PATTERNS

The distribution of DIMs in the Winagami area appears random due to the paucity of sample coverage. However, the presence of any DIMs in the area is significant. Kimberlites and associated intrusives are generally small, localised features. Kimberlites are rarely greater than 1 km in diameter. Considering how quickly material is incorporated into the base of glacial ice, moved upwards, diluted and deposited, DIMs found in the lower englacial to basal zones are likely within a few hundred metres or less of the point source. DIMs can display well-defined dispersal trends useful in determining provenance and ice flow patterns. Unfortunately, the distance between samples collected from within the Winagami area is too great to define valid dispersal trends. They are, however, useful in determining areas where more detailed sampling should be conducted.

Surface samples yielding DIMs were collected from both sand and gravel deposits and from supraglacial and melt-out tills. Sample 4212, was collected from pre-glacial fluvial gravels at Watino. This gravel unit lies within a major paleochannel. Since fluvial systems tend to concentrate heavy minerals in the coarser lag deposits, the DIMs present at this site likely came from a source further west in the paleochannel. Till samples with DIMs along the Little Smoky River (94-SAB-9 and 94-SB-14) lie proximal to a paleochannel. Ice moving southwards may have picked up DIMs from heavy mineral concentrated lags in pre-glacial or glaciofluvial deposits within this channel. If the DIMs came from the paleochannel, their point source is unknown.

Samples yielding DIMs proximal to the Puskwaskau Hills are likely related to the same volcanic episode that emplaced the Mountain Lake kimberlite. Surface samples 94-SB-76 and 94-SB-39, both of which yielded chromites, were collected proximal to creeks which drain the Puskwaskau Hills. Since the DIMs were retrieved from surface samples, the samples may have been contaminated by fluvial processes. Alternatively, the DIMs may have been incorporated into the till by topographically controlled glacial ice that eroded portions of the Wapiti Formation that forms the Puskwaskau Hills. The eclogitic garnet from a surface till sample collected at 94-SB-35, is likely from a distal source located to the north, up-ice, in the Puskwaskau Hills.

The englacial melt-out till sample of borehole 93-SAB-13 yielded two DIMs from an unknown point source. Overlain by glaciolacustrine sediments, borehole 93-SAB-13 is situated along the southern flank of in an infilled paleochannel, the Shaftesbury. Fluvial sediments from the paleochannel may be the source of the DIMs. Borehole 93-SAB-6, located at Peavine Creek, also lies within an infilled paleochannel, the High Prairie. Till samples from the borehole yielded five DIMs in the lower melt-out to basal till unit and only one DIM in the upper supraglacial till. The abundance of DIMs down core supports a nearby source; however, the position of the borehole within a paleochannel is problematic. Two sources of the DIMs are possible. Regional ice flow directions are to the southwest and south in this region. Thus it is possible that the Laurentide Ice Sheet eroded a kimberlite or associated intrusives north or northeast of Peavine Creek and deposited the material in the channel as it advanced southwards. Alternatively, ice streaming in the channel may have incorporated the DIMs from a source within the channel. Since the High Prairie channel joins the Bezanson channel near Watino, the DIMs in borehole 93-SAB-6 may have the same source as those found in the fluvial sands and gravels at Watino.

The borehole till sample collected northwest of Sturgeon Lake, 94-SAB-15, contained several kimberlitic and eclogitic garnets. Borehole 94-SAB-15 is situated along the southern axis of the Puskwaskau trench, a region likely underlain by faults related to the PRA, such as the Belloy Fault. Overburden thickness in the trench is less than 20 m and numerous small circular lakes exist along the trench axis. The amount of DIMs found in the basal portion of borehole 94-SAB-15, which happened to intersect bedrock, is significant. Dilution of lithological and geochemical components in till is rapid. The lower englacial to basal tills become homogeneous very quickly. As a result, the presence of DIMs in the basal till indicates that the source of the DIMs must be close by. If the source was distal, such as the Mountain Lake kimberlite, the number of DIMs in the till should have been significantly reduced. It would have been unlikely that any DIMs from such a distal source would have been detected in the upper englacial melt-out or supraglacial tills. Therefore, the source of the DIMs in borehole 94-SAB-15 likely came from within the Puskwaskau trench. If so, the ice during the Late Wisconsinan was topographically controlled by the Puskwaskau Hills during the earlier stages of glaciation and flowed towards the southeast within the trench.

Borehole PR95-3 was drilled in 1995 as part of a regional AGS study (Fenton *et al*., 1997). The borehole, drilled approximately 3.5 km southwest of the Mountain Lake kimberlite, yielded kimberlitic and eclogitic garnets in both the basal and the ablation tills. The Mountain Lake kimberlite may be the point source of the DIMs in the supraglacial/meltout till sample, indicating ice flow to the south and southwest. However, it may not be the point source of the DIMs in the basal till sample because of the distance between the borehole and the kimberlite. Kimberlites tend to occur in clusters or fields, as seen within the Lac de Gras, Fort à la Corne and the Buffalo Head Hills regions. It is possible that the DIMs in the basal till may have come from yet unknown kimberlites or related intrusives located up-ice of borehole PR95-3 within the trench.

The source of the DIMs found in boreholes 94-SAB-11 and 94-SAB-12 is uncertain, since it is unclear which borehole actually contained the DIMs. If they were from an englacial melt-out or basal till sample in borehole 94-SAB-11, the point source may be from within a paleochannel, the Bezanson, which lies just north of the borehole. Alternatively, if the DIMs came from the englacial melt-out or basal till sample in borehole 94-SAB-12, the point source may lie up-ice of Fahler, south or southeast of Lac Magloire.

8.0 QUATERNARY HISTORY

Although much of the Quaternary history and chronology of northern Alberta is still poorly understood due to a lack of surficial and stratigraphic information, great efforts are being taken by the mining industry and government agencies to update their databases. Information pertaining to bedrock topography and overburden thickness is generally regional in scale and limited to drilling associated with hydrological, oil, gas and mineral exploration and to rare stratigraphic sections. However, more detailed compilations by the AGS and several consulting firms are in progress as results from drilling programs are released to the public. Unfortunately, studies on chronostratigraphy of Quaternary aged sediments are still limited by the lack of datable material and suitable sections found to date.

8.1 GEOLOGICAL HISTORY

Prior to the Wisconsinan, the Winagami area was probably similar in topographic appearance to today. Numerous rivers and their tributaries drained the region, flowing eventually towards the northeast. The Bezanson, Shaftesbury, High Prairie and Valleyview channels were likely occupied during this time by the original Peace, Smoky and Little Smoky rivers, respectively. The Tangent channel may have also been occupied by a tributary to the original Smoky or Little Smoky rivers. Invariably these rivers deposited sediments as channel fill, bars, and floodplains (stratigraphic unit A). Based on the limited information available, these Tertiary rivers and their tributaries continued to incise the bedrock and deposit fluvial sediments throughout the Tertiary and well into the Quaternary prior to glaciation.

The onset of glaciation in the region is problematic. Well logs from several different sources, consistently mention the presence of two gravel/sand units separated by relatively impermeable sediments of possible glacial origin within the paleochannels. The exposure at Watino is an exception. Based on information for the Watino section, infilling and incision of the valleys by rivers continued until ca.

23 ka; the upper portion of the Watino Non-glacial Interval (Fenton, 1984). No evidence of prior glaciations has been documented in sections in the Watino area. In addition, preserved stratigraphic sections elsewhere along the Bezanson and other paleochannels are lacking due primarily to extensive slumping along current valley walls. However, the lack of prior glacial evidence in the Watino region should be viewed with caution, for several reasons. The area contains a major depositional hiatus ranging in age from the upper portions of the Shaftesbury Formation (95 Ma) to at least the start of the Tertiary (65 Ma). In addition, the oldest date (ca. 44 ka) is from Mid-Wisconsinan fluvial sediments (Westgate *et al.,* 1971; 1972). Dates from wood, indicate that the underlying non-glacial gravels below the known Mid-Wisconsinan fluvial sediments are older than 40 ka.

Three possible models of pre-glacial gravel deposition in the Watino section are presented. If, the gravels are conformable with the overlying fluvial sediments, as suggested by Liverman *et al.* (1989), and are thus Mid-Wisconsinan in age, there is a depositional hiatus or unconformity of up to 95 Ma duration. If the upper surface of the gravel unit is an unconformity, and is Tertiary in age, as suggested by Churcher and Wilson (1979) and Edwards and Scafe (1994), there is a gap of at least 1.63 Ma for which no data exists. The third possible model is that the gravels are Quaternary in age and were deposited in an interstadial or interglacial period prior to the Wisconsinan, such as the Sangamonian.

There are two major considerations to take in account when analysing the three depositional models. The first is uplift and tectonism associated with the formation and subsidence of the PRA during the Tertiary. Uplift and subsidence would have enhanced river incision and, subsequently, erosion of the sediments by fluvial processes. As a result, a significant amount of material was removed, including the Dunvegan Formation, creating the hiatus overlying the Shaftesbury Formation. The second consideration is the depth to which subsequent fluvial systems will incise a pre-existing channel that may or may not have originally been infilled. As an example, the present Smoky River has incised a channel that is deeper than the Bezanson Channel, exposing the underlying Shaftesbury

Formation. Incision by fluvial systems during the latter part of the Tertiary and up to the Mid-Wisconsinan may have removed sediments of both glacial and non-glacial origin.

Assuming that the basal gravels within the Watino section are conformable with the overlying fluvial sands and are Mid-Wisconsinan in age, there is a 95 Ma hiatus due to erosion and/or non-deposition (model one). The Dunvegan Formation is missing from this region, indicating that river incision combined with PRA uplift likely removed material of Upper Cretaceous to Tertiary age, from within the channel. If the Bezanson Channel has been occupied by several generations of rivers, deposits of later age, such as till deposited during the Early Wisconsinan, may have also been removed from selected portions of the channel. In such a case, the Watino section is anomalous and not representative of the stratigraphic sequence of the entire channel.

In the second model, the missing material between the Shaftesbury Formation and the Tertiary gravels may also be a result of erosion and river incision related to uplift of the PRA. The gravels were likely deposited by the river that originally incised the Bezanson Channel. Uplift associated with the PRA continued periodically into the Tertiary. These periodic bouts of uplift may have caused the river occupying the Bezanson Channel to incise and erode its own fluvial deposits, or cut a new channel, abandoning the old one. It is possible that earlier ice advances may have deposited sediments within the main Bezanson Channel. After deglaciation, isostatic rebound promoted river incision and some, or in the case of the Watino sections, all of the glacial material was removed. During the Mid-Wisconsinan, floodplain sediments from the latest river to occupy the channel were deposited above the exposed gravels.

The third model of pre-glacial deposition is a combination of both previous models. PRA associated uplift and subsequent river incision selectively removed sediments deposited within the Bezanson Channel of Tertiary and early Quaternary age. Sediments deposited during earlier glaciations in the channel may have been eroded by river incision during an interstadial or interglacial stage prior to the Mid-

Wisconsinan. Fluvial activity during this non-glacial episode may have deposited the gravels. As in model two, evidence of ice advance between this non-glacial episode and the Mid-Wisconsinan one in terms of sediments in the channel may have been removed by river incision caused by isostatic rebound. Floodplain sediments of Mid-Wisconsinan were likely deposited in a similar scenario as above.

The limited amount of geological data available from the Bezanson Channel can be used to argue any of the above three models of sedimentation and erosion. However, only the Mid-Wisconsinan and younger sediments represented in the Watino section can be related to the Quaternary sediments found throughout the Winagami study area with confidence. All other information in the Watino section and its stratigraphic relationship to other channels in the region is speculative.

During the Late Wisconsinan, the Laurentide Ice Sheet advanced from the north and northeast, covering the entire region from the Peace River area to Grande Prairie and south of the Winagami map area shortly after 22 ka (Fenton, 1984; Klassen, 1989). Glaciofluvial sediments and pro-glacial sediments were deposited in localised depressions and channels as pre-existing drainage of the area was obstructed by the advancing ice. Tongues of topographically directed ice along the margin of the advancing ice likely occupied, infilled and possibly broadened the pre-existing river channels. As the Laurentide Ice Sheet continued to advance, the thickness of the ice increased, eventually overriding the highest elevations (e.g., 825 m in the Puskwaskau Hills). Drumlins, flutes and ridges produced beneath the actively flowing ice support the strong ice-flow direction towards the south and southwest.

Possibly in the middle or near the end of the Late Wisconsinan, the Laurentide Ice Sheet thinned and weakened. Topography again controlled ice flow and the orientation of meltwater channels. West of the Winagami Map Sheet, a portion of the Laurentide Ice Sheet appears to have been diverted by some obstacle, perhaps Cordilleran ice. Alternatively, thinning Laurentide Ice may have formed localised ice tongues. Smaller topographically controlled ice lobes, situated at the margin of the Laurentide Ice Sheet, were diverted towards the southeast in the southwestern portion of the Winagami area as evidenced by flute and ridge orientation.

Several large pro-glacial lakes formed during the initial stages of deglaciation and infilled several of the broader meltwater channels. The largest of these lakes were Lake Fahler and Lake Valleyview (Henderson, 1959). Diamicts, resulting from debris flows and iceberg debris, were laid down in lakes proximal to the ice margin. The majority of these waterlain diamicts are restricted to the edges of Lake Fahler. Massive to rhythmically laminated silts and clays were subsequently deposited both over the waterlain diamicts and distally within Lake Fahler and Lake Valleyview. As deglaciation progressed, old drainage routes reopened and most of the pro-glacial lakes drained rapidly via large, broad meltwater channels. Lake Valleyview appears to have been ice-damned for a longer period of time than the other pro-glacial lakes in the region. Evidence of pro-glacial lake levels include multiple strand lines that parallel the western flank of the Little Smoky River near Valleyview (Plate 5.10).

Continuing deglaciation allowed the stabilisation of drainage patterns for the region. Pre-extant rivers incised new channels into the underlying glacial sediments. Occasionally, these rivers followed meltwater channels and linear pro-glacial lakes, such as the Little Smoky River near Valleyview, while others cut new channels sub-parallel to the pre-glacial river valleys. Conditions may have been arid enough during the latter stages of deglaciation to allow the formation of large-scale dune fields west of Watino. Later, aeolian processes, primarily deflation, reworked pre-existing glaciolacustrine material to form the dune fields and to modify the ice-contact stagnation deposits east of Watino in a similar fashion as seen in the Grande Prairie area (Halsey, 1989).

The date of complete deglaciation in the Winagami area is uncertain. Carbon 14 dating of organic muds and bones (Table 1.1), yielded dates up to 10,200±110 yrs. B.P. (Jackson and Pawson, 1984; Burns, 1986). Organic, colluvial, alluvial and aeolian sediments continue to be deposited in the region.

8.2 STYLE OF GLACIATION AND DEGLACIATION

During the Late Wisconsinan, the Laurentide Ice Sheet was subject to topographic control in the early and later stages of glaciation. Ice tongues at the advancing ice margin in the early stages of glaciation likely eroded and broadened the pre-existing paleochannels. As the main body of the Laurentide Ice Sheet advanced, these ice-filled channels were overridden. Ice thickness in the region increased, causing subsidence and enhancement of structural weaknesses within the underlying substrate. This weakening of the substrate likely increased its permeability making it susceptible to possible ice-thrusting (Kupsch, 1962; Moran *et al.*, 1980; Fenton, 1987; Andriashek and Fenton, 1989; Sugden and John, 1991).

The Laurentide Ice Sheet appears to have been primarily warm-based in the Winagami area as evidenced by streamlined features, including flutes, drumlins and ridges. Regelation and pressure melting at the base of the ice were the main method of debris entrainment within the ice as evidenced by the rapid dilution of substrate material within the lowermost portion of borehole cores. The friability and softness of the substrate promoted debris entrainment within the ice, enhancing dilution and homogeneity of the sediments within the till column. Eroded material was preferentially deposited in topographic lees, such as depressions on the southwest flanks of the Puskwaskau Hills ridges. These topographic lees correspond to areas of reduced pressure beneath the ice. Glacial material deposited on the northern and northeastern side (stoss) of major topographic features such as the Puskwaskau Hills, is thinner, more compact and comprises basal till, lodgement or deformational, at the bedrock interface (e.g., 94-SAB-08). Possible deformational tills at the base of several boreholes contain high proportions of the underlying substrate within their matrices and as rip-up clasts. These tills are extremely compact and almost monolithic in clast composition. In addition to the high proportion of rip-up clasts, the deformational tills often contain microfaults or shear planes.

Limited exposures of possible glacially thrusted bedrock in the study area suggest that the Laurentide Ice Sheet may have been locally cold-based. The majority of the thrusted bedrock documented near Birch Hills and section 94-SB-67 comprises sandstone with siltstone interbeds. Sandstone units in the study area are soft, friable and porous. Meltwater from warm-based thermal regimes beneath the ice easily saturates the sandstone units in the substrate. Subsequent freezing of the water within the substrate as the thermal regime cools enhances structural weaknesses making the substrate more susceptible to large-scale plucking by colder-based ice (freeze-thaw). Similar thrusting of porous bedrock has been observed in New Brunswick (Broster and Seaman, 1991; Balzer, 1992) and elsewhere in Alberta (Kupsch, 1962; Moran *et al.*, 1980; Fenton, 1987; Andriashek and Fenton, 1989).

During the later stages of glaciation, the ice thinned, becoming susceptible to topographic control again and likely formed localised ice tongues. Stagnant or inactive ice began to downwaste and ablate differentially, depositing till and various meltwater deposits. Broad northwest to southeast trending belts of hummocky moraine, including the "prairie doughnut" features, were deposited in the eastern portion of the study area and appear to mark ice margin positions.

Deglaciation appears to have been rapid, commencing ca. 14 ka (Mandryk, 1996). Typical deglaciation features associated with meltwater and ice margin standstills such as eskers, kames, and end moraines are scarce and isolated. This lack of deglaciation features seems typical of the northern portions of Alberta. It is possible that portions of the Laurentide Ice Sheet in the Winagami area thinned due to sublimation. Meltwater deposits occur primarily in the spillways and till reworked by meltwater is not prevalent elsewhere in the study area.

As deglaciation progressed, meltwater from the ablating ice infilled the topographically lower regions in the northeast during the peak of Late Wisconsinan glaciation. The ice margin still blocked the major drainage outlets, allowing glacial lakes Puskwaskau II and Valleyview II (also known as Fahler I) to expand in size between 13 and 12 ky BP (Henderson, 1959; St.-Onge, 1972). The formation of the lakes promoted thinning of the adjacent ice sheet causing calving of icebergs into the pro-glacial lake. Diamicts formed by sediment gravity flows from the adjacent ice sheet margin were deposited into the lakes. Dropstones were deposited in more distal regions of the lake as the icebergs melted. As the ice continued to retreat, old drainage routes were re-opened, isostatic rebound commenced and the depressions drained rapidly via the meltwater channels towards Lesser Slave Lake. According to Mandryk (1996), the pro-glacial lakes in the study area may have completely drained by ca. 11 ka.

Radiocarbon ^{14}C dates from basal peat indicate that peat development was locally established by 8 ka (L. Halsey, *pers. comm.,* 1995). Prevailing Westerlies coming from the Cordilleran region eroded the exposed glaciolacustrine deposits forming regional dune fields. Isostatic rebound promoted river incision and the development of the current drainage system in the study area. As the climate warmed, plant succession migrated northwards, stabilising the dune fields and covering most of the study area with the Boreal forest present today. Localised forest fires and more recently, horticulture has resulted in the removal of significant vegetative cover in some regions, allowing reactivation of the dune fields east of Watino. Agricultural and grazing practices have removed significant forest cover, resulting in increased surface runoff and slumping along the major river and stream valleys.

9.0 SIGNIFICANCE FOR MINERAL EXPLORATION

Quaternary geology and history is important to mineral exploration in Alberta. The paucity of information pertaining to bedrock topography, drift thickness and glacial ice flow patterns in many parts of Alberta affects the outcome of exploration programs. The objective of mineral exploration is to find specific types of deposits; for example, precious metals or diamondiferous kimberlites. In many cases, these deposits are small in terms of areal extent and often restricted to specific bedrock types or contacts.

Bedrock topography and drift thickness are related to each other, since one will determine the other. Bedrock topography determines whether the bedrock or substrate unit of interest is intact or has been removed by fluvial or glacial processes. Drift thickness determines whether exploration or exploitation of the bedrock or substrate unit of interest is economically viable or lies beneath too much overburden material.

In the study area, numerous paleochannels have been defined, many of which contain over 100 m of multiple glacial and fluvial units. Although the paleochannels are deep, only the Bezanson and Shaftesbury channels appear to have eroded or removed bedrock units of economic interest, such as the Shaftesbury Formation. In addition, both of these channels are infilled with more than 100 m of sediments, making them economically unfeasible exploration targets. Geophysical anomalies, particularly magnetic ones, located within these channels should be considered low priority for exploration regardless of their quality. In many cases, magnetic anomalies within infilled channels are often associated with heavy mineral deposits in fluvial sediments.

Diamond exploration in the Winagami area is hampered by the presence of infilled paleochannels. The distribution of diamond indicator minerals (DIMs) such as garnets (kimberlitic and eclogitic), chromites, chrome diopsides, ilmenites and picroilmenites in surface till or stream samples are used to determine the location of the point source of the material. However, if those samples are collected from within an infilled paleochannel, there are multiple potential sources of the DIMs. The original kimberlite or associated intrusives may have been eroded by fluvial or glacial processes. Rivers or streams may have eroded the point source (primary source) during incision or surface runoff and moved the material downstream. Glacial ice may have eroded and entrained the material from the actual point source or may have picked it up from a secondary source such as fluvial sediments or an earlier till unit. Multiple till units separated by fluvial (glacial or non-glacial) sediments are present or suspected in most of the paleochannels in the Winagami area. Since, the origin of the middle fluvial unit and the lower till (?) unit is generally unknown, the provenance of material contained in these units is also uncertain. Several of the boreholes and samples containing DIMs, including 4212, 93-SAB-06, 94-SAB-11 and 94-SAB-14, are located within and proximal to these infilled paleochannels. Although the DIMs were collected from the most recent till unit, with the exception of 4212, it is unknown whether the DIMs were from secondary or primary sources prior to glacial entrainment and deposition.

Dispersal analyses, using clast lithology and geochemistry of glacial sediments, have been used as an exploration tool in Europe (Kauranne, 1958, 1959) and Canada (Shilts, 1976, 1984; McConnell and Batterson, 1987; Coker and DiLabio, 1989; DiLabio, 1990; Klassen, 1997; McClenaghan *et al.,* 1997). The use of glacial dispersal patterns has been employed in Canada since the mid-1970s to determine the movement of the Laurentide Ice Sheet and its effect on dispersion (Shilts, 1976; 1984). Dispersal patterns produced by boulders (boulder tracing), pebbles (smaller version of boulder tracing) and sample matrices (geochemistry) have long been used by industry and government agencies to pinpoint deposits of economic concern. The importance of dispersal analyses in exploration programs for base and precious metals and, more recently, diamonds, should not be underestimated. In 1991, dispersal analysis using DIMs from the heavy mineral fraction of sand collected from till and frost boil sampling in the NWT led to the discovery of the Lac de Gras kimberlite field.

In the study area, dispersal patterns based on geochemistry, lithology, granulometry and DIMs are not well defined and are of limited use in determining ice flow direction. Unfortunately, the lack of well-defined dispersal patterns is likely a function of the regional sampling grid used. The size of the initial sampling grid influences the morphology of the dispersal patterns and anomalies. Shilts (1976) indicated that dispersal analyses using large sampling grids rarely gave accurate dispersal patterns. Lithological analysis of the sand to granule sized clasts in the till verifies ice flow movement from the north and northeast by the presence of certain rock types such as granites and gneisses from the Canadian Shield, pink to purple quartzites from the Athabasca area and pyrite from the Shaftesbury Formation.

Erosion and entrainment of the bedrock by the Laurentide Ice Sheet within and north of the study area was facilitated by the extremely soft and friable nature of the shales, siltstones and sandstones. Tills in the study area contain high proportions of silt and clay in their matrices regardless of their stratigraphic position within the till column. In addition, studies of the geochemical signature transition from the bedrock to the lower till indicates that homogeneity within the till column is acquired very quickly, within three metres at the most. Material from point sources will be entrained and diluted very rapidly within the till column. If the material has a terminal grade of silt to clay size, it is unlikely that it will be preserved in samples collected from within the ablation to englacial zones of the till column due to dilution. However, if material with low terminal grades are present in the till sample, the source must be nearby, likely within a few hundred metres at the most. In the case of DIMs, the minerals tend to have terminal grades in the sand size range. Therefore, the preservation potential of DIMs in the upper portions of the till column are increased considerably. However, the concentration of DIMs within an ablation or englacial till sample will be greatly reduced due to dilution. The higher the concentration of DIMs within a sample, the closer the point source must be. It is the freshness of the DIMs that actually indicates the proximity of the sample to its point source. The more abraded or frosted the DIMs are, the more distal the source, and vice versa. DIMs eroded from the primary source (e.g. kimberlite pipe) by glacial ice tend to be more angular and fresher in appearance.

The presence of any exotic material, such as a DIM, in a surface till sample is anomalous due to the scarcity and limited size of the point sources and the extremely low odds of discovery of the material at the surface. There are several samples with anomalous concentrations of geochemical elements and/or DIMs in the study area. In most cases, the anomalous samples were collected from till that is proximal to the underlying bedrock unit, particularly the Wapiti Formation. In addition, the majority of the anomalous samples are concentrated around the Puskwaskau Hills suggesting that the Wapiti Formation or, in the case of the DIMs, kimberlite pipes and associated intrusives may be the source material. Since the overall background geochemistry of the surface tills is similar to that of the Wapiti Formation, the source of most of the geochemical anomalies is likely a function of the proximity of the bedrock to the sample.

In the case of the DIMs, a more localised source is expected. Anomalous samples collected from borehole PR95-3 near Mountain Lake may be related to the Mountain Lake kimberlite or possibly a second, yet undocumented kimberlite within the Puskwaskau trench. At the southern end of the trench, borehole 94-SAB-15 contains multiple DIMs. In this area, the ice was topographically controlled during the early stages of glaciation, and moved down the trench towards the southeast. As a result, the DIMs within borehole 94-SAB-15 must have come from a proximal source up-ice within the Puskwaskau trench.

In general, exploration conducted in the Winagami area should be aware that the drift thickness, concentration of anomalous material and proximity of the source unit of interest are related. As till thickness increases, dilution of the source material increases rapidly up the stratigraphic till column. This results in a widening and dilution of the dispersal pattern of the source material at the surface where most sampling programs are conducted. Regional sampling programs may completely miss the dispersal pattern, particularly if the pattern is small. If an anomalous sample is collected during the regional program, detailed sampling should be conducted up-ice of the sample to better define the dispersal pattern. The stratigraphic sequence is straightforward in most regions of the study area and well-defined dispersal patterns could be used to find exploration targets. However, if the stratigraphic sequence contains multiple glacial and/or fluvial units, as is the case within many of the paleochannels in the Winagami area, the chance of back-tracking the dispersal pattern to its primary source decreases significantly. Anomalous samples and dispersal patterns found in the Winagami area should be analysed in conjunction with the underlying bedrock topography, drift thickness, hydrology and Quaternary geology to determine the best and most economical methods of regional or follow-up exploration.

10.0 CONCLUSIONS

The Quaternary geology of the Winagami study area is difficult to interpret due to the paucity of stratigraphic and geochronologic data. Surficial units within the area include sediments deposited during Late Wisconsinan glaciation and deglaciation, the majority of which have undergone post-depositional modification.

The surficial deposits in the Winagami area are primarily comprised of: loamy ablation and englacial till; glaciofluvial sand, silt and gravel; and glaciolacustrine silts, clays and diamicts, all deposited during the Late Wisconsinan glaciation and its subsequent deglaciation. Ablation and englacial till of variable thickness blankets the southern half of the study area, but is restricted to areas of higher elevation in the northern half. The lithological composition of the granules, pebbles and cobbles within the tills has a significant Canadian Shield provenance. Material of local provenance such as shale, siltstone, sandstone, coal, pyrite and ironstone, represent a small proportion of the larger clasts within the till, however, they form the bulk of the material comprising the till matrices. The till units have undergone post-glacial modification, as evidenced by oxidation stains along fractures, weathered granules and pebbles, and gypsum crystallisation. A thick blanket of glaciolacustrine sediments covers the northern half of the study area and infills the Valleyview Channel in the southeast. Glaciofluvial and reworked ice-contact material is restricted primarily to the broad, shallow meltwater channels. Localised deposits of post-glacial origin are present throughout the study area as fens, swamps, dunes, floodplains, river terraces, channel bars and slump blocks. Localised exposures of ice-thrusted bedrock indicate variable thermal regimes existing at the base of the Laurentide Ice Sheet.

The stratigraphy of the Winagami region is complex due to the irregularity of drift thickness and the underlying bedrock topography. In general, the Quaternary sediments vary from a veneer at the top of the Birch Hills to over 150 m in the paleochannels. A lack of good time-stratigraphic markers outside of the Watino section hinders correlation between units in the individual paleochannels.

At least five major paleochannels of probable Tertiary age exist within the study area. All of these channels are infilled by thick sequences of overburden comprised of glacial and non-glacial sediments of variable age. All of the channels appear to contain basal gravels of pre-glacial origin. The age of these gravels is debatable, and researchers have placed it as early as the Tertiary to as late as the Mid-Wisconsinan. Above the gravel lies a sequence of glacial and non-glacial sediments varying in age from possibly Late Tertiary to the present. Previous workers have used the Watino section as a type section in the absence of correlative units or good time-stratigraphic markers, which has lead to the current confusion surrounding the Quaternary history of the region. Data from the Watino section and the Little Smoky River provide two different stratigraphic sequences within the Bezanson and the High Prairie channels, respectively. The Watino section contains no evidence of glaciation prior to the Mid-Wisconsinan. Drilling along the Little Smoky River indicates that the High Prairie Channel contains two very thick till units separated by a glaciofluvial unit over a basal gravel. Unlike the Watino section, there are no dates available for the glaciofluvial or lower till unit, and therefore its stratigraphic relevance to the Watino section is uncertain. Reports from other researchers have indicated that the Shaftesbury and other parts of the Bezanson channels also contain a stratigraphic sequence similar to that within the High Prairie Channel. However, these reports do not indicate what type of material comprises the unit overlying the basal gravels. It is possible that this lower unit may represent an earlier Wisconsinan glacial advance. If this is the case, the Watino section may be an anomaly within the channel, and is not representative of the regional Quaternary geology. The uppermost till, glaciofluvial and glaciolacustrine units in the channels are chronostratigraphically correlative to units found elsewhere in the study area, deposited during the Late Wisconsinan glaciation and deglaciation.

Overall, the Quaternary geology of the region is consistent with at least one glaciation of Late Wisconsinan age. The main directions of glacial advance were to the south and southwest. Southeasterly ice flow directions, within and proximal to the Puskwaskau Hills and Birch Hills, indicate that the ice was topographically controlled. Flute, ridge and drumlinoid orientation, and ice-thrusted bedrock support both ice flow directions. The lack of strong cross-cutting and overlapping stratigraphic relationships between the two ice-flow patterns and their deposits, suggest that both flow patterns were related to the same advance of the Laurentide Ice Sheet. Topographically controlled ice was thinner and may have consisted of ice-streaming along the margin of the Laurentide Ice Sheet prior to the main ice advance, and during the early stages of deglaciation. The stronger, more direct ice flow pattern to the south and southwest indicates that the ice during the main Late Wisconsinan advance was thick enough to override topographic features.

Deglaciation may have commenced ca. 14 ka and progressed rapidly. Between 13 and 12 ky BP, meltwater produced by the ablating ice sheet infilled depressions exposed as the ice margin retreated. Drainage routes were still blocked during this period, resulting in the creation of large pro-glacial lakes that covered most of the northern half of the study area and the Valleyview Channel. Drainage routes were reopened as the ice margin retreated to the northeast, and the lakes drained rapidly through meltwater channels towards Lesser Slave Lake. Organic sediment deposition was well established by 8 ka, based on basal peat dates. Strong westerly winds eroded the exposed glaciolacustrine sediments, transporting a portion of them into a regional dune field near Watino. Isostatic rebound may have promoted river incision and slumping along the newly developing drainage systems. As the climate warmed, the periglacial environment gave way to Boreal forest, stabilising the dune fields.

Dispersal patterns within the till units do not produce well-defined trends, but rather individual anomalous sample sites and regions. The lack of distinct dispersal trends is attributed to the limited sampling grid and the number of samples analysed. Granulometric, lithological and geochemical analyses indicate that tills in the Winagami study area are compositionally homogenous. Geochemical dispersal patterns in surface samples display anomalies, often coincidental, that are restricted to five main areas; Crooked Creek, Valleyview, north to northeast of

Sturgeon Lake, the northwestern edge of the Puskwaskau Hills and along the Little Smoky River. These anomalies are attributed to two possible sources. Anomalous samples collected proximal to drainage systems, like the Little Smoky River are likely hydrological phenomena and should be viewed with caution. The majority of the remaining samples reflect regions where the Wapiti Formation is near surface, suggesting that the bedrock is the likely source of anomalous geochemical element concentrations.

The borehole core geochemistry indicates that the dilution rate of local material entrained by the ice is rapid, resulting in almost complete homogeneity within three metres of the till – bedrock contact. The majority of dilution occurs within the lowermost 0.5 m. The terminal grade of the entrained material determines the dilution rate of the material within the till matrices. Shale, siltstone and sandstone of local provenance were highly susceptible to disaggregation and entrainment by ice, due to their soft and friable nature. Since the terminal grade of the majority of the local bedrock is within the silt to clay range, the tills contain high proportions of silt and clay within their matrices. Minerals with higher terminal grades, such as DIMs, are preserved as sand grains or larger, albeit highly diluted, in the upper till column. Their higher terminal grade makes the DIMs useful for drift prospecting when analysed in conjunction with the local ice flow directions and stratigraphy.

Terminal grade is useful in determining glacial transport distances in the Winagami area. If a till unit contains high concentrations of material with a low terminal grade, in the form of sand-sized grains or larger, the source of the material is proximal to the sample. For example, coal pebbles in till at the base of a borehole indicate proximity to the underlying Wapiti Formation. Material with high terminal grades, such as DIMs, also indicate proximity to a source, if they are present in high concentrations and the grains appear fresher or less weathered. The rapid dilution rate of material within the till indicates that samples containing anomalous concentrations of distinctive rock types, DIMs or geochemical elements, are likely within a few kilometres of the source of the anomalous material. In the case of anomalous samples collected over the Wapiti Formation, where the till is thinner, the source may be within one kilometre. Samples collected from infilled channels cannot be connected to a primary source with certainty since the stratigraphy and history of the sediments infilling the channels are debatable.

In conclusion, the glacial history of the Winagami area is still enigmatic. Evidence of at least one glacial advance of the Laurentide Ice Sheet into the area during the Late Wisconsinan is widespread and undeniable. Unfortunately, the limited amount of data that may support earlier glacial advances is speculative. The key to the Quaternary history of the region prior to the Late Wisconsinan lies within the paleochannels. Future research must focus on the geochronology of channel stratigraphy to determine whether the Late Wisconsinan advance was the only glacial event to affect the region.

Dispersal patterns within the surface and borehole samples are of limited use in determining ice flow directions; however, they do provide information on the dynamics of debris entrainment and deposition within the till column. In addition, dispersal patterns associated with specific rock types of limited areal extent (e.g., DIMs from a kimberlite) are good indicators of provenance and transport distance within the ice. Dispersal patterns or trends can be a significant tool in exploration in the Winagami area, provided that they are analysed in conjunction with bedrock topography, drift thickness and glacial history.

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APPENDICES

APPENDIX 1

SECTION AND BOREHOLE LOCATIONS

Appendix 1 - Section and Borehole Locations

SECTION	NTS	DLS	Sec	Tp	R	W of	Datum	Zone	UTM (n)	UTM (e)	Elev (m)
93-SB-01	83 N/11	16	34	77	23	5	NAD27	U11	6175075	470675	556
93-SB-02	83 N/12	10	32	77	23	5	NAD27	U11	6174475	466800	564
93-SB-03	83 N/11	8	7	78	22	5	NAD27	U11	6177400	475550	564
93-SB-04	83 N/14	16	34	78	23	5	NAD27	U11	6184850	470750	556
93-SB-05	83 N/14	8	26	79	23	5	NAD27	U11	6192125	470450	549
93-SB-06	83 N/14	13	11	78	22	5	NAD27	U11	6178325	480575	572
93-SB-07	83 N/11	15	9	77	21	5	NAD27	U11	6168600	488025	579
93-SB-08	83 N/11	3	16	77	21	5	NAD27	U11	6168675	487500	579
93-SB-09	83 N/11	16	31	76	21	5	NAD27	U11	6165375	484950	587
93-SB-10	83 N/11	14	12	76	22	5	NAD27	U11	6158825	482475	556
93-SB-11A	83 N/11	12	27	76	22	5	NAD27	U11	6162975	478800	564
93-SB-11B	83 N/11	12	27	76	22	5	NAD27	U11	6162970	478800	564
93-SB-11C	83 N/11	12	27	76	22	5	NAD27	U11	6162960	478800	562
93-SB-11D	83 N/11	12	27	76	22	5	NAD27	U11	6162950	478800	561
93-SB-12	83 N/13	15	32	78	26	5	NAD27	U11	6185150	437800	549
93-SB-13	83 N/13	13	35	78	26	5	NAD27	U11	6185100	441800	564
93-SB-14	83 N/13	8	20	78	26	5	NAD27	U11	6180825	438250	567
93-SB-15	83 N/13	1	15	78	26	5	NAD27	U11	6178725	441325	567
93-SB-16	83 N/12	1	14	77	26	5	NAD27	U11	6169000	442950	579
93-SB-17	83 N/12	4	25	77	26	5	NAD27	U11	6172225	443375	573
93-SB-18	83 N/12	4	29	77	25	5	NAD27	U11	6172150	446400	572
93-SB-19	83 N/12	14	31	77	24	5	NAD27	U11	6175225	455225	564
93-SB-20	83 N/12	4	2	78	25	5	NAD27	U11	6175375	451275	572
93-SB-21	83 N/13	16	17	78	25	5	NAD27	U11	6180000	447975	565
93-SB-22	83 N/13	2	30	78	24	5	NAD27	U11	6181775	455625	564
93-SB-23	83 N/13	13	33	78	24	5	NAD27	U11	6184575	457850	549
93-SB-24	83 N/13	1	1	79	25	5	NAD27	U11	6185075	452175	564
93-SB-25	83 N/13	8	18	80	25	5	NAD27	U11	6198625	444250	396
93-SB-26	83 N/13	1	18	80	25	5	NAD27	U11	6198375	444375	445
93-SB-27	83 N/13	5	5	80	25	5	NAD27	U11	6195425	444450	564
93-SB-28	83 N/13	2	29	79	25	5	NAD27	U11	6191650	445400	564
93-SB-29	83 N/13	16	22	79	25	5	NAD27	U11	6191525	448950	564
93-SB-30	83 N/13	15	12	80	25	5	NAD27	U11	6197950	451925	564
93-SB-31	83 N/13	8	19	80	24	5	NAD27	U11	6200225	454225	564
93-SB-32	83 N/13	1	28	80	24	5	NAD27	U11	6201250	457425	578
93-SB-33	83 N/13	1	15	79	24	5	NAD27	U11	6188325	458725	552
93-SB-34	83 N/13	9	1	79	24	5	NAD27	U11	6185825	462225	556
93-SB-35	83 N/13	16	13	79	24	5	NAD27	U11	6189525	462275	567
93-SB-36	83 N/13	15	20	80	23	5	NAD27	U11	6201050	465200	572
93-SB-37	83 N/13	10	22	79	23	5	NAD27	U11	6190800	468425	465
93-SB-38	83 N/13	2	28	79	23	5	NAD27	U11	6191475	466625	549
93-SB-39	83 N/5	5	3	75	26	5	NAD27	U11	6146800	439500	640
93-SB-40	83 N/5	15	8	75	26	5	NAD27	U11	6149575	437300	622
93-SB-41	83 N/12	8	23	75	26	5	NAD27	U11	6151600	442775	619
93-SB-42	83 N/5	4	18	75	25	5	NAD27	U11	6149850	444475	632
93-SB-43	83 N/5	14	34	74	25	5	NAD27	U11	6146175	451800	658
93-SB-44	83 N/5	15	35	74	25	5	NAD27	U11	6146100	454025	655
93-SB-45	83 N/12	12	29	75	23	5	NAD27	U11	6153400	465700	573
93-SB-46	83 N/11	9	16	77	20	5	NAD27	U11	6169700	498300	614
93-SB-47	83 N/11	4	30	76	20	5	NAD27	U11	6162150	493575	620
93-SB-48	83 N/11	8	1	76	21	5	NAD27	U11	6156400	493375	597
93-SB-49	83 N/11	1	4	76	20	5	NAD27	U11	6155675	498075	646
93-SB-50	83 N/11	1	29	75	20	5	NAD27	U11	6152425	496375	608
93-SB-51	83 N/11	13	19	75	20	5	NAD27	U11	6152300	493725	588
93-SB-52	83 N/11	12	27	75	21	5	NAD27	U11	6153225	488550	565
93-SB-53	83 N/11	8	36	75	22	5	NAD27	U11	6154550	483300	518
93-SB-54	83 N/11	2	5	77	22	5	NAD27	U11	6165475	476525	558
93-SB-55	83 N/14	12	19	78	20	5	NAD27	U11	6180700	493525	611
93-SB-56	83 N/14	3	4	80	20	5	NAD27	U11	6194550	495650	620
93-SB-57	83 N/14	4	27	79	21	5	NAD27	U11	6191400	486900	602
93-SB-58	83 N/14	1	2	79	21	5	NAD27	U11	6184825	489675	602
93-SB-59	83 N/14	1	13	80	23	5	NAD27	U11	6197875	471800	567
93-SB-60	83 N/11	16	15	75	23	5	NAD27	U11	6150575	470500	575
93-SB-61	83 N/11	13	23	75	23	5	NAD27	U11	6152350	470600	570
93-SB-62	83 N/11	14	23	75	22	5	NAD27	U11	6152325	481100	549
93-SB-63	83 N/11	1	27	75	22	5	NAD27	U11	6152475	480325	565
93-SB-64	83 N/11	13	27	75	22	5	NAD27	U11	6153750	478725	564
93-SB-65A	83 N/11	2	1	76	23	5	NAD27	U11	6155675	473150	564
93-SB-65B	83 N/11	2	1	76	23	5	NAD27	U11	6155750	473150	556
93-SB-65C	83 N/11	3	1	76	23	5	NAD27	U11	6155700	473025	541
93-SB-65D	83 N/11	14	36	75	23	5	NAD27	U11	6155600	472975	526
93-SB-65E1	83 N/11	3	1	76	23	5	NAD27	U11	6156000	472875	511
93-SB-65E2	83 N/11	3	1	76	23	5	NAD27	U11	6156000	472875	503
93-SB-66	83 N/11	4	27	77	23	5	NAD27	U11	6172300	469100	564

Appendix 1 - Section and Borehole Locations

SECTION	NTS	DLS	Sec	Tp	R	W of	Datum	Zone	UTM (n)	UTM (e)	Elev (m)
93-SB-67A	83 N/12	11	34	77	24	5	NAD27	U11	6174500	460075	411
93-SB-67B	83 N/12	11	34	77	24	5	NAD27	U11	6174500	460075	389
93-SB-67C	83 N/12	11	34	77	24	5	NAD27	U11	6174450	459950	419
93-SB-67D	83 N/12	11	34	77	24	5	NAD27	U11	6174450	459975	419
93-SB-67E	83 N/12	6	34	77	24	5	NAD27	U11	6174225	459850	381
93-SB-67F	83 N/12	5	34	77	24	5	NAD27	U11	6174375	459750	396
93-SB-67G	83 N/12	5	34	77	24	5	NAD27	U11	6174375	459775	396
93-SB-67H	83 N/12	5	34	77	24	5	NAD27	U11	6174380	459775	407
93-SB-68	83 N/12	10	34	77	24	5	NAD27	U11	6174800	460325	434
93-SB-69A	83 N/12	6	21	77	24	5	NAD27	U11	6170900	458275	427
93-SB-69B	83 N/12	7	21	77	24	5	NAD27	U11	6171050	458575	419
93-SB-70	83 N/12	16	34	77	24	5	NAD27	U11	6175125	460650	396
93-SB-71	83 N/11	13	20	76	22	5	NAD27	U11	6161775	475600	427
93-SB-72	83 N/11	16	19	76	22	5	NAD27	U11	6161975	475475	419
94-SB-01	83 N/6	10	33	74	21	5	NAD27	U11	6145300	489475	533
94-SB-02	83 N/4	11	3	71	24	5	NAD27	U11	6108225	461475	683
94-SB-03	83 N/4	16	10	71	24	5	NAD27	U11	6110475	462050	715
94-SB-04	83 N/4	7	6	71	24	5	NAD27	U11	6108050	456925	719
94-SB-05	83 N/4	13	20	70	24	5	NAD27	U11	6104050	459500	715
94-SB-06	83 N/6	5	33	72	22	5	NAD27	U11	6125650	478875	707
94-SB-07	83 N/6	2	6	73	22	5	NAD27	U11	6126675	476500	735
94-SB-08	83 N/3	12	16	72	22	5	NAD27	U11	6121150	478875	727
94-SB-09	83 N/3	5	29	71	22	5	NAD27	U11	6114150	477175	735
94-SB-10	83 N/3	14	20	71	21	5	NAD27	U11	6113550	487650	671
94-SB-11	83 N/12	7	21	77	24	5	NAD27	U11	6171050	458575	419
94-SB-12	83 N/12	11	34	77	24	5	NAD27	U11	6174450	459975	393
94-SB-13	83 N/3	1	18	70	21	5	NAD27	U11	6100825	488350	632
94-SB-14	83 N/3	4	18	70	21	5	NAD27	U11	6100725	487375	643
94-SB-15	83 N/3	4	16	70	22	5	NAD27	U11	6100875	480575	693
94-SB-16	83 N/3	12	4	70	22	5	NAD27	U11	6098575	480600	735
94-SB-17	83 K/14	1	26	69	22	5	NAD27	U11	6094225	485050	632
94-SB-18	83 N/3	8	34	69	22	5	NAD27	U11	6096475	483700	677
94-SB-19	83 N/3	9	13	70	23	5	NAD27	U11	6101750	477225	707
94-SB-20	83 N/4	13	33	71	26	5	NAD27	U11	6116825	439875	648
94-SB-21	83 N/4	4	28	71	26	5	NAD27	U11	6114300	439625	649
94-SB-22	83 N/4	1	21	71	26	5	NAD27	U11	6112425	440800	643
94-SB-23	83 N/5	9	29	72	26	5	NAD27	U11	6124525	439675	686
94-SB-24	83 N/5	9	25	72	1	6	NAD27	U11	6124700	436500	664
94-SB-25	83 N/4	3	1	72	26	5	NAD27	U11	6117250	444900	686
94-SB-26	83 N/4	1	22	71	26	5	NAD27	U11	6112500	442800	648
94-SB-27	83 N/4	4	2	71	26	5	NAD27	U11	6107550	443050	640
94-SB-28	83 N/4	1	10	70	26	5	NAD27	U11	6099750	444700	674
94-SB-29	83 N/4	1	33	70	26	5	NAD27	U11	6106275	442925	625
94-SB-30	83 N/4	16	4	70	26	5	NAD27	U11	6099250	443975	678
94-SB-31	83 N/4	9	27	69	26	5	NAD27	U11	6095650	444650	683
94-SB-32	83 N/4	9	13	70	26	5	NAD27	U11	6102100	448000	686
94-SB-33	83 N/4	1	26	71	26	5	NAD27	U11	6114100	444400	664
94-SB-34	83 N/4	16	7	71	25	5	NAD27	U11	6110700	447325	674
94-SB-35	83 N/4	4	32	70	25	5	NAD27	U11	6105875	449875	707
94-SB-36	83 N/4	4	27	70	25	5	NAD27	U11	6104550	452975	733
94-SB-37	83 N/4	14	34	70	25	5	NAD27	U11	6107350	453600	735
94-SB-38	83 N/4	13	36	69	25	5	NAD27	U11	6097450	456150	732
94-SB-39	83 N/3	4	30	70	22	5	NAD27	U11	6104275	477325	677
94-SB-40	83 N/3	8	7	71	22	5	NAD27	U11	6109575	477025	680
94-SB-41	83 N/3	1	13	71	23	5	NAD27	U11	6110500	475050	693
94-SB-42	83 N/3	15	24	71	22	5	NAD27	U11	6113550	484550	677
94-SB-43	83 N/3	4	14	70	22	5	NAD27	U11	6100725	483825	732
94-SB-44	83 N/3	8	22	70	22	5	NAD27	U11	6102975	483725	719
94-SB-45	83 N/3	13	32	70	21	5	NAD27	U11	6106825	488700	680
94-SB-46	83 N/3	4	27	70	21	5	NAD27	U11	6103925	491925	640
94-SB-47	83 N/3	5	31	70	20	5	NAD27	U11	6106250	496875	668
94-SB-48	83 N/3	12	8	71	20	5	NAD27	U11	6109700	496800	675
94-SB-49	83 N/3	12	22	71	20	5	NAD27	U11	6112850	500000	703
94-SB-50	83 N/6	10	21	72	20	5	NAD27	U11	6122600	499575	614
94-SB-51	83 N/3	16	35	71	21	5	NAD27	U11	6116450	493450	645
94-SB-52	83 N/3	9	15	72	21	5	NAD27	U11	6121200	491800	655
94-SB-53	83 N/3	14	8	72	20	5	NAD27	U11	6120000	497450	610
94-SB-54	83 N/6	8	36	72	21	5	NAD27	U11	6125525	494750	642
94-SB-55	83 N/6	14	21	73	21	5	NAD27	U11	6133025	489200	652
94-SB-56	83 N/6	12	25	72	22	5	NAD27	U11	6124325	483750	652
94-SB-57	83 N/6	12	2	73	22	5	NAD27	U11	6127650	482400	649
94-SB-58	83 N/6	2	17	73	22	5	NAD27	U11	6129875	478100	701
94-SB-59	83 N/6	1	16	73	22	5	NAD27	U11	6130225	480450	652
94-SB-60	83 N/6	3	27	73	23	5	NAD27	U11	6133125	471350	710

Appendix 1 - Section and Borehole Locations

SECTION	NTS	DLS	Sec	Tp	R	W of	Datum	Zone	UTM (n)	UTM (e)	Elev (m)
94-SB-61	83 N/6	1	30	73	22	5	NAD27	U11	6133100	477100	658
94-SB-62	83 N/3	1	2	72	22	5	NAD27	U11	6116850	483450	681
94-SB-63	83 N/3	2	15	72	22	5	NAD27	U11	6120125	481350	698
94-SB-64	83 N/6	2	25	73	22	5	NAD27	U11	6133075	484650	643
94-SB-65	83 N/7	4	15	73	20	5	NAD27	U11	6129850	500200	613
94-SB-66	83 N/6	13	32	73	20	5	NAD27	U11	6136225	497100	610
94-SB-67	83 N/6	3	29	73	20	5	NAD27	U11	6133075	497225	631
94-SB-68	83 N/6	9	8	74	20	5	NAD27	U11	6138850	498350	591
94-SB-69	83 N/6	12	20	74	20	5	NAD27	U11	6142175	496800	579
94-SB-70	83 N/6	4	25	74	21	5	NAD27	U11	6142875	493750	564
94-SB-71	83 N/6	13	19	74	20	5	NAD27	U11	6142450	495200	579
94-SB-72	83 N/6	8	15	74	21	5	NAD27	U11	6140125	491850	599
94-SB-73	83 N/6	7	33	74	21	5	NAD27	U11	6144850	489550	518
94-SB-74	83 N/6	16	24	74	22	5	NAD27	U11	6142675	485025	590
94-SB-75	83 N/6	4	13	74	22	5	NAD27	U11	6139700	484050	594
94-SB-76	83 N/6	8	19	74	22	5	NAD27	U11	6141875	477100	579
94-SB-77	83 N/3	2	1	70	23	5	NAD27	U11	6097500	476625	739
94-SB-78	83 N/3	13	34	69	23	5	NAD27	U11	6097450	472600	719
94-SB-79	83 N/5	4	9	73	26	5	NAD27	U11	6128675	439800	792
94-SB-80	83 N/5	12	17	74	26	5	NAD27	U11	6140825	438300	648
94-SB-81	83 N/12	1	35	77	24	5	NAD27	U11	6174000	462525	465
94-SB-82	83 N/6	12	4	75	21	5	NAD27	U11	6146975	487225	480
94-SB-83	83 M/9	5	36	75	2	6	NAD27	U11	6155200	425900	587
94-SB-84	83 M/9	2	2	76	2	6	NAD27	U11	6156450	424850	434
94-SB-85	83 M/8	7	26	74	1	6	NAD27	U11	6143825	434550	579
94-SB-86	83 M/1	12	9	72	2	6	NAD27	U11	6120100	420125	533
94-SB-87	83 M/1	2	18	72	2	6	NAD27	U11	6121225	417700	610
94-SB-88	83 M/8	8	20	72	2	6	NAD27	U11	6123150	420025	465
94-SB-89	83 N/12	1	2	78	24	5	NAD27	U11	6175475	462525	450
94-SB-90	83 N/13	13	26	80	26	5	NAD27	U11	6202650	439800	564
94-SB-91	83 N/4	8	6	72	23	5	NAD27	U11	6117650	467225	811
95-SB-01	83 N/4	5	22	70	26	5	NAD27	U11	6103250	443200	648
95-SB-02	83 N/4	16	4	70	26	5	NAD27	U11	6099250	443975	678
95-SB-03	83 N/12	14	10	77	25	5	NAD27	U11	6168800	450250	572
95-SB-04	83 N/12	4	14	77	25	5	NAD27	U11	6169250	451150	549
95-SB-05	83 N/12	3	20	77	26	5	NAD27	U11	6171050	437200	671
95-SB-06	83 N/12	12	17	77	25	5	NAD27	U11	6169900	446300	572

Appendix 1 - Section and Borehole Locations

BORE HOLE	NTS	DLS	Sec	Tp	R	W of	Datum	Zone	UTM (n)	UTM (e)	Elev (m)
93-SAB-03	83N/14	3	28	80	20	5	NAD27	U11	6201050	495550	602
93-SAB-04	83N/14	16	35	80	23	5	NAD27	U11	6204200	470600	565
93-SAB-06	83N/11	12	27	76	22	5	NAD27	U11	6163025	478775	564
93-SAB-07	83N/11	15	36	75	23	5	NAD27	U11	6155700	473275	564
93-SAB-10	83N/11	13	12	77	23	5	NAD27	U11	6168600	472350	556
93-SAB-13	83N/13	4	5	80	25	5	NAD27	U11	6295025	444475	562
93-SAB-14	83N/13	13	21	79	23	5	NAD27	U11	6191400	465650	565
94-SAB-02	83N/5	2	3	73	26	5	NAD27	U11	6127225	442375	847
94-SAB-04	83N/4	1	22	70	26	5	NAD27	U11	6102650	444700	652
94-SAB-06	83N/3	16	24	70	22	5	NAD27	U11	6103800	487025	701
94-SAB-08	83N/3	12	5	72	22	5	NAD27	U11	6117700	477150	780
94-SAB-09	83N/3	13	2	72	21	5	NAD27	U11	6118250	492150	648
94-SAB-10	83N/6	13	36	73	23	5	NAD27	U11	6136250	474150	657
94-SAB-11	83N/12	14	19	75	25	5	NAD27	U11	6152700	444900	620
94-SAB-12	83N/14	13	23	78	21	5	NAD27	U11	6181375	490225	594
94-SAB-14	83N/6	9	28	74	21	5	NAD27	U11	6143725	489900	581
94-SAB-15	83N/4	1	16	71	24	5	NAD27	U11	6110575	460725	716

APPENDIX 2

SAMPLE DESCRIPTIONS

Appendix 2 - Sample Descriptions

SAMPLE #	DEPTH (m)	SAMPLE DESCRIPTION
Section		
93-SB-05a	0.80	Mottled, loamy till, fractured
93-SB-05b	1.75	Mottled, loamy till, fractured
93-SB-05c	2.60	Mottled, loamy till, fractured
93-SB-06a	0.50	Silty-clay till with silt stringers
93-SB-06b	0.88	Clay diamict, some silt stringers
93-SB-06c	0.50	Gravel lag interbedded with clay diamict
93-SB-07a	0.85	Massive clay
93-SB-07b	1.55	Massive silty-clay diamict
93-SB-08a	0.80	Massive, silty-clay till
93-SB-08b	1.90	Massive, silty-clay till
93-SB-09a	1.80	Sand and gravel, oxidised
93-SB-09b	2.25	Loamy till, massive
93-SB-10a	1.35	Mottled, loamy till, fractured
93-SB-10b	2.60	Mottled, loamy till, fine sand lenses
93-SB-11b	4.70	Laminated, clay diamict, white specks
93-SB-11c	6.10	Laminated, clay diamict, white specks
93-SB-11d	6.90	Mottled, loamy till
93-SB-11e	8.00	Mottled, loamy till
93-SB-11f	7.50	Fine sandy-silt rip-up lens
93-SB-26a	1.25	Mottled, loamy till, white veining
93-SB-26b	2.20	Loamy till, some stratification
93-SB-26c	1.80	Stratified loamy diamict, flow nose
93-SB-32	0.79	Mottled, loamy till, massive
93-SB-38a	1.35	Laminated, loamy till
93-SB-38b	1.95	Laminated, loamy till
93-SB-38c	3.00	Massive, loamy till, very compact
93-SB-39a	0.60	Laminated, clay diamict
93-SB-39b	1.35	Laminated, silty-clay till, gypsum lenses
93-SB-39c	2.00	Mottled, silty-clay till, fine sand lenses
93-SB-39d	3.10	Mottled, silty-clay till, fine sand lenses
93-SB-40a	1.15	Laminated silt, clay, and loamy till
93-SB-40b	1.30	Mottled, loamy till, white veining
93-SB-40c	2.20	Stratified, loamy till and fine sand
93-SB-40o	2.50	Coal fragments
93-SB-41a	0.45	Massive, loamy till
93-SB-41b	1.15	Mottled, silty-clay till, medium sand laminae
93-SB-42a	0.48	Massive, sandy-clay till, fine sand lens
93-SB-42b	1.00	Mottled, loamy till, gypsum pockets
93-SB-43a	1.50	Loamy diamict, highly weathered
93-SB-43b	2.35	Mottled, loamy till, silty-fine sand laminae
93-SB-44a	1.00	Silty-clay till, highly convoluted
93-SB-44b	1.30	Loamy till, highly convoluted, rip-up lenses
93-SB-44g	0.70	Poorly sorted, oxidised gravel
93-SB-44o	2.50	Organic lens
93-SB-46	1.10	Massive, silty-clay diamict
93-SB-47a	0.40	Mottled, loamy till, compact
93-SB-47b	1.30	Mottled, loamy till, fine sand pockets
93-SB-48	1.00	Mottled, silty-clay till
93-SB-50a	0.80	Massive, silty-clay till, gypsum veining
93-SB-50b	1.40	Massive, loamy till, gypsum veining, fine sand
93-SB-51	1.70	Massive, silty-clay till, gypsum veining
93-SB-52a	1.15	Mottled, silty-clay till, gypsum veining
93-SB-52b	2.50	Massive, loamy till, fractured
93-SB-52c	3.50	Massive, silty-clay till, fractured
93-SB-53a	1.10	Laminated, silty-clay till and silty-clay
93-SB-53b	2.05	Mottled, silty-clay till, white specks
93-SB-53c	3.25	Massive, loamy till, white veining
93-SB-55a	0.73	Slightly mottled, silty-clay till, compact
93-SB-55b	0.95	Slightly mottled, silty-clay till, white lenses
93-SB-56	1.00	Massive, silty-clay till, very compact
93-SB-62	1.65	Massive, silty-clay diamict
93-SB-65a	1.35	Mottled, loamy till, fine sand lenses
93-SB-65b	0.90	Mottled, loamy till, very compact
93-SB-65c	2.85	Mottled, loamy till, very compact
93-SB-67a	14+	Cross-stratified gravel and coarse sand
93-SB-67b	10+	Cross-stratified gravel and coarse sand

Appendix 2 - Sample Descriptions

SAMPLE #	DEPTH (m)	SAMPLE DESCRIPTION
93-SB-67c	6+	Wood fragment
93-SB-67d	6.5+	Organics, coal and fine sand
93-SB-67e	7.00	Oxidised gravel and coarse to medium sand
93-SB-68a	7.00	Coal
93-SB-68b	7.25	Cross-stratified gravel and fine-coarse sand
93-SB-72a	4.00	Mottled, silty till, oxidised, some sand
93-SB-72b	8.50	Massive, clay-silty till, very compact
94-dune	0.50	Sand
94-SB-01a	1.12	Loamy till, fine-medium sand stringers
94-SB-01b	2.12	Loamy till, fine-medium sand stringers
94-SB-01c	1.40	Loamy till, fine-medium sand stringers
94-SB-01d	1.75	Laminated, fine-medium sand
94-SB-01e	2.20	Stratified siltstone and sandstone
94-SB-01f	2.10	Gravel
94-SB-02	1.20	Clay till, irregular lenses and laminae of silt
94-SB-03a	0.68	Massive, loamy till, coal fragments
94-SB-03b	1.35	Massive, loamy till
94-SB-04a	0.50	Massive brown-grey clay
94-SB-04b	0.70	Mottled, silty till
94-SB-04c	1.40	Mottled, silty till, calcareous
94-SB-05	1.25	Mottled, silty till
94-SB-06a	1.20	Fine-medium sand, well-sorted
94-SB-06b	1.50	Stratified fine sand and clay, some granules
94-SB-06c	1.80	Fine-medium sand, well-sorted
94-SB-07	0.80	loamy till
94-SB-08	2.30	Fine sand, well-sorted, massive
94-SB-09	1.15	Loamy till, mottled
94-SB-10	1.20	Mottles, loamy till, calcareous
94-SB-11a	3.20	Fine-medium sand, laminated
94-SB-11b	0.90	Weathered loamy till, fine sand laminae
94-SB-12a	6.00	Medium sand, well-sorted, shells
94-SB-12b	5.00	Massive to laminated silty clay, convoluted
94-SB-13a	0.75	Stratified silty-clay
94-SB-13b	1.04	Very fine sand and silt, laminated
94-SB-14a	0.45	Massive clay, minor silt
94-SB-14b	0.75	Clay, rhythmic lamination
94-SB-14c	1.15	Laminated, loamy till and clay, coal and wood
94-SB-14d	1.70	Massive, fine sandy-clay till, coal and petrified wood
94-SB-14e	2.60	Massive, fine sandy-clay till, coal and petrified wood
94-SB-14f	0.20	Mottled, loamy till
94-SB-15	1.00	Silty till
94-SB-16a	0.40	Silt, colour lamination
94-SB-16b	0.70	Mottled. silty-clay till
94-SB-16c	1.20	Fine-medium sand, clay blebs
94-SB-16d	1.10	Fine-medium sand, clay blebs, red-brown staining
94-SB-16e	1.50	Medium sand, well-sorted
94-SB-17a	1.05	Rhythmically laminated silt and clayey-silt
94-SB-17b	2.90	Laminated clay and very fine sand
94-SB-18	0.75	Massive, silty till
94-SB-19a	1.00	Massive, clay till, calcareous
94-SB-19b	1.25	Massive, loamy till, calcareous
94-SB-20	0.80	Mottled, loamy till
94-SB-21a	0.45	Loam
94-SB-21b	0.60	Silty-clay loam
94-SB-21c	1.35	Massive, very fine sand and silt
94-SB-21d	1.70	Laminated, fine and coarse sand
94-SB-21e	1.85	Laminated, fine sand and organics
94-SB-21f	2.00	Massive, loamy till, minor sand
94-SB-22a	0.90	Massive, fine sand and clay
94-SB-22b	1.30	Clay till, marl laminae and pockets
94-SB-23	1.00	Massive, loamy till
94-SB-24a	0.55	Massive, silty till
94-SB-24b	0.95	Massive, silty till, calcareous
94-SB-25a	0.80	Massive, loamy till, minor sand
94-SB-25b	1.20	Massive, loamy till, minor sand
94-SB-26aa	0.65	Mottled, very fine sand and silt
94-SB-26ab	1.15	Massive, loamy till
94-SB-26ac	1.50	Massive, clayey till, calcareous

Appendix 2 - Sample Descriptions

SAMPLE #	DEPTH (m)	SAMPLE DESCRIPTION
94-SB-26b	3.05	Massive, silty till, calcareous
94-SB-27	1.10	Gravel, some sand, poorly sorted
94-SB-28	1.15	Mottled, loamy till
94-SB-29a	0.95	White shelly lenses
94-SB-29b	1.00	Fine sandy-silt waterlain diamict
94-SB-29c	1.30	Fine sandy-silt waterlain diamict
94-SB-29d	1.60	Silty fine sand
94-SB-29e	2.00	Silty-clay diamict
94-SB-29f	2.25	Laminated silty fine sand
94-SB-29g	2.70	Massive, medium sand, well-sorted
94-SB-29h	0.80	Blocky, loamy till
94-SB-29i	1.60	Silt and clay
94-SB-30a	0.70	Massive, loamy till, calcareous
94-SB-30b	1.30	Massive, loamy till, calcareous
94-SB-31a	0.95	Massive silty clay, calcareous
94-SB-31b	1.15	Massive clayey silt, calcareous
94-SB-32	1.05	Mottled, clayey waterlain diamict
94-SB-33a	0.65	Clayey silt
94-SB-33b	1.15	Clayey silt, calcareous
94-SB-33c	1.35	Medium sand, moderately sorted
94-SB-34	0.95	Massive silty clay
94-SB-35a	0.65	Massive, loamy till, calcareous
94-SB-35b	1.05	Massive, loamy till, minor sand, calcareous
94-SB-35c	2.30	Massive, loamy till, minor sand, calcareous
94-SB-36	0.75	Massive, loamy waterlain diamict, some sand
94-SB-37	0.90	Massive, loamy till
94-SB-38	1.03	Medium sand, organic and marl lenses
94-SB-39	1.15	Laminated, silty till, calcareous
94-SB-40	1.15	Massive, loamy till
94-SB-41	1.40	Silty till, laminae of marl, calcareous
94-SB-42a	0.80	Massive, loamy till
94-SB-42b	1.80	Massive, loamy till, calcareous
94-SB-43	1.00	Massive, silty till
94-SB-44	1.20	Colour laminated silty clay
94-SB-45a	0.60	Laminated silt and fine sand
94-SB-45b	1.30	Massive, clayey diamict
94-SB-46a	0.80	Massive, clayey-silt diamict
94-SB-46b	1.25	Massive, loamy diamict
94-SB-47	1.00	Silty till, subtle lamination, calcareous
94-SB-48	1.00	Massive, silty till, calcareous
94-SB-49	1.05	Massive, silty-clay diamict, calcareous
94-SB-50a	0.48	Laminated silty clay, calcareous
94-SB-50b	0.85	Mottled, loamy till, calcareous
94-SB-50c	1.30	Massive, silty till, calcareous
94-SB-51a	0.65	Massive, clay till, calcareous, marl pockets
94-SB-51b	1.55	Massive, silty till, calcareous, marl and gypsum
94-SB-52a	0.75	Massive, silty till, calcareous
94-SB-52b	1.40	Massive, silty till, calcareous
94-SB-53	0.50	Laminated fine sand and silt
94-SB-54a	0.15	Massive, silty-clay diamict
94-SB-54b	0.35	Massive, silty till
94-SB-54c	1.05	Laminated clayey silt
94-SB-54d	0.65	Fine-medium sand, minor gravel
94-SB-55a	0.70	Massive, silty-clay diamict, some sand
94-SB-55b	1.00	Massive, silty-clay till, some sand
94-SB-56a	0.45	Mottled, clayey-silt waterlain diamict
94-SB-56b	1.30	Laminated, silty-fine sand and silty clay, organics
94-SB-57	1.35	Mottled, clayey-fine sand and silt
94-SB-58	1.40	Mottled, loamy till
94-SB-59a	0.80	Massive, clayey-silt, marl laminae
94-SB-59b	1.30	Fine-coarse sand with silt and clay, some gravel
94-SB-59c	2.00	Cross-laminated coarse sand and gravel
94-SB-60	1.30	Mottled, loamy till
94-SB-61a	0.55	Massive medium-fine sand, moderately-well sorted
94-SB-61b	1.30	Massive, loamy till
94-SB-62	1.10	Mottled, silty till, calcareous
94-SB-63a	0.55	Massive fine sand, stringers of diamict
94-SB-63b	0.65	Lens of silty-clay diamict

Appendix 2 - Sample Descriptions

SAMPLE #	DEPTH (m)	SAMPLE DESCRIPTION
94-SB-64a	0.65	Mottled, loamy till, calcareous
94-SB-64b	1.65	Mottled, loamy till, calcareous
94-SB-65	0.95	Medium-coarse sand and gravel
94-SB-66a	0.30	Massive, silty-clay waterlain diamict
94-SB-66b	0.80	Laminated, silty till
94-SB-66c	1.60	Massive, silty till
94-SB-67	1.80	Compact, silty-clay sandstone
94-SB-68	1.15	Massive, loamy till, calcareous
94-SB-69a	1.00	Laminated silty clay
94-SB-69b	4.10	Mottled silty clay
94-SB-69c	5.00	Massive, loamy till
94-SB-69d	10.00	Massive, loamy till
94-SB-70a	11.00	Laminated fine sand
94-SB-70b	12.50	Banded sandstone, iron staining
94-SB-71	1.10	Massive, silty till, calcareous
94-SB-72	1.20	Massive, silty till
94-SB-73a	3.48	Crushed wood and organics
94-SB-73b	5.70	Massive, loamy till
94-SB-73c	2.50	Rhythmites of clay and diamict
94-SB-74a	0.80	Massive silty clay, calcareous
94-SB-74b	1.10	Massive, silty till, calcareous
94-SB-74c	1.80	Mottled, loamy till, calcareous
94-SB-74d	3.50	Mottled, loamy till, calcareous
94-SB-75a	2.00	Massive, loamy till, silt stringers
94-SB-75b	4.50	Massive, loamy till, silt stringers
94-SB-75c	7.50	Massive, loamy till, silt stringers
94-SB-76c	2.20	Massive, loamy till, calcareous
94-SB-76d	5.20	Massive, loamy till, calcareous
94-SB-76e	8.50	Massive, loamy till, calcareous
94-SB-77	0.75	Silty till, fine sand stringers, calcareous
94-SB-78	1.05	Massive, loamy till, calcareous
94-SB-79	1.00	Massive, clayey-silt waterlain diamict, calcareous
94-SB-80	1.05	Massive, loamy till
94-SB-81	1.50	Massive, loamy till
94-SB-82a	8.00	Silty-fine sand diamict with shale
94-SB-82b	10.00	Grey shale, fossiliferous
94-SB-83	1.80	Stratified sand and gravel
94-SB-89	5.00	Micaceous, silty-fine sandstone, stratified
94-SB-91a	4.10	Massive, loamy till, calcareous
94-SB-91b	7.40	Massive, loamy till
Drill Core		
93-SAB-06	2.13	Laminated silt and clay
93-SAB-06	3.35	Finely laminated clay, calcareous laminae
	4.11	Thinly laminated silty-clay diamict
	5.79	Thinly laminated, clayey diamict
	7.16	Laminated, clayey-silt diamict
	8.53	Laminated loamy till, fractured
	9.91	Massive, loamy till, fractured
	11.28	Massive, loamy till
	12.65	Massive, loamy till
	14.02	Massive, loamy till
	15.39	Massive, loamy till
	16.76	Massive, loamy till
	19.05	Massive, loamy till
	20.42	Massive, loamy till
	21.79	Massive, loamy till
	23.16	Massive, loamy till
	24.54	Massive, loamy till
	25.91	Massive, loamy till
	27.28	Massive, loamy till
	28.65	Massive, loamy till
	30.02	Massive, loamy till
	31.39	Massive, loamy till
	32.77	Massive, loamy till
	37.64	Massive, loamy till
	39.01	Massive, loamy till

Appendix 2 - Sample Descriptions

SAMPLE #	DEPTH (m)	SAMPLE DESCRIPTION
	40.39	Massive, loamy till
	41.76	Massive, loamy till
	43.13	Massive, loamy till
	44.50	Massive, loamy till
93-SAB-13	1.52	Stratified silt and sandy-silt, calcareous
	2.44	Laminated sandy-silt, and clay, calcareous
	3.66	Finely stratified silt and fine sand, calcareous
	5.03	Thinly laminated silt and clay, convoluted
	5.33	Massive silty clay, fine sand lenses
	6.86	Laminated fine sandy-silt and silt/clay, calcareous
	8.38	Massive silty clay, fine sand lenses
	9.91	Contorted laminae of silt and clay, calcareous
	10.52	Massive silty clay, fine sand lenses
	12.65	Contorted laminae of silt and clay, calcareous
	13.72	Massive silty clay, fine sand lenses
	14.94	Massive clayey diamict
	16.00	Massive silty clay, fine sand lenses
	17.53	Silt, some silty-clay laminae, calcareous
	19.05	Massive silty clay, fine sand lenses
	20.57	Laminated clayey-silt, convoluted
	21.34	Stratified silty till, calcareous silt lenses
	22.10	Massive, loamy till
	23.32	Stratified silty till, calcareous silt lenses
	24.38	Massive, loamy till
	25.76	Massive, loamy till
	27.13	Massive, loamy till
	28.50	Massive, loamy till
	29.87	Massive, loamy till
	31.24	Massive, loamy till
	32.61	Massive, loamy till
	34.00	Massive, loamy till
	35.36	Massive, loamy till
	36.73	Massive, loamy till
	38.10	Massive, loamy till
	39.47	Massive, loamy till
	40.84	Massive, loamy till
94-SAB-02	1.22	Mottled loamy till, clay patches
	3.35	Massive, loamy till, contains bedrock
	3.81	Grey, silty-clay sandstone
94-SAB-08	0.76	Massive, loamy till, minor sand, calcareous
	2.13	Massive, loamy till, minor sand, calcareous
	2.44	Laminated silty-clay, calcareous
	5.33	Laminated, fine-medium, silty sandstone, grey
94-SAB-09	1.22	Massive, silty till
	3.51	Massive, silty till, some mottling
	9.60	Massive, loamy till
	15.70	Massive, loamy till, silt lenses
	21.79	Massive, loamy till
	27.89	Massive, loamy till
	35.81	Massive, loamy till
	40.08	Massive, loamy till
94-SAB-10	1.52	Mottled loamy till, minor sand
	4.72	Mottled loamy till, minor sand
	5.33	Laminated fine sand and silty-clay sand
	6.86	Massive, loamy till
	10.52	Massive, loamy till
	12.04	Brown, clayey siltstone
94-SAB-11	1.52	Mottled loamy till, minor sand, calcareous
	4.11	Mottled loamy till, minor sand, calcareous
	8.38	Massive loamy till
	8.84	Massive, fine sand, well-sorted, blue-grey
	10.97	Laminated loamy till

Appendix 2 - Sample Descriptions

SAMPLE #	DEPTH (m)	SAMPLE DESCRIPTION
	13.72	Massive, loamy till
	18.44	Laminated silty till and silt
	18.90	Grey, clayey siltstone
94-SAB-15	2.74	Mottled silty till, calcareous
	5.18	Laminated silty till, calcareous
	10.67	Massive, loamy till
	16.76	Massive to laminated, silty till
	18.75	Massive silty till, minor sand
	19.20	Monolithic silty-clay diamict with shale granules

APPENDIX 3

BOREHOLE DESCRIPTIONS

Hole no.: 93-SAB-003
Sheet: 83N/14
Zone: U11

UTM (n): 6201050
UTM (e): 495550
LDS: 3-28-80-20 W5

Elevation: 602 m
T.D.: 97.0 ft

Date Started: 19-08-1993
Date Completed: 20-08-1993

Core Length							
Drilled (ft)		Measured (cm)		ID	Core Interval		Description
From	To	From	To	Code	From	To	
0	2.5	0	103	Ah	0	13	A horizon, disturbed, sharp lower contact
				U1	13	30	Clayey silt, laminated dark grey and light brown, soft, weathered granules of siltstone, calcareous, sharp lower contact
				U2	30	38	Clayey silt, laminated, light brown, very calcareous, no granules, sharp lower contact
				U3	38	53	Silt till, dark grey with light brown, vague stratification, abundant granules of siltstone, carbonates and quartzites, often weathered, gypsum pockets, compact, sharp lower contact
				U4	53	94	Silty clay to clayey silt, discontinuous laminae, no apparent granules or pebbles, thick veins and fractures with calcareous crystals, sharp lower contact
				U5	94	103	Clayey silt till, dark grey with thin brown silty laminae, convoluted at the top and become more horizontal downcore, several granules and small pebbles (weathered carbonates, granites, siltstone, sandstone, quartzites), calcareous crystals
2.5	7.5	103	258	U5	103	258	Same as above
7.5	12.5	258	321	U5	258	321	Same as above, large siltstone cobble (8 cm length) caused poor recovery, calcareous crystals disappear after 10.5 ft
12.5	17.5	321	469	U5	321	345	Same as above, gradational lower contact
				U5a	345	376	Similar to unit 5 but silt laminae and lenses are much thicker, gradational lower contact
				U5	376	469	Same as unit 5 above, orange, brown-grey to grey, large oxidized pebbles (granites, gneiss, carbonates, quartzites, shale) and veins of gypsum crystals after 4.21 m, orange, poorly sorted, calcareous, silty fine sand
17.5	22.5	469	602	U5	469	602	Same as above
22.5	27.5	602	698	U5	602	660	Same as above, sharp lower contact
				U6		679	Medium to coarse sand, moderately sorted, massive, some granules of granites and mafic volcanics, light brown, sharp lower contact
				U5		698	Same as unit 5 above, sharp lower contact
27.5	32.5	0	0	NCR	0	0	Lost core, residue in barrel suggest that it may have been unit 6

Appendix 3 - Borehole Descriptions

Core Length				ID	Core Interval		Description
Drilled (ft)		Measured (cm)					
From	To	From	To	Code	From	To	
32.5	37.5	0	88	U7	0	83	Fine to medium sand, moderately sorted, light brown beige, small pebbles of granites and mafic volcanics, interfingered and sharp upper and lower contact
				U8	83	88	Similar to the lower portion of unit 5
37.5	52	0	0	NCR	0	0	No core taken
52	57	0	152	U8	0	33	Same as unit 8 above, sharp angled lower contact
				U9	33	42	Clayey silty till, dark grey, massive, abundand granules and small pebbles (shale quartzite, granites, carbonates, black chert), weakly calcareous, compact and massive, sharp angled lower contact
				U8	42	90	Same as unit 8 above, sharp angled lower contact
				U9	90	116	Same as unit 9 above, sharp angled lower contact
				U8	116	122	Same as unit 8 above, sharp angled lower contact
				U9	122	152	Same as unit 9 above
57	62	152	309	U9	152	309	Same as unit 9 above
62	67	309	461	U9	309	461	Same as unit 9 above, core slivered
67	72	461	613	U9	461	613	Same as unit 9 above, core slivered
72	77	613	650	U9	613	650	Same as unit 9 above, core slivered, fragments of pink quartzite
77	82	650	799	U9	650	799	Same as unit 9 above, abundant granules (esp. quartzites), greywacke and quartzites up to 8 cm, massive
82	87	799	958	U9	799	958	Same as unit 9 above, lower contact uncertain but likely sandstone or sand
87	92.5	0	0	NCR	0	0	Hit saturated sand or sandstone, drill links separated, no core recovery
92.5	97	0	0	NCR	0	0	Hit saturated sand or sandstone, drill links separated, no core recovery

Hole no.: 93-SAB-004
Sheet: 83N/14
Zone: U11

UTM (n): 6204200
UTM (e): 470600
LDS: 16-35-80-23 W5

Elevation: 565 m
T.D.: 52.5 ft

Date Started: 19-08-1993
Date Completed: 19-08-1993

Core Length								
Drilled (ft)		Measured (cm)		ID	Core Interval		Description
From	To	From	To	Code	From	To	
0	2.5	0	64	Fill	0	37	Mixed fill, medium brown
				A	37	57	A soil horizon
				B1	57	64	Finely laminated silt, no granules, fissile, dry, light grey and light orange with orange spots
2.5	7.5	64	221	B1	64	68	Same as above, subtle lower contact
				B2	68	101	Similar to B1, silty clay to clayey silt, no granules, mod compact to fissile, orange brown to olive grey-green, not calcareous, sharp lower contact
				U1	101	145	Same as B2, laminated, clay content increases downcore, orange brown to olive grey-green, calcareous, sharp lower contact
				U2	145	221	Silty clay, mottled dark grey with patches and lenses of med brown, very fissile, not calcareous, lenses are calcareous
7.5	12.5	221	369	U2	221	251	Same as above, sharp lower contact
				U3	251	340	silty clay, convoluted laminae, no granules, dark grey and med brown, silt is calcareous, gradational lower contact to more horizontal laminae
				U4	340	369	Same as unit 3 but with thicker and more horizontal laminae of brown clay (1mm -1.5 cm), fizzes along fractures and silt planes, sharp lower contact
12.5	17.5	369	484	U5	369	392	Same as unit 4, large gypsum crystals in fractures, larger calcareous silt lenses, gradational lower contact
				U6	392	475	Predominately brown silty clay with thin dark grey clay laminae, abundant oxidized gypsum pockets, gypsum crystals up to 1 cm in length, calcareous silt lenses and laminae thicken downcore, subtle lower contact
				U7	475	484	Dark grey clay with some thin brown silty clay laminae
17.5	22.5	484	635	U7	484	506	Same as above, sharp interfingering lower contact
				U8	506	599	Clayey silt till, predominately brown, dark grey clay laminae, granules and pebbles content increases downcore, clasts are soft and weathered (brown siltstone, granite, crystalline, carbonates, shale), very compact, interfingered lower contact
				U9	599	635	Dark grey clayey silt till, very compact, lots of granules and small clasts, same lithologies as unit 8

Appendix 3 - Borehole Descriptions

Core Length							
Drilled (ft)		Measured (cm)		ID	Core Interval		Description
From	To	From	To	Code	From	To	
22.5	27.5	635	662	U9	635	662	Same as above, lower contact lost during core recovery
27.5	32.5	662	711	U10	662	711	Silty fine sand, mod sorted, rare granules but contains fragments of pink gneiss, massive, very calcareous, light yellow brown, lower 12 cm of core is laminated with dark grey clayey silt and very fine sand, sharp lower contact
32.5	37.5	711	806	U11	711	806	Med silty sand, blebs of calcareous olive grey clay, massive, non calcareous, orange brown
37.5	42.5	806	947	U11	806	830	Same as above, laminated lower contact with bedrock
				U12	830	850	Silty clay to clayey silt laminae with sulphuric yellow laminae, orange fractures, large gypsum crystals, subtle lower contact
				U13	850	947	Very finely laminated silt and silty clay bedrock, dark grey and beige, very large gypsum crystals and veins
42.5	47.5	947	1028	U13	947	1028	Same as above, but no more gypsum crystals
47.5	52.5	1028	1098	U13	1028	1098	Same as above

Hole no.: 93-SAB-006
Sheet: 83N/11
Zone: U11

UTM (n): 6163025
UTM (e): 478775
LDS: 12-27-76-22 W5

Elevation: 564 m
T.D.: 148.5 ft

Date Started: 24-08-1993
Date Completed: 25-08-1993

Core Length				ID	Core Interval		Description
Drilled (ft)		Measured (cm)					
From	To	From	To	Code	From	To	
0	2.5	0	83	U1	0	58	Thinly laminated silty clay; calcareous; dark grey and light brown; sharp lower contact
				U2	58	60	Loose, eluviated, powdery silt; non calcareous; sharp lower contact
				U3	60	64	Silty clay; strongly calcareous; thinly laminated, subtle lower contact
				U4	64	83	Loose, powdery clay and silt
2.5	7.5	83	201	U4	83	96	Same as above unit 4; sharp lower contact
				U5	96	146	Finely laminated silt and clay; dark grey and light brown; calcareous white veins; contorted at top, horizontal down core; subtle lower contact
				U6	146	201	Same as unit 5, but contains pockets and lenses of white moderately calcareous material
7.5	12.5	201	345	U6	201	215	Same as unit 6 above; sharp lower contact
				U7	215	225	Massive, clayey silt; light brown; calcareous; interlaminated lower contact
				U8	225	238	Massive, silt clay; dark brown - grey; blebs of light brown silt; white calcareous crystals; calcareous; interlaminated lower contact
				U6	238	255	Same as unit 6 above; sharp lower contact
				U8	255	278	Same as unit 8 above
				U9	278	345	Laminated silt and clay (1mm - 32 cm); dark grey and light brown; non calcareous; calcareous white veins; very compact; subtle lower contact
12.5	17.5	345	503	U10	345	503	Silty clay "diamict"; similar to unit 9; contorted laminated at top; pockets of oxidized orange-brown; rare small igneous granules
17.5	22.5	503	652	U10	503	525	Same as unit 10 above; sharp lower contact
				U11	525	545	Similar to unit 10 but browner; rare small weathered granules; moderately calcareous; small pockets and laminae of beige silt; subtle lower contact
				U12	545	562	Similar to unit 11 but dark brown-grey; pockets and laminae of unit 11; subtle lower contact
				U11	562	578	Same as unit 11 above
				U12	578	620	Same as unit 12 above; sharp lower contact
				U13	620	652	Quasi-till; thinly laminated clayey silt; dark grey, brown grey and orange brown; locally calcareous in fractures and weathering rinds; gypsum crystals
22.5	27.5	652	776	U13	652	776	Same as unit 13 above
27.5	32.5	776	926	U13	776	781	Same as unit 13 above; subtle lower contact

Appendix 3 - Borehole Descriptions

Core Length							
Drilled (ft)		Measured (cm)		ID	Core Interval		Description
From	To	From	To	Code	From	To	
				U14	781	884	Similar to unit 13; more weathered granules and pebbles (pink sandstone, siltstone, quartzite, carbonate); orange subvertical fractures; sharp, interfingered lower contact
				U15	884	926	Massive silt clay till; dark grey; abundant small pebbles and granules (pink sandstone/quartzite, carbonate, siltstone, granite, igneous and volcanic other); large oxidized fractures; non calcareous, compact
32.5	37.5	926	1087	U15	926	1005	Same as unit 15 above; subtle lower contact
				U16	1005	1087	Similar to unit 15, no fractures; abundant clasts (shaleale, black chert, red sandstone/quartzitet, granites, carbonate, igneous and volcanic other); large gypsum crystals
37.5	42.5	1087	1249	U16	1087	1249	Same as unit 16 above, shale and red clasts more abundant, facetted flat-iron pebbles
42.5	47.5	1249	1409	U16	1249	1409	Same as unit 16 above, fewer granite clasts
47.5	52.5	1409	1563	U16	1409	1563	Same as unit 16 above, more shale clasts
52.5	57.5	1563	1639	U16	1563	1639	Same as unit 16 above, large pink sandstone cobble at 54'
57.5	62.5	1639	1662	U16	1639	1662	Same unit, poor core recovery, fragments of pink sandstone
62.5	67.5	1662	1819	U16	1662	1819	Same as above, upper portion fractured and churned (unrecovered core from previous drill run), more quartz, quartzite and siltstone clasts
67.5	72.5	1819	1979	U16	1819	1979	Same as above, more mafic volcanict clasts
72.5	77.5	1979	2141	U16	1979	2141	Same as above, still several large granite clasts
77.5	82.5	2141	2299	U16	2141	2299	Same as above, large siltstone with weathering rim at 77.6'
82.5	87.5	2299	2458	U16	2299	2458	Same as above, large coal fragment at 83'
87.5	92.5	2458	2613	U16	2458	2613	Same unit 16 as above
92.5	97.5	2613	2768	U16	2613	s	Same as above
97.5	102.5	2768	2881	U16	2768	2881	Same as above
102.5	107.5	2881	3041	U16	2881	3041	Same as above
107.5	112.5	3041	3202	U16	3041	3202	Same as above
112.5	117.5	3202	3223	U16	3202	3223	Same as above, poor recovery, large coal fragment at 115', soft green granule at 117.5'
117.5	122.5	3223	3237	U16	3223	3237	Same unit 16 as above, poor recovery
122.5	123.5	3237	3271	U16	3237	3271	Same unit 16 as above
123.5	128.5	3271	3396	U16	3271	3396	Same as above, but contains calcareous lenses of pale green-white medium sand; lots of igneous and soft green granules
128.5	133.5	3396	3556	U16	3396	3556	Same as above, thin laminae in lower 3 cm of core of calcareous beige-grey fine sand
133.5	138.5	3556	3712	U16	3556	3712	Same unit 16 as above, lots red granites, siltstone, chert, volcanic other and soft green clasts
138.5	143.5	3712	3868	U16	3712	3868	Same as above, lots coal, shale granites, carbonates, siltstone, chert, sandstone/quartzite
143.5	148.5	3868	4024	U16	3868	4024	Same as above, thin laminae of light brown, calcareous very fine sand (<1 mm)

Hole no.: 93-SAB-007 UTM (n): 6155700
Sheet: 83N/11 UTM (e): 473275
Zone: U11 LDS: 15-36-75-23 W5

Elevation: 564 m Date Started: 25-08-1993
T.D.: 140.0 ft Date Completed: 26-08-1993

Core Length							
Drilled (ft)		Measured (cm)		ID	Core Interval		Description
From	To	From	To	Code	From	To	
0	2.5	0	67	fill	0	9	Road fill
				O	9	22	Oh/Of organic layer
				Ae	22	25	Eluviated non calcareous silt
				U1	25	67	B horizon, thinly laminated clay and silt, non calcareous, grey, brown and orange laminae
2.5	7.5	67	194	U1	67	70	Same as unit 1 above, sharp lower contact
				U2	70	194	Thinly laminated silty clay and clayey silt and silt (2 - 10 mm), orange, brown and grey laminae, very calcareous; sharp lower contact
7.5	12.5	194	354	U3	194	240	Similar to unit 2 above, highly convoluted and mottled; medium brown with grey veining; very calcareous; subtle lower contact
				U4	240	270	Similar to unit 3 above, abundant white calcareous subvertical fractures; subtle lower contact
				U5	270	325	Similar to unit 4 above, but no white veining, still very calcareous, abundant organic flecks, sharp lower contact
				U6	325	354	Silty clay, some laminae (1 cm), generally brown grey, calcareous
12.5	17.5	354	520	U6	354	361	Same unit 6 as above, sharp lower contact
				U7	361	433	Silty clay, grey-brown, laminated of orange-brown silt, calcareous, sharp lower contact
				U8	433	445	Similar to unit 7 above, but abundant calcareous crystals, sharp lower contact
				U9	445	520	Laminated clayey silt and silt, brown-grey and grey, moderate to weakly calcareous, abundant white calcareous laminae
17.5	22.5	520	680	U9	520	680	Same as unit 9 above, subvertical veining with gypsum crystals, subtle lower contact
22.5	27.5	680	840	U10	680	840	Silty clay similar to unit 9, grey, non calcareous, localized laminae separating massive sections
27.5	32.5	840	1000	U10	840	869	Same as unit 10 above, sharp lower contact
				U11	869	1000	Similar to unit 10, but with beige calcareous fine sand "granules" and orange silt veins
32.5	37.5	1000	1161	U11	1000	1092	Same as unit 11 above; interfingered lower contact
				U12	1092	1161	Massive clayey silt till, dark grey, non calcareous, abundant granules and small pebbles (purple/pink sandstone/quartzite, carbonate, mafic crystalline, shale, siltstone, granite)

Appendix 3 - Borehole Descriptions

Core Length				ID	Core Interval		Description
Drilled (ft)		Measured (cm)					
From	To	From	To	Code	From	To	
37.5	42.5	1161	1321	U12	1161	1321	Same as unit 12 above, more weathered diorites and volcanic others
42.5	47.5	1321	1448	U12	1321	1448	Same as above, coal clasts
47.5	52.5	1448	1601	U12	1448	1601	Same as above
52.5	57.5	1601	1661	U12	1601	1661	Same as above, facetted carbonate pebbles
57.5	62.5	1661	1719	U12	1661	1719	Same as above, 6 cm sandstone at 62.5'
62.5	67.5	1719	1859	U12	1719	1859	Same as above
67.5	72.5	1859	2016	U12	1859	2016	Same as above
72.5	77.5	2016	2169	U12	2016	2169	Same as above, larger and more shale clasts
77.5	82.5	2169	2328	U12	2169	2328	Same as above, 11 cm siltstone clast at 2189 cm, 4.5 cm granite clast at 2211 cm
82.5	87.5	2328	2485	U12	2328	2485	Increase in small pebbles (1-2 cm), abundant red granites
87.5	92.5	2485	2637	U12	2485	2637	Same as above
92.5	97.5	2637	2797	U12	2637	2797	Same as above, appearance of small coal clasts
97.5	102.5	2797	2957	U12	2797	2957	Same as above
102.5	107.5	2957	3116	U12	2957	3116	Same as above
107.5	112.5	3116	3273	U12	3116	3273	Same as above, clast content increases
112.5	117.5	3273	3390	U12	3273	3390	Same as above, but core is ripped due to a granite pebble
117.5	122.5	3390	3545	U12	3390	3545	Same as above, 5 cm pink sandstone clast at 3423 cm
122.5	127.5	3545	3701	U12	3545	3701	Same as above, increase in brown siltstone clasts
127.5	132.5	3701	3859	U12	3701	3859	Same as above, 5 cm siltstone at 3729 cm
132.5	137.5	3859	3992	U12	3859	3992	Same as above, 8 cm pink sandstone at 3895 cm
137.5	140	3992	4025	U12	3992	4025	Same as above

Hole no.: 93-SAB-010
Sheet: 83N/11
Zone: U11

UTM (n): 6168600
UTM (e): 472350
LDS: 13-12-77-23 W5

Elevation: 556 m
T.D.: 137.5 ft

Date Started: 26-08-1993
Date Completed: 27-08-1993

Core Length				ID	Core Interval		Description
Drilled (ft)		Measured (cm)					
From	To	From	To	Code	From	To	
0	2.5	0	92	Fill	0	57	Road fill
				U1	57	62	Oh/Of layer
				U2	62	65	Eluviated calcareous silty fine sand
				U3	65	78	B horizon, silty fine sand, massive, light yellow brown
				U4	78	92	B horizon, thinly laminated fine sand and silt, non calcareous, grey, brown and orange laminae
2.5	7.5	92	224	U4	92	102	Same as above, subtle lower contact
				U5	102	144	Silt, massive at top to thinly laminated at base, calcareous, mottled light grey, brown & orange, subtle lower contact
				U6	144	215	Laminated silt, clay and fine sand, calcareous, sharp lower contact
				U7	215	224	Clayey silt, compact, very thinly laminated, brown to dark grey, non calcareous, covoluted between 7.5-9'
7.5	12.5	224	379	U7	224	279	Same as above, sharp angled lower contact
				U8	279	333	Clayey silt, laminated and contorted, brown, grey and orange, fractured with gypsum crystals, sharp angled lower contact, subtle lower contact
				U9	333	379	Silty clay, massive with few thin and contorted stringers of silt, dark brown grey, fractured with gypsum crystals, non calcareous, appearance of red granules
12.5	17.5	379	539	U10	379	439	Similar to unit 9 above, greyer in colour, 0.75 cm granite dropstone, subtle lower contact
				U11	439	539	Alternating bands of silty clay and clayey silt about 25-35 cm thick, brown-grey to grey, brown units are calcareous, some convoluted beds, abundant gypsum crystals between 14.5-15.5', subtle lower contact
17.5	22.5	539	704	U12	539	704	Similar to above, no convoluted beds, darker grey, large subvertical fractures with gypsum crystals at 636 cm
22.5	27.5	704	870	U12	704	870	Same unit as above, more massive, increased abundance of granite and carbonate dropstones
27.5	32.5	870	1028	U12	870	1028	Same as above, vague lamination
32.5	37.5	1028	1186	U12	1028	1093	Same as above, sharp lower contact

Appendix 3 - Borehole Descriptions

Core Length				ID	Core Interval		Description
Drilled (ft)		Measured (cm)					
From	To	From	To	Code	From	To	
				U13	1093	1098	Similar to unit 12, but contains thicker fine silt bands, calcareous and water saturated, light brown grey colour, sharp lower contact
				U12	1098	1106	Same as unit 12 above
				U13	1106	1110	Same as unit 13 above
				U12	1110	1137	Same as unit 12 above
				U13	1137	1147	Same as unit 13 above
				U12	1147	1177	Same as unit 12 above
				U13	1177	1180	Same as unit 13 above
				U12	1180	1186	Same as unit 12 above
37.5	42.5	1186	1314	U13	1186	1268	Same as unit 13 above
				U14	1268	1314	Interbedded sequence of unit 12 and unit 13, each about 8-10 cm thick
42.5	47.5	1314	1469	U14	1314	1357	Same as above, sharp lower contact
				U15	1357	1469	Clayey silt, massive, compact, non calcareous, dark grey, pockets of light grey silt, tiny red granules
47.5	52.5	1469	1632	U15	1469	1478	Same as above, sharp lower contact
				U16	1478	1632	Clayey silt diamict, dark grey, gritty, small granules of weathered shale, siltstone, carbonate and sandstone
52.5	57.5	1632	1792	U16	1632	1792	Same as above, gradational lower contact
57.5	62.5	1792	1952	U17	1792	1952	Clayey silt till, similar in appearance to unit 16 but contains abundant granules and small pebbles (carbonate, shale, siltstone, chert)
62.5	67.5	1952	2111	U17	1952	2111	Same as above, more weathered granite and volcanic clasts
67.5	72.5	2111	2272	U17	2111	2272	Same as above
72.5	77.5	2272	2430	U17	2272	2430	Same as above
77.5	82.5	2430	2590	U17	2430	2590	Same as above, increasing amounts of igneous clasts
82.5	87.5	2590	2748	U17	2590	2748	Same as above, clasts still weathered
87.5	92.5	2748	2908	U17	2748	2908	Same as above, 4.5 cm red granite at 92', 6 cm brown quartzite at 90.5'
92.5	97.5	2908	3068	U17	2908	3068	Same unit as above
97.5	102.5	3068	3227	U17	3068	3227	Same as above, increased amount of dark grey shale clasts
102.5	107.5	3227	3385	U17	3227	3385	Same as above, larger clasts
107.5	112.5	3385	3441	U17	3385	3441	Same as above
112.5	117.5	3441	3453	U17	3441	3453	Same unit, but poor core recovery, shards of drill in core
117.5	122.5	3453	3467	U17	3453	3467	Same unit, but poor core recovery, shards of drill in core
122.5	127.5	0	0	U17	0	0	No core recovery, pushed drill plug to clear obstruction
127.5	132.5	0	156	U17	0	156	Same till as above
132.5	137.5	156	316	U17	156	316	Same as above

Hole no.: 93-SAB-013 UTM (n): 6295025
Sheet: 83N/13 UTM (e): 444475
Zone: U11 LDS: 4-5-80-25 W5

Elevation: 562 m Date Started: 28-08-1993
T.D.: 137.5 ft Date Completed: 28-08-1993

Core Length							
Drilled (ft)		Measured (cm)		ID	Core Interval		Description
From	To	From	To	Code	From	To	
0	2.5	0	102	U1	0	28	Interbedded silt and fine sand, brown, calcareous, contorted, sharp lower contact
				U2	28	40	Clayey silt, brown, calcareous, two large weathered gypsum pockets, sharp lower contact
				U3	40	102	Stratified clayey silt and silty sand, mottled light brown to dark brown grey, calcareous, water-saturated
2.5	7.5	102	259	U3	102	147	Same as above, sharp lower contact
				U4	147	174	Stratified clayey silt and silt, mottled orange brown, light brown and dark brown grey, calcareous, water-saturated, pockets of gypsum crystals, abrupt lower contact
				U5	174	259	Stratified massive light yellow silt and medium-dark brown fine sandy silt, laminae range from 1 to 170 mm, oxidized fractures with gypsum crystals, calcareous
7.5	12.5	259	416	U5	259	278	Same as above, sharp lower contact
				U6	278	374	Stratified brown fine sandy silt and orange brown to brown grey silty clay, silt units are massive, calcareous, 0.5 to 10 cm thick and water-saturated; clay unit is thinly laminated, calcareous, and oxidized along siltier planes, sharp lower contact
				U7	374	416	Silty fine sand, horizontal stratification, grey brown to orange brown, calcareous
12.5	17.5	416	524	U7	416	435	Same as above, sharp lower contact
				U6	435	462	Same as unit 6 above, sharp lower contact
				U7	462	472	Same as unit 7 above, sharp lower contact
				U8	472	524	Thinly laminated and convoluted silty clay and clayey silt, dark brown grey with some light brown, moderately calcareous, large gypsum rosettes, pocket of weathered pink sand, sharp lower contact
17.5	22.5	524	685	U8	524	535	Same as above, sharp lower contact
				U9	535	679	Massive dark grey silty clay, small lenses and granules of grey to pink fine sand, weakly calcareous, sharp lower contact
				U10	679	685	Stratified brown fine sandy silt, water-saturated and calcareous with laminae of grey silty clay and brown silt, laminae are horizontal to sinuous
22.5	27.5	685	803	U10	685	786	Same as above, sharp lower contact
				U9	786	803	Same as unit 9 above, larger silt pockets

Appendix 3 - Borehole Descriptions

Core Length				ID	Core Interval		Description
Drilled (ft)		Measured (cm)					
From	To	From	To	Code	From	To	
27.5	32.5	803	963	U9	803	873	Same as above, sharp lower contact
				U10	873	885	Same as unit 10 above, sharp lower contact
				U9	885	963	Same as unit 9 above, flasers of light beige silt, sharp lower contact
32.5	37.5	963	1125	U11	963	1018	Brown grey silt with contorted laminae and lenses of brown grey silt and clay, calcareous, water-saturated, sharp lower contact
				U9	1018	1125	Same as unit 9 above, thicker interfingering silt bands
37.5	42.5	1125	1275	U9	1125	1224	Same as unit 9 above, sharp lower contact
				U11	1224	1275	Same unit 11 as above
42.5	47.5	1275	1433	U11	1275	1282	Same unit 11 as above, sharp lower contact
				U9	1282	1433	Same unit 9 as above
47.5	52.5	1433	1588	U9	1433	1472	Same unit 9 as above, sharp angled lower contact
				U12	1472	1492	Massive, dark grey clayey silt till, weakly calcareous, weathered clasts of dark grey shale, brown carbonates, siltstone, sharp angled lower contact
				U9	1492	1507	Same unit 9 as above, sharp angles lower contact
				U12	1507	1516	Massive dark grey clayey silt till, weakly calcareous, weathered clasts of dark grey shale, brown carbonates, siltstone, sharp angled lower contact
				U9	1516	1530	Same unit 9 as above, sharp angled lower contact
				U12	1530	1545	Massive dark grey clayey silt till, weakly calcareous, weathered clasts of dark grey shale, brown carbonates, siltstone, sharp angled lower contact
				U13	1545	1588	Greenish grey calcareous silt, water-saturated with thin laminae of non calcareous dark grey silty clay
52.5	57.5	1588	1750	U13	1588	1591	Same as above unit 13, sharp lower contact
				U9	1591	1678	Same unit 9 as above, sharp slightly angular lower contact
				U13	1678	1750	Same unit 13 as above, less calcareous
57.5	62.5	1750	1893	U13	1750	1825	Same as above, sharp lower contact
				U9	1825	1834	Same unit 9 above, sharp lower contact
				U14	1834	1841	Similar to unit 13 but contains thicker and better defined laminae of silt and silty clay, some convolution, sharp lower contact
				U9	1841	1893	Same as unit 9 above, interfingering calcareous silt laminae
62.5	67.5	1893	2057	U9	1893	1983	Same as above, sharp lower contact
				U14	1983	2057	Same as unit 14 above, highly convoluted, calcareous
67.5	72.5	2057	2217	U14	2057	2137	Same as unit 14 above, sharp lower contact
				U15	2137	2217	Dark grey, silty to clayey till, non calcareous, small pockets of calcareous grey brown silt; abundant weathered granules and small pebbles of red granites, brown carbonates, quartzite, shale, siltstone and volcanics, very compact, vague lamination
72.5	77.5	2217	2377	U15	2217	2224	Same as unit 15 above, subtle slightly angular lower contact

Appendix 3 - Borehole Descriptions

Core Length							
Drilled (ft)		Measured (cm)		ID	Core Interval		Description
From	To	From	To	Code	From	To	
				U16	2224	2266	Massive, dark grey clayey-silt till, very gritty, abundant granules and small pebbles up to 3 cm, non calcareous, mafics, weathered siltstone, brown carbonates, red granites, black chert, grey shale, sharp lower contact
				U15	2266	2348	Same as unit 15 above, but more clayey, more clasts, weakly calcareous, sharp lower contact
				U17	2348	2369	Similar to unit 15 above, but stratified and lighter in colour, bands of light brown silty clay and grey brown silt, still a till with a few weathered granules, sharp lower contact
				U16	2369	2377	Massive clayey silt till, dark grey, lots of granules and pebbles, very weak to non calcareous, red granites, black cherts, brown carbonates, mafic volcanics, grey and brown shales, grey siltstone, brown quartzite
77.5	82.5	2377	2537	U16	2377	2537	Same as unit 16 above
82.5	87.5	2537	2699	U16	2537	2699	Same as unit 16 above
87.5	92.5	2699	2859	U16	2699	2859	Same as unit 16 above, 6 cm yellow quartzite at 90'
92.5	97.5	2859	3021	U16	2859	3021	Same as unit 16 above, appearance of pink sandstone, 6.5 cm brown-red quartzite at 2896 cm
97.5	102.5	3021	3179	U16	3021	3179	Same unit 16 as above
102.5	107.5	3179	3335	U16	3179	3335	Same unit 16 as above
107.5	112.5	3335	3496	U16	3335	3496	Same unit 16 as above, 5 cm brown quartzite at 112.5'
112.5	117.5	3496	3654	U16	3496	3654	Same unit 16 as above
117.5	122.5	3654	3814	U16	3654	3814	Same unit 16 as above
122.5	127.5	3814	3975	U16	3814	3975	Same unit 16 as above, seems to have fewer pebbles
127.5	132.5	3975	4135	U16	3975	4135	Same unit 16 as above, 4 cm beige siltstone at 3987 cm
132.5	137.5	4135	4297	U16	4135	4297	Same unit 16 as above, 5 cm brown quartzite at 4150 cm

Appendix 3 - Borehole Description

Hole no.: 93-SAB-014
Sheet: 83N/13
Zone: U11

UTM (n): 6191400
UTM (e): 465650
LDS: 13-21-79-23 W5

Elevation: 565 m
T.D.: 82.5 ft

Date Started: 29-08-1993
Date Completed: 29-08-1993

Core Length							Description
Drilled (ft)		Measured (cm)		ID	Core Interval		
From	To	From	To	Code	From	To	
0	7.5	0	87	fill	0	22	Fill, sharp lower contact
				U1	22	77	Thinly laminated light brown clayey silt, dark grey silty clay and white silt, calcareous, compact, subtle lower contact
				U2	77	87	Laminated and contorted light brown silty clay and dark grey silty clay, moderately to weakly calcaeous
7.5	12.5	87	243	U2	87	140	Same unit 2 as above, subtle lower contact
				U3	140	202	Laminated orange to beige calcareous silt and brown to dark grey weakly calcareous silty clay, laminae 1 to 10 mm, some contortion due to drilling, thicker silt unit between 166 cm and 171 cm, sharp lower contact
				U4	202	243	Laminated dark grey silty clay, light brown calcareous silt and orange brown silty clay, abundant organic flecks and gypsum crystals, moderately to weakly calcareous, a few weathered clasts of carbonates and siltstones
12.5	17.5	243	406	U4	243	292	Same unit 4 as above, sharp lower contact
				U5	292	324	Light brown to brown grey clayey silt, extensive fracturing and veining with gypsum crystals, weakly calcareous, fractures are calcareous, sharp lower contact
				U6	324	354	Contorted laminae of dark grey silty clay and orange brown clayey silt with gypsum crystals, oxidized areas are calcareous, rare granules, compact, sharp lower contact
				U7	354	406	Laminated clayey silt till, some contortion of laminae, dark brown grey to light brown, abundant gypsum crystals and some fracturing, several small pebbles and granules, weathered carbonates, siltstones, cherts and volcanics
17.5	22.5	406	559	U7	406	490	Same unit 7 as above, sharp lower contact
				U8	490	559	Massive, clayey silt till with vague lamination and mottling, grey brown to light brown, abundant gypsum crystals, small pebbles and granules, red granites, grey shale, yellow carbonates, orange and beige siltstones, non calcaeous
22.5	27.5	559	704	U8	559	704	Same unit 8 as above, but well defined lamination (1-5 mm), more granules
27.5	32.5	704	867	U8	704	867	Same unit 8 as above, blue staining and orange oxidization along fractures, pockets of white non calcareous powder

Appendix 3 - Borehole Description

Core Length				ID	Core Interval		Description
Drilled (ft)		Measured (cm)					
From	To	From	To	Code	From	To	
32.5	37.5	867	1022	U8	867	1022	Same unit 8 as above
37.5	42.5	1022	1173	U8	1022	1173	Same unit 8 as above
42.5	47.5	1173	1335	U8	1173	1185	Same unit 8 as above, sharp lower contact
				U9	1185	1210	Massive, dark grey clayey silt till, abundant small pebbles and granules, brown carbonates, red granite, grey shale, chert, gypsum crystals, sharp angled lower contact
				U8	1210	1315	Same unit 8 as above, more red to pink sandstone, becoming a darker grey colour, thick 1 cm laminae of yellow calcareous silt, sharp lower contact
				U10	1315	1335	Similar to unit 9 but contains very thin laminae of unit 8, abundant granules and small pebbles, moderately to weakly calcareous, sharp lower contact
47.5	52.5	1335	1495	U8	1335	1349	Same unit 8 as above, sharp lower contact
				U9	1349	1362	Same unit 9 as above, sharp lower contact
				U8	1362	1364	Same unit 8 as above, sharp lower contact
				U9	1364	1373	Same unit 9 as above, sharp lower contact
				U8	1373	1390	Same unit 8 as above, sharp lower contact
				U9	1390	1425	Same unit 9 as above, 6 cm red granite and 3 cm mafic volcanic at 1403 cm, gradational lower contact
				U10	1425	1437	Same unit 10 as above, more weathered than fresh clasts, gradational lower contact
				U8	1437	1495	Same unit 8 as above, sharp lower contact
52.5	57.5	1495	1652	U9	1495	1580	Same unit 9 as above, sharp lower contact
				U8	1580	1587	Same unit 8 as above, sharp lower contact
				U10	1587	1591	Same unit 10 as above, sharp lower contact
				U8	1591	1601	Same unit 8 as above, sharp lower contact
				U9	1601	1652	Same unit 9 as above
57.5	62.5	1652	1799	U9	1652	1658	Same unit 9 as above, sharp lower contact
				U8	1658	1693	Same unit 8 as above, core ripped and broken, lots of clasts, sharp lower contact
				U10	1693	1799	Similar to unit 10 above, silty layers very calcareous, same clast lithologies as before, sharp lower contact
62.5	67.5	1799	1952	U8	1799	1838	Same unit 8 as above, sharp lower contact
				U9	1838	1952	Dk grey massive till of unit 9, abundant small pebbles and granules, carbonates, shale, siltstones, pink sandstone, red granites, chert, sharp lower contact
67.5	72.5	1952	2108	U8	1952	1965	Same unit 8 as above, irregular lenses, angular and irregular lower contact
				U9	1965	2108	Same unit 9 as above, 9 cm red-brown siltstone at 1982 cm
72.5	77.5	2108	2268	U9	2108	2151	Same unit 9 as above, sharp lower contact
				U11	2151	2154	Massive, very fine sand, grey, calcareous, sharp lower contact
				U9	2154	2268	Same unit 9 as above
77.5	82.5	2268	2420	U9	2268	2420	Same unit 9 as above

Hole no.: 94-SAB-002
Sheet: 83N/5
Zone: U11

UTM (n): 6127225
UTM (e): 442375
LDS: 2-3-73-26 W5

Elevation: 647 m
T.D.: 20.0 ft

Date Started: 03-08-1994
Date Completed: 03-08-1994

Core Length							
Drilled (ft)		Measured (cm)		ID	Core Interval		Description
From	To	From	To	Code	From	To	
0	2.5	0	95	U1	0	14	Fine sandy silt till, abundant pebbles and granules, brown grey, weakly calcareous, subtle lower contact
				U2	14	95	Silty till, massive, weakly to non calcareous, abundant weathered clasts, carbonate and coal fragments, mottled grey, orange and brown
2.5	7.5	95	231	U2	95	195	Same unit 2 as above, subtle lower contact
				U3	195	231	Stratified silty clay till, very compact, non calcareous, weathered granules and clasts, mottled grey and brown
7.5	12.5	231	376	U3	231	352	Same unit 3 as above, possible siltstone zone near base, loses stratification down core, subtle lower contact
				U4	352	367	Clayey sand till, grey, strong bedrock component, non calcareous, very compact, gradational lower contact
				U5	367	376	Silty fine sandstone, grey, well sorted, upper contact is oxidized and grades into the till
12.5	20	376	499	U5	376	499	Same unit 5 as above

Hole no.: 94-SAB-004
Sheet: 83N/4
Zone: U11

UTM (n): 6102650
UTM (e): 444700
LDS: 1-22-70-26 W5

Elevation: 652 m
T.D.: 142.5 ft

Date Started: 03-08-1994
Date Completed: 04-08-1994

Core Length							
Drilled (ft)		Measured (cm)		ID	Core Interval		Description
From	To	From	To	Code	From	To	
0	2.5	0	67	U1	0	27	Silty fine sand, massive, medium brown, non calcareous, sharp lower contact
				U2	27	38	Silty clay till, massive, compact, brown with a slight grey tinge, non calcareous, several granules, sharp lower contact
				U3	38	59	Coarse sand, granules and small pebbles, poorly sorted, orange brown, calcareous, very sharp lower contact
				U4	59	67	Similar to unit 2 above, weakly calcareous, sharp lower contact
2.5	7.5	67	207	U5	67	112	Fine to medium sand, well sorted, coulour stratification of orange, grey and brown, water-saturated, sharp oxidized lower contact
				U6	112	207	Silty clay diamict, mottled brown and dark grey, rare granules, massive and very compact
7.5	12.5	207	369	U6	207	221	Same unit 6 as above, subtle lower contact
				U7	221	283	Silty clay till, dark grey with some lighter brown mottling, massive, a few granules and small pebbles, clasts are weathered, weakly to moderately calcareous, compact, gradational lower contact
				U8	283	316	Thinly laminated clay, dark grey and brown, weakly calcareous, laminae 2 mm thick, sharp lower contact
				U9	316	325	Silty clay diamict, mottled brown and dark grey with a pink tinge, abundant broken clasts, calcareous, sharp lower contact
				U10	325	369	Clayey silt till, very compact and massive, dark grey, weakly calcareous, abundant weathered and soft granules and small pebbles
12.5	17.5	369	528	U10	369	528	Same unit 10 as above, clasts are less weathered, more mafic crystalline clasts
17.5	22.5	528	620	U10	528	620	Same unit 10 as above
22.5	27.5	620	678	U10	620	678	Same unit 10 as above, very compact, more granules, core is ribboned due to 9 cm quartzite pebble
27.5	32.5	678	838	U10	678	838	Same unit 10 as above, green shale clasts appearing, very compact
32.5	37.5	838	991	U10	838	991	Same unit 10 as above, core is ribboned at base
37.5	42.5	991	1138	U10	991	1138	Same unit 10 as above, core is ribboned
42.5	47.5	1138	1298	U11	1138	1144	Fine sand, well sorted, dark grey, very calcareous, no apparent clasts, sharp lower contact

Appendix 3 - Borehole Descriptions

Core Length				ID Code	Core Interval		Description
Drilled (ft)		Measured (cm)					
From	To	From	To		From	To	
				U10	1144	1164	Same as unit 10 above, but strongly calcareous, sharp lower contact
				U11	1164	1166	Same as unit 11 above, sharp lower contact
				U10	1166	1193	Same as unit 10 above, sharp lower contact
				U11	1193	1195	Same as unit 11 above, sharp lower contact
				U10	1195	1279	Same as unit 10 above, sharp lower contact
				U11	1279	1281	Same as unit 11 above, sharp lower contact
				U10	1281	1298	Same as unit 10 above, subtle lower contact
47.5	52.5	1298	1460	U10/U11	1298	1402	Stratified unit 10 and 11
				U10	1402	1460	Same as unit 10 above, abundant granules, dark grey, strongly calcareous
52.5	57.5	1460	1619	U10	1460	1514	Same as unit 10 above, coulour stratification of dark grey and lighter grey, lighter grey areas are less calcareous than the dark grey layers, subtle lower contact
				U10/U11	1514	1535	Stratified unit 10 and 11
				U10	1535	1579	Same unit 10 as above, sharp lower contact
				U12	1579	1581	Clayey fine sand, yellowy beige, calcareous, sharp lower contact
				U10	1581	1592	Same as unit 10 above, sharp lower contact
				U13	1592	1596	Fine sand, well sorted, clean, pink tinge, calcareous, sharp lower contact
				U10	1596	1619	Same as unit 10 above, dark grey, lower half of core is ribboned
57.5	62.5	1619	1743	U10	1619	1743	Same unit 10 as above, core still ribboned
62.5	67.5	1743	1830	U10	1743	1830	Same unit 10 as above, core still ribboned
67.5	72.5	1830	1912	U10	1830	1912	Same unit 10 as above, core still ribboned
72.5	77.5	1912	2014	U10	1912	2014	Same unit 10 as above, core still ribboned
77.5	82.5	2014	2078	U10	2014	2078	Same unit 10 as above, core still ribboned
82.5	87.5	2078	2173	U10	2078	2173	Same unit 10 as above, core still ribboned
87.5	92.5	2173	2292	U10	2173	2292	Same unit 10 as above, core still ribboned
92.5	97.5	0	0	NCR	0	0	Plug sent down to dislodge obstruction
97.5	102.5	0	161	U10	0	161	Same as unit 10 above, massive, very compact, abundant granules and small pebbles, fewer weathered granules
102.5	107.5	161	321	U10	161	321	Same unit 10 as above
107.5	112.5	321	480	U10	321	480	Same unit 10 as above, abundant soft green shale granules (very calcareous)
112.5	117.5	480	640	U10	480	640	Same unit 10 as above
117.5	122.5	640	800	U10	640	800	Same unit 10 as above, still calcareous
122.5	127.5	800	920	U10	800	920	Same unit 10 as above, core is ribboned
127.5	137.5	0	0	NCR	0	0	Plug sent down to dislodge obstruction
137.5	142.5	0	160	U10	0	26	Same as unit 10 above, sharp lower contact
				U14	26	33	Massive silt, light grey, very calcareous, sharp lower contact
				U10	33	160	Same as unit 10 above

Hole no.: 94-SAB-006
Sheet: 83N/3
Zone: U11

UTM (n): 6103800
UTM (e): 487025
LDS: 16-24-70-22 W5

Elevation: 701 m
T.D.: 49.5 ft

Date Started: 04-08-1994
Date Completed: 04-08-1994

Core Length							
Drilled (ft)		Measured (cm)		ID	Core Interval		Description
From	To	From	To	Code	From	To	
0	2.5	0	76	U1	0	18	Silty clay diamict, very hard and compact, non calcareous, mottled dark grey and brown, some weathered granules, sharp lower contact
				U2	18	55	Laminated silt, dry and loose, light grey and dark grey, non calcareous, no granules, sharp lower contact
				U3	55	76	Silty clay, compact and rooty, a few weathered granules, possibly a diamict, non calcareous
2.5	7.5	76	208	U3	76	123	Same unit 3 as above, becomes calcareous after 84 cm, sharp lower contact
				U4	123	134	Fine sand and granules, poorly sorted, dry, loose, oxidized orange, calcareous, weathered cobble, sharp lower contact
				U5	134	208	Laminated silty clay till, light orange, green brown and grey brown , laminae 2-3 mm, very hard and compact, abundant weathered granules and clasts, coal, carb
							Hit obstacle in borehole, moved 3 ft over and drilled new hole to 7.5 ft, then resumed sampling
7.5	12.5	206	346	U5	206	231	Same unit 5 as above, sharp lower contact
				U6	231	236	Silt, dry and loose, light brown, weakly to non calcareous wavy and highly irregular lower contact
				U5	236	250	Same unit 5 as above, sharp lower contact
				U7	250	255	Laminated silty fine sand, light yellow to bright orange, well sorted, very calcareous, sharp lower contact
				U5	255	346	Same unit 5 as above
12.5	17.5	346	506	U5	346	506	Same unit 5 as above, darker in colour, more green brown, weakly calcareous
17.5	22.5	506	666	U5	506	666	Same unit 5 as above, very compact, calcareous light tan silt layer between 546 and 548 cm
22.5	27.5	666	821	U5	666	821	Same unit 5 as above, darkening in coulour, appearance of dark orange laminae and spots with gypsum crystals
27.5	32.5	821	981	U5	821	981	Same unit 5 as above
32.5	37.5	981	1128	U5	981	1101	Same unit 5 as above, lamination becoming more vague, subtle lower contact

Appendix 3 - Borehole Descriptions

Core Length				ID	Core Interval		Description
Drilled (ft)		Measured (cm)					
From	To	From	To	Code	From	To	
37.5	42.5	1128	1276	U6	1101	1128	Similar to unit 5 above, but dark grey in coulour and contains large blobs, granules and thin laminae of pale green fine sandy silty clayey diamict, non calcareous, still contains orange brown granules
				U6	1128	1132	Same unit 6 as above, sharp lower contact
				U7	1132	1178	Massive, clayey fine sand, blue grey, top of unit is oxidized orange, sharp lower contact
				U6	1178	1195	Similar to unit 6 above but a very dark grey coulour and laminated with unit 7
				U8	1195	1276	Massive clay till, dark grey, compact, non calcareous, several granules and pebbles, mica, coal and other fresh clasts
42.5	47.5	1276	1436	U8	1276	1346	Same unit 8 as above, subtle lower contact
				U6	1346	1360	Similar to unit 6 above, almost lense like, bluish clayey fine sand, suble lower contact
				U8	1360	1386	Same as unit 8 above, sharp lower contact
				U9	1386	1422	Thinly laminated blue grey silt, med gy silt and dark blue green silt, non calcareous, sharp lower contact
				U8	1422	1436	Same as unit 8 above
47.5	49.5	1436	1488	U8	1436	1488	Same as unit 8 above, hit dense coal clast at 49.5', drill could not move obstruction

Hole no.: 94-SAB-008
Sheet: 83N/3
Zone: U11

UTM (n): 6117700
UTM (e): 477150
LDS: 12-5-72-22 W5

Elevation: 780 m
T.D.: 22.5 ft

Date Started: 05-08-1994
Date Completed: 05-08-1994

Core Length							
Drilled (ft)		Measured (cm)		ID	Interval		Description
From	To	To	From	Code	From	To	
0	2.5	0	84	Om	0	2	Organic debris and leaves
				Ah/e	2	23	Clayey to silty, oxidized in places, sharp lower contact
				U1	23	60	Brown silty-clay till, clasts are weathered and limited in number, oxidized, non calcareous, subtle lower contact
				U2	60	84	Clayey silt till, gritty, green brown, massive, calcareous specks, broken and weathered clasts
2.5	7.5	84	178	U2	84	178	Same unit 2 as above, subtle lamination appears, clast content increases, white calcareous lenses and laminae, weathered granite, siltstone, coal
7.5	12.5	178	347	U2	178	184	Same unit 2 as above, sharp lower contact
				U3	184	309	Silty clay to clayey silt, vague lamination, weakly to moderately calcareous, green brown with orange flecks, laminae more apparent at base of unit, no clasts, sharp lower contact
				U4	309	347	Massive silty clay, non calcareous, dark green brown, no apparent clasts, sharp lower contact
12.5	17.5	347	487	U5	347	395	Massive clayey silt, green brown, no clasts, non calcareous, gradational and interlaminated lower contact
				U4	395	449	Same unit 4 as above, sharp lower contact
				U6	449	480	Laminated silty clay, several granules, dark brown grey and orange, top of unit is fragmented siltstone, weakly calcareous, sharp lower contact
				U7	480	487	Clayey silt, rare granules, dark brown grey, non calcareous, sharp lower contact
17.5	22.5	487	595	U8	487	595	Fine to medium sand (bedrock), well sorted, minor clay, thinly laminated, dark grey, very rare granules

Hole no.: 94-SAB-009
Sheet: 83N/3
Zone: U11

UTM (n): 6118250
UTM (e): 492150
LDS: 13-2-72-21 W5

Elevation: 648 m
T.D.: 132.5 ft

Date Started: 05-08-1994
Date Completed: 05-08-1994

Core Length				ID	Core Interval		Description
Drilled (ft)		Measured (cm)					
From	To	From	To	Code	From	To	
0	2.5	0	50	Fill	0	10	Road fill
				U1	10	50	Silty clay till, massive, dark brown grey with minor lighter brown mottling, abundant weathered clasts, calcareous flecks, generally non calcareous
2.5	7.5	50	210	U1	50	160	Same unit 1 as above, subtle lower contact
				U2	160	210	Similar to unit 1 above, but more clast-rich and browner in coulour, still mottled and massive, non calcareous, abundant coal fragments and gypsum crystals
7.5	12.5	210	370	U2	210	328	Same unit 2 as above, subtle lower contact
				U3	328	370	Silty clay till, grey with some lighter brown mottling, lots of gypsum crystals, smaller pebbles and granules, weakly calcareous
12.5	17.5	370	530	U3	370	530	Same unit 3 as above, darker grey, several small pebbles and granules, coal, sandstone, gypsum crystals, quartzite, carbonates, siltstone, granite
17.5	22.5	530	690	U3	530	690	Same unit 3 as above, dark brown grey, mottling is rare, vague lamination, no more gypsum crystals
22.5	27.5	690	850	U3	690	850	Same unit 3 as above, larger coal pebbles appearing
27.5	32.5	850	1004	U3	850	1004	Same unit 3 as above, more fresher clasts
32.5	37.5	1004	1130	U3	1004	1130	Same unit 3 as above, more green shale granules, several wispy and irregular calcareous silty laminae between 1159 and 1171 cm
37.5	42.5	1130	1290	U3	1130	1290	Same unit 3 as above, dark grey colour
42.5	47.5	1290	1414	U3	1290	1414	Same unit 3 as above
47.5	52.5	1414	1573	U3	1414	1573	Same unit 3 as above, silt lenses at 52' and a blue green sandstone clast at 1520 cm
52.5	57.5	1573	1733	U3	1573	1733	Same unit 3 as above
57.5	62.5	1733	1892	U3	1733	1892	Same unit 3 as above, more green soft shale clasts
62.5	67.5	1892	2051	U3	1892	2051	Same unit 3 as above, green clasts are larger
67.5	72.5	2051	2210	U3	2051	2210	Same unit 3 as above
72.5	77.5	2210	2370	U3	2210	2370	Same unit 3 as above, more coal pebbles, including one 4 cm at 2250 cm and a smaller one at 2314 cm
77.5	82.5	2370	2530	U3	2370	2530	Same unit 3 as above, becoming more clayey

Appendix 3 - Borehole Descriptions

Core Length							
Drilled (ft)		Measured (cm)		ID	Core Interval		Description
From	To	From	To	Code	From	To	
82.5	87.5	2530	2680	U3	2530	2680	Same unit 3 as above, now a clay till
87.5	92.5	2680	2803	U3	2680	2803	Same unit 3 as above, 3.5 cm quartzite at 2801 cm
92.5	97.5	2803	2962	U3	2803	2962	Same unit 3 as above
97.5	102.5	2962	3122	U3	2962	3122	Same unit 3 as above
102.5	117.5	0	0	NCR	0	0	Sent plug down to dislodge obstruction
117.5	122.5	0	159	U3	0	159	Same as unit 3 above, dark grey, massive, several large pebbles, mafic volcanics, granite
122.5	127.5	159	319	U3	159	319	Same unit 3 as above
127.5	132.5	319	479	U3	319	479	Same unit 3 as above

Hole no.: 94-SAB-010
Sheet: 83N/6
Zone: U11

UTM (n): 6136250
UTM (e): 474150
LDS: 13-36-73-23 W5

Elevation: 657 m
T.D.: 47.5 ft

Date Started: 08-08-1994
Date Completed: 08-08-1994

Core Length							
Drilled (ft)		Measured (cm)		ID	Core Interval		Description
From	To	From	To	Code	From	To	
0	2.5	0	84	U1	0	33	Silty-clay diamict, possibly disturbed, mottled brown and grey, several weathered clasts, sharp lower contact
				U2	33	42	Very fine sand and silt, light brown grey, loose, dry, non calcareous, sharp lower contact
				U3	42	48	Peaty, organic rich, black band, non calcareous, sharp lower contact
				U2	48	63	Same as unit 2 above, sharp lower contact
				U4	63	84	Clayey silt, massive, mottled orange brown and light green brown, weakly calcareous, sharp lower contact
2.5	7.5	84	184	U5	84	110	Disturbed silty-clay till mixed with poorly-sorted, orange oxidized coarse sand and gravel, abundant organic chunks, subtle lower contact
				U6	110	164	Silty-clay till from unit 5 above, mottled dark grey and dark brown, abundant soft and weathered granules and pebbles, small pockets of sand, weakly to non calcareous, sharp lower contact
				U7	164	184	Clayey silt, mottled orange and dark grey brown, rare granules, calcareous
7.5	12.5	184	334	U7	184	247	Same unit 7 as above, sharp lower contact
				U6	247	270	Same as unit 6 above, subtle lower contact
				U8	270	275	Similar to unit 6 above, but contains four calcareous and light tan silt laminae (0.7 mm each), subtle lower contact
				U6	275	334	Same as unit 6 above, sandy patches appearing
12.5	17.5	334	459	U6	334	459	Same unit 6 as above
17.5	22.5	459	551	U6	459	469	Same unit 6 as above, sharp lower contact
				U9	469	551	Laminated, clean, poorly to moderately sorted, tan to brown fine sand and orange to grey brown silty to clayey fine sand, weakly calcareous, sharp lower contact
22.5	27.5	551	625	U10	551	625	Massive silty-clay till, dark grey, weakly calcareous, abundant granules, pebbles and cobbles, 9 cm carbonate at 625 cm
27.5	32.5	625	786	U10	625	786	Same unit 10 as above
32.5	37.5	786	946	U10	786	943	Same unit 10 as above, sharp lower contact
				U11	943	946	Clayey fine sand and gravel, poorly sorted, oxidized, contains chunks of unit 10

Appendix 3 - Borehole Descriptions

Core Length				ID	Core Interval		Description
Drilled (ft)		Measured (cm)					
From	To	From	To	Code	From	To	
37.5	42.5	946	1104	U11	946	961	Same unit 11 as above, sharp lower contact
				U12	961	1104	Siltstone (bedrock) thinly laminated, brown, very compact and hard, gradational lower contact
42.5	47.5	1104	1224	U13	1104	1144	Same as unit 12 above, but grades from brown to green downcore
				U14	1144	1224	Same as unit 12 above, but green

Appendix 3 - Borehole Description

Hole no.: 94-SAB-011
Sheet: 83N/12
Zone: U11

UTM (n): 6152700
UTM (e): 444900
LDS: 14-19-75-25 W5

Elevation: 620 m
T.D.: 69.5 ft

Date Started: 08-08-1994
Date Completed: 08-08-1994

Core Length							
Drilled (ft)		Measured (cm)		ID	Core Interval		Description
From	To	From	To	Code	From	To	
0	2.5	0	91	Fill	0	39	Sandy mangled diamict
				U1	39	48	Loamy, organic rich, black mat, non calcareous, sharp lower contact
				U2	48	91	Mottled clayey silt till with some sand, orange brown , grey and brown, non calcareous, abundant granules and gypsum crystals, massive and compact
2.5	7.5	91	251	U2	91	251	Same unit 2 as above
7.5	12.5	251	378	U2	251	378	Same unit 2 as above, losing some of the orange coulour, less calcareous, clasts still weathered
12.5	17.5	378	539	U2	378	439	Same unit 2 as above, gradational lower contact
				U3	439	539	Massive silty clay till, dark grey, compact, abundant shield and carbonate clasts and granules, weakly calcareous
17.5	22.5	539	692	U3	539	692	Same unit 3 as above, lots of granite, carbonates, mafic, chert and coal clasts, 7cm carbonates at 692 cm and 612 cm
22.5	27.5	692	851	U3	692	851	Same unit 3 as above
27.5	32.5	851	998	U3	851	913	Same unit 3 as above, sharp lower contact
				U4	913	944	Fine sand, well sorted, wet, blue grey, non calcareous, sharp lower contact
				U3	944	996	Same as unit 3 above, but contains thin lenses of unit 4, sharp lower contact
				U4	996	998	Same as unit 4 above, sharp lower contact
32.5	37.5	998	1160	U5	998	1010	Massive silty till, dark grey, similar in clast composition as unit 3 above, sharp lower contact
				U3	1010	1160	Same as unit 3 above
37.5	42.5	1160	1320	U3	1160	1211	Same as unit 3 above, sharp lower contact
				U4	1211	1214	Same as unit 4 above, sharp lower contact
				U3	1214	1247	Same as unit 3 above, sharp lower contact
				U5	1247	1251	Same as unit 5 above, sharp lower contact
				U3	1251	1320	Same as unit 3 above
42.5	47.5	1320	1479	U3	1320	1479	Same unit 3 as above
47.5	52.5	1479	1637	U3	1479	1637	Same unit 3 as above

Appendix 3 - Borehole Description

Core Length							
Drilled (ft)		Measured (cm)		ID	Core Interval		Description
From	To	From	To	Code	From	To	
52.5	57.5	1637	1795	U3	1637	1795	Same unit 3 as above, 4.5 cm granite at 1700 cm
57.5	62.5	1795	1955	U3	1795	1874	Same unit 3 as above, subtle lower contact
				U6	1874	1936	Similar silty clay till as unit 3 but contains abundant bands and specks of silty material similar to unit 4, gradational lower contact
				U7	1936	1955	Banded silt (possibly siltstone), dense and compact, no granules, dark grey and light grey
62.5	67.5	1955	2112	U7	1955	2112	Same unit 7 as above
67.5	69.5	2112	2217	U7	2112	2217	Same unit 7 as above

Hole no.: 94-SAB-012
Sheet: 83N/14
Zone: U11

UTM (n): 6181375
UTM (e): 490225
LDS: 13-23-78-21 W5

Elevation: 594 m
T.D.: 74.0 ft

Date Started: 09-08-1994
Date Completed: 09-08-1994

Core Length							
Drilled (ft)		Measured (cm)		ID	Core Interval		Description
From	To	From	To	Code	From	To	
0	2.5	0	75	Fill	0	5	Road fill
				Om	5	12	Organic mat
				U1	12	75	Silty clay diamict, vague lamination, mottled dark grey, dark brown and med brown, non calcareous, small clasts
2.5	7.5	75	238	U1	75	90	Same as unit 1 above, subtle lower contact
				U2	90	238	Massive silty clay till, weakly calcareous, mottled brown and dark brown grey, weathered clasts, siltstone, carbonates, shale, coal, granite
7.5	12.5	238	398	U2	238	362	Same as unit 2 above, subtle lower contact
				U3	362	398	Similar to unit 2 above, but thickly laminated (2-5 mm), light brown and dark grey brown, non calcareous, sharp lower contact
12.5	17.5	398	558	U4	398	534	Similar to unit 2 above, but splotchy in appearance, dark brown grey and brown, subtle lower contact
				U3	534	558	Same as unit 3 above, sharp lower contact
17.5	22.5	558	717	U4	558	591	Same as unit 4 above, subtle lower contact
				U5	591	661	Same as unit 4 above, but contains abundant gypsum crystals in pockets and veins, subtle lower contact
				U6	661	717	Similar to unit 3 above, but contains abundant gypsum crystals, weakly calcareous, subtle lower contact
22.5	27.5	717	878	U5	771	786	Same as unit 5 above, sharp lower contact
				U7	786	820	Massive silty clay till, dark grey, mainly fresh clasts, sandstone, shale, granite, carbonates, mafic volcanics, siltstone, weakly calcareous, subtle lower contact
				U5	820	840	Same as unit 5 above, subtle lower contact
				U7	840	878	Same as unit 7 above
27.5	32.5	878	1027	U7	878	1027	Same unit 7 as above
32.5	37.5	0	0	NCR	0	0	Drilled through footage
37.5	42.5	0	159	U7	0	45	Same unit 7 as above, sharp lower contact

Appendix 3 - Borehole Descriptions

Core Length				ID	Core Interval		Description
Drilled (ft)		Measured (cm)					
From	To	From	To	Code	From	To	
				U8	45	159	Laminated silty clay till, orange to green brown and dark grey, browner laminae are moderately to strongly calcareous, grey portions are weakly calcareous, some gypsum crystals, lots of clasts, often weathered, sharp lower contact
42.5	47.5	159	311	U7	159	186	Same unit 7 as above, sharp lower contact
				U9	186	200	Massive silt, rare small pebbles and granules, green grey, calcareous, sharp lower contact
				U7	200	311	Same as unit 7 above
47.5	52.5	311	470	U7	311	470	Same unit 7 as above, 6 cm granite at 370 cm, 6 cm carbonate at 450 cm
52.5	57.5	470	629	U7	470	629	Same unit 7 as above, 4 cm brown quartzite at 493 cm, 4 cm blue-green carbonate at 517 cm
57.5	62.5	629	789	U7	629	789	Same unit 7 as above
62.5	67.5	789	948	U7	789	948	Same unit 7 as above, 5 cm pink granite at 851 cm
67.5	72.5	948	1107	U7	948	1107	Same unit 7 as above, some blebs and thin laminae of light grey silt
72.5	73.5	1107	1132	U7	1107	1132	Same unit 7 as above, extremely compact
73.5	74	0	0	NCR	0	0	Put plug in borehole to clear obstruction if present, too compact to drill further, may have hit a dark grey siltstone

Hole no.: 94-SAB-014
Sheet: 83N/6
Zone: U11

UTM (n): 6143725
UTM (e): 489900
LDS: 9-28-74-21 W5

Elevation: 581 m
T.D.: 97.5 ft

Date Started: 07-08-1994
Date Completed: 07-08-1994

Core Length							
Drilled (ft)		Measured (cm)		ID	Interval		Description
From	To	From	To	Code	From	To	
0	2	0	51	U1	0	51	Fine to medium sand with granules and pebbles, poorly sorted, brown, calcareous, likely fill, moved drill 3 times
0	7.5	0	115	U1	0	25	New site, same unit 1 as above, sharp lower contact
				U2	25	115	Silty clay till, laminated brown and dark grey, clast rich at top of unit, clast content increases downcore, weathered granules and small pebbles, layers are weakly to strongly calcareous
7.5	12.5	115	258	U2	115	258	Same unit 2 as above, browner in coulour, very compact, laminae 2-5 mm, mildly calcareous
12.5	17.5	258	418	U2	258	418	Same unit 2 as above, still laminated, more coal clasts and gypsum crystals, abundant soft weathered clasts
17.5	22.5	418	578	U2	418	578	Same unit 2 as above, darker grey in coulour, still laminated, abundant oxidized fractures with gypsum crystals, mafic volcanics, granite, soft siltstone, carbonates
22.5	27.5	578	737	U2	578	737	Same unit 2 as above, laminae up to 7 cm in thickness
27.5	32.5	737	892	U2	737	892	Same unit 2 as above, but layers of laminated till and dark grey till, 737-798 cm is dark grey till with rare brown laminae, 798 cm to 804 cm is laminated, 804 cm to 840 cm is dark grey till, 840 cm to 892 is laminated, pockets of gypsum crystals
32.5	37.5	892	1004	U2	892	976	Same unit 2 as above, laminated, subtle lower contact
				U3	976	1004	Silty clay till, dark grey, similar to the dark grey till of unit 2, mildly calcareous, abundant granules and small pebbles
37.5	42.5	1004	1163	U3	1004	1163	Same unit 3 as above, massive, very compact, abundant fresh clasts
42.5	47.5	1163	1322	U3	1163	1322	Same unit 3 as above, some green sandy clasts
47.5	52.5	1322	1482	U3	1322	1482	Same unit 3 as above
52.5	57.5	1482	1599	U3	1482	1599	Same unit 3 as above
57.5	62.5	1599	1759	U3	1599	1759	Same unit 3 as above, appearance of ironstone granules
62.5	67.5	1759	1919	U3	1759	1919	Same unit 3 as above, more pebble rich
67.5	72.5	1919	2078	U3	1919	2078	Same unit 3 as above, appearance of dark grey shale clasts
72.5	77.5	2078	2238	U3	2078	2238	Same unit 3 as above

Appendix 3 - Borehole Descriptions

Core Length							
Drilled (ft)		Measured (cm)		ID	Interval		Description
From	To	From	To	Code	From	To	
77.5	82.5	2238	2393	U3	2238	2393	Same unit 3 as above, appearance of green silty patches
82.5	87.5	2393	2553	U3	2393	2553	Same unit 3 as aobve, several small coal clasts and silt lenses
87.5	92.5	2553	2713	U3	2553	2713	Same as unit 3 above, no more silt lenses
92.5	97.5	2713	2871	U3	2713	2764	Same as unit 3 above, subtle lower contact
				U4	2764	2776	Same material as unit 3 above, but core ripped apart by fragments and laminae of green sandstone, subtle lower contact
				U3	2776	2826	Same as unit 3 above, subtle lower contact
				U5	2826	2846	Same dark till of unit 3 above laminated with well-sorted, olive green fine sand, gradational and interlaminated lower contact
				U6	2846	2871	Fine sand, few granules, well sorted, olive green, compact

Hole no.: 94-SAB-015
Sheet: 83N/4
Zone: U11

UTM (n): 6110575
UTM (e): 460725
LDS: 1-16-71-24 W5

Elevation: 716 m
T.D.: 78.0 ft

Date Started: 19-08-1994
Date Completed: 19-08-1994

Core Length							
Drilled (ft)		Measured (cm)		ID	Core Interval		Description
From	To	From	To	Code	From	To	
0	2.5	0	42	Ah	0	11	Massive, silty clay, calcareous, dark brown, rooty, sharp lower contact
				U1	11	18	Medium sand and gravel, poorly sorted, dark brown, calcareous, well rounded quartzites and sandstones, sharp lower contact
				U2	18	20	Silty clay, dark brown, calcareous, sharp lower contact
				U3	20	24	Clayey silt, mottled green grey and black, weakly calcareous, sharp lower contact
				U4	24	32	Massive silty clay, weakly to non calcareous, green grey, sharp lower contact
				U3	32	42	Same as unit 3 above
2.5	7.5	42	107	U3	42	93	Same as unit 3 above, lower contact uncertain due to mangled core
				U5	93	107	Massive and mottled silty clay till, orange and dark brown grey, weakly calcareous, abundant weathered and oxidized clasts, lower contact uncertain
7.5	9	0	0	NCR	0	0	Drilled to remove obstruction, no core recovery
9	14	0	159	U6	0	159	Silty clay till, mottled, massive to vague lamination, dark grey and light brown, abundant weathered granules, carbonates, shale, diorite, granite, mafics, weakly calcareous, subtle lower contact
14	18	159	237	U6a	159	237	Same till as unit 6, but coulour lamination very pronounced, laminae 0.5 to 3 cm, more calcareous, fresher pebbles, some orange medium sand pockets, lower contact uncertain
18	23	237	317	U7	237	317	Massive silty clay till, dark grey, ribboned, abundant fresh granules and small pebbles, calcareous, lower contact uncertain
23	28	0	0	NCR	0	0	Drilled to remove obstruction, no core recovery
28	33	0	158	U8	0	158	Massive, silty clay till, dark grey, weakly calcareous, quartzites, mafic volcanics, green shale, yellow shale, brown siltstone, carbonates, granite, coal, very compact
33	38	158	209	U8	158	209	Same unit 8 as above, coal clasts are larger
38	43	209	368	U8	209	368	Same unit 8 as above, layer of granules of dark brown shale, green siltstone and coal between 209 and 259 cm
43	48	368	527	U8	368	527	Same unit 8 as above
48	53	527	667	U8	527	667	Same unit 8 as above, 8 cm beige sandstone at 556 cm
53	58	667	825	U8	667	770	Same unit 8 as above, sharp lower contact

Appendix 3 - Borehole Descriptions

Core Length							
Drilled (ft)		Measured (cm)		ID	Core Interval		Description
From	To	From	To	Code	From	To	
				U9	770	825	Massive, clayey silt till, lighter grey than unit 8, but still dark, very granule-rich, weathered clasts, orange siltstone, brown shale, green shale, coal, very compact
58	63	825	978	U9	825	968	Same unit 9 as above, but increase in dark grey shale clasts, more sandy, gradational lower contact
				U10	968	978	Clayey silt diamict, abundant dark grey shale granules, no other lithologies present, very compact non to weakly calcareous
63	68	978	1183	U10	978	1031	Same unit 10 as above, subtle lower contact
				U10a	1031	1045	Similar to unit 10 above, but contains white laminae (3 mm), non calcareous, subtle lower contact
				U10	1045	1100	Same as unit 10 above, sharp lower contact
				U11	1100	1183	Massive, dark grey clay-silt with light grey silt flecks (possibly siltstone), very compact, non calcareous, sharp lower contact
68	73	1183	1313	U12	1183	1205	Silty to clayey sand, almost gravelly, possibly a diamict, dark black, dark grey shale clasts, lower contact gradational
				U12a	1205	1238	Similar to unit 12, but interlaminated with unit 13, coulour lightens downcore, lower contact is gradational
				U13	1238	1275	Laminated grey clayey silt and lighter grey silt, becomes slightly greener downcore, occasional lenses with coal granules near the base of the unit, gradational lower contact
				U14	1275	1313	Clayey siltstone, massive, green with lighter green silt flecks, non calcareous, gradational lower contact
73	78	1313	1420	U14a	1313	1356	Similar to unit 14 above, but like a diamict, shale clasts in a siltstone matrix, gradational lower contact
				U14	1356	1403	Same as unit 14 above, but grades colour-wise into a dark red grey brown and lighter red brown, gradational lower contact
				U15	1403	1420	Siltstone, similar to unit 14 above, but dark red grey brown and lighter red brown

APPENDIX 4

GRANULOMETRIC DATA

SECTION	Depth (m)	Sand %	Silt %	Clay %	Graphic Mean	Standard Deviation	Material
93-SB-05a	0.80	25	35	40	7.97	5.53	Loamy till
93-SB-05b	1.75	27	39	34	8.93	7.01	Loamy till
93-SB-05c	2.60	28	39	33	12.93	12.03	Loamy till
93-SB-06a	0.50	12	25	63	13.15	8.23	Silty clay till
93-SB-06b	0.88	1	14	85	24.43	13.76	Clayey diamict
93-SB-06c	0.50	37	17	46	7.43	6.16	Silty clay diamict
93-SB-07a	0.85	6	15	79	8.70	2.18	Clay
7a dup	0.85	6	14	80	8.90	2.22	Clay
93-SB-07b	1.55	6	21	73	14.48	8.73	Silty clay diamict
93-SB-08a	0.80	8	18	74	16.90	10.26	Silty clay till
93-SB-08b	1.90	6	23	71	14.65	8.87	Silty clay till
93-SB-09b	2.25	21	44	35	7.07	4.01	Loamy till
93-SB-10a	1.35	22	41	37	7.17	4.15	Loamy till
93-SB-10b	2.60	22	39	39	7.07	3.92	Loamy till with fine sand lenses
93-SB-11b	4.70	2	19	79	11.37	4.15	Clayey diamict
93-SB-11c	6.10	3	22	75	10.27	3.33	Clayey diamict
93-SB-11d	6.90	23	48	29	6.32	3.52	Loamy till
93-SB-11e	8.00	22	48	30	6.60	3.74	Loamy till
93-SB-26a	1.25	31	41	28	5.63	2.83	Loamy till
93-SB-26b	2.20	22	33	45	7.35	3.81	Loamy till
93-SB-26c	1.80	25	33	42	7.27	3.55	Loamy diamict (flow)
93-SB-32	0.79	24	35	41	7.13	4.14	Loamy till
93-SB-38a	1.35	37	39	24	5.63	3.67	Loamy till
93-SB-38b	1.95	23	29	48	8.20	5.02	Loamy till
93-SB-38c	3.00	26	42	32	6.42	3.60	Loamy till
93-SB-39a	0.60	7	8	85	17.70	11.84	Clayey diamict
93-SB-39b	1.35	15	21	64	9.07	3.57	Silty clay till
93-SB-39c	2.00	19	26	55	10.07	6.93	Silty clay till
93-SB-39d	3.10	19	24	57	11.10	8.14	Silty clay till
93-SB-40a	1.15	21	22	57	7.87	3.74	Loamy till with laminated silt and clay
93-SB-40b	1.30	34	31	35	16.08	16.88	Loamy till
93-SB-40c	2.20	37	22	41	10.93	11.38	Loamy till with sand
93-SB-41a	0.45	23	23	54	8.23	4.61	Loamy till
41a dup	0.45	23	26	51	9.30	6.68	Loamy till
93-SB-41b	1.15	15	25	60	8.97	3.90	Silty clay till
41b dup	1.15	12	16	72	11.73	5.74	Silty clay till
93-SB-42a	0.48	26	17	57	13.50	12.17	Sandy clay till with fine sand lenses
42a dup	0.48	27	18	55	17.07	15.99	Sandy clay till with fine sand lenses
93-SB-42b	1.00	27	28	45	8.43	6.01	Loamy till
42b dup	1.00	25	25	50	13.30	12.34	Loamy till
93-SB-43a	1.50	24	25	51	9.83	7.19	Loamy till
43a dup	1.50	25	27	48	8.90	6.91	Loamy till
93-SB-43b	2.35	26	24	50	9.75	7.77	Loamy till with fine sand-silt laminae
43b dup	2.35	25	26	49	10.85	9.48	Loamy till with fine sand-silt laminae
93-SB-44a	1.00	14	41	45	8.45	4.00	Silty clay till
44a dup	1.00	24	26	50	7.93	4.85	Loamy till
93-SB-44b	1.30	26	20	54	8.47	5.45	Loamy till
44b dup	1.30	17	40	43	8.67	6.24	Silty clay till
93-SB-46	1.10	4	26	70	10.03	3.73	Silty clay diamict
93-SB-47a	0.40	23	24	43	8.78	6.66	Loamy till
93-SB-47b	1.30	27	44	29	6.38	3.63	Loamy till with fine sand pockets
93-SB-48	1.00	14	34	52	9.53	5.72	Silty clay till
93-SB-50a	0.80	16	34	50	7.10	2.45	Silty clay till
93-SB-50b	1.40	25	43	32	7.03	5.00	Loamy till with fine sand
93-SB-51	1.70	3	42	55	7.58	2.34	Silty clay till
93-SB-52a	1.15	10	29	61	8.87	3.63	Silty clay till
93-SB-52b	2.50	21	33	46	7.50	4.15	Loamy till
93-SB-52c	3.50	16	32	52	7.92	3.53	Silty clay till
93-SB-53a	1.10	6	22	72	9.25	2.55	Silty clay till
93-SB-53b	2.05	7	23	70	9.32	3.07	Silty clay till
93-SB-53c	3.25	23	23	44	8.17	6.44	Loamy till
93-SB-55a	0.73	18	35	47	10.52	7.70	Silty clay till
93-SB-55b	0.95	10	33	57	9.77	5.23	Silty clay till
93-SB-56	1.00	16	40	44	8.27	4.85	Silty clay till
93-SB-62	1.65	16	33	51	8.38	4.39	Silty clay diamict
93-SB-65a	1.35	21	39	40	7.72	4.84	Loamy till with fine sand lenses
94-dune	0.50	83	7	10	3.32	1.89	Sand
94-SB-01b	2.12	23	39	38	7.18	4.04	Loamy till with fine to medium sand stringers
94-SB-02	1.20	4	16	80	28.90	19.26	Clayey till with silt laminae
94-SB-03b	1.35	28	30	42	6.85	3.84	Loamy till
94-SB-04c	1.40	17	23	60	10.22	6.40	Silty till

SECTION	Depth (m)	Sand %	Silt %	Clay %	Graphic Mean	Standard Deviation	Material
94-SB-05	1.25	18	34	48	8.08	4.10	Silty till
94-SB-07	0.80	24	27	49	7.75	4.30	Loamy till
94-SB-10	1.20	22	31	47	7.38	3.71	Loamy till
94-SB-11b	0.90	21	43	36	7.30	4.17	Loamy till with fine sand laminae
94-SB-15	1.00	13	27	67	7.88	2.51	Silty till
94-SB-16b	0.70	12	21	67	9.35	3.80	Laminated silty clay
94-SB-18	0.75	9	20	71	10.70	4.87	Silty till
94-SB-21f	2.00	22	32	46	12.25	10.77	Loamy till
94-SB-23	1.00	22	31	47	8.08	4.77	Loamy till
94-SB-24b	0.95	12	24	64	9.80	4.85	Silty till
94-SB-25b	1.20	23	32	45	8.17	5.50	Loamy till
94-SB-26ac	1.50	5	15	80	29.02	19.22	Clayey till
94-SB-26b	3.05	10	20	70	11.57	6.00	Silty till
94-SB-28	1.15	24	29	47	7.43	4.07	Loamy till
94-SB-29e	2.00	19	34	47	8.10	4.32	Silty clay diamict
94-SB-29h	0.80	23	29	48	8.42	5.69	Loamy till
94-SB-30b	1.30	25	34	41	7.32	4.53	Loamy till
94-SB-32	1.05	7	14	79	10.13	3.28	Clayey waterlain till
94-SB-35a	0.65	24	31	45	7.35	4.10	Loamy till
94-SB-35c	2.30	26	31	43	7.40	4.78	Loamy till
94-SB-36	0.75	24	30	46	8.62	5.91	Loamy waterlain till with sand
94-SB-37	0.90	26	31	43	7.17	4.01	Loamy till
94-SB-39	1.15	10	21	69	9.17	2.96	Silty till laminae
94-SB-40	1.15	22	29	49	8.02	4.56	Loamy till
94-SB-41	1.40	9	25	66	9.97	4.30	Silty till with marl laminae
94-SB-42b	1.80	23	34	43	7.20	3.69	Loamy till
94-SB-43	1.00	14	28	58	9.22	4.68	Silty till
94-SB-45b	1.30	8	14	78	12.38	5.17	Clayey diamict
94-SB-46b	1.25	21	44	35	8.92	6.58	Loamy diamict
94-SB-47	1.00	16	37	47	8.05	4.06	Silty till
94-SB-48	1.00	10	20	70	11.90	6.15	Silty till
94-SB-49	1.05	11	30	59	9.87	5.15	Silty clay diamict
94-SB-50c	1.30	9	18	73	11.27	5.14	Silty till
94-SB-51b	1.55	13	27	60	9.33	4.52	Silty till
94-SB-52a	0.75	13	28	59	8.88	3.98	Silty till
94-SB-52b	1.40	12	29	59	9.18	4.16	Silty till
94-SB-54b	0.35	17	24	59	8.47	3.95	Silty till
94-SB-55b	1.00	33	17	50	7.97	4.72	Silty clay till
94-SB-58	1.40	42	31	27	5.43	3.50	Loamy till
94-SB-60	1.30	21	34	45	7.43	3.94	Loamy till
94-SB-61b	1.30	26	31	43	7.27	3.97	Loamy till
94-SB-62	1.10	13	28	59	9.85	5.53	Silty till
94-SB-64b	1.65	21	34	45	9.12	6.46	Loamy till
94-SB-66c	1.60	20	31	49	7.35	3.31	Silty till
94-SB-71	1.10	8	19	72	10.22	3.80	Silty till
94-SB-72	1.20	18	30	52	7.75	3.57	Silty till
94-SB-73b	5.70	12	41	37	7.38	4.60	Loamy till
94-SB-74b	1.10	11	22	67	9.60	3.93	Silty till
94-SB-74d	3.50	22	41	37	6.85	3.40	Loamy till
94-SB-75a	2.00	25	33	42	7.82	4.88	Loamy till with silt stringers
94-SB-75c	7.50	28	34	38	6.60	3.52	Loamy till with stringers
94-SB-76c	2.20	25	32	43	7.63	4.76	Loamy till
94-SB-77	0.75	20	33	45	7.75	4.04	Silty till with fine sand stringers
94-SB-78	1.05	23	27	50	7.92	4.21	Loamy till
94-SB-79	1.00	18	49	33	7.30	3.99	Clay silt waterlain till
94-SB-80	1.05	23	33	44	8.08	5.77	Loamy till
94-SB-81	1.50	47	29	24	5.45	3.77	Loamy till
94-SB-91a	4.10	27	28	45	7.77	4.76	Loamy till
94-SB-91b	7.40	25	36	39	7.25	4.33	Loamy till

SECTION	Depth (m)	Sand %	Silt %	Clay %	Graphic Mean	Standard Deviation	Material
Drill Core							
93-SAB-06	3.35	2	15	83	11.60	3.69	Laminated clays
	5.79	2	16	82	10.53	2.64	Clay diamict, laminae
	8.53	23	39	38	7.38	4.75	Loamy till, laminae
	9.91	22	38	40	7.63	4.78	Loamy till
	12.65	21	39	40	7.37	4.36	Loamy till
	15.39	21	39	40	7.20	3.99	Loamy till
	19.05	21	41	38	7.60	4.68	Loamy till
	21.79	21	37	42	7.37	4.01	Loamy till
	24.54	20	38	42	7.87	4.73	Loamy till
	27.28	21	39	40	8.53	6.04	Loamy till
	30.02	21	38	41	8.00	5.07	Loamy till
	32.77	21	35	44	7.33	3.80	Loamy till
	39.01	23	36	41	8.13	5.44	Loamy till
	41.76	25	34	41	7.98	5.71	Loamy till
	44.50	24	34	42	8.23	5.82	Loamy till
93-SAB-13	14.94	1	20	79	10.40	2.63	Clayey diamict
	20.57	0	55	45	8.52	3.47	Clayey silt laminae, convoluted
	21.34	7	23	70	9.40	3.06	Silty till with silt lenses
	22.10	22	34	44	7.35	4.15	Loamy till
	23.32	11	32	57	8.70	3.68	Silty till with silt lenses
	24.38	26	36	38	6.73	3.98	Loamy till
	27.13	26	36	38	7.25	4.63	Loamy till
	29.87	28	34	38	7.13	4.79	Loamy till
	32.61	25	34	41	7.12	4.31	Loamy till
	35.36	27	33	40	6.93	4.19	Loamy till
	38.10	28	31	41	7.17	4.73	Loamy till
	40.84	28	32	40	7.03	4.40	Loamy till
94-SAB-02	1.22	30	33	37	6.65	3.58	Loamy till with clay patches
	3.35	34	30	36	7.07	4.81	Loamy till with bedrock
	3.81	50	21	29	5.67	3.15	Silty clay sandstone
94-SAB-08	0.76	26	31	43	8.00	5.01	Loamy till
	2.13	24	35	41	7.83	5.12	Loamy till
	2.44	8	40	52	9.17	4.51	Silty clay, laminae
	5.33	72	11	17	4.55	3.51	Silty sandstone
94-SAB-09	1.22	12	34	54	8.45	3.48	Silty till
	3.51	17	28	55	8.25	4.07	Silty till
	9.60	23	33	44	7.40	4.26	Loamy till
	15.70	30	30	40	7.12	4.46	Loamy till with silt lenses
	21.79	26	30	44	7.53	4.55	Loamy till
	27.89	25	34	41	7.38	4.45	Loamy till
	35.81	28	35	37	6.88	4.15	Loamy till
	40.08	26	33	41	7.43	4.60	Loamy till
94-SAB-10	1.52	23	34	43	7.30	3.68	Loamy till
	4.72	30	34	36	6.82	4.40	Loamy till
	6.86	27	33	40	7.25	4.29	Loamy till
	10.52	26	34	40	7.28	4.49	Loamy till
	12.04	12	68	20	6.13	2.32	Clayey siltstone
94-SAB-11	1.52	27	32	41	7.47	4.86	Loamy till
	4.11	23	40	37	7.38	4.32	Loamy till
	8.38	30	35	35	7.18	5.10	Loamy till
	10.97	23	28	49	8.00	4.63	Loamy till, laminae
	13.72	21	30	49	8.07	4.61	Loamy till
	18.44	14	36	50	8.02	3.51	Laminated silty till + silt
	18.90	7	63	30	6.82	2.33	Clayey siltstone
94-SAB-15	2.74	12	30	48	7.93	4.69	Silty till
	5.18	18	31	41	7.35	4.69	Silty till
	10.67	31	31	38	7.27	5.00	Loamy till
	16.76	10	31	59	8.78	3.38	Silty till
	18.75	19	37	44	7.47	3.59	Silty till
	19.20	2	37	61	9.72	3.96	Silty clay diamict with shale(monolithic)

APPENDIX 5

LITHOLOGICAL DATA

Appendix 5 - Lithological Data

SECTION	Depth (m)	Quartz	Carb	I/M	Qtzte	Ss	Volc	Coal	Zst/sh	Pyrite	Fe-st	Gypsum	Other
93-SB-05a	0.80	36	11	32	4	6	1	0	3	0	2	5	0
93-SB-05b	1.75	16	14	28	2	3	2	0	5	0	0	30	0
93-SB-05c	2.60	26	11	25	1	4	1	0	1	0	0	31	0
93-SB-06a	0.50	56	4	27	2	1	0	1	2	0	1	6	0
93-SB-06b	0.88	2	92	2	2	0	1	0	1	0	0	0	0
93-SB-06c	0.50	48	3	27	5	5	1	2	4	0	3	2	0
93-SB-07a	0.85	5	1	8	0	1	0	1	1	0	0	83	0
7a dup	0.85	6	1	8	0	1	0	1	2	0	0	81	0
93-SB-07b	1.55	2	4	8	0	0	1	1	2	0	0	82	0
93-SB-08a	0.80	2	2	7	1	0	0	1	2	0	1	84	0
93-SB-08b	1.90	31	10	13	0	0	0	1	1	0	trace	44	0
93-SB-09b	2.25	59	7	20	3	1	1	2	4	0	2	1	0
93-SB-10a	1.35	66	4	23	1	1	1	1	2	0	1	0	0
93-SB-10b	2.60	53	5	24	1	1	0	1	9	0	2	4	0
93-SB-11b	4.70	53	9	25	6	6	0	0	0	0	0	1	0
93-SB-11c	6.10	53	11	22	2	2	0	1	9	0	0	0	0
93-SB-11d	6.90	39	10	17	3	3	0	0	0	0	0	27	1
93-SB-11e	8.00	53	13	18	2	1	1	2	7	0	1	2	0
93-SB-26a	1.25	58	7	19	3	1	2	1	5	0	1	3	0
93-SB-26b	2.20	56	5	21	2	2	2	2	5	0	1	4	0
93-SB-26c	1.80	53	6	25	2	1	2	2	4	0	1	4	0
93-SB-32	0.79	53	7	31	2	1	1	1	2	0	1	1	0
93-SB-38a	1.35	40	12	33	3	1	1	1	7	0	trace	2	0
93-SB-38b	1.95	49	9	26	2	2	1	2	9	0	0	0	0
93-SB-38c	3.00	54	5	31	1	2	1	1	4	0	1	0	0
93-SB-39a	0.60	58	7	18	2	3	1	1	4	1	2	3	0
93-SB-39b	1.35	19	51	18	2	1	1	1	4	0	1	2	0
93-SB-39c	2.00	21	51	19	1	0	1	1	4	0	1	1	0
93-SB-39d	3.10	21	52	19	1	1	0	1	3	0	1	1	0
93-SB-40a	1.15	51	22	21	1	0	0	1	2	0	1	1	0
93-SB-40b	1.30	63	11	19	1	1	0	1	2	trace	1	1	0
93-SB-40c	2.20	61	11	21	1	1	1	trace	1	0	1	2	0
93-SB-41a	0.45	56	5	29	1	2	0	1	2	0	3	1	0
41a dup	0.45	57	5	28	2	2	0	1	2	0	2	1	0
93-SB-41b	1.15	32	24	24	1	1	0	1	1	0	1	15	0
41b dup	1.15	32	23	24	0	1	0	1	1	0	1	17	0

Appendix 5 - Lithological Data

SECTION	Depth (m)	Quartz	Carb	I/M	Qtzte	Ss	Volc	Coal	Zst/sh	Pyrite	Fe-st	Gypsum	Other
93-SB-42a	0.48	61	2	24	2	5	1	2	2	0	1	0	0
42a dup	0.48	60	2	25	2	5	1	2	2	0	1	0	0
93-SB-42b	1.00	64	2	26	1	1	1	2	2	0	1	0	0
42b dup	1.00	63	3	25	1	2	1	2	2	0	1	0	0
93-SB-43a	1.50	57	8	22	2	1	2	1	3	1	3	0	0
43a dup	1.50	56	9	22	1	1	3	1	2	1	4	0	0
93-SB-43b	2.35	61	8	24	1	1	1	1	3	0	0	trace	0
43b dup	2.35	61	8	25	1	1	1	1	2	0	0	0	0
93-SB-44a	1.00	58	7	23	1	2	1	2	3	0	2	1	0
44a dup	1.00	58	7	23	1	1	1	2	3	0	3	1	0
93-SB-44b	1.30	56	8	24	2	1	1	2	4	0	2	0	0
44b dup	1.30	57	8	23	1	2	1	2	4	0	2	0	0
93-SB-46	1.10	51	16	25	0	1	1	2	3	0	1	0	0
93-SB-47a	0.40	49	17	27	1	2	0	1	2	trace	1	0	0
93-SB-47b	1.30	50	21	20	1	1	1	1	1	0	2	2	0
93-SB-48	1.00	54	13	23	1	1	1	1	2	trace	2	2	0
93-SB-50a	0.80	24	59	11	3	2	0	0	0	0	0	0	1
93-SB-50b	1.40	51	16	23	2	1	1	1	1	0	1	3	0
93-SB-51	1.70	6	90	3	0	1	0	0	0	0	0	0	0
93-SB-52a	1.15	34	36	18	1	0	0	2	5	0	1	3	0
93-SB-52b	2.50	19	57	10	8	6	0	0	0	0	0	0	0
93-SB-52c	3.50	14	67	7	6	6	0	0	0	0	0	0	0
93-SB-53a	1.10	16	76	1	0	7	0	0	0	0	0	0	0
93-SB-53b	2.05	58	6	23	2	1	0	2	4	0	2	2	0
93-SB-53c	3.25	29	5	15	1	3	0	2	2	0	1	42	0
93-SB-55a	0.73	58	6	24	2	1	1	2	3	0	2	1	0
93-SB-55b	0.95	59	13	21	1	0	1	1	2	0	0	2	0
93-SB-56	1.00	53	8	24	3	2	2	1	3	trace	2	2	0
93-SB-62	1.65	49	25	21	1	2	0	trace	1	0	0	1	0
93-SB-65a	1.35	58	5	31	2	1	2	trace	5	0	1	0	0
94-dune	0.50	72	23	1	0	0	0	3	1	0	0	0	0
94-SB-01b	2.12	65	1	21	2	1	0	2	2	0	1	5	0
94-SB-02	1.20	31	46	13	0	2	0	2	3	0	1	2	0
94-SB-03b	1.35	52	8	31	2	1	1	1	2	0	2	0	0
94-SB-04c	1.40	55	7	26	2	1	0	1	2	0	3	3	0
94-SB-05	1.25	56	6	21	2	4	1	3	2	0	5	0	0

Appendix 5 - Lithological Data

SECTION	Depth (m)	Quartz	Carb	I/M	Qtzte	Ss	Volc	Coal	Zst/sh	Pyrite	Fe-st	Gypsum	Other
94-SB-07	0.80	54	2	27	2	2	0	3	4	0	4	2	0
94-SB-10	1.20	57	7	21	2	2	0	3	2	0	3	3	0
94-SB-11b	0.90	48	3	21	1	2	0	1	23	0	0	1	56
94-SB-15	1.00	56	4	25	2	2	0	2	4	0	2	3	0
94-SB-16b	0.70	57	3	26	2	1	1	4	3	0	1	2	0
94-SB-18	0.75	59	2	27	2	4	0	1	2	0	1	2	0
94-SB-21f	2.00	56	11	23	1	3	0	3	1	0	1	1	0
94-SB-23	1.00	51	2	32	2	3	1	2	3	0	2	2	0
94-SB-24b	0.95	59	8	22	1	1	1	2	3	0	2	1	0
94-SB-25b	1.20	61	9	22	0	1	1	1	2	0	2	1	0
94-SB-26ac	1.50	57	12	23	1	1	0	1	1	0	2	2	0
94-SB-26b	3.05	56	6	24	1	0	0	3	3	0	4	3	0
94-SB-28	1.15	56	4	26	2	3	1	2	2	0	1	3	0
94-SB-29e	2.00	34	4	14	1	1	3	8	27	0	7	1	0
94-SB-29h	0.80	54	6	25	1	3	2	2	3	0	2	2	0
94-SB-30b	1.30	47	11	29	2	2	2	trace	3	0	4	0	0
94-SB-32	1.05	56	8	21	1	1	2	2	5	0	2	2	0
94-SB-35a	0.65	58	6	21	2	1	2	2	5	0	2	1	0
94-SB-35c	2.30	55	12	27	1	1	0	1	2	0	1	0	0
94-SB-36	0.75	61	4	17	2	2	0	5	2	0	1	6	0
94-SB-37	0.90	56	3	29	2	3	0	2	2	0	1	2	0
94-SB-39	1.15	45	32	16	0	1	0	1	1	0	1	3	0
94-SB-40	1.15	59	3	24	2	1	1	2	4	0	2	2	0
94-SB-41	1.40	59	4	27	1	3	0	1	2	0	1	2	0
94-SB-42b	1.80	56	9	23	2	4	0	1	2	0	2	1	0
94-SB-43	1.00	57	6	21	1	1	0	3	4	0	4	2	1
94-SB-45b	1.30	55	2	33	1	1	0	3	2	0	1	2	0
94-SB-46b	1.25	68	4	8	3	2	0	trace	6	0	7	2	0
94-SB-47	1.00	59	7	21	2	3	0	1	2	0	3	2	0
94-SB-48	1.00	51	3	26	1	1	0	10	5	0	2	1	0
94-SB-49	1.05	56	3	26	2	2	0	2	3	0	3	3	0
94-SB-50c	1.30	8	10	11	0	0	0	3	1	0	1	66	0
94-SB-51b	1.55	54	12	24	1	2	0	1	2	0	1	3	0
94-SB-52a	0.75	59	8	23	2	2	1	trace	2	0	2	1	0
94-SB-52b	1.40	61	3	26	1	1	0	1	2	0	3	2	0
94-SB-54b	0.35	55	5	28	1	1	0	2	2	0	2	4	0

Appendix 5 - Lithological Data

SECTION	Depth (m)	Quartz	Carb	I/M	Qtzte	Ss	Volc	Coal	Zst/sh	Pyrite	Fe-st	Gypsum	Other
94-SB-55b	1.00	51	2	33	2	1	1	1	2	1	2	4	0
94-SB-58	1.40	19	8	18	0	0	1	6	23	0	25	0	0
94-SB-60	1.30	54	1	33	2	3	1	1	1	0	0	4	0
94-SB-61b	1.30	54	3	26	2	3	1	3	2	0	3	3	0
94-SB-62	1.10	58	11	23	1	1	0	2	2	0	2	0	0
94-SB-64b	1.65	58	5	26	1	2	1	trace	4	0	2	1	0
94-SB-66c	1.60	26	5	22	1	1	0	1	3	0	1	40	0
94-SB-71	1.10	28	14	18	1	1	0	2	2	0	1	33	0
94-SB-72	1.20	53	28	13	1	0	0	1	2	0	1	1	0
94-SB-73b	5.70	48	5	17	3	1	1	2	4	0	3	16	0
94-SB-74b	1.10	54	9	23	3	1	0	2	3	0	2	3	0
94-SB-74d	3.50	53	6	25	1	2	0	2	4	0	2	5	0
94-SB-75a	2.00	54	5	24	2	2	1	4	4	0	1	3	0
94-SB-75c	7.50	59	4	15	2	2	2	10	4	0	1	1	0
94-SB-76c	2.20	55	3	31	2	2	1	1	2	0	0	3	0
94-SB-77	0.75	56	7	15	0	1	1	2	3	0	15	0	0
94-SB-78	1.05	51	5	26	2	2	0	3	4	0	5	2	0
94-SB-79	1.00	0	42	0	0	0	0	41	0	0	0	17	0
94-SB-80	1.05	54	7	25	1	2	1	2	3	0	2	3	0
94-SB-81	1.50	49	2	26	3	3	2	8	4	0	1	2	0
94-SB-91a	4.10	55	5	24	1	2	1	5	3	0	2	2	0
94-SB-91b	7.40	52	4	15	5	1	1	8	13	0	1	0	0

Appendix 5 - Lithological Data

BORE HOLE	Depth (m)	Quartz	Carb	I/M	Qtzte	Ss	Volc	Coal	Zst/sh	Pyrite	Fe-st	Gypsum	Other
93-SAB-06	3.35	61	5	25	2	0	2	0	5	0	0	0	0
	5.79	25	15	15	0	13	2	0	10	0	0	20	0
	8.53	79	4	12	trace	trace	1	0	2	1	1	0	0
	9.91	75	8	14	2	trace	trace	trace	1	0	0	0	0
	12.65	79	2	14	1	trace	trace	trace	3	1	0	0	0
	15.39	76	2	20	trace	trace	1	trace	1	trace	trace	0	0
	19.05	72	1	25	trace	trace	1	trace	1	trace	trace	0	0
	21.79	69	2	25	trace	trace	2	1	0	1	0	0	0
	24.54	67	1	26	1	trace	2	trace	2	1	0	0	0
	27.28	67	2	27	1	trace	2	trace	trace	1	0	0	0
	30.02	62	2	29	1	1	1	0	2	1	0	0	1
	32.77	66	2	26	trace	1	1	1	1	2	0	0	0
	39.01	64	3	28	1	1	trace	1	1	1	0	0	0
	41.76	56	4	30	1	2	1	2	2	2	0	0	0
	44.50	57	5	30	1	0	1	2	2	trace	1	0	1
93-SAB-13	14.94	60	15	17	0	2	0	0	6	0	0	0	0
	21.34	64	9	17	1	1	0	0	8	trace	0	0	0
	22.10	67	5	20	1	1	trace	0	5	1	0	0	0
	23.32	62	5	25	1	2	1	1	2	1	0	0	0
	24.38	57	8	25	0	3	1	1	1	3	1	0	0
	27.13	73	2	23	0	0	trace	trace	1	1	trace	0	0
	29.87	64	3	27	1	1	1	trace	2	1	0	0	0
	32.61	56	5	26	2	2	1	1	5	1	0	0	1
93-SAB-13	35.36	53	8	24	2	2	1	3	5	0	1	1	0
	38.10	54	5	27	2	2	1	3	3	2	1	0	0
	40.84	51	5	32	2	2	1	2	4	1	0	0	0
94-SAB-02	1.22	35	17	29	2	2	0	2	3	0	3	7	0
	3.35	12	31	19	2	2	0	13	8	trace	5	8	0
	3.81*	5	51	0	0	0	0	39	5	0	0	0	0
94-SAB-08	0.76	58	12	19	1	1	0	1	4	0	4	0	0
	2.13	65	12	18	0	0	1	2	1	0	1	0	0
94-SAB-08	2.44	0	98	0	0	0	0	2	0	0	0	0	0
	5.33	0	0	0	0	0	0	100	0	0	0	0	0

Appendix 5 - Lithological Data

BORE HOLE	Depth (m)	Quartz	Carb	I/M	Qtzte	Ss	Volc	Coal	Zst/sh	Pyrite	Fe-st	Gypsum	Other
94-SAB-09	1.22	51	32	13	0	0	0	1	2	0	0	1	0
	3.51	53	12	19	1	1	0	2	3	0	2	7	0
	9.60	53	5	24	2	2	1	3	8	1	0	1	0
	15.70	57	4	27	0	1	1	4	4	2	0	0	0
	21.79	49	2	27	1	3	2	13	3	0	0	0	0
	27.89	54	2	29	1	2	1	6	2	1	0	2	0
	35.81	60	3	26	1	1	1	3	4	1	0	0	0
	40.08	58	2	25	1	1	1	6	4	1	0	1	0
94-SAB-10	1.52	53	2	31	2	2	0	trace	2	0	3	5	0
	4.72	52	5	27	2	1	1	3	3	0	5	1	0
	6.86	54	4	24	3	3	1	4	4	0	1	2	0
	10.52	51	3	31	1	3	1	2	4	3	1	0	0
	12.04	0	0	0	0	0	0	2	96	0	2	0	0
94-SAB-11	1.52	56	5	24	3	1	2	1	3	2	2	1	0
	4.11	49	5	30	1	2	1	3	7	trace	1	1	0
	8.38	52	5	31	1	2	1	1	3	1	1	2	0
	10.97	61	3	25	3	1	2	3	2	trace	0	0	0
	13.72	62	4	21	1	2	2	3	2	2	1	0	0
	18.44	54	2	21	1	2	0	7	12	0	1	0	0
	18.90*	45	26	24	0	0	0	5	0	0	0	0	0
94-SAB-15	2.74	55	9	23	3	2	0	1	3	0	0	4	0
	5.18	53	8	28	2	2	1	1	3	0	trace	2	0
	10.67	56	4	26	2	4	1	2	3	1	0	1	0
	16.76	58	3	24	1	2	1	5	4	0	1	1	0
	18.75	13	6	8	0	0	0	28	33	0	12	0	0
	19.20*	24	6	8	0	0	0	9	13	0	0	0	40

APPENDIX 6

GEOCHEMICAL DATA

APPENDIX 6A

AA DATA

Sample #	WIN #	Zn PPM	Cu PPM	Pb PPM	Ni PPM	Co PPM	Ag PPM	Mn PPM	Cd PPM	Fe %	Mo PPM	V PPM
SECTIONS												
93-SB-05A	WIN 001	116.0	32.0	16.0	29.0	9.0	0.3	173.0	0.2	2.9	3.0	177.0
93-SB-05B	WIN 002	111.0	30.0	16.0	31.0	9.0	<0.2	236.0	0.2	3.1	5.0	173.0
93-SB-05C	WIN 003	113.0	35.0	15.0	32.0	10.0	<0.2	251.0	<0.2	3.1	4.0	165.0
93-SB-06A	WIN 099	112.0	39.0	18.0	32.0	9.0	0.4	224.0	0.2	2.9	5.0	190.0
93-SB-06B	WIN 005	110.0	38.0	16.0	44.0	9.0	0.2	158.0	<0.2	3.6	6.0	260.0
93-SB-06C	WIN 006	112.0	36.0	16.0	40.0	11.0	0.3	434.0	0.2	4.0	5.0	196.0
93-SB-07A	WIN 007	101.0	37.0	15.0	37.0	12.0	<0.2	250.0	0.3	3.2	4.0	201.0
93-SB-07B	WIN 008	108.0	47.0	15.0	39.0	13.0	0.2	310.0	0.3	3.2	5.0	191.0
93-SB-08A	WIN 009	105.0	34.0	16.0	36.0	10.0	<0.2	227.0	0.2	3.3	4.0	204.0
93-SB-08B	WIN 010	106.0	35.0	19.0	34.0	9.0	<0.2	204.0	<0.2	3.2	4.0	181.0
93-SB-09B	WIN 011	128.0	46.0	16.0	33.0	10.0	<0.2	196.0	0.3	2.9	5.0	175.0
93-SB-09B	WIN 062	116.0	32.0	16.0	33.0	9.0	0.3	206.0	0.4	2.9	5.0	167.0
93-SB-10A	WIN 012	102.0	30.0	16.0	35.0	10.0	<0.2	168.0	<0.2	2.7	3.0	164.0
93-SB-10B	WIN 013	109.0	31.0	17.0	34.0	10.0	<0.2	201.0	<0.2	3.0	5.0	170.0
93-SB-11B	WIN 014	107.0	39.0	16.0	38.0	9.0	<0.2	165.0	0.5	3.0	4.0	210.0
93-SB-11C	WIN 015	110.0	39.0	18.0	35.0	10.0	<0.2	231.0	0.2	3.4	5.0	191.0
93-SB-11D	WIN 016	106.0	35.0	15.0	31.0	11.0	0.2	174.0	<0.2	3.2	5.0	162.0
93-SB-11E	WIN 017	102.0	31.0	18.0	33.0	9.0	<0.2	172.0	0.3	3.1	6.0	162.0
93-SB-26A	WIN 018	86.0	28.0	16.0	32.0	10.0	<0.2	274.0	0.2	2.9	5.0	138.0
93-SB-26B	WIN 019	100.0	30.0	15.0	32.0	10.0	<0.2	220.0	0.2	2.9	5.0	156.0
93-SB-26C	WIN 020	77.0	22.0	12.0	28.0	8.0	<0.2	297.0	0.3	2.7	6.0	126.0
93-SB-32	WIN 021	108.0	36.0	18.0	31.0	7.0	<0.2	145.0	<0.2	3.6	5.0	175.0
93-SB-32	WIN 063	113.0	38.0	19.0	31.0	6.0	0.4	135.0	0.2	2.8	4.0	173.0
93-SB-38A	WIN 022	99.0	29.0	14.0	34.0	11.0	<0.2	340.0	<0.2	3.1	4.0	135.0
93-SB-38B	WIN 023	109.0	34.0	17.0	33.0	11.0	<0.2	248.0	0.2	3.2	4.0	176.0
93-SB-38C	WIN 024	112.0	31.0	16.0	31.0	9.0	0.2	221.0	<0.2	3.0	6.0	162.0
93-SB-39A	WIN 025	117.0	38.0	19.0	35.0	10.0	0.2	190.0	<0.2	3.5	6.0	200.0
93-SB-39B	WIN 026	116.0	36.0	17.0	45.0	15.0	0.3	382.0	0.4	3.5	7.0	189.0
93-SB-39C	WIN 027	114.0	33.0	18.0	37.0	12.0	0.4	280.0	0.2	3.6	6.0	184.0
93-SB-39D	WIN 028	115.0	35.0	17.0	32.0	10.0	0.4	180.0	0.2	3.2	4.0	181.0
93-SB-40A	WIN 029	88.0	31.0	14.0	35.0	11.0	0.2	296.0	<0.2	2.9	6.0	157.0
93-SB-40B	WIN 030	102.0	28.0	16.0	36.0	11.0	0.2	375.0	<0.2	3.5	6.0	145.0
93-SB-40C	WIN 031	107.0	30.0	16.0	34.0	10.0	0.3	336.0	<0.2	3.6	7.0	150.0
93-SB-40C	WIN 064	105.0	33.0	17.0	31.0	10.0	0.2	340.0	0.3	3.4	6.0	140.0
93-SB-41A	WIN 032	98.0	30.0	17.0	38.0	11.0	0.2	380.0	<0.2	3.8	5.0	148.0
93-SB-41B	WIN 033	106.0	31.0	16.0	43.0	14.0	0.3	375.0	0.2	3.9	5.0	177.0
93-SB-42A	WIN 034	99.0	29.0	19.0	25.0	7.0	0.3	96.0	<0.2	3.3	6.0	168.0
93-SB-42B	WIN 035	85.0	33.0	13.0	43.0	7.0	0.4	233.0	<0.2	2.7	5.0	139.0
93-SB-43A	WIN 100	106.0	34.0	16.0	30.0	9.0	0.4	198.0	<0.2	3.1	7.0	160.0
93-SB-43B	WIN 037	103.0	37.0	15.0	33.0	10.0	0.2	182.0	<0.2	2.9	5.0	156.0
93-SB-44A	WIN 038	89.0	47.0	13.0	35.0	10.0	0.3	210.0	0.2	2.9	5.0	147.0
93-SB-44B	WIN 039	103.0	38.0	17.0	34.0	10.0	0.3	173.0	0.4	3.0	5.0	173.0
93-SB-46	WIN 040	79.0	37.0	15.0	35.0	11.0	<0.2	384.0	0.2	3.2	4.0	184.0
93-SB-47A	WIN 041	84.0	31.0	17.0	28.0	8.0	0.4	241.0	0.2	3.2	5.0	171.0
93-SB-47B	WIN 042	87.0	29.0	14.0	30.0	9.0	0.3	334.0	0.2	2.9	6.0	141.0
93-SB-47B	WIN 065	94.0	30.0	15.0	32.0	10.0	<0.2	332.0	0.2	2.9	4.0	145.0
93-SB-48	WIN 101	99.0	33.0	16.0	30.0	9.0	0.5	210.0	0.2	2.7	6.0	176.0
93-SB-50A	WIN 044	77.0	28.0	12.0	31.0	11.0	<0.2	286.0	<0.2	2.5	6.0	156.0
93-SB-50B	WIN 045	103.0	31.0	17.0	29.0	9.0	0.2	260.0	0.2	3.3	5.0	162.0
93-SB-51	WIN 046	70.0	29.0	12.0	31.0	10.0	0.2	288.0	<0.2	2.7	5.0	134.0
93-SB-52A	WIN 047	98.0	41.0	18.0	40.0	13.0	0.2	392.0	0.2	3.0	7.0	179.0
93-SB-52B	WIN 048	96.0	33.0	17.0	29.0	9.0	0.3	206.0	0.2	2.9	7.0	155.0
93-SB-52C	WIN 049	109.0	35.0	19.0	36.0	11.0	0.4	263.0	0.4	3.2	5.0	159.0
93-SB-53A	WIN 050	103.0	37.0	18.0	37.0	12.0	0.2	320.0	0.4	3.2	6.0	204.0
93-SB-53B	WIN 051	100.0	34.0	17.0	34.0	11.0	0.3	286.0	0.3	3.4	6.0	181.0
93-SB-53C	WIN 052	101.0	33.0	18.0	28.0	8.0	0.2	165.0	0.2	3.0	5.0	166.0
93-SB-53C	WIN 066	112.0	33.0	15.0	29.0	8.0	0.2	168.0	<0.2	2.8	4.0	167.0
93-SB-55A	WIN 053	102.0	38.0	16.0	41.0	7.0	0.4	143.0	<0.2	3.2	5.0	168.0
93-SB-55B	WIN 054	90.0	31.0	13.0	31.0	9.0	0.3	240.0	0.2	3.0	6.0	172.0
93-SB-56	WIN 055	99.0	33.0	18.0	30.0	8.0	0.3	260.0	<0.2	3.4	4.0	153.0
93-SB-62	WIN 056	107.0	32.0	16.0	29.0	9.0	0.5	174.0	0.2	3.1	5.0	172.0
93-SB-65A	WIN 057	107.0	35.0	18.0	31.0	8.0	0.3	242.0	0.2	2.7	7.0	157.0
93-SB-65B	WIN 058	109.0	33.0	17.0	33.0	10.0	0.4	316.0	0.3	2.8	6.0	154.0
93-SB-65C	WIN 059	105.0	32.0	15.0	32.0	10.0	0.3	320.0	0.3	2.7	5.0	146.0
93-SB-72A	WIN 060	114.0	33.0	15.0	29.0	8.0	0.3	225.0	0.2	2.9	6.0	166.0
93-SB-72A	WIN 067	103.0	32.0	16.0	32.0	10.0	0.4	304.0	0.2	3.1	5.0	155.0
93-SB-72B	WIN 061	116.0	31.0	17.0	30.0	9.0	<0.2	234.0	0.3	2.9	6.0	162.0

Sample #	WIN #	Zn PPM	Cu PPM	Pb PPM	Ni PPM	Co PPM	Ag PPM	Mn PPM	Cd PPM	Fe %	Mo PPM	V PPM
BOREHOLES												
93-SAB-06												
3.35 m	WIN 068	98.0	41.0	13.0	33.0	9.0	0.2	210.0	0.2	2.9	5.0	172.0
5.79 m	WIN 069	105.0	65.0	16.0	34.0	12.0	0.2	263.0	0.3	3.1	6.0	176.0
8.53 m	WIN 070	112.0	38.0	17.0	32.0	8.0	0.3	208.0	0.3	2.8	6.0	149.0
9.91 m	WIN 083	112.0	41.0	16.0	30.0	8.0	<0.2	207.0	0.2	2.9	6.0	160.0
9.91 m	WIN 102	114.0	40.0	15.0	31.0	8.0	0.3	208.0	0.3	3.0	5.0	163.0
12.65 m	WIN 072	114.0	32.0	13.0	30.0	8.0	0.3	240.0	<0.2	2.7	6.0	165.0
15.39 m	WIN 073	116.0	33.0	15.0	30.0	9.0	0.4	206.0	0.2	2.8	5.0	162.0
19.05 m	WIN 074	113.0	57.0	15.0	33.0	8.0	0.2	218.0	0.2	2.9	6.0	167.0
21.79 m	WIN 075	107.0	31.0	14.0	29.0	8.0	0.2	224.0	0.3	2.6	5.0	157.0
24.54 m	WIN 076	110.0	32.0	13.0	30.0	9.0	0.3	220.0	0.2	2.8	6.0	162.0
27.28 m	WIN 077	115.0	31.0	16.0	31.0	9.0	<0.2	225.0	0.3	2.7	6.0	167.0
30.02 m	WIN 078	108.0	32.0	15.0	29.0	9.0	0.2	229.0	<0.2	2.6	5.0	162.0
32.77 m	WIN 079	107.0	31.0	16.0	28.0	8.0	0.2	200.0	0.3	2.5	7.0	147.0
32.77 m	WIN 084	115.0	31.0	16.0	30.0	8.0	0.3	211.0	0.3	3.1	5.0	167.0
39.01 m	WIN 080	104.0	30.0	15.0	30.0	8.0	<0.2	232.0	0.2	2.8	5.0	156.0
41.76 m	WIN 081	113.0	49.0	17.0	32.0	9.0	<0.2	268.0	0.4	3.0	5.0	153.0
44.50 m	WIN 103	106.0	37.0	16.0	30.0	8.0	0.3	245.0	0.3	2.9	4.0	167.0
93-SAB-13												
14.94 m	WIN 085	113.0	50.0	18.0	36.0	9.0	0.2	268.0	0.8	3.2	4.0	204.0
20.57 m	WIN 086	100.0	40.0	12.0	29.0	8.0	<0.2	345.0	0.6	2.8	7.0	146.0
20.57 m	WIN 097	98.0	38.0	11.0	29.0	9.0	0.3	330.0	0.8	2.4	4.0	148.0
21.34 m	WIN 087	113.0	46.0	24.0	34.0	9.0	0.2	250.0	0.7	3.0	5.0	179.0
22.10 m	WIN 088	102.0	36.0	18.0	30.0	9.0	0.3	257.0	0.3	2.9	4.0	149.0
23.32 m	WIN 089	117.0	40.0	17.0	35.0	9.0	0.4	296.0	0.5	2.6	6.0	175.0
24.38 m	WIN 090	114.0	37.0	18.0	32.0	8.0	0.2	275.0	0.3	2.5	6.0	156.0
27.13 m	WIN 091	118.0	36.0	16.0	32.0	8.0	0.3	260.0	0.4	2.7	5.0	162.0
29.87 m	WIN 092	113.0	39.0	15.0	34.0	9.0	0.4	258.0	0.3	2.5	7.0	159.0
32.61 m	WIN 093	116.0	34.0	15.0	33.0	9.0	0.4	240.0	0.2	2.7	6.0	155.0
35.36 m	WIN 094	112.0	37.0	16.0	34.0	8.0	0.4	251.0	0.4	2.3	7.0	162.0
38.10 m	WIN 095	112.0	35.0	15.0	32.0	8.0	0.3	254.0	0.4	2.6	4.0	156.0
40.84 m	WIN 096	117.0	44.0	17.0	33.0	9.0	0.2	257.0	0.3	2.7	5.0	162.0
40.84 m	WIN 098	113.0	47.0	16.0	32.0	8.0	0.4	265.0	0.4	2.7	7.0	162.0
STANDARDS												
standard	WIN 004	79.0	23.0	13.0	31.0	10.0	0.2	430.0	0.2	2.8	4.0	146.0
standard	WIN 036	72.0	24.0	12.0	28.0	9.0	0.3	410.0	0.2	2.9	4.0	128.0
standard	WIN 043	72.0	23.0	13.0	29.0	9.0	0.3	467.0	0.2	2.8	6.0	136.0
standard	WIN 071	80.0	25.0	11.0	29.0	9.0	0.2	459.0	0.2	2.7	4.0	131.0
standard	WIN 082	85.0	25.0	14.0	28.0	8.0	0.2	440.0	0.2	2.7	6.0	139.0

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Sample #	WIN #	Ag PPM	Cd PPM	Cu PPM	Co PPM	Fe %	Li PPM	Mn PPM	Mo PPM	Ni PPM	Pb PPM	V PPM	Zn PPM
SECTIONS													
94-SB-01B	WIN209	0.2	0.3	30	20	3.00	29	400	6	42	15	186	101
94-SB-02	WIN210	0.2	0.2	36	25	3.20	33	420	7	48	16	230	109
94-SB-03B	WIN211	0.2	0.4	36	17	3.50	27	490	5	47	19	192	118
94-SB-04C	WIN212	0.2	0.3	34	19	3.10	29	394	4	43	16	197	107
94-SB-05	WIN213	0.2	0.2	23	17	2.40	27	240	3	29	14	144	78
94-SB-07	WIN215	0.2	0.2	32	9	2.80	21	163	4	31	16	170	86
94-SB-09B	WIN216	0.2	0.2	36	17	3.20	29	304	3	37	18	193	108
94-SB-10	WIN218	0.2	0.3	33	19	3.20	26	372	6	44	18	188	100
94-SB-11B	WIN305	0.4	0.4	30	9	3.30	28	360	6	38	16	173	114
94-SB-14	94G 102	0.4	0.2	35	15	3.30	15	395	4	40	17	145	106
94-SB-14C	WIN223	0.2	0.2	30	12	2.70	17	168	6	27	17	170	98
94-SB-14E	WIN225	0.2	0.3	27	17	2.80	18	183	3	29	18	140	100
94-SB-15	WIN227	0.2	0.2	46	15	3.00	25	130	4	28	15	197	82
94-SB-16B	WIN306	0.4	0.2	29	16	3.10	32	152	4	31	15	220	99
94-SB-18	WIN229	0.3	0.2	38	17	3.30	33	269	4	56	17	235	101
94-SB-19B	WIN230	0.2	0.2	32	20	3.10	28	285	5	36	16	190	110
94-SB-20	WIN232	0.2	0.2	33	16	2.90	19	486	4	42	14	169	104
94-SB-21F	WIN234	0.2	0.3	34	21	3.00	22	570	5	45	19	163	97
94-SB-22B	WIN260	0.3	0.4	34	24	3.10	27	394	6	42	17	210	96
94-SB-23	WIN309	0.6	0.2	37	19	3.20	31	354	7	76	15	199	104
94-SB-24B	WIN238	0.3	0.3	34	18	3.00	24	382	4	40	15	188	103
94-SB-25B	WIN310	0.2	0.2	33	16	3.30	26	400	3	42	16	178	94
94-SB-26AC	WIN245	0.4	0.2	33	19	3.10	33	224	5	36	13	220	89
94-SB-26B	WIN247	0.2	0.2	35	21	3.00	34	422	5	45	18	197	106
94-SB-28	WIN203	0.3	0.2	35	17	3.00	27	340	5	42	20	193	108
94-SB-29E	WIN249	0.2	0.4	33	16	2.80	16	381	4	36	16	152	102
94-SB-29H	WIN250	0.2	0.3	30	20	2.70	22	568	4	40	19	167	97
94-SB-30B	WIN208	0.2	0.4	35	21	3.40	20	642	6	51	20	183	113
94-SB-32	WIN251	0.4	0.2	32	15	3.30	27	373	3	38	16	204	96
94-SB-35	94G 057	0.2	0.3	40	14	3.50	20	389	4	40	13	184	115
94-SB-35A	WIN254	0.2	0.2	33	15	3.20	26	342	5	42	14	187	97
94-SB-35C	WIN256	0.3	0.4	31	18	3.00	24	320	5	33	15	180	102
94-SB-36	WIN257	0.2	0.7	31	15	2.10	14	140	5	30	20	128	67
94-SB-37	WIN262	0.3	0.3	36	20	3.10	23	389	6	41	21	175	103
93-SA-B38	94G 091	0.2	0.5	41	15	3.70	26	408	5	49	15	207	119
94-SB-39	WIN263	0.3	0.4	35	18	3.00	30	385	5	39	15	202	110
93-SB-39	94G 104	0.3	0.2	39	15	3.40	22	325	8	42	13	193	119
94-SB-40	WIN265	0.2	0.2	36	22	2.90	22	570	4	68	17	173	85
94-SB-41	WIN267	0.4	0.2	32	13	2.80	30	300	6	36	17	207	102
94-SB-42B	WIN268	0.3	0.3	36	21	3.20	25	406	5	40	14	175	110
94-SB-43	WIN270	0.2	0.5	36	13	2.30	19	325	5	33	16	168	91
94-SB-45B	WIN300	0.2	0.2	44	23	3.40	42	335	5	53	18	242	105
94-SB-46B	WIN231	0.4	0.2	28	17	2.70	19	254	5	34	13	146	95
94-SB-47	WIN311	0.4	0.2	32	18	3.30	37	425	4	41	13	190	104
94-SB-48	WIN202	0.2	0.2	34	20	3.10	35	260	5	42	16	217	96
94-SB-49	WIN205	0.2	0.2	34	13	2.60	19	160	2	34	14	148	83
94-SB-50C	WIN273	0.2	0.3	36	14	3.30	34	234	3	36	17	230	113
94-SB-51B	WIN274	0.2	0.2	32	14	2.80	30	343	3	39	12	212	104
93-SB-52	94G 092	0.3	0.4	38	18	3.80	25	366	4	48	14	202	126
94-SB-52A	WIN276	0.2	0.3	33	17	3.00	30	320	4	38	16	204	106
94-SB-52B	WIN278	0.2	0.2	33	13	3.00	31	341	3	40	16	203	108
94-SB-54B	WIN312	0.4	0.6	36	15	3.60	40	413	5	48	18	235	115
94-SB-55B	WIN283	0.2	0.2	36	12	3.00	30	251	4	48	17	218	105
94-SB-58	WIN285	0.5	0.2	36	13	3.10	16	294	4	38	13	186	97
94-SB-60	WIN287	0.3	0.2	37	15	3.30	26	406	5	55	19	203	111
94-SB-61B	WIN288	0.4	0.2	40	18	3.50	22	370	4	44	19	188	109
94-SB-62	WIN289	0.3	0.3	33	16	3.30	28	380	5	39	15	193	102
94-SB-64B	WIN207	0.2	0.3	36	17	3.20	29	370	5	43	18	194	115
94-SB-66C	WIN290	0.2	0.3	34	14	3.00	37	266	5	43	17	209	108
94-SB-71	WIN240	0.2	0.2	38	16	2.90	37	332	7	43	17	227	121
94-SB-72	WIN293	0.3	0.2	31	18	3.00	30	264	8	41	14	184	97
94-SB-73B	WIN294	0.3	0.4	31	14	3.00	34	280	4	37	15	180	110
94-SB-74B	WIN295	0.2	0.2	34	14	3.10	35	311	5	39	17	197	112
94-SB-74D	WIN206	0.3	0.4	34	16	3.10	35	290	6	40	15	207	119
94-SB-75A	WIN280	0.2	0.5	34	14	3.10	29	381	4	41	16	197	115
94-SB-75C	WIN296	0.2	0.2	32	19	2.90	25	429	4	39	16	162	105
94-SB-76	94G 107	0.4	0.3	36	14	3.10	22	371	4	44	11	190	109
94-SB-76C	WIN308	0.3	0.3	33	17	3.20	33	326	6	37	17	193	110

Sample #	WIN #	Ag PPM	Cd PPM	Cu PPM	Co PPM	Fe %	Li PPM	Mn PPM	Mo PPM	Ni PPM	Pb PPM	V PPM	Zn PPM
94-SB-77	WIN201	0.2	0.3	34	15	2.90	20	311	3	35	17	154	101
94-SB-77	WIN219	0.2	0.2	34	16	2.50	17	325	5	33	18	152	101
94-SB-78	WIN298	0.4	0.2	36	22	3.10	22	584	6	45	19	170	103
94-SB-79	WIN301	0.2	0.3	24	10	1.20	11	87	4	32	13	101	61
94-SB-80	WIN302	0.3	0.3	37	14	3.20	31	407	5	43	17	193	118
94-SB-81	WIN261	0.5	0.5	26	17	2.60	20	386	4	36	16	143	92
94-SB-81	WIN279	0.3	0.6	27	11	2.70	21	390	6	34	16	155	95
94-SB-91A	WIN303	0.4	0.2	34	17	3.00	24	389	6	37	15	169	109
94-SB-91B	WIN304	0.3	0.2	34	18	3.30	24	212	4	38	18	171	112
BOREHOLES													
94-SAB-02													
1.22 m	WIN214	0.2	0.4	33	22	3.10	17	1050	5	43	17	148	109
3.35 m	WIN217	0.2	0.5	33	20	3.40	15	701	2	56	17	155	113
3.81 m	WIN221	0.2	0.2	31	22	3.10	16	626	4	43	14	184	103
3.81 m	WIN239	0.2	0.2	31	18	3.00	15	637	3	43	12	162	101
94-SAB-08													
0.76 m	WIN222	0.2	0.2	32	20	2.60	25	351	4	34	15	143	95
2.13 m	WIN224	0.2	0.2	28	18	2.50	18	286	5	31	16	137	92
2.44 m	WIN226	0.2	0.2	24	14	2.40	12	81	6	18	17	112	56
5.33 m	WIN228	0.2	0.2	28	19	2.50	15	540	6	41	11	144	95
94-SAB-09													
1.22 m	WIN246	0.3	0.2	35	23	2.60	35	443	4	43	13	188	109
3.51 m	WIN220	0.2	0.3	37	14	3.30	33	278	6	37	17	217	120
9.60 m	WIN269	0.4	0.3	34	17	3.30	31	315	6	37	14	205	109
15.70 m	WIN307	0.5	0.3	33	12	3.00	29	379	6	39	14	184	103
21.79 m	WIN272	0.4	0.2	34	17	2.90	25	345	4	37	14	187	107
27.89 m	WIN284	0.4	0.2	33	14	2.80	26	374	4	38	14	180	104
35.81 m	WIN252	0.2	0.6	32	18	2.70	26	338	4	39	15	181	107
40.08 m	WIN286	0.4	0.5	33	15	3.10	25	367	5	39	14	182	112
94-SAB-10													
1.52 m	WIN233	0.2	0.2	42	18	3.70	23	538	4	58	14	196	112
4.72 m	WIN235	0.2	0.2	36	20	3.20	24	362	5	37	15	181	121
6.86 m	WIN237	0.4	0.2	34	17	3.10	25	415	4	40	13	176	112
10.52 m	WIN242	0.2	0.2	35	21	2.90	27	352	5	39	13	170	112
12.04 m	WIN241	0.2	0.2	43	17	3.00	24	229	3	44	12	168	106
12.04 m	WIN259	0.3	0.4	47	18	3.30	25	304	5	45	14	186	107
94-SAB-11													
1.52 m	WIN248	0.5	0.2	34	20	3.40	30	468	6	43	16	174	111
4.11 m	WIN253	0.4	0.4	33	20	3.20	27	225	6	40	14	194	115
8.38 m	WIN297	0.4	0.2	34	20	3.10	28	336	5	38	13	186	114
10.97 m	WIN255	0.2	0.2	33	22	3.10	30	326	6	40	13	203	119
13.72 m	WIN275	0.2	0.4	33	15	2.90	29	350	5	38	15	206	103
18.44 m	WIN258	0.2	0.5	42	20	3.80	23	595	5	47	12	194	116
18.9 m	WIN264	0.2	0.4	48	19	3.90	24	572	4	53	12	198	118
94-SAB-15													
2.74 m	WIN266	0.2	0.4	35	17	3.00	27	424	7	40	19	190	102
5.18 m	WIN277	0.3	0.3	37	13	3.00	27	345	5	36	18	186	115
10.67 m	WIN281	0.4	0.4	30	15	2.90	25	345	6	34	16	166	102
10.67 m	WIN299	0.5	0.2	31	16	3.00	30	363	4	36	16	173	109
16.76 m	WIN292	0.2	0.2	39	26	3.30	25	279	3	39	15	166	106
18.75 m	WIN291	0.2	0.2	39	13	2.70	16	301	6	37	16	140	94
19.2 m	WIN244	0.2	0.3	48	23	3.00	16	211	7	49	17	151	126

APPENDIX 6B

INAA DATA

Sample #	WIN #	Au	Sb	As	Ba	Br	Cd	Ce	Cs	Cr	Co	Eu	Hf	Ir	Fe	La	Lu	Mo	Ni	Rb	Sm	Sc	Se	Ag	Na	Ta	Te	Tb	Th	Sn	W	U	Yb	Zn	Zr
		PPB	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPB	%	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	%	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM
SECTIONS																																			
93-SB-05A	WIN 001	2	0.4	5.3	510	1.5	-5	36	3.2	47	6	-1	2	-50	1.5	17	-0.2	-1	22	63	2.8	7.2	-5	-2	0.19	0.5	-10	-0.5	5.5	-100	-1	1.7	1	-100	220
93-SB-05B	WIN 002	4	1.1	13	980	1.4	-5	67	5.5	94	12	1	7	-50	3.1	36	-0.2	1	33	110	6.1	13	-5	-2	0.54	1.2	-10	0.8	12	-100	1	4.3	3	120	400
93-SB-05C	WIN 003	-2	1.1	14	930	2.1	-5	64	5.1	86	11	1	6	-50	3.2	35	-0.2	-1	48	110	5.8	12	-5	-2	0.52	1.2	-10	0.6	11	-100	-1	4.2	2	130	310
93-SB-06A	WIN 099	3	1	14	900	2.9	-5	70	6.7	100	13	1	4	-50	3.4	39	-0.2	-1	41	120	6.4	15	-5	-2	0.41	1	-10	0.7	13	-100	1	4.2	2	-100	310
93-SB-06B	WIN 005	-2	1.5	14	1400	8.7	-5	76	9.1	120	12	1	4	-50	3.4	46	-0.2	-1	56	160	6.8	18	-5	-2	0.37	1.3	-10	0.8	14	-100	1	3.7	2	120	-200
93-SB-06C	WIN 006	-2	1.3	21	930	3.1	-5	67	6.5	110	15	1	4	-50	4.1	38	-0.2	1	63	120	6.1	15	-5	-2	0.47	1.3	-10	0.8	12	-100	-1	4.2	2	120	240
93-SB-07A	WIN 007	5	1	12	930	4.3	-5	70	7.5	100	14	-1	4	-50	3.2	40	-0.2	1	57	140	6.3	16	-5	-2	0.41	1.1	-10	0.8	13	-100	1	4.7	2	100	270
93-SB-07B	WIN 008	2	1	13	970	2.7	-5	73	7.3	110	18	1	4	-50	3.6	40	-0.2	-1	48	140	6.6	16	-5	-2	0.51	1.3	-10	0.8	13	-100	1	5.1	2	130	230
93-SB-08A	WIN 009	2	1	12	990	3.2	-5	68	6.9	110	14	1	4	-50	3.1	39	-0.2	-1	41	130	6.3	15	-5	-2	0.45	1.3	-10	0.8	13	-100	-1	5	2	110	-200
93-SB-08B	WIN 010	2	1	13	890	2.8	-5	70	6.9	98	12	1	4	-50	3.5	39	-0.2	1	48	130	6.4	15	-5	-2	0.47	1.2	-10	0.7	13	-100	1	5.6	2	100	380
93-SB-09B	WIN 011	3	1.2	18	880	1.6	-5	64	5.5	87	11	-1	6	-50	3.2	37	-0.2	-1	36	120	6.1	14	-5	-2	0.54	1.3	-10	0.7	12	-100	1	4.4	2	120	-200
93-SB-09B	WIN 062	4	1.2	19	910	2	-5	69	6.4	100	14	1	6	-50	3.3	37	-0.2	1	44	110	6.3	13	-5	-2	0.53	1.2	-10	0.7	12	-100	-1	4.5	3	130	220
93-SB-10A	WIN 012	-2	1.2	13	940	2.1	-5	65	5.9	100	13	1	6	-50	2.9	38	0.2	-1	41	110	6.2	14	-5	-2	0.56	1.2	-10	0.7	12	-100	1	4.3	3	-100	350
93-SB-10B	WIN 013	4	1.1	13	900	1.6	-5	67	5.7	100	13	1	6	-50	3.1	37	-0.2	1	31	110	6.1	14	-5	2	0.57	1.2	-10	0.9	12	-100	-1	5.2	3	110	370
93-SB-11B	WIN 014	4	1	11	930	1.7	-5	73	8.2	110	12	2	4	-50	3.5	43	-0.2	-1	62	140	6.7	18	-5	-2	0.41	1.1	-10	0.6	14	-100	2	4.7	2	140	280
93-SB-11C	WIN 015	-2	1	13	980	1.8	-5	72	8	110	12	1	5	-50	3.5	42	0.2	-1	49	140	6.7	17	-5	-2	0.49	1	-10	0.8	13	-100	1	4.4	2	140	-200
93-SB-11D	WIN 016	4	1	16	880	1.5	-5	65	5.5	96	13	-1	5	-50	3	35	0.3	1	42	110	6.1	13	-5	-2	0.54	1.2	-10	0.6	11	-100	1	3.8	3	-100	220
93-SB-11E	WIN 017	5	1.1	13	910	1.4	-5	66	5.8	96	12	1	7	-50	2.9	38	0.2	1	54	120	6.4	14	-5	-2	0.56	1.2	-10	0.7	12	-100	-1	4.9	2	140	290
93-SB-26A	WIN 018	2	0.9	13	730	2.3	-5	62	4.9	88	13	1	7	-50	2.9	36	0.3	-1	19	110	6.1	12	-5	-2	0.55	1.2	-10	0.9	11	-100	1	3.8	2	-100	220
93-SB-26B	WIN 019	4	0.9	13	720	2.6	-5	67	5.7	95	13	1	5	-50	3.2	37	-0.2	1	35	120	6.2	14	-5	-2	0.56	1.2	-10	0.6	12	-100	1	4.9	2	110	360
93-SB-26C	WIN 020	-2	1.1	10	840	5	-5	53	3.1	77	10	1	14	-50	2.2	31	0.3	-1	28	75	5.6	9.1	-5	-2	0.57	1	-10	0.7	10	-100	-1	3.8	3	-100	640
93-SB-32	WIN 021	7	1.3	17	970	1.9	-5	68	5.9	110	8	1	7	-50	3.5	41	0.4	-1	44	98	7.6	15	-5	-2	0.52	1.1	-10	0.9	13	-100	-1	3.9	3	110	320
93-SB-32	WIN 063	6	1.3	17	930	1.6	-5	71	6.4	100	8	1	6	-50	3.5	42	0.3	-1	40	100	7.5	14	-5	-2	0.47	1.1	-10	1	13	-100	1	3.9	3	140	-200
93-SB-38A	WIN 022	3	1	13	810	2.1	-5	52	4.8	83	13	-1	5	-50	2.9	31	-0.2	-1	40	95	5.4	11	-5	-2	0.51	1.2	-10	0.6	10	-100	2	4.6	2	120	-200
93-SB-38B	WIN 023	-2	1	13	950	2.4	-5	63	5.8	110	14	1	6	-50	3.2	38	0.3	-1	40	110	6.1	14	-5	-2	0.54	1.2	-10	0.7	12	-100	-1	5	3	170	-200
93-SB-38C	WIN 024	3	1.2	16	1000	2.4	-5	65	5.9	110	11	-1	8	-50	3.3	38	-0.2	2	38	110	6.5	13	-5	-2	0.56	1.2	-10	0.8	13	-100	-1	5.3	2	120	-200
93-SB-39A	WIN 025	4	1.3	14	1100	3.2	-5	72	8.7	120	13	2	5	-50	3.9	44	0.2	-1	43	150	6.9	18	-5	-2	0.49	1.1	-10	0.7	14	-100	-1	3.9	2	150	320
93-SB-39B	WIN 026	4	1.2	14	990	2.9	-5	72	7.8	120	16	1	4	-50	3.6	42	0.2	-1	47	140	6.5	17	-5	-2	0.49	1.2	-10	0.7	13	-100	-1	4.2	2	130	360
93-SB-39C	WIN 027	-2	1.2	15	950	2.6	-5	66	6.4	100	15	1	5	-50	3.4	38	0.3	1	48	130	6.4	15	-5	-2	0.58	1.2	-10	1	12	-100	-1	4.5	2	130	290
93-SB-39D	WIN 028	6	1.2	15	1000	2	-5	64	6.5	99	14	1	5	-50	3.6	38	0.3	-1	40	130	6.4	15	-5	-2	0.63	1.2	-10	0.7	12	-100	-1	4.6	2	140	-200
93-SB-40A	WIN 029	3	1	12	870	2.1	-5	57	6.1	97	14	1	4	-50	2.7	34	0.3	1	29	98	5.4	13	-5	-2	0.4	0.9	-10	0.6	11	-100	-1	3.3	2	110	-200
93-SB-40B	WIN 030	3	1.3	17	1000	2.4	-5	57	5	87	12	-1	6	-50	3.2	33	0.3	1	54	99	5.9	12	-5	2	0.57	1	-10	0.9	11	-100	-1	3.4	2	-100	220
93-SB-40C	WIN 031	3	1.3	16	1000	2.3	-5	60	4.8	88	13	1	7	-50	3.4	35	0.4	2	37	100	6	13	-5	-2	0.6	1.1	-10	0.8	11	-100	-1	4	3	170	270
93-SB-40C	WIN 064	3	1.2	16	950	2	-5	64	5	95	14	-1	6	-50	3.2	34	0.2	2	47	95	5.7	12	-5	4	0.55	1.1	-10	0.9	11	-100	1	3.7	3	-100	260
93-SB-41A	WIN 032	3	1.2	13	1000	3	-5	56	5.4	85	14	1	5	-50	3.1	35	0.2	-1	42	97	5.8	13	-5	-2	0.59	1.1	-10	0.8	11	-100	1	3.8	2	100	360
93-SB-41B	WIN 033	3	1.2	14	950	3.5	-5	67	6.8	110	13	1	4	-50	3.2	37	0.2	1	36	130	6.2	15	-5	-2	0.49	1	-10	0.6	12	-100	-1	4.4	3	140	-200
93-SB-42A	WIN 034	3	1.2	17	860	1.1	-5	59	5.6	100	8	1	6	-50	3.8	35	0.3	1	33	120	5.4	16	-5	-2	0.61	1.1	-10	0.8	13	-100	-1	3.7	2	140	230
93-SB-42B	WIN 035	-2	1.3	16	1200	3.2	-5	68	5.4	100	12	2	6	-50	3.5	43	0.4	-1	45	95	7.3	14	-5	-2	0.71	1	-10	0.9	12	-100	-1	4.1	3	110	360
93-SB-43A	WIN 100	5	1.2	14	970	2.1	-5	62	5.1	95	14	1	6	-50	3.4	32	0.2	-1	53	88	5.8	14	-5	-2	0.63	0.9	-10	0.7	11	-100	-1	3.2	3	130	210
93-SB-43B	WIN 037	2	1.2	16	940	1.6	-5	58	4.7	96	11	1	6	-50	3.4	35	0.4	1	42	110	5.9	14	-5	-2	0.65	1	-10	0.8	11	-100	1	3.2	2	100	-200
93-SB-44A	WIN 038	8	1.4	6	950	3.3	-5	44	3.6	130	16	2	3	-50	3.5	26	0.3	-1	30	80	5.1	17	-5	-2	1.1	0.7	-10	0.6	7.7	-100	1	2.6	2	-100	-200
93-SB-44B	WIN 039	-2	1.3	14	980	2	-5	63	5.9	97	14	2	5	-50	3.7	35	0.4	1	64	100	6	16	-5	-2	0.71	1	-10	0.9	11	-100	1	3.1	3	110	390
93-SB-46	WIN 040	3	1	12	1000	3.7	-5	65	6.9	110	11	1	4	-50	3.2	39	0.3	-1	41	130	6.3	16	-5	-2	0.39	1.2	-10	0.6	12	-100	1	3.4	2	-100	-200
93-SB-47A	WIN 041	3	1	14	990	4.6	-5	62	5.2	81	11	1	5	-50	3	35	0.3	2	20	110	5.7	13	-5	-2	0.54	1	-10	0.9	11	-100	-1	3.5	2	-100	290
93-SB-47B	WIN 042	4	1.1	16	820	2.8	-5	61	5.1	85	15	1	5	-50	3.2	33	0.3	3	39	99	5.7	13	-5	-2	0.55	1	-10	0.7	11	-100	-1	3.3	2	-100	-200
93-SB-47B	WIN 065	-2	1	14	820	2.7	-5	62	5.2	89	15	1	5	-50	3.1	34	0.2	2	42	89	5.6	12	-5	-2	0.52	1.1	-10	0.5	11	-100	-1	3.4	3	100	290
93-SB-48	WIN 101	3	1.1	15	980	3	-5	68	6.2	92	11	1	5	-50	3.2	36	-0.2	-1	48	100	6.2	13	-5	-2	0.48	1.1	-10	0.7	12	-100	-1	3.8	2	-100	290
93-SB-50A	WIN 044	-2	0.9	11	710	2.6	-5	57	5.8	93	12	-1	3	-50	2.7	33	0.3	-1	35	110	5.1	13	-5	-2	0.36	0.9	-10	0.5	10	-100	2	2.8	2	120	250
93-SB-50B	WIN 045	-2	1.2	17	880	2	-5	66	5.6	96	12	-1	6	-50	3.2	36	0.4	2	33	110	6.1	14	-5	-2	0.53	1.2	-10	0.8	12	-100	1	3.3	2	120	-200
93-SB-51	WIN 046	-2	0.8	8.6	690	3.4	-5	52	5.7	81	11	1	2	-50	2.5	30	0.2	-1	-10	98	4.6	12	-5	-2	0.31	0.7	-10	-0.5	8.8	-100	-1	2.9	2	-100	-200
93-SB-52A	WIN 047	3	1.1	13	880	3.4	-5	74	6.9	110	18	1	5	-50	3.4	40	0.2	1	60	130	6.2	14	-5	-2	0.5	1.1	-10	0.9	13	-100	1	4.5	3	160	250
93-SB-52B	WIN 048	2	1.1	14	970	3.2	-5	67	6.1	100	13	1	7	-50	3.3	40	-0.2	-1	45	120	6.3	13	-5	-2	0.6	1.2	-10	1	12	-100	1	4.7	3	-100	240
93-SB-52C	WIN 049	2	1.1	15	940	3.2	-5	71	6.9	110	18	-1	5	-50	3.5	41	0.3	-1	57	120	6.4	14	-5	-2	0.58	1.3	-10	0.9	13	-100	-1	4.8	3	150	350
93-SB-53A	WIN 050	-2	1	13	850	2.9	-5	71	7	95	15	-1	4	-50	3.3	40	0.2	-1	40	130	6.2	14	-5	-2	0.51	1.1	-10	0.8	13	-100	1	4.3	2	130	400
93-SB-53B	WIN 051	3	1	15	900	2.9	-5	74	7.4	110	17	1	5	-50	3.7	43	0.2	1	45	140	6.5	15	-5	-2	0.52	1.2	-10	0.8	13	-100	1	4.5	3	130	-200
93-SB-53C	WIN 052	3	1.1	16	910	1.9	-5	66	6.3	87	13	1	6	-50	3.2	39	0.3	1	35	110	6.2	13	-5	-2	0.62	1.2	-10	1	12	-100	1	4.7	3	140	260
93-SB-53C	WIN 066	-2	1.1	17	920	1.8	-5	71	6.5	110	11	-1	6	-50	3.1	38	-0.2	2	47	120	6.4	13	-5	-2	0.59	1	-10	0.8	13	-100	1	4.9	3	100	290

Sample #	WIN #	Au	Sb	As	Ba	Br	Cd	Ce	Cs	Cr	Co	Eu	Hf	Ir	Fe	La	Lu	Mo	Ni	Rb	Sm	Sc	Se	Ag	Na	Ta	Te	Tb	Th	Sn	W	U	Yb	Zn	Zr
		PPB	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPB	%	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	%	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM
93-SB-55A	WIN 053	5	1.2	17	990	3.4	-5	75	6.3	93	11	1	6	-50	3.6	52	0.3	1	59	110	8.4	14	-5	-2	0.62	1.3	-10	1.1	13	-100	-1	5.6	5	100	300
93-SB-55B	WIN 054	3	0.9	11	980	4.7	-5	62	6.7	95	12	1	4	-50	2.9	35	-0.2	1	38	110	5.4	13	-5	2	0.39	1.1	-10	0.8	11	-100	-1	3.4	2	100	-200
93-SB-56	WIN 055	2	1.1	16	950	2.4	-5	72	5.7	89	14	2	6	-50	3.4	39	0.3	1	44	100	6.6	13	-5	-2	0.56	1	-10	0.8	12	-100	1	3.7	3	130	320
93-SB-62	WIN 056	3	1	14	890	2.2	-5	70	6.1	86	12	1	6	-50	3.3	39	-0.2	1	41	110	6.2	13	-5	-2	0.51	1.3	-10	0.9	12	-100	1	4.6	3	-100	380
93-SB-65A	WIN 057	3	1	14	940	1.5	-5	68	5.6	99	14	-1	6	-50	3.1	37	0.2	1	43	100	6.1	13	-5	-2	0.54	1.1	-10	0.9	12	-100	1	4.5	3	110	420
93-SB-65B	WIN 058	3	1.1	14	910	1.7	-5	61	5.6	92	15	1	6	-50	3.3	36	0.2	1	56	100	5.9	13	-5	-2	0.57	1.1	-10	0.9	11	-100	1	4.2	3	110	440
93-SB-65C	WIN 059	5	1.1	14	930	1.6	-5	68	5.7	95	15	1	6	-50	3.3	36	0.2	1	54	100	6.1	13	-5	-2	0.6	1.1	-10	1	12	-100	2	4.3	3	130	280
93-SB-72A	WIN 060	3	1.1	18	960	1.6	-5	67	5.8	84	12	1	6	-50	3.4	37	-0.2	-1	41	100	6.2	13	-5	-2	0.55	1	-10	0.7	12	-100	1	4.5	3	100	270
93-SB-72A	WIN 067	-2	1	17	870	1.9	-5	67	5.5	90	12	1	6	-50	3.3	36	-0.2	2	27	100	5.9	12	-5	-2	0.51	1.1	-10	0.7	11	-100	1	4.1	3	120	-200
93-SB-72B	WIN 061	4	1.1	14	870	1.6	-5	61	5.7	93	16	1	6	-50	3.1	35	-0.2	1	46	110	5.9	13	-5	-2	0.59	1.2	-10	0.6	11	-100	1	4.1	3	100	320
BOREHOLES																																			
93-SAB-06																																			
3.35 m	WIN 068	3	1.2	12	870	2	-5	72	8.4	110	14	1	3	-50	3.3	42	-0.2	-1	53	140	6.2	16	-5	-2	0.37	1.1	-10	0.6	14	-100	1	4	2	130	-200
5.79 m	WIN 069	4	1	16	950	2	-5	77	7.9	120	23	1	4	-50	3.7	42	0.2	1	49	120	6.5	16	-5	-2	0.4	1.3	-10	0.9	13	-100	1	3.9	2	110	220
8.53 m	WIN 070	3	1.2	16	990	1.8	-5	61	6.6	93	14	1	6	-50	3	35	-0.2	2	45	110	6.4	11	-5	-2	0.47	1.3	-10	0.8	12	-100	1	4.8	2	100	350
9.91 m	WIN 083	3	1.1	16	920	1.8	-5	73	6.2	110	14	1	6	-50	3.2	38	0.3	1	46	110	6.2	13	-5	-2	0.54	1.1	-10	0.8	12	-100	-1	4.4	3	140	230
9.91 m	WIN 102	5	1.1	16	900	2.2	-5	65	6	100	13	1	6	-50	3.1	36	-0.2	1	56	110	6.1	13	-5	-2	0.48	1.2	-10	0.8	12	-100	1	4.5	3	-100	210
12.65 m	WIN 072	2	1.2	16	950	1.9	-5	62	5.9	97	13	1	6	-50	3.2	36	-0.2	1	31	110	6.3	12	-5	-2	0.5	1.3	-10	0.8	12	-100	1	4.9	3	100	270
15.39 m	WIN 073	-2	1.1	16	960	1.9	-5	60	6.5	88	13	1	5	-50	2.9	35	-0.2	2	38	120	6.3	12	-5	-2	0.48	1.1	-10	0.8	12	-100	1	4.7	2	110	240
19.05 m	WIN 074	5	1.1	17	940	1.9	-5	62	6.5	100	13	1	6	-50	3	36	-0.2	1	46	110	6.3	12	-5	-2	0.49	1	-10	0.9	12	-100	1	4.9	2	-100	220
21.79 m	WIN 075	-2	1.1	16	910	1.6	-5	62	6.4	89	12	1	5	-50	3	35	-0.2	2	38	120	6.1	12	-5	-2	0.49	1.3	-10	0.7	12	-100	-1	4.4	3	100	-200
24.54 m	WIN 076	-2	1	17	930	1.8	-5	64	6.1	90	13	1	5	-50	3	35	-0.2	1	44	100	6	12	-5	-2	0.48	1.2	-10	0.8	12	-100	-1	4.2	2	100	-200
27.28 m	WIN 077	3	1	17	910	1.5	-5	65	6	91	13	1	5	-50	3.1	36	-0.2	1	34	110	6	13	-5	-2	0.49	1.2	-10	0.8	12	-100	1	4.3	3	-100	-200
30.02 m	WIN 078	-2	1	17	950	1.9	-5	69	6.4	96	13	-1	6	-50	3.2	38	-0.2	1	46	110	6.1	13	-5	-2	0.54	1.1	-10	0.8	12	-100	-1	4.4	3	120	300
32.77 m	WIN 079	3	1	17	920	1.8	-5	66	6.4	91	15	1	6	-50	3.4	38	0.3	-1	27	110	6.2	14	-5	-2	0.53	1.2	-10	0.6	12	-100	2	4.3	3	120	290
32.77 m	WIN 084	4	1.1	18	980	1.9	-5	73	6.5	110	16	1	6	-50	3.5	41	-0.2	1	55	120	6.4	15	-5	-2	0.56	1.3	-10	0.7	12	-100	-1	4.4	3	110	-200
39.01 m	WIN 080	-2	1.1	16	880	1.8	-5	64	5.4	110	12	-1	6	-50	3.2	37	0.2	1	28	100	6	13	-5	-2	0.57	0.9	-10	0.8	12	-100	1	4.2	3	110	240
41.76 m	WIN 081	-2	1.1	15	920	1.7	-5	66	5.6	100	14	1	6	-50	3.3	37	-0.2	1	36	110	6	13	-5	-2	0.59	1.2	-10	0.8	12	-100	-1	4.3	2	130	290
44.50 m	WIN 103	4	1.1	15	890	1.8	-5	70	6.1	110	14	1	6	-50	3.4	36	-0.2	2	42	100	6	14	-5	2	0.57	1	-10	1	12	-100	2	4.2	3	-100	240
93-SAB-13																																			
14.94 m	WIN 085	3	1	12	970	2.1	-5	74	8.3	110	14	-1	3	-50	3.8	42	-0.2	-1	46	130	6.3	16	-5	-2	0.37	1.1	-10	0.7	13	-100	-1	4.4	3	140	-200
20.57 m	WIN 086	4	1.1	10	810	1	-5	58	3.7	76	10	1	5	-50	2.5	32	-0.2	-1	24	81	5.1	11	-5	-2	0.56	0.9	-10	-0.5	10	-100	1	3.2	2	100	260
20.57 m	WIN 097	-2	1.2	10	840	0.9	-5	54	3.9	77	11	1	5	-50	2.5	31	-0.2	-1	36	80	5.3	11	-5	-2	0.52	1	-10	0.6	10	-100	1	3.6	2	-100	210
21.34 m	WIN 087	3	1	13	950	1.4	-5	82	7.8	110	14	1	4	-50	3.5	42	-0.2	1	34	130	6.4	16	-5	-2	0.46	1.1	-10	0.8	13	-100	1	4.4	3	110	210
22.10 m	WIN 088	5	1	13	890	2	-5	69	6.2	97	14	1	6	-50	3.2	37	-0.2	-1	48	100	6	13	-5	-2	0.48	1.1	-10	0.8	12	-100	1	4.2	2	110	260
23.32 m	WIN 089	3	1.1	14	1100	1.2	-5	72	7	110	16	1	5	-50	3.5	39	0.2	1	49	120	6.3	15	-5	-2	0.5	1.1	-10	0.9	12	-100	1	4.3	3	120	280
24.38 m	WIN 090	4	1.2	14	950	1.6	-5	58	5.9	81	14	1	6	-50	3.3	35	-0.2	-1	51	100	5.7	13	-5	-2	0.56	1	-10	0.8	11	-100	1	4.2	3	100	280
27.13 m	WIN 091	-2	1.2	14	1000	1.2	-5	63	6	95	13	1	6	-50	3.2	35	0.2	1	38	110	5.7	13	-5	-2	0.57	0.9	-10	0.9	11	-100	-1	4.2	3	120	-200
29.87 m	WIN 092	5	1.2	13	960	1.9	-5	64	5.6	97	13	1	6	-50	3.3	37	-0.2	1	47	98	5.7	13	-5	-2	0.57	1.1	-10	0.8	11	-100	1	4.1	3	-100	-200
32.61 m	WIN 093	-2	1.2	14	1000	1.5	-5	58	5.8	94	12	1	6	-50	3.1	33	-0.2	1	48	110	5.8	12	-5	2	0.5	1.1	-10	0.7	11	-100	-1	4.4	2	-100	240
35.36 m	WIN 094	4	1.2	15	1000	1.8	-5	64	5.9	98	13	1	6	-50	3.3	35	-0.2	1	43	110	6.1	13	-5	-2	0.54	1.2	-10	0.8	12	-100	-1	4.4	2	110	220
38.10 m	WIN 095	4	1.2	14	970	1.6	-5	64	5.7	110	13	-1	6	-50	3.2	34	-0.2	2	46	110	6	13	-5	-2	0.54	1	-10	0.6	12	-100	-1	4.4	3	120	340
40.84 m	WIN 096	3	1.1	14	990	1.2	-5	61	6	88	13	1	5	-50	3.1	33	-0.2	-1	50	99	5.9	13	-5	-2	0.51	0.9	-10	0.9	12	-100	1	4.5	2	-100	320
40.84 m	WIN 098	52	1.2	14	990	1.8	-5	62	5.5	93	15	1	5	-50	3.1	34	-0.2	1	39	100	5.8	13	-5	-2	0.51	1	-10	0.8	11	-100	1	4.1	2	100	270
STANDARDS																																			
standard	WIN 004	-2	1	8.3	670	3.2	-5	52	3.8	71	11	-1	5	-50	2.6	30	-0.2	1	33	93	5	11	-5	-2	0.92	1	-10	0.6	10	-100	-1	3.9	1	110	280
standard	WIN 036	-2	1	8.1	650	3.2	-5	53	3.8	77	11	1	4	-50	2.7	31	0.2	1	47	96	5	11	-5	-2	0.94	0.9	-10	0.6	10	-100	-1	3.9	2	130	-200
standard	WIN 043	-2	1	7.9	640	3.2	-5	55	3.6	74	11	-1	5	-50	2.7	31	-0.2	-1	18	95	5	11	-5	-2	1	0.7	-10	0.7	10	-100	-1	4	2	-100	250
standard	WIN 071	3	1	8.1	650	3.2	-5	47	3.6	60	12	-1	4	-50	2.4	28	-0.2	1	45	83	4.9	9.1	-5	-2	0.76	0.7	-10	0.6	10	-100	-1	3.9	2	-100	220
standard	WIN 082	-2	0.9	7.9	630	2.9	-5	57	3.6	68	13	-1	4	-50	2.7	31	-0.2	1	36	85	4.8	10	-5	-2	0.88	0.8	-10	0.6	10	-100	-1	3.8	2	100	200

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Sample #	WIN #	Au	Sb	As	Ba	Br	Ce	Cs	Cr	Co	Eu	Hf	Fe	La	Lu	Mo	Ni	Rb	Sm	Sc	Ag	Na	Ta	Tb	Th	W	U	Yb	Zn	Zr
		PPB	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	%	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	%	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM
SECTIONS																														
94-SB-01B	WIN209	4	1.1	12.0	740	2.0	67	5.1	81	14	1	6	3.00	32	0.2	1	10	84	5.2	11	2	0.62	1.2	0.8	10	1	3.8	2	100	200
94-SB-02	WIN210	3	1.4	12.0	1000	5.4	83	7.3	87	19	1	4	4.00	40	0.2	1	39	120	6.6	15	2	0.51	0.8	0.9	12	1	3.7	2	100	200
94-SB-03B	WIN211	4	1.2	15.0	950	3.0	73	5.9	90	17	1	6	3.60	35	0.2	1	37	87	5.7	11	2	0.50	1.2	0.6	10	1	3.1	2	130	200
94-SB-04C	WIN212	2	1.2	12.0	1100	2.1	72	6.5	96	13	1	5	3.50	37	0.2	1	30	100	6.0	13	2	0.55	1.3	0.6	12	1	3.1	2	120	200
94-SB-05	WIN213	2	0.9	10.0	1000	1.1	71	4.6	83	21	1	10	2.90	35	0.2	1	28	79	6.0	11	2	0.83	0.8	0.9	11	1	3.5	3	100	440
94-SB-07	WIN215	2	1.1	11.0	840	1.0	51	5.3	100	8	1	6	3.60	29	0.2	1	30	75	4.6	14	2	0.81	1.2	0.7	11	1	2.9	2	110	380
94-SB-09B	WIN216	2	1.0	11.0	990	2.7	67	5.7	75	9	1	5	3.10	35	0.2	1	33	84	5.7	12	2	0.61	0.9	0.8	10	1	2.8	3	100	440
94-SB-10	WIN218	4	1.2	13.0	970	2.4	69	5.7	79	12	1	6	3.40	34	0.2	1	42	86	5.6	12	2	0.63	1.1	0.8	10	1	2.7	3	100	200
94-SB-11B	WIN305	2	1.1	15.0	860	1.8	62	4.8	79	11	1	6	3.50	33	0.2	1	41	80	5.5	12	2	0.76	0.8	0.8	11	1	4.4	3	100	560
94-SB-14	94G 102	4	1.8	19.0	1100	1.3	69	5.2	110	18	1	7	3.50	39	0.3	1	41	100	6.2	13	2	1.10	1.1	0.9	12	1	4.3	3	140	200
94-SB-14C	WIN223	2	1.0	11.0	890	0.8	63	5.1	86	8	1	5	3.00	32	0.2	1	35	82	5.3	11	2	0.85	1.1	0.5	9.2	1	2.9	3	100	200
94-SB-14E	WIN225	2	1.2	12.0	850	0.8	61	4.2	110	8	1	6	3.00	31	0.2	1	29	74	5.1	11	2	1.00	0.9	0.6	9.2	1	3.4	3	100	200
94-SB-15	WIN227	2	1.2	14.0	730	1.7	65	6.5	84	11	1	6	3.70	35	0.2	1	10	110	5.2	15	2	0.61	0.9	0.8	12	1	3.3	2	100	450
94-SB-16B	WIN306	2	1.1	13.0	1100	1.8	67	6.5	90	10	1	5	3.70	33	0.2	1	32	110	4.2	14	2	0.51	1.0	0.5	12	1	2.8	2	100	470
94-SB-18	WIN229	2	1.2	13.0	960	3.5	80	7.5	110	14	1	5	4.00	45	0.2	1	49	100	7.2	16	2	0.51	1.1	1.0	12	1	3.3	3	110	200
94-SB-19B	WIN230	2	1.0	12.0	870	2.3	66	5.1	80	16	1	5	3.70	35	0.2	1	26	91	5.4	13	2	0.81	1.0	0.8	10	2	3.6	3	120	200
94-SB-20	WIN232	2	1.3	12.0	990	2.5	58	4.3	110	17	1	6	3.10	28	0.2	1	46	79	5.0	12	2	0.75	1.0	0.5	9.4	1	2.9	1	150	370
94-SB-21F	WIN234	2	1.4	11.0	1000	1.9	66	5.0	97	22	1	5	3.20	30	0.2	1	50	91	5.3	12	2	0.76	1.0	0.6	10	1	2.8	2	100	200
94-SB-22B	WIN260	2	1.2	10.0	1000	4.9	69	6.2	98	16	1	4	3.10	35	0.2	1	35	89	5.6	13	2	0.49	0.9	0.7	10	1	2.7	2	110	200
94-SB-23	WIN309	2	1.2	15.0	900	1.9	80	6.0	86	15	1	6	3.60	49	0.4	1	79	82	7.3	13	2	0.58	1.2	1.2	11	1	3.1	3	100	360
94-SB-24B	WIN238	4	1.1	12.0	1000	4.5	72	6.1	100	17	1	6	3.40	35	0.2	1	35	93	5.9	13	2	0.77	1.1	0.7	10	1	3.1	2	130	200
94-SB-25B	WIN310	4	1.2	12.0	1300	2.5	62	5.3	84	15	1	5	3.40	35	0.2	1	46	77	5.7	12	2	0.66	1.0	0.7	10	1	2.9	2	110	430
94-SB-26AC	WIN245	2	1.1	9.4	850	5.6	69	6.7	86	10	1	4	3.20	38	0.3	1	40	99	6.2	14	2	0.42	0.9	0.8	11	1	2.6	3	110	450
94-SB-26B	WIN247	2	1.2	12.0	970	1.9	70	6.7	98	19	1	5	3.60	37	0.2	1	24	100	5.9	14	2	0.60	1.0	0.6	11	1	3.2	3	100	200
94-SB-28	WIN203	2	1.4	13.0	890	2.6	72	5.5	95	13	1	5	3.20	35	0.2	1	10	93	5.9	12	2	0.56	1.0	1.0	11	1	3.0	3	100	350
94-SB-29E	WIN249	6	1.1	7.2	880	0.5	64	4.9	110	14	1	5	3.50	31	0.2	1	10	84	5.1	12	2	1.00	0.9	0.6	10	1	4.1	2	100	200
94-SB-29H	WIN250	2	1.1	10.0	880	1.1	67	4.9	78	16	1	6	3.40	34	0.2	1	45	93	5.6	12	2	0.66	1.2	0.7	11	1	3.8	3	110	200
94-SB-30B	WIN208	7	1.6	16.0	1100	3.1	77	5.7	100	22	1	7	3.70	33	0.2	1	20	90	5.9	12	2	0.56	1.1	0.6	11	1	2.9	2	180	200
94-SB-32	WIN251	2	1.0	8.5	910	2.8	73	6.0	90	12	1	3	3.20	38	0.2	1	45	120	5.7	12	2	0.46	1.0	0.6	12	1	2.9	2	100	200
94-SB-35	94G 057	8	1.2	14.0	920	1.8	64	5.9	110	15	1	6	3.40	37	0.2	1	42	110	6.0	13	2	0.58	0.9	1.0	11	1	3.6	3	160	200
94-SB-35A	WIN254	2	1.2	15.0	1100	2.5	83	5.5	110	14	1	6	3.70	39	0.3	1	10	91	6.3	13	2	0.62	1.2	1.0	11	1	2.8	3	100	200
94-SB-35C	WIN256	3	1.1	14.0	960	1.8	71	5.2	96	13	1	5	3.50	34	0.2	1	28	94	5.7	12	2	0.58	1.0	0.8	11	1	3.2	2	110	360
94-SB-36	WIN257	2	1.8	4.5	1100	4.2	54	3.4	62	5	1	5	2.20	27	0.2	1	33	60	4.3	10	3	1.10	0.8	0.8	9.1	1	3.5	2	100	200
94-SB-37	WIN262	4	1.2	13.0	930	3.3	68	5.8	85	14	1	6	3.70	36	0.2	1	42	93	6.1	13	2	0.60	1.0	0.9	11	1	3.0	3	100	200
93-SA-B38	94G 091	6	1.1	15.0	960	2.9	79	7.5	120	16	1	5	3.60	40	0.2	1	41	110	6.2	14	2	0.52	1.3	0.6	12	1	5.1	3	160	500
94-SB-39	WIN263	2	1.2	12.0	1000	3.0	69	6.3	84	15	1	5	3.20	35	0.2	1	26	98	5.8	12	2	0.60	1.0	0.9	10	1	3.6	2	120	530
93-SB-39	94G 104	5	1.2	14.0	970	1.5	73	6.4	110	16	1	6	3.20	38	0.2	3	47	110	6.1	14	2	0.56	1.3	0.7	11	1	5.0	3	150	310
94-SB-40	WIN265	2	1.4	12.0	870	3.2	100	5.6	100	20	2	7	3.60	55	0.5	1	65	74	10.7	14	2	0.84	1.0	1.5	10	2	2.8	4	100	200
94-SB-41	WIN267	2	1.2	12.0	1000	4.1	80	6.9	110	16	1	6	3.80	41	0.2	1	59	120	6.5	15	2	0.70	1.2	0.8	12	1	3.9	3	180	200
94-SB-42B	WIN268	5	1.1	13.0	900	3.5	57	5.0	78	20	1	5	3.40	30	0.2	1	25	71	5.1	12	2	0.70	0.9	0.7	9.2	1	3.2	2	100	200
94-SB-43	WIN270	5	1.3	12.0	1100	3.6	63	5.3	100	13	1	5	2.90	33	0.2	1	44	88	5.5	13	5	1.00	0.8	0.9	10	1	3.0	2	130	200
94-SB-45B	WIN300	2	1.4	14.0	1000	1.9	120	8.9	110	29	2	5	4.30	52	0.3	1	50	120	10.2	17	6	0.46	1.3	1.7	14	1	3.6	4	100	200
94-SB-46B	WIN231	3	1.2	15.0	990	2.2	78	3.9	98	12	1	10	3.40	35	0.3	1	39	74	6.1	12	2	1.00	1.2	0.8	10	1	3.3	3	120	470
94-SB-47	WIN311	2	1.0	12.0	800	3.2	69	6.1	90	16	1	5	3.20	34	0.2	1	41	100	5.5	12	2	0.55	0.8	0.6	10	1	3.9	2	100	370
94-SB-48	WIN202	2	1.3	12.0	1000	2.6	68	7.2	93	15	1	5	3.60	36	0.2	1	39	98	6.2	14	2	0.51	1.3	0.9	11	1	2.9	3	130	200
94-SB-49	WIN205	2	1.2	6.7	1000	4.0	53	5.2	83	9	1	5	3.10	26	0.2	1	24	82	4.4	12	2	1.00	1.2	0.6	9.3	1	2.8	2	100	200
94-SB-50C	WIN273	7	1.2	13.0	1100	3.3	76	7.2	130	16	1	5	3.50	40	0.2	1	10	110	6.4	14	2	0.56	1.3	1.0	12	1	4.1	2	150	200
94-SB-51B	WIN274	2	1.0	11.0	860	2.6	63	5.9	85	15	1	4	3.10	33	0.2	1	29	110	5.3	12	2	0.51	0.9	0.8	10	1	4.1	2	100	200
93-SB-52	94G 092	5	1.4	21.0	990	2.8	80	7.3	120	18	1	7	3.80	43	0.3	2	53	120	6.8	15	3	0.59	1.4	1.1	13	1	5.4	3	230	200
94-SB-52A	WIN276	2	1.0	12.0	1100	3.9	70	5.6	110	13	1	6	3.80	36	0.2	1	44	81	5.8	12	2	0.55	1.2	0.5	11	2	3.0	2	130	200
94-SB-52B	WIN278	4	1.1	13.0	980	3.5	77	5.9	110	16	1	5	3.30	32	0.2	2	44	110	5.6	11	2	0.52	1.1	0.7	11	1	3.3	2	100	200
94-SB-54B	WIN312	2	1.1	15.0	900	3.5	87	7.0	110	19	1	7	3.80	40	0.2	2	55	120	6.3	14	2	0.50	1.5	1.0	12	1	3.6	2	100	200
94-SB-55B	WIN283	4	1.4	13.0	1000	3.2	79	6.2	120	14	1	8	3.80	40	0.2	1	34	100	7.1	14	2	0.69	1.3	1.1	13	1	3.5	3	110	500
94-SB-58	WIN285	2	1.6	11.0	1000	0.5	51	4.6	120	14	1	6	4.00	30	0.2	1	10	71	5.8	15	2	0.92	1.1	0.5	9.3	1	2.8	3	100	200
94-SB-60	WIN287	2	1.3	15.0	1100	2.2	69	6.2	87	17	1	5	3.60	35	0.2	1	50	97	5.9	12	2	0.60	1.1	0.8	11	1	3.1	2	140	200
94-SB-61B	WIN288	3	1.3	15.0	810	2.2	69	4.6	96	17	1	6	3.70	36	0.2	1	41	78	6.9	13	2	0.67	1.1	0.9	10	1	2.9	2	100	500
94-SB-62	WIN289	4	1.1	12.0	930	2.5	67	6.1	87	13	1	4	3.30	37	0.2	1	10	110	5.8	13	2	0.57	1.0	0.8	11	1	3.3	2	190	430
94-SB-64B	WIN207	2	1.4	13.0	900	2.2	53	5.1	94	14	1	6	3.60	30	0.2	1	10	81	5.2	12	2	0.66	1.0	0.7	8.8	1	3.0	2	100	200
94-SB-66C	WIN290	5	1.0	11.0	810	2.7	71	6.8	100	16	1	4	3.30	35	0.2	1	36	100	5.6	13	2	0.52	1.0	0.6	10	1	4.3	2	100	200
94-SB-71	WIN240	2	1.1	14.0	940	3.8	79	8.2	120	16	1	5	4.30	39	0.2	1	46	120	6.3	16	2	0.45	1.2	0.9	12	1	4.5	3	140	200
94-SB-72	WIN293	4	1.4	13.0	1200	4.0	63	5.6	100	13	1	6	3.10	32	0.2	1	25	96	5.7	11	2	0.55	1.1	0.7	10	1	3.5	3	100	200
94-SB-73B	WIN294	2	0.9	14.0	810	1.8	66	5.9	91	12	1	6	3.20	35	0.2	1	29	97	5.7	12	2	0.57	1.3	0.9	11	1	4.1	2	100	200
94-SB-74B	WIN295	2	1.1	13.0	950	2.9	70	6.6	83	12	1	5	3.20	36	0.2	1	31	110	6.0	12	2	0.45	1.0	0.7	11	1	3.9	3	100	200
94-SB-74D	WIN206	2	1.2	13.0	920	1.2	68	6.8	83	15	1	5	3.20	34	0.2	1	41	110	5.8	12	2	0.50	0.8	0.6	11	1	4.2	2	100	200
94-SB-75A	WIN280	2	1.3	15.0	1000	2.0	72	6.6	100	15	1	7	3.80	36	0.2	1	10	100	6.2	14	2	0.76	1.5	0.9	11	1	4.1	2	110	200
94-SB-75C	WIN296	2	1.0	10.0	870	1.5	63	4.9	80	15	1	6	3.20	29	0.2	1	34	84	5.2	11	2	0.85	0.9	0.5	10	1	3.4	2	100	200

1994 - INAA DATA

Sample #	WIN #	Au	Sb	As	Ba	Br	Ce	Cs	Cr	Co	Eu	Hf	Fe	La	Lu	Mo	Ni	Rb	Sm	Sc	Ag	Na	Ta	Tb	Th	W	U	Yb	Zn	Zr
		PPB	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	%	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	%	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM
94-SB-76	94G 107	6	1.2	15.0	1000	1.6	66	6.0	120	17	1	6	3.50	38	0.2	1	50	110	6.2	14	2	0.68	1.2	1.0	11	1	4.4	3	130	370
94-SB-76C	WIN308	2	1.0	12.0	880	1.1	73	6.6	110	14	1	6	3.40	36	0.2	1	47	96	5.9	13	2	0.64	1.4	0.7	11	1	4.1	2	100	200
94-SB-77	WIN201	2	1.4	12.0	900	1.3	60	4.8	84	12	1	5	2.80	29	0.2	1	34	80	4.9	12	2	1.20	0.8	0.8	9.1	1	3.7	2	100	200
94-SB-77	WIN219	2	1.3	11.0	840	1.1	54	4.6	85	13	1	4	2.80	27	0.2	1	37	72	4.6	11	2	1.20	0.8	0.6	8.6	1	3.4	2	170	200
94-SB-78	WIN298	2	1.3	12.0	1100	3.4	65	4.6	77	20	1	6	3.30	31	0.2	1	43	81	5.5	12	2	0.91	1.0	0.6	11	1	3.2	3	100	450
94-SB-79	WIN301	3	1.1	10.0	900	1.3	67	3.2	220	8	1	10	1.50	30	0.2	1	29	110	4.7	8.6	2	1.40	0.9	0.7	9.1	1	3.3	2	110	320
94-SB-80	WIN302	3	1.3	16.0	1100	2.5	69	6.0	97	18	1	6	3.90	35	0.2	1	32	100	6.0	13	3	0.65	1.1	0.8	11	1	3.2	2	100	550
94-SB-81	WIN261	2	1.1	11.0	910	1.0	66	4.1	88	17	1	7	3.20	33	0.2	1	34	90	5.4	11	2	0.92	1.2	0.8	10	1	3.5	2	100	380
94-SB-81	WIN279	3	1.1	11.0	910	1.1	70	3.8	93	14	1	7	2.90	31	0.2	1	39	74	5.3	10	2	0.88	1.0	0.8	10	1	3.2	2	130	200
94-SB-91A	WIN303	4	1.2	11.0	900	1.7	63	5.1	97	19	1	4	3.30	30	0.2	1	39	83	5.0	12	2	0.79	0.8	0.5	10	1	3.4	3	120	330
94-SB-91B	WIN304	2	1.1	14.0	880	1.5	56	5.3	100	11	1	5	3.40	30	0.2	1	32	92	5.1	12	2	0.79	1.0	0.8	9.5	2	3.5	2	150	200
BOREHOLES																														
94-SAB-02																														
1.22 m	WIN214	2	1.6	12.0	1100	0.6	57	5.0	100	24	1	5	3.40	27	0.2	1	50	72	4.6	12	2	1.00	0.9	0.6	8.5	1	2.8	2	100	200
3.35 m	WIN217	2	1.4	14.0	1000	0.5	61	4.2	110	18	1	5	3.70	26	0.2	1	49	67	4.7	13	2	1.10	0.9	0.9	8.9	1	3.0	2	110	200
3.81 m	WIN221	2	0.8	4.5	590	0.5	47	1.5	97	19	1	6	3.50	25	0.2	1	44	43	4.0	16	2	1.50	0.8	0.5	7.9	1	4.0	1	140	200
3.81 m	WIN239	18	0.8	4.6	650	0.5	46	1.7	99	20	1	6	3.30	24	0.2	1	44	47	4.1	15	2	1.50	0.5	0.5	8.2	2	4.0	2	150	400
94-SAB-08																														
0.76 m	WIN222	2	1.2	10.0	1100	1.8	65	4.6	96	14	1	5	3.20	30	0.2	1	10	76	5.0	12	2	1.20	1.0	0.5	10	1	3.8	2	100	200
2.13 m	WIN224	2	1.0	11.0	1000	1.2	53	4.3	77	14	1	5	3.00	31	0.2	1	47	66	4.9	11	2	1.10	0.8	0.7	11	1	3.7	2	100	410
2.44 m	WIN226	5	0.9	2.7	930	0.5	50	3.2	110	6	1	4	2.80	24	0.2	1	16	68	3.6	12	2	1.50	1.1	0.5	8.4	1	4.4	2	100	200
5.33 m	WIN228	2	1.0	24.0	1200	0.5	56	1.8	170	15	1	6	2.80	26	0.2	1	35	56	3.9	15	2	1.70	1.2	0.5	8.3	1	3.4	2	100	580
94-SAB-09																														
1.22 m	WIN246	5	1.1	13.0	990	2.5	77	6.3	85	20	1	5	3.80	39	0.2	1	48	110	6.0	13	2	0.57	1.3	1.0	12	1	3.9	3	140	200
3.51 m	WIN220	3	1.2	15.0	880	3.1	70	6.9	110	13	1	5	4.20	38	0.2	1	55	120	6.0	16	2	0.66	1.3	0.6	11	1	5.0	3	140	200
9.60 m	WIN269	2	1.1	14.0	940	2.6	72	6.4	85	12	1	6	3.50	35	0.2	1	31	110	5.8	13	5	0.57	1.1	0.8	11	1	4.3	3	100	200
15.70 m	WIN307	2	1.0	11.0	870	1.2	70	5.1	100	14	1	5	3.50	31	0.2	1	31	82	5.4	12	2	0.74	0.9	0.7	10	1	4.4	3	100	200
21.79 m	WIN272	2	0.9	11.0	860	1.0	55	5.2	87	14	1	5	3.40	30	0.2	1	43	84	5.2	12	2	0.71	1.0	0.8	9.2	1	3.3	2	100	200
27.89 m	WIN284	3	1.1	12.0	820	1.5	68	5.3	80	13	1	5	3.60	32	0.2	2	53	90	5.6	13	2	0.77	1.2	0.8	10	1	3.5	2	110	200
35.81 m	WIN252	6	1.1	13.0	870	1.0	62	4.9	83	14	1	5	3.50	32	0.3	2	36	93	5.3	12	2	0.75	1.1	0.7	9.2	1	3.5	3	110	490
40.08 m	WIN286	5	1.2	13.0	810	1.4	65	5.1	82	14	1	6	3.60	31	0.2	1	47	100	5.5	12	2	0.77	1.2	0.5	9.4	1	3.6	2	130	400
94-SAB-10																														
1.52 m	WIN233	4	1.4	12.0	960	1.9	63	4.9	98	20	1	5	4.20	30	0.2	1	76	76	5.5	14	2	0.77	1.2	0.8	8.4	1	2.4	3	100	200
4.72 m	WIN235	5	1.3	14.0	1000	1.4	65	5.2	82	15	1	6	3.70	33	0.2	1	50	94	5.5	13	2	0.69	1.1	0.9	10	1	3.6	2	120	320
6.86 m	WIN237	4	1.1	13.0	980	1.6	67	5.3	98	15	1	6	3.70	32	0.2	1	35	89	5.5	13	2	0.74	1.0	0.6	10	1	3.8	2	100	370
10.52 m	WIN242	2	1.1	12.0	1000	1.3	69	6.0	99	16	1	6	3.70	33	0.2	1	40	100	5.6	14	2	0.73	1.1	0.5	10	1	3.4	3	170	200
12.04 m	WIN241	2	1.0	4.4	1100	0.6	49	3.4	130	16	1	4	3.90	23	0.2	1	50	62	4.6	16	2	1.30	0.8	0.5	5.8	1	2.5	2	140	390
12.04 m	WIN259	2	1.1	4.5	1100	0.5	42	4.0	120	17	1	4	3.90	24	0.2	1	71	74	4.7	16	2	1.40	0.8	0.8	5.9	1	2.8	2	100	200
94-SAB-11																														
1.52 m	WIN248	2	1.2	16.0	990	3.1	66	5.2	72	15	1	6	3.40	32	0.2	1	27	92	5.5	12	2	0.55	1.0	0.7	10	2	3.6	3	100	440
4.11 m	WIN253	2	1.2	15.0	950	0.9	61	5.0	99	13	1	5	3.90	33	0.2	1	28	90	5.4	13	2	0.66	0.9	0.8	10	1	4.0	3	170	200
8.38 m	WIN297	2	1.1	14.0	950	1.5	68	5.1	74	13	1	6	3.40	33	0.2	1	31	89	5.7	12	2	0.64	0.8	0.9	10	1	3.6	2	100	590
10.97 m	WIN255	2	1.3	16.0	1100	1.4	74	5.6	130	17	1	6	3.90	33	0.2	1	29	110	5.7	13	2	0.72	1.2	0.8	11	1	4.0	2	150	200
13.72 m	WIN275	2	1.0	12.0	840	1.4	63	5.3	80	13	1	5	3.40	33	0.2	1	50	98	5.6	13	2	0.68	1.0	0.6	10	1	3.3	2	100	460
18.44 m	WIN258	2	1.3	12.0	1200	0.5	39	4.3	110	17	1	5	4.30	23	0.2	1	34	73	4.4	14	2	0.91	0.9	0.5	6.9	1	2.7	2	100	200
18.9 m	WIN264	6	1.4	7.5	890	0.5	50	4.2	120	20	1	3	4.60	22	0.2	1	48	83	4.4	16	2	1.00	0.8	0.6	6.4	1	2.6	2	140	200
94-SAB-15																														
2.74 m	WIN266	2	1.1	12.0	900	1.7	63	5.9	88	15	1	5	3.40	33	0.2	1	27	94	5.3	12	2	0.59	1.1	0.6	10	1	3.0	2	120	200
5.18 m	WIN277	2	1.1	14.0	860	1.2	78	5.2	96	11	1	6	3.50	35	0.2	1	33	100	5.7	13	2	0.59	1.2	0.9	11	1	4.2	2	140	200
10.67 m	WIN281	4	1.0	12.0	930	1.3	65	5.6	75	13	1	6	3.20	33	0.2	1	62	90	5.8	11	2	0.60	1.4	0.9	10	1	3.7	2	100	360
10.67 m	WIN299	4	1.1	12.0	920	1.7	70	5.8	76	13	2	7	3.50	35	0.2	1	43	84	5.9	11	2	0.66	1.0	1.0	11	1	3.9	2	100	570
16.76 m	WIN292	2	1.2	13.0	860	0.7	64	5.3	90	16	1	6	3.80	31	0.2	2	44	89	5.4	13	2	0.75	0.9	0.8	10	1	3.4	3	140	200
18.75 m	WIN291	7	1.3	11.0	1000	0.5	56	5.0	81	15	1	5	3.10	30	0.2	1	27	90	5.1	13	2	1.10	1.0	0.9	11	1	4.3	2	100	200
19.2 m	WIN244	6	1.7	13.0	1700	0.5	59	5.9	70	18	1	4	3.50	27	0.2	2	64	94	4.6	14	2	0.88	0.9	0.6	11	1	7.4	2	130	380

APPENDIX 6C

DIAMOND MINERAL INDICATOR DATA

Diamond Mineral Indicator Data

SAMPLE #	UTM (n)	UTM (e)	LOCATION	DATA REFERENCE	DEPTH (m)	LITHOLOGY	DIAMOND MINERAL INDICATORS								
							Garnets						Other		
							G1,2	G7,8,9, G10,11	Kimberlitic	G3,4,6	G5	Eclogitic	Chrome Diopsides	Chromites	Total
Surface samples															
4212*	117.6336	55.71403	Watino	Dufresne *et al.* (1995)	?	Ter S&G	0	0	**0**	1	0	**1**	**0**	**7**	**8**
94-SB-14	6100725	487375	Little Smoky River	Dufresne *et al.* (1995)	2.5-3.0	till	0	0	**0**	0	0	**0**	**0**	**1**	**1**
94-SB-35	6105875	449875	Clarkson Valley	Dufresne *et al.* (1995)	2.0-3.0	till	0	0	**0**	0	1	**1**	**0**	**0**	**1**
94-SB-38	6097450	456150	Pelican Lake	Dufresne *et al.* (1995)	2.0-3.0	till	0	0	**0**	0	0	**0**	**0**	**0**	**0**
94-SB-39	6104275	477325	Woodpecker Creek	Dufresne *et al.* (1995)	1.5-2.0	till	0	0	**0**	0	0	**0**	**0**	**1**	**1**
94-SB-52	6121200	491800	High Prairie Road	Dufresne *et al.* (1995)	1.5-2.0	till	0	0	**0**	0	0	**0**	**0**	**0**	**0**
94-SB-76	6141875	477100	Wabatanisk Creek	Dufresne *et al.* (1995)	4.0-5.0	till	0	0	**0**	0	0	**0**	**0**	**1**	**1**
NAT95-121*	117.727	55.46164	Mountain Lake	Pawlowicz *et al.* (1998)	1.0-1.5	till	0	0	**0**	0	0	**0**	**0**	**0**	**0**
Borehole samples															
93-SAB-13	6295025	444475	Winagami north	Dufresne *et al.* (1995)	25.0-40.8	till	0	1	**1**	0	0	**0**	**1**	**0**	**2**
93-SAB-6A	6163025	478775	Peavine	Dufresne *et al.* (1995)	9.9-24.5	till	0	0	**0**	1	0	**1**	**0**	**0**	**1**
93-SAB-6B	6163025	478775	Peavine	Dufresne *et al.* (1995)	30.0-44.5	till	0	4	**4**	0	1	**1**	**0**	**0**	**5**
94-SAB-4	6102650	444700	Swan Lake	Pawlowicz *et al.* (1998)	35.1-43.4	till	0	0	**0**	0	0	**0**	**0**	**0**	**0**
94-SAB-9	6118250	492150	Stumpy Lake	Pawlowicz *et al.* (1998)	36.6-40.4	till	1	0	**1**	0	0	**0**	**0**	**0**	**1**
94-SAB-11**	6152700	444900	Whitemud	Pawlowicz *et al.* (1998)	14.5-18.0	till	0	1	**1**	1	0	**1**	**1**	**0**	**3**
94-SAB-12**	6181375	490225	Fahler	Pawlowicz *et al.* (1998)	18.4-22.4	till									
94-SAB-14	6143725	489900	Little Smoky R.	Pawlowicz *et al.* (1998)	24.2-28.3	till	0	0	**0**	0	0	**0**	**0**	**0**	**0**
94-SAB-15	6110575	460725	Youngs Point	Pawlowicz *et al.* (1998)	13.1-17.1	till	0	1	**1**	2	1	**3**	**0**	**0**	**4**
PR95-3A*	117.7235	55.4195	Mountain Lake	Pawlowicz *et al.* (1998)	1.0-5.2	till	0	2	**2**	0	0	**0**	**0**	**0**	**2**
PR95-3B*	117.7235	55.4195	Mountain Lake	Pawlowicz *et al.* (1998)	14.6-21.6	till	0	1	**1**	0	1	**1**	**0**	**0**	**2**

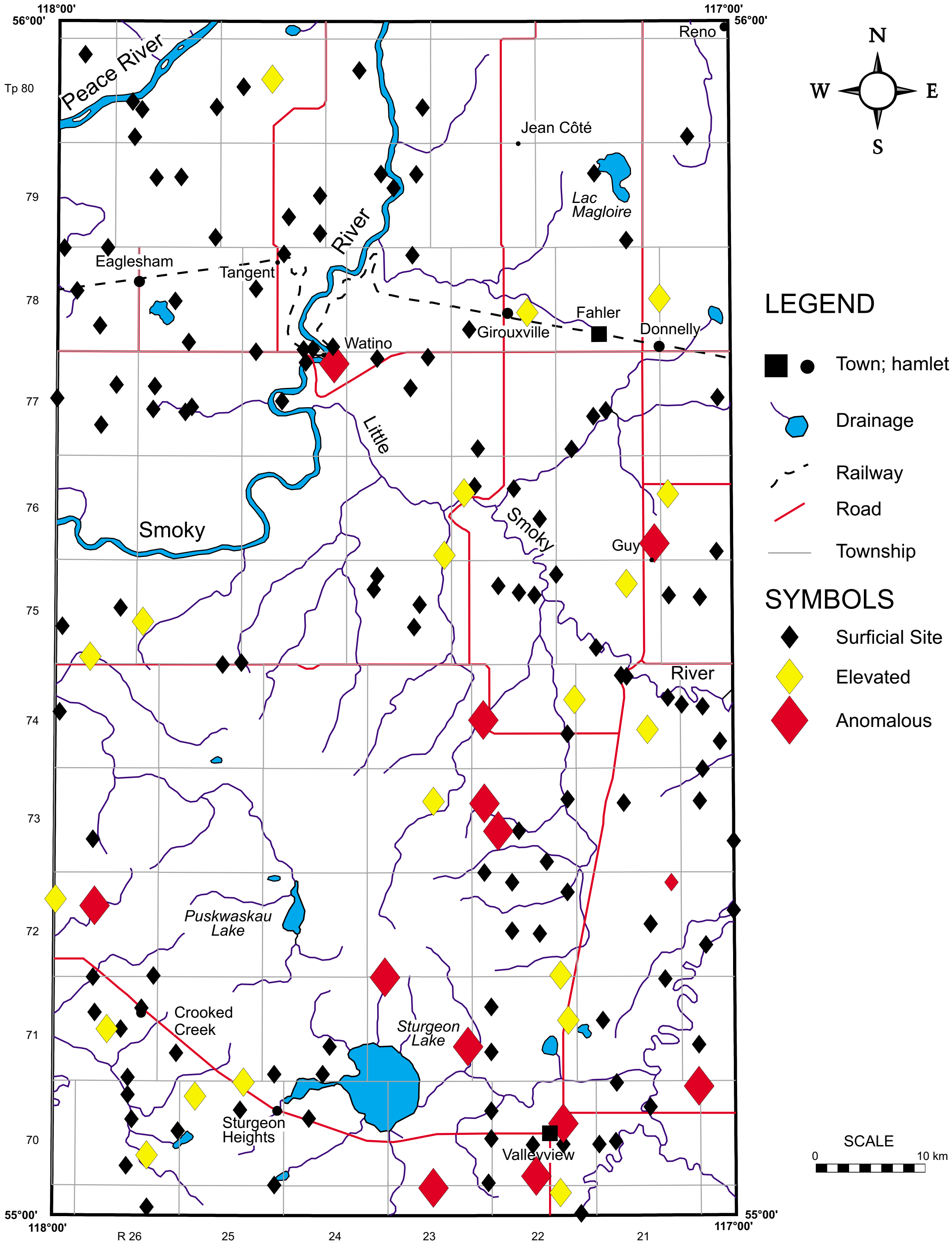
* Sample collected by the AGS.
** Microprobe data from AGS lumped sample results together

APPENDIX 7

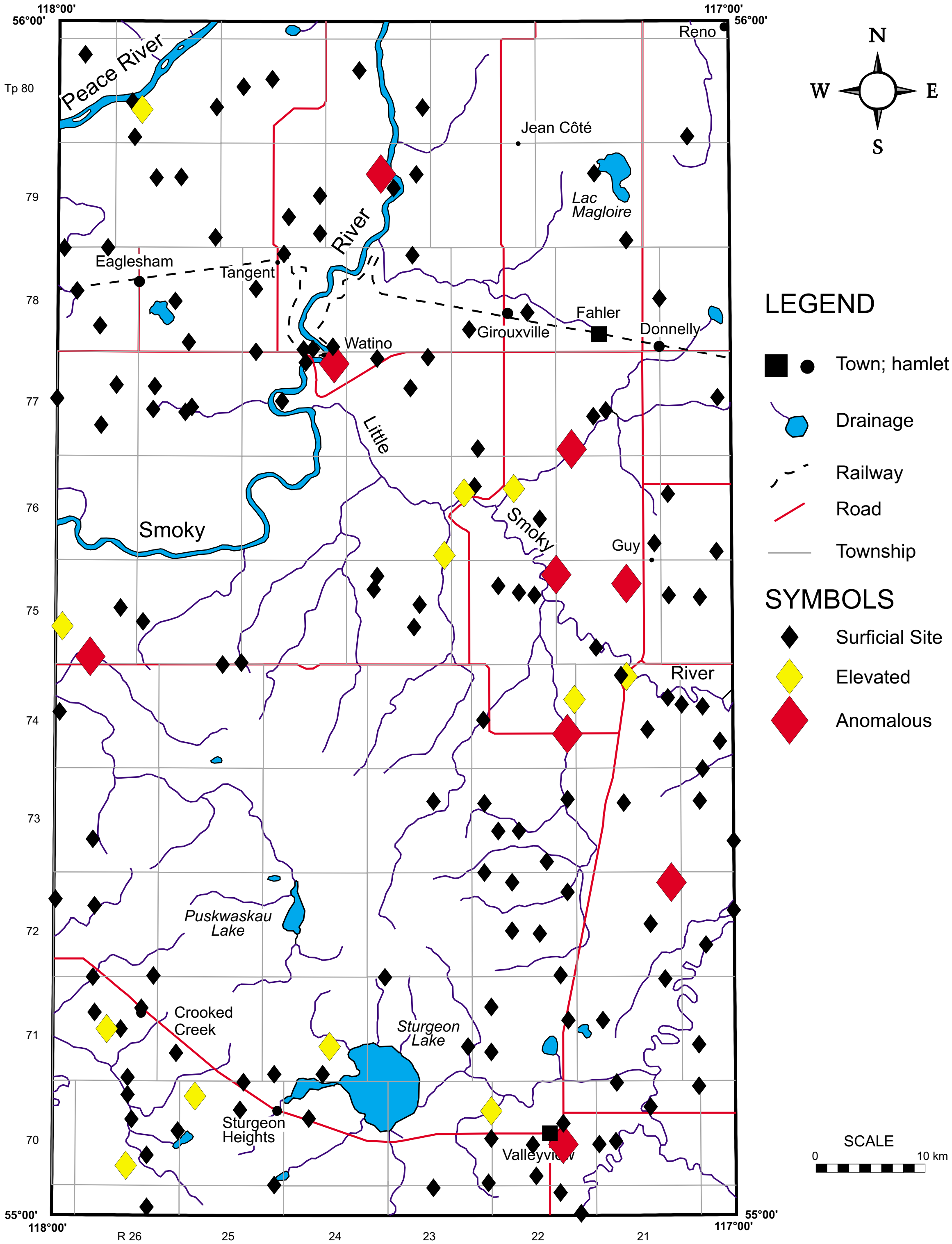
DISPERSAL PATTERNS AND TRENDS

APPENDIX 7A

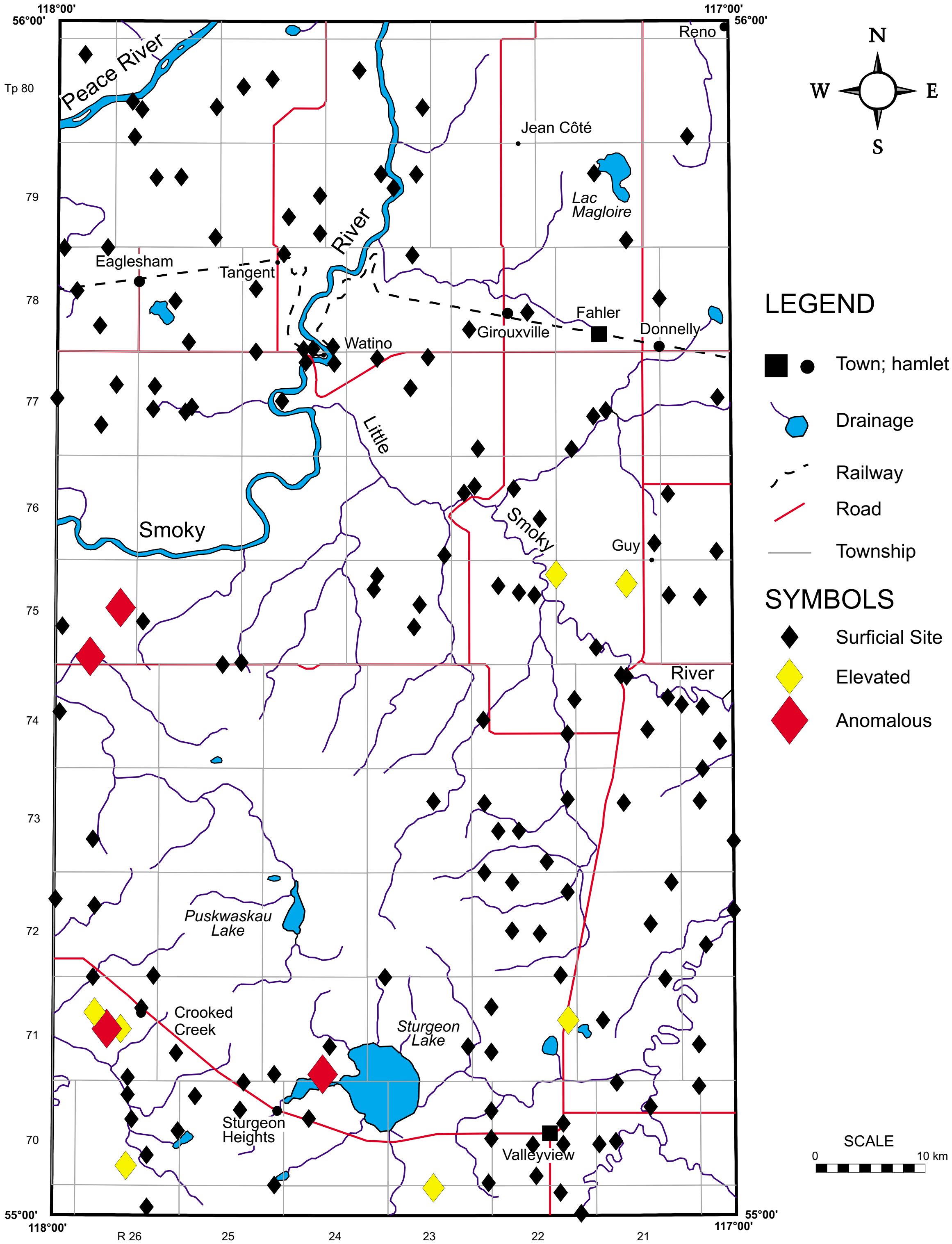
SURFACE SAMPLE DISPERSAL PATTERNS



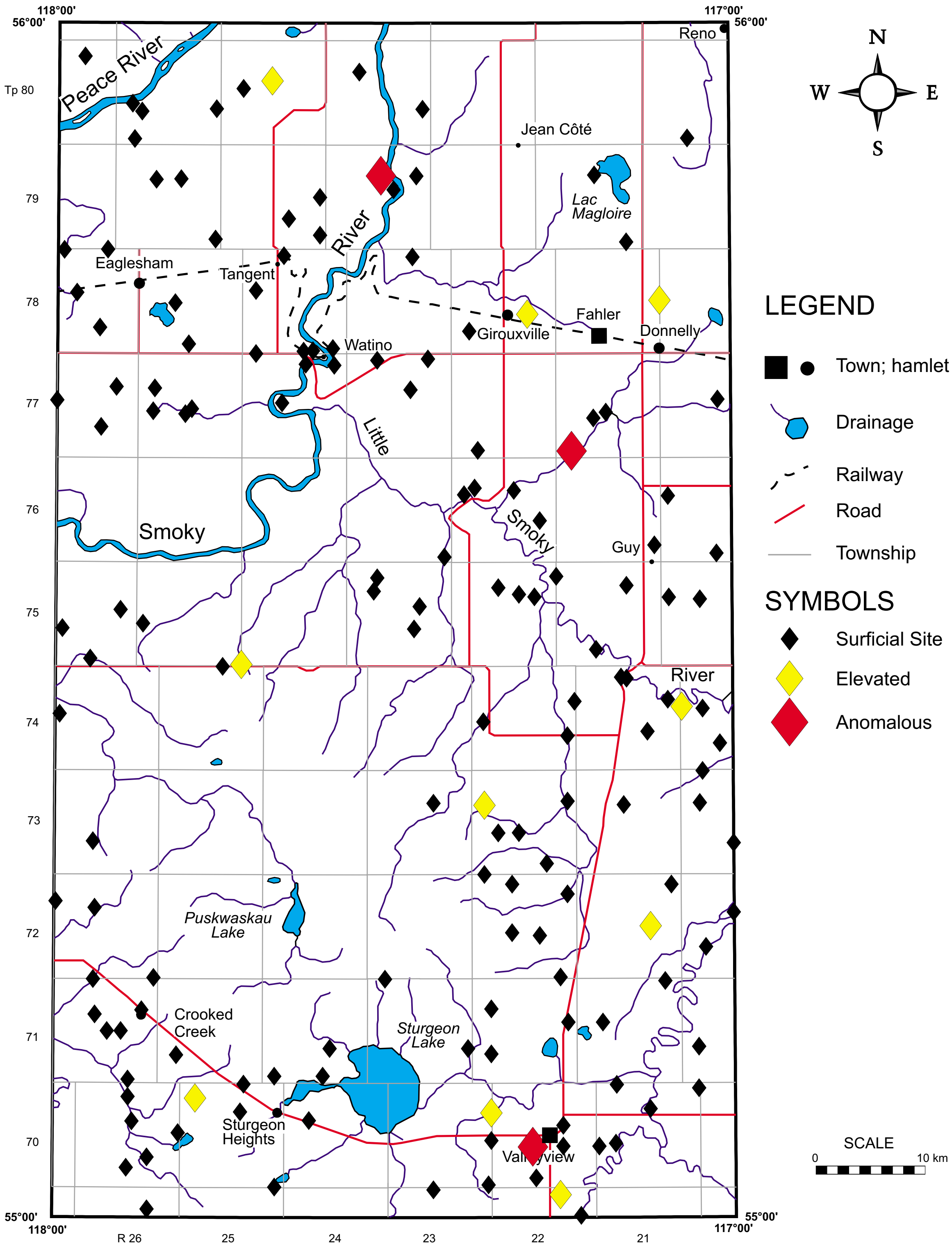
Ag (AA) concentration in surface samples.



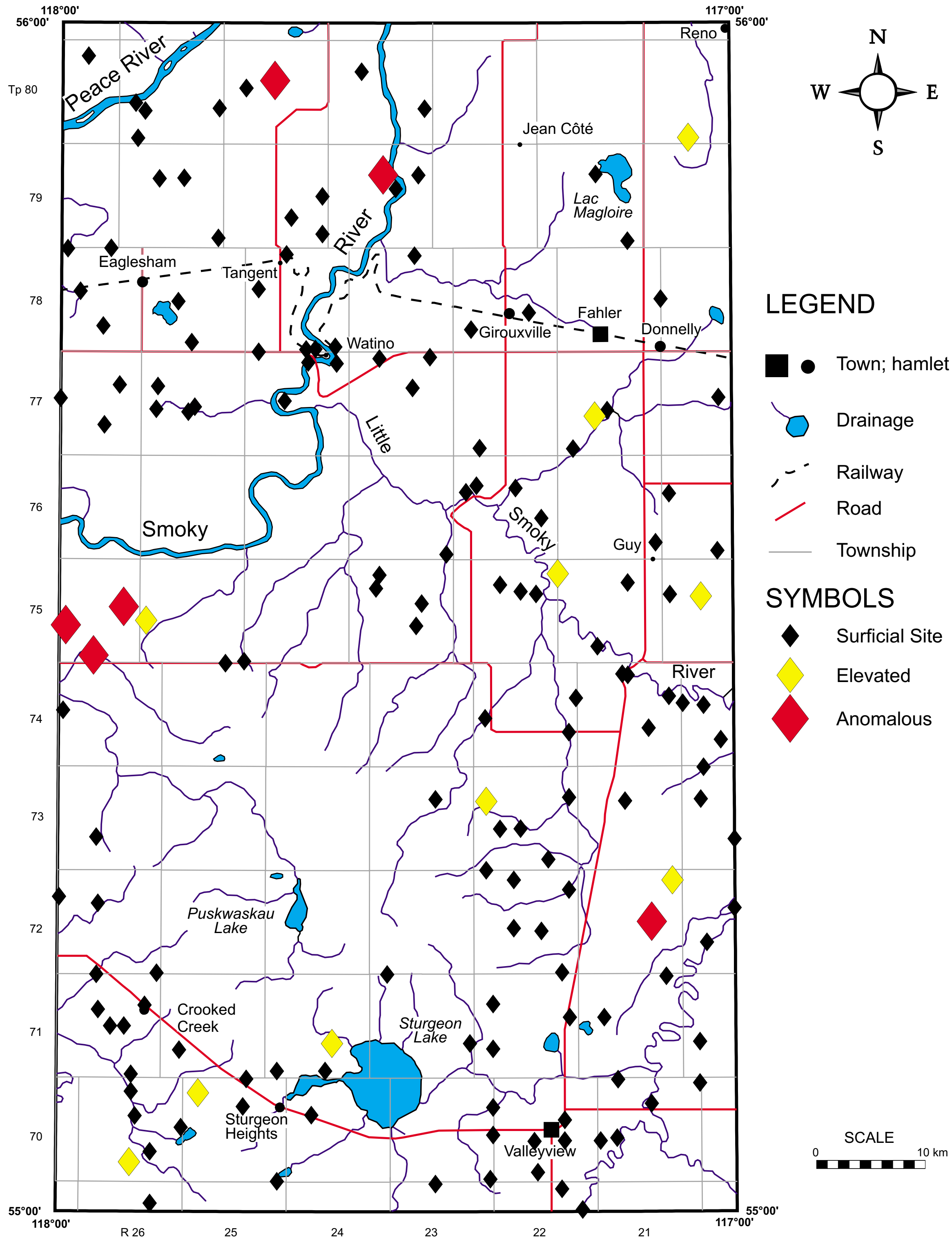
Cd (AA) concentration in surface samples.



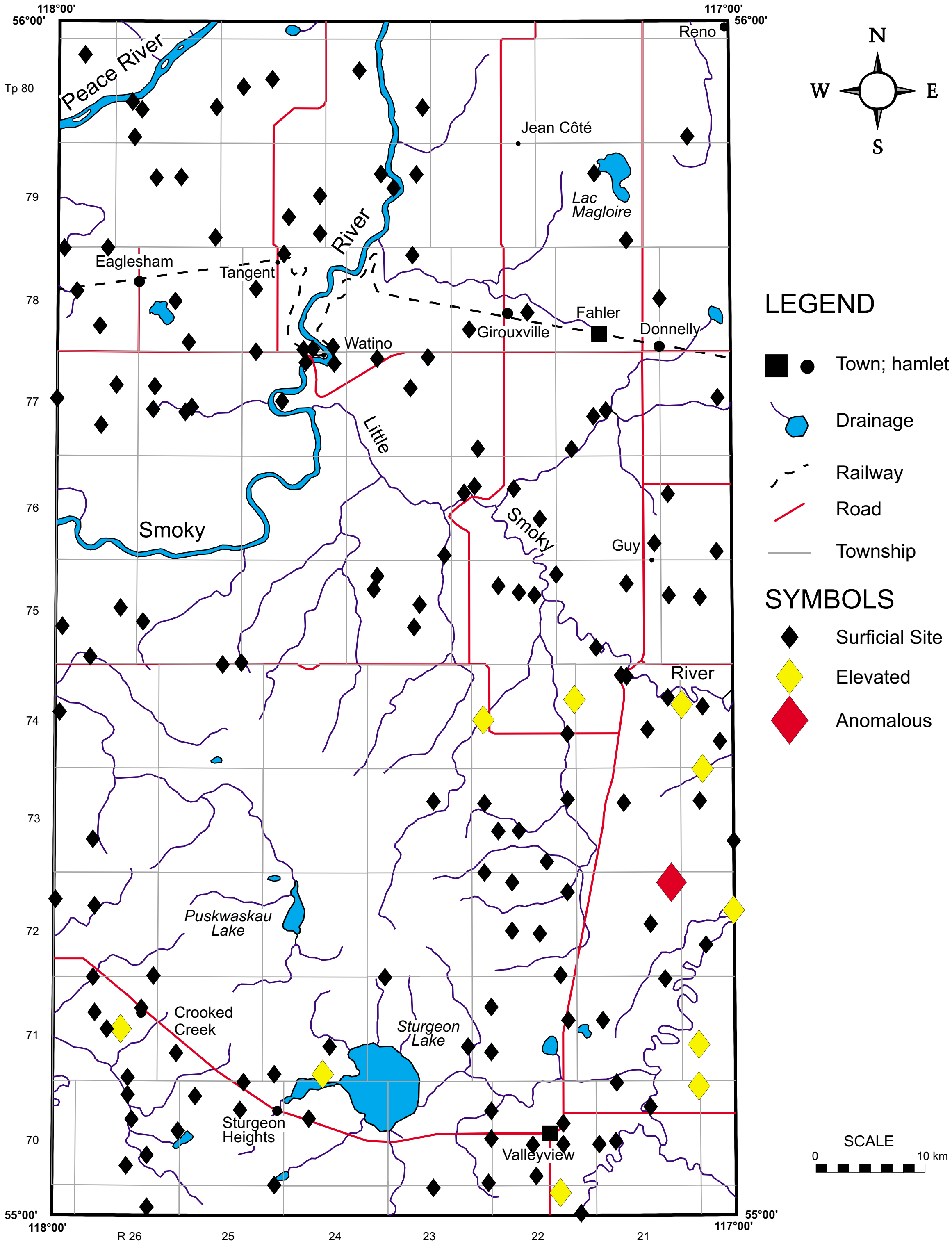
Co (AA)concentration in surface samples.



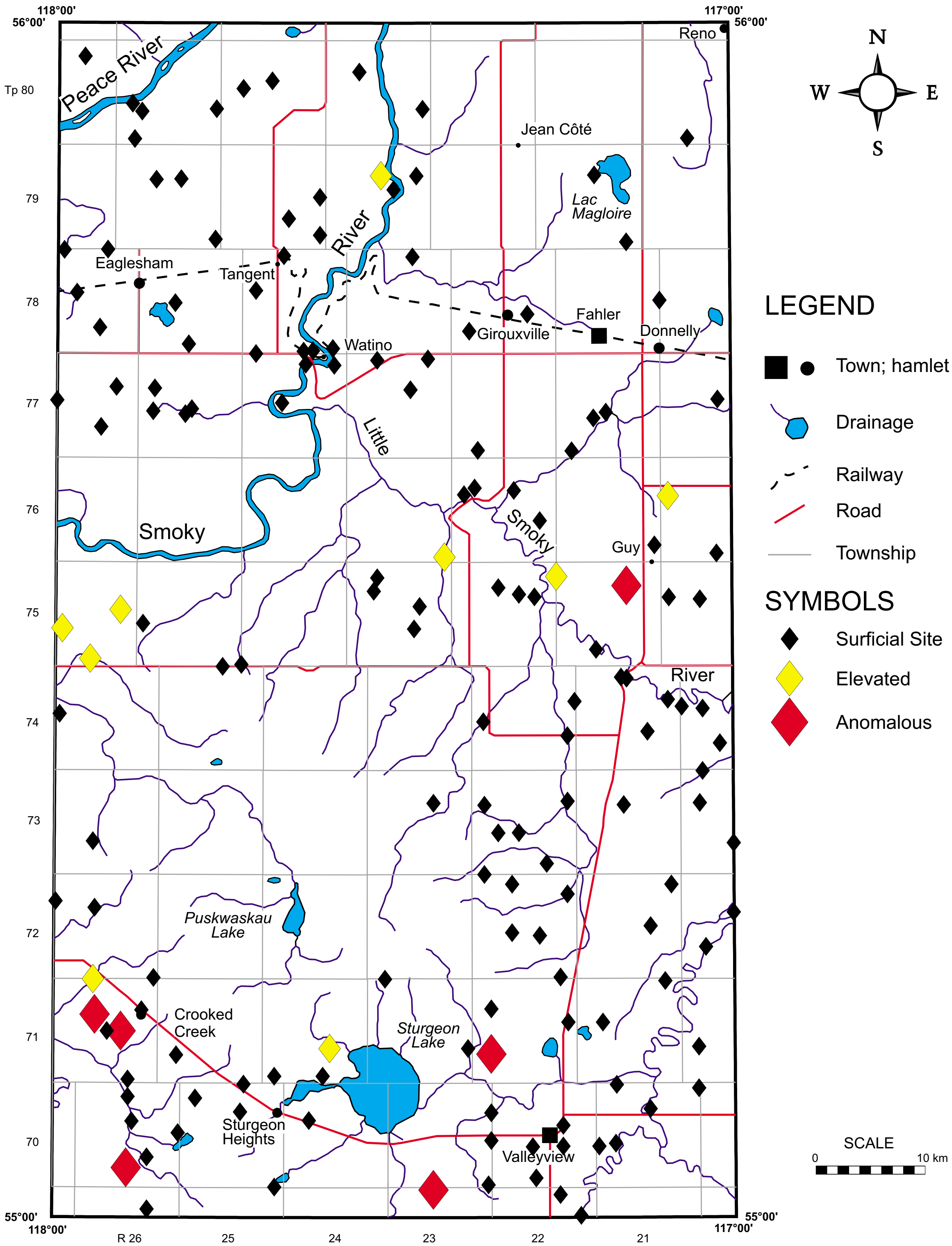
Cu (AA)concentration in surface samples.



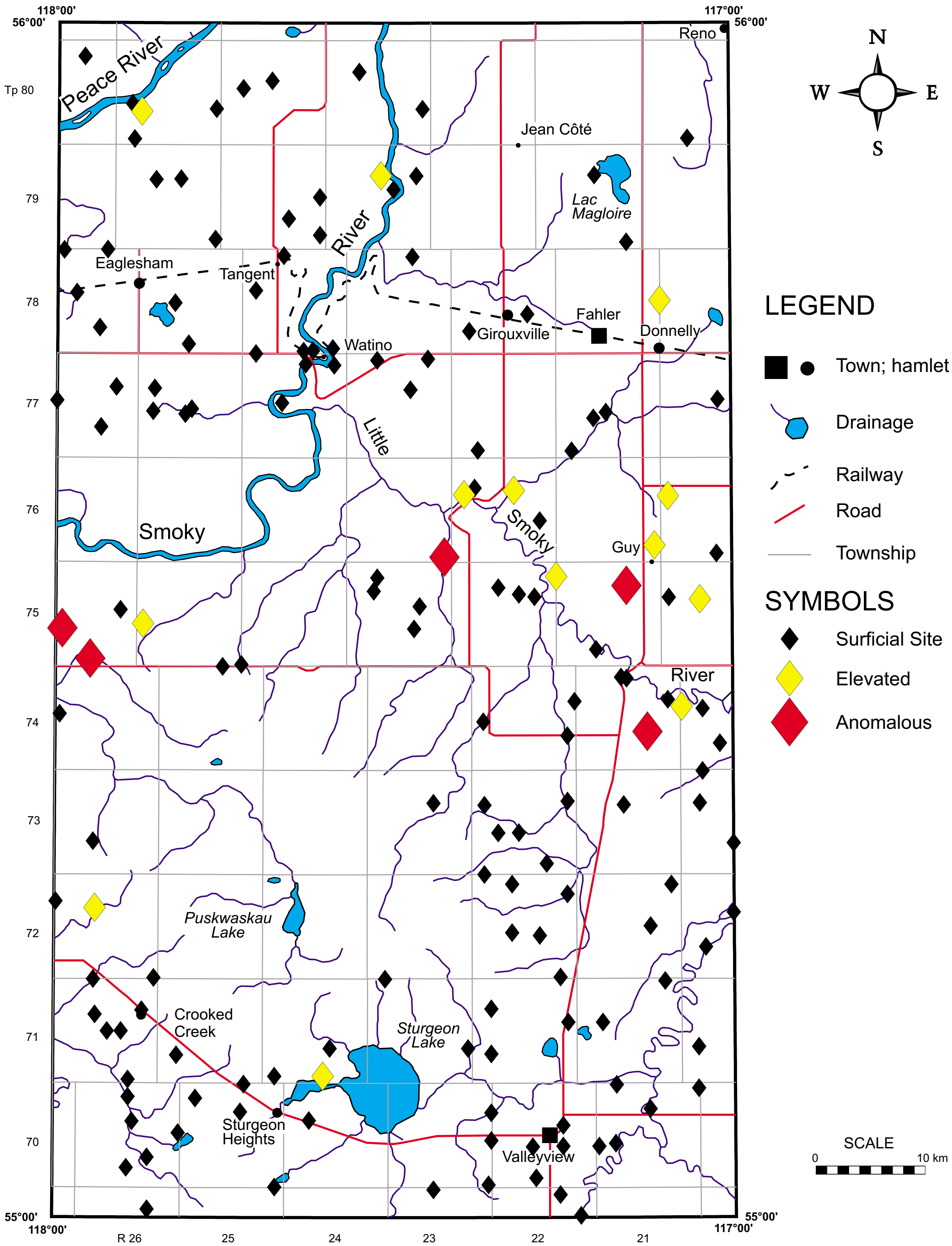
Fe (AA) concentration in surface samples.



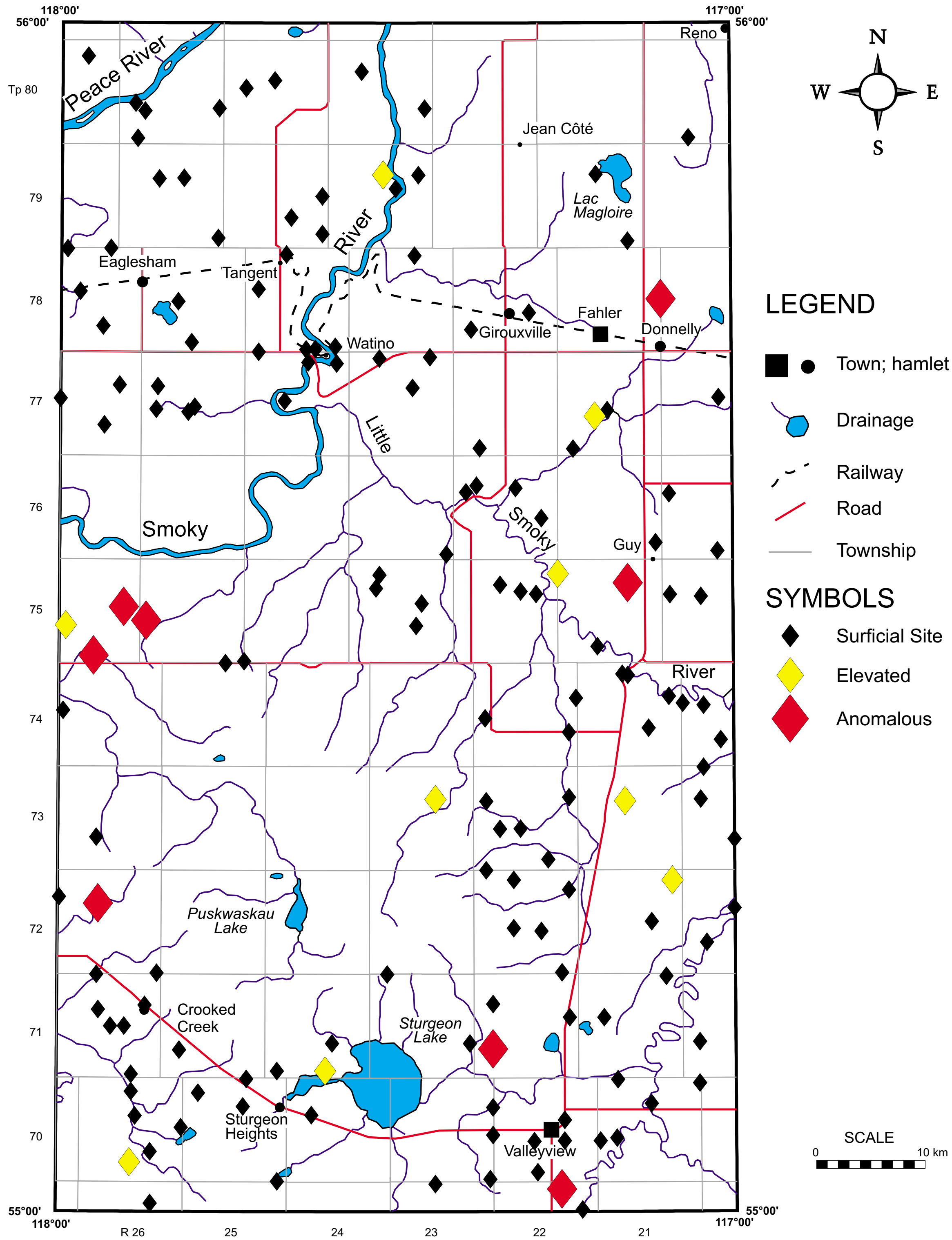
Li (AA) concentration in surface samples.



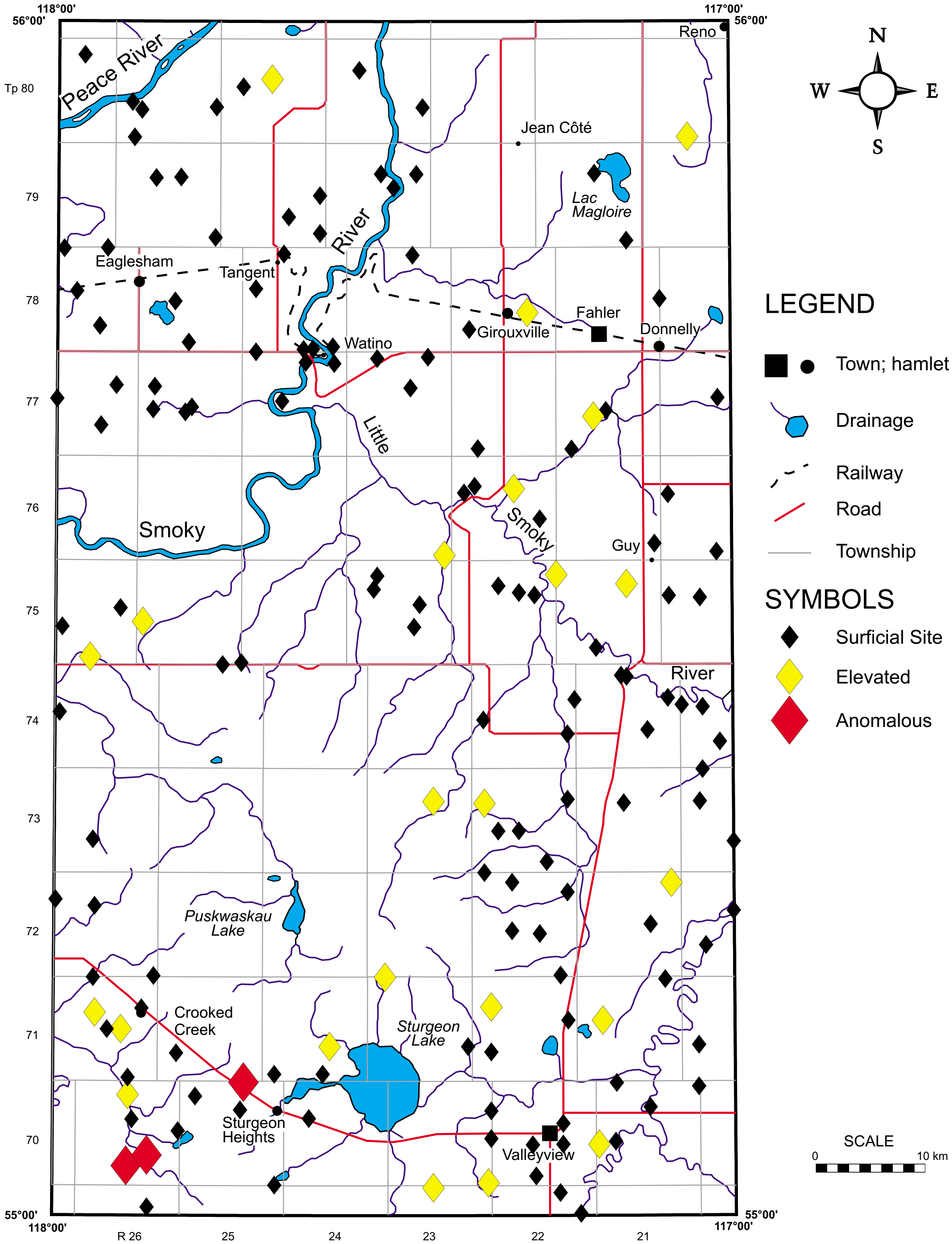
Mn (AA) concentration in surface samples.



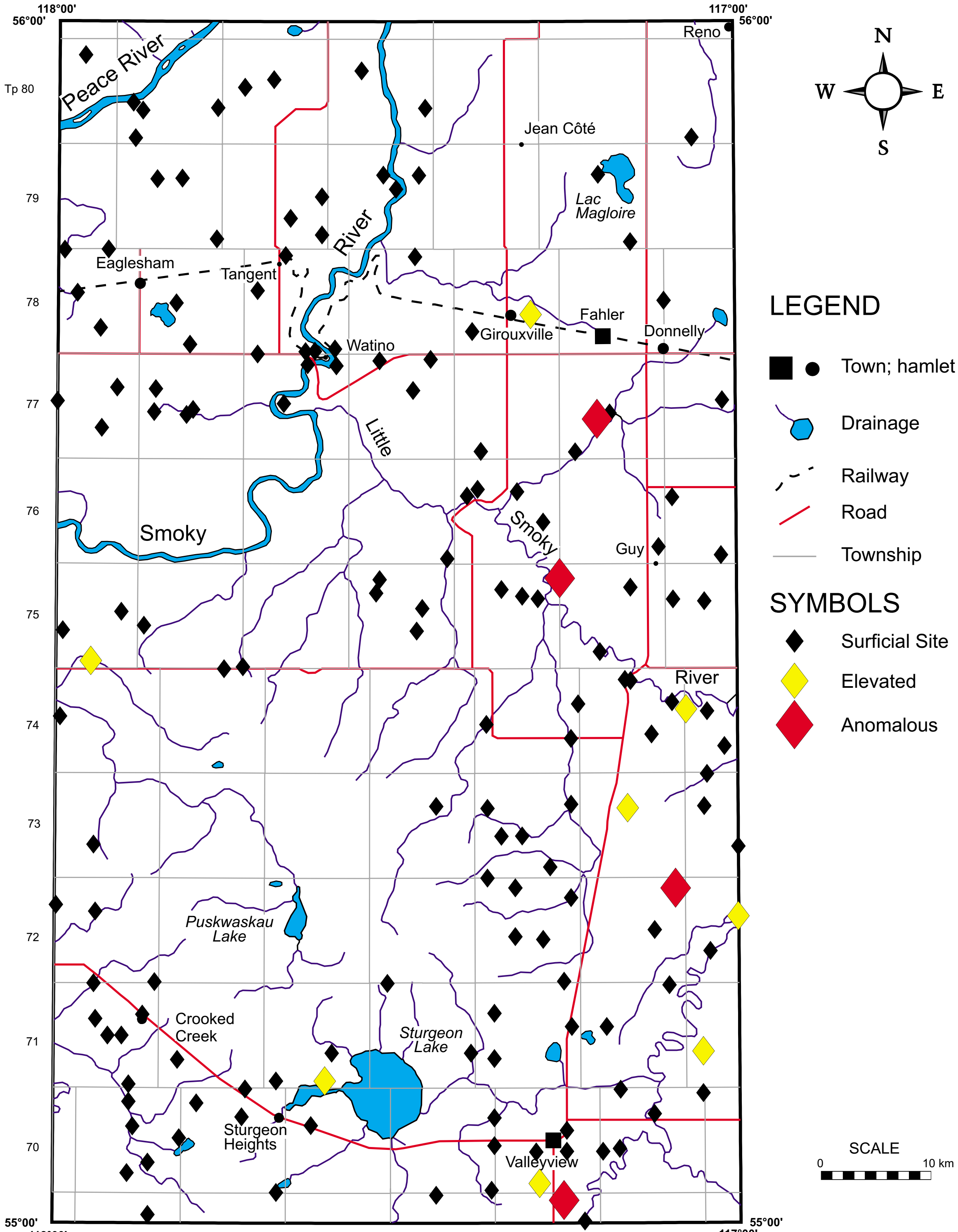
Mo (AA) concentration in surface samples.



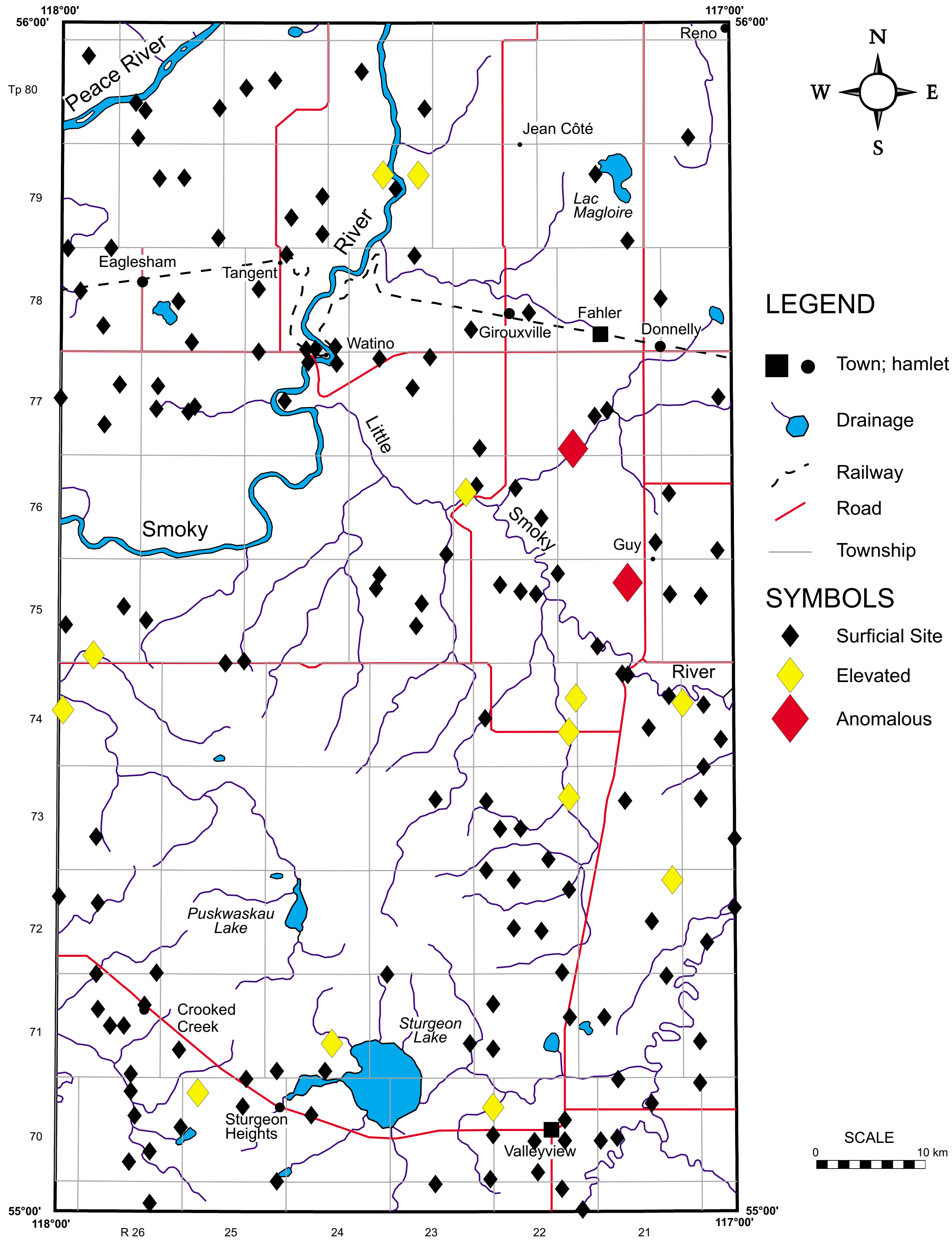
Ni (AA) concentration in surface samples.



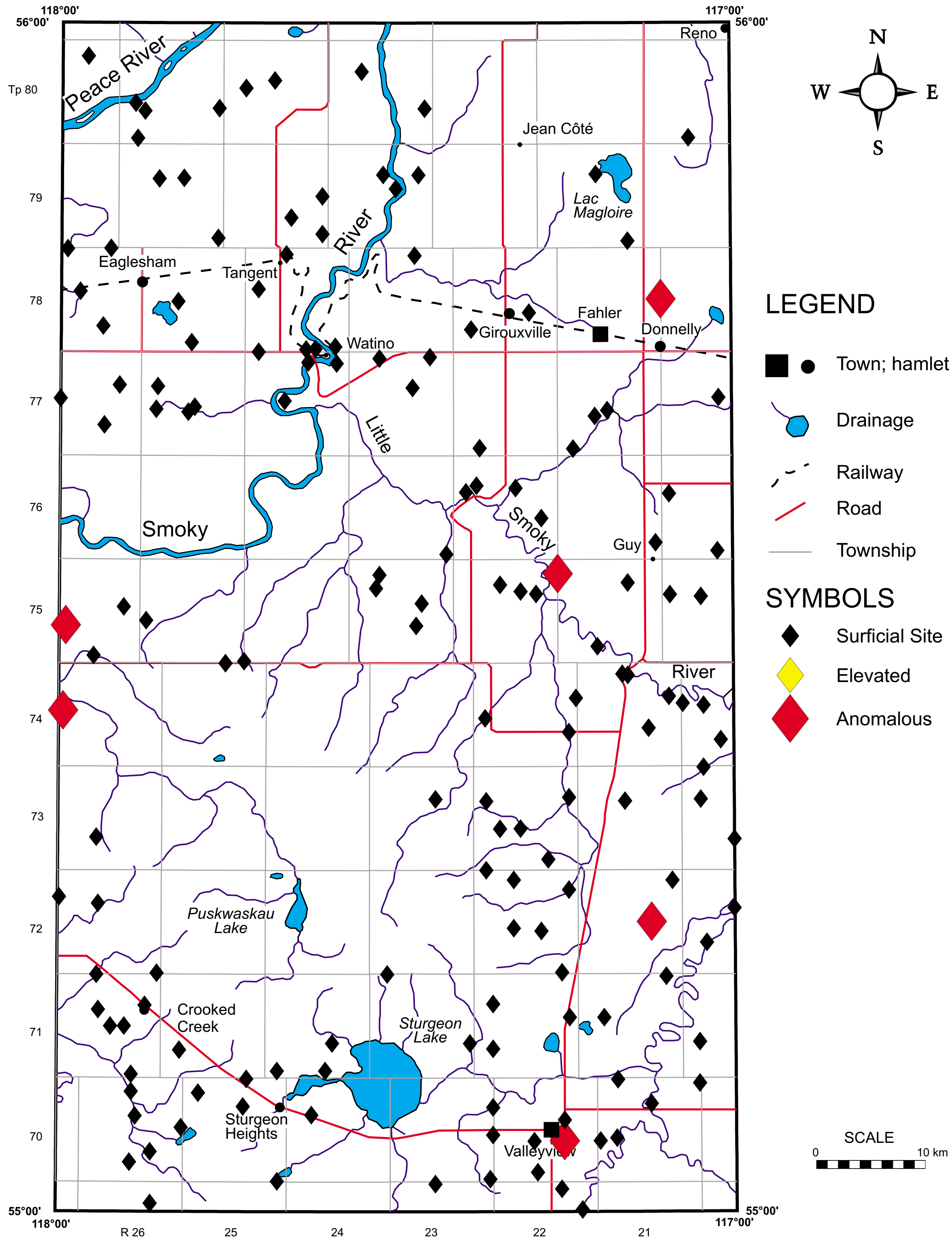
Pb (AA) concentration in surface samples.



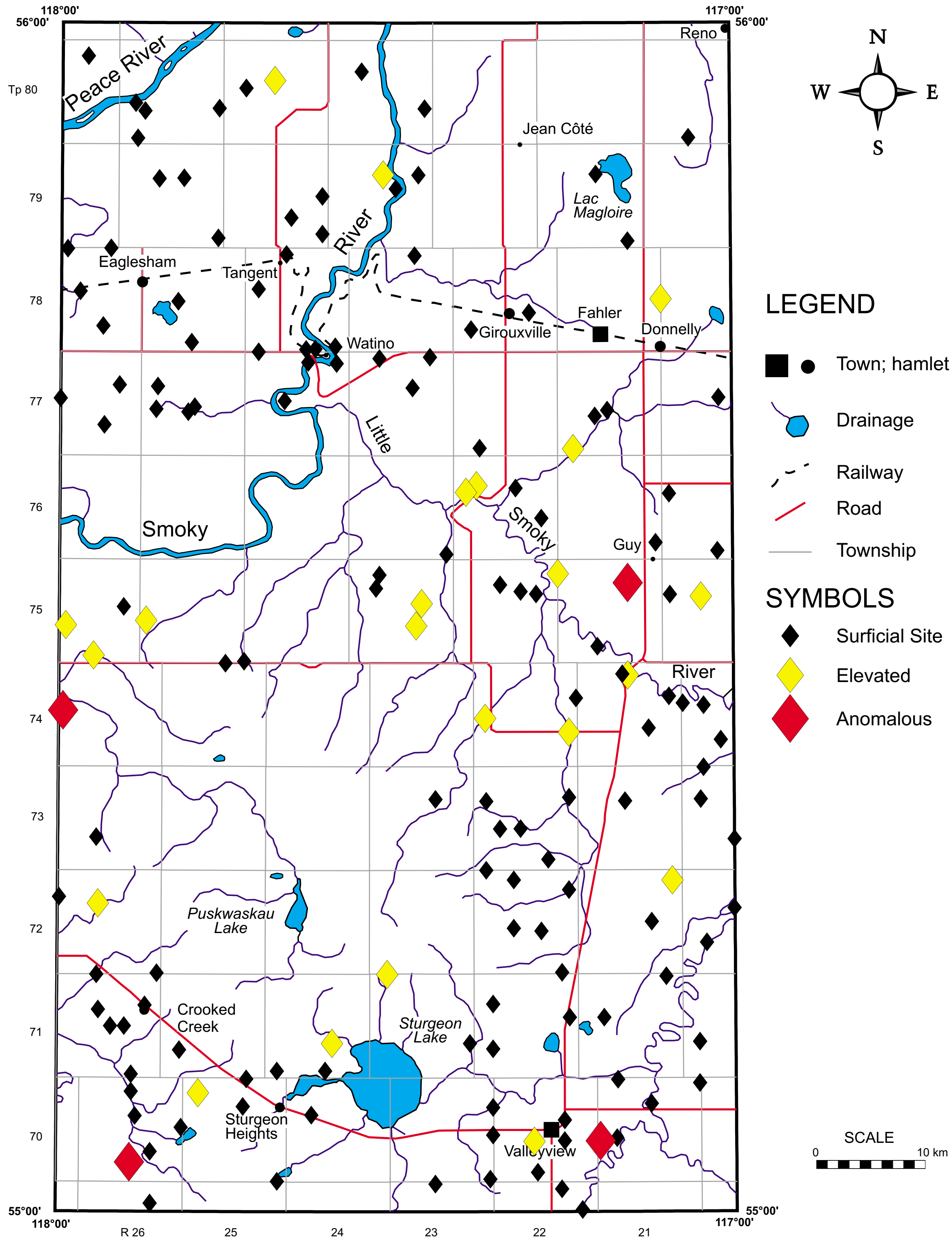
V (AA) concentration in surface samples.



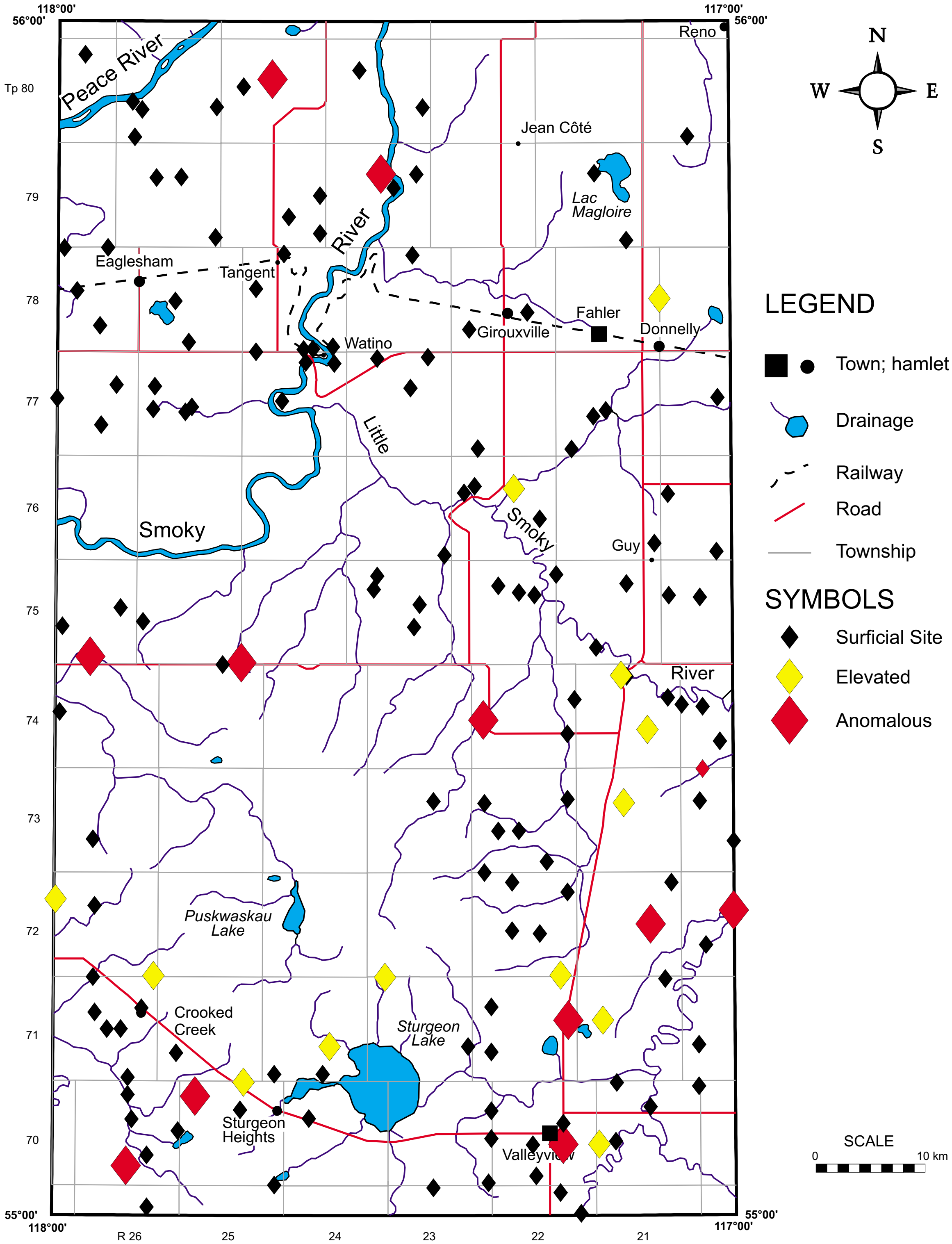
Zn (AA) concentration in surface samples.



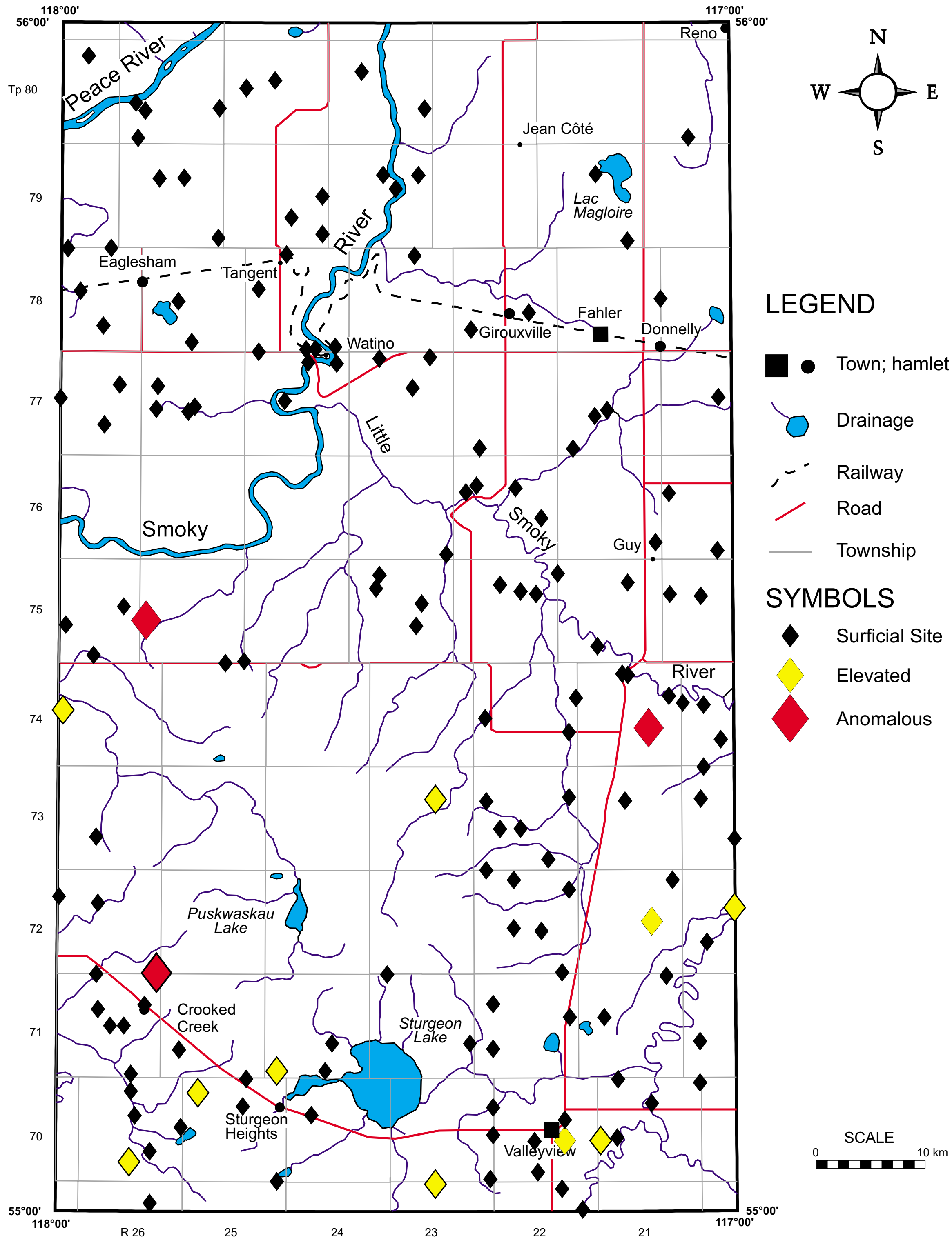
Ag (INAA) concentration in surface samples.



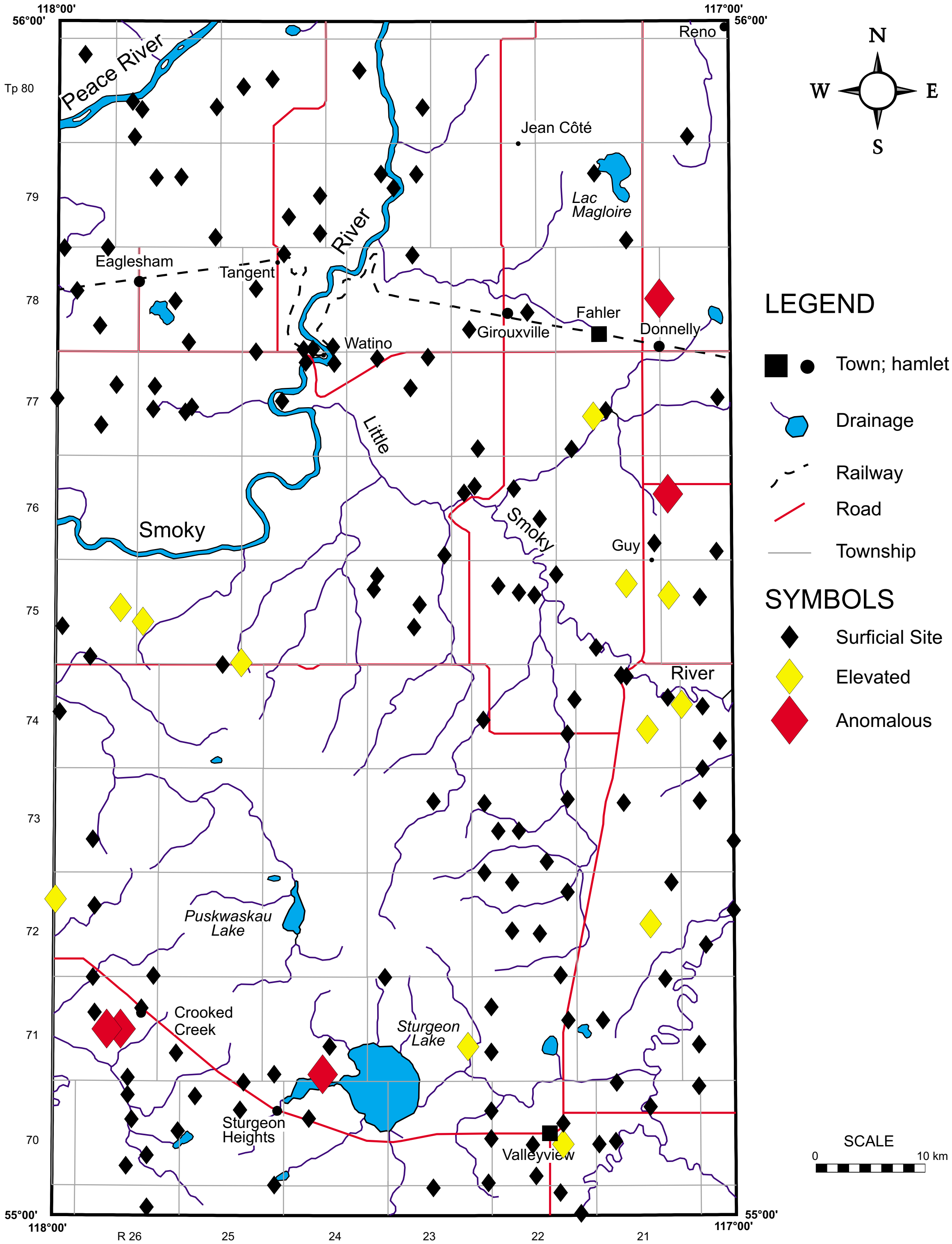
As (INAA) concentration in surface samples.



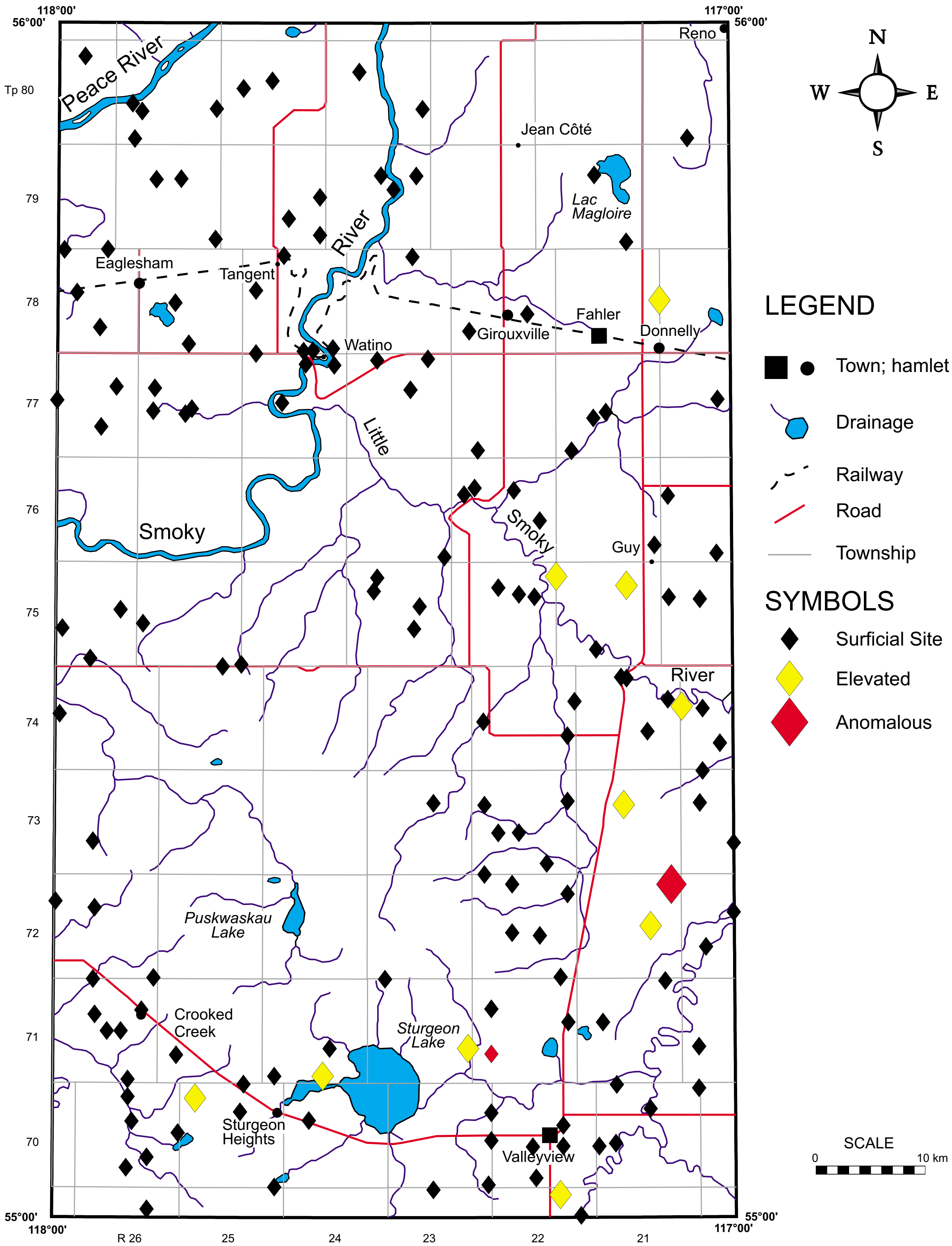
Au (INAA) concentration in surface samples.



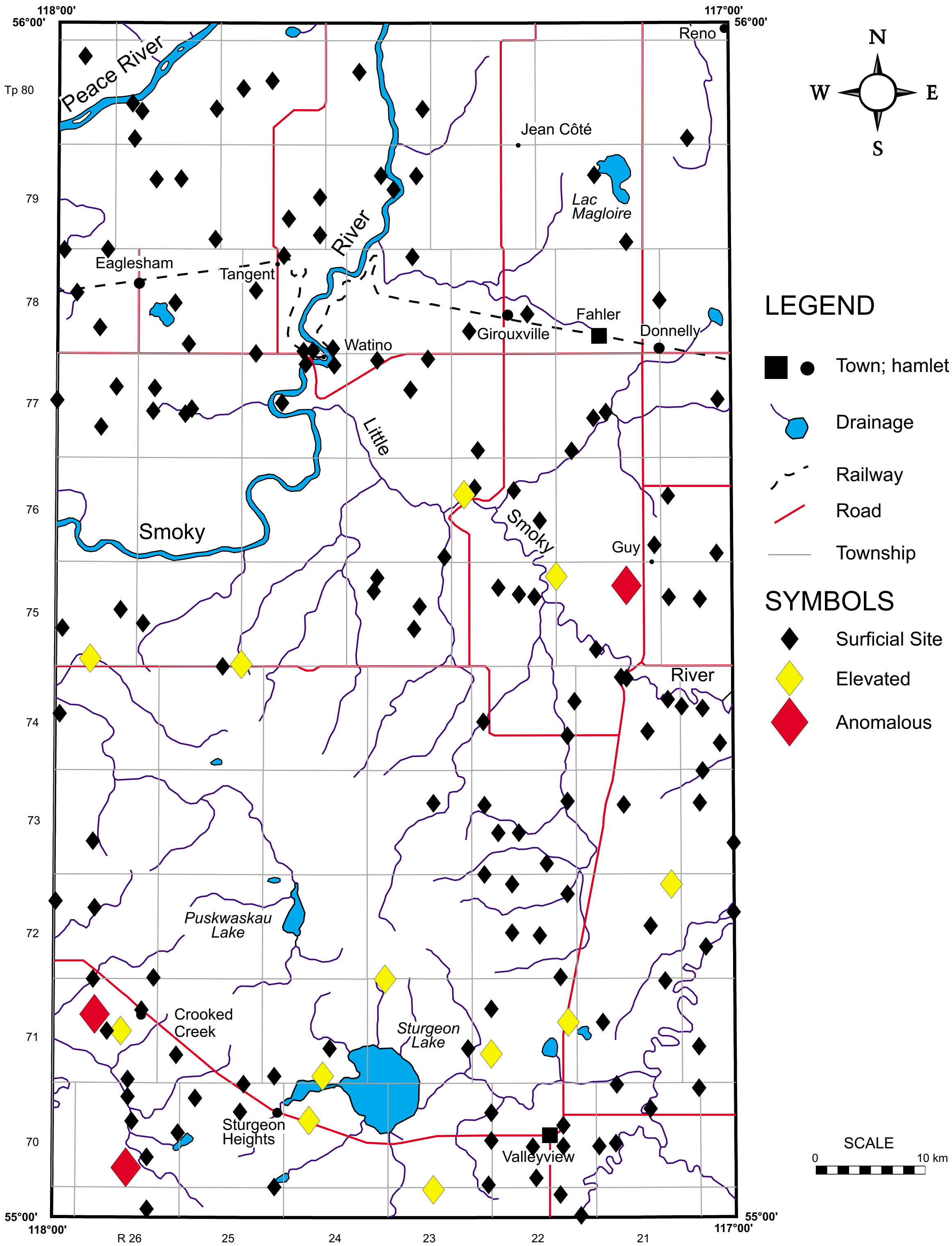
Ba (INAA) concentration in surface samples.



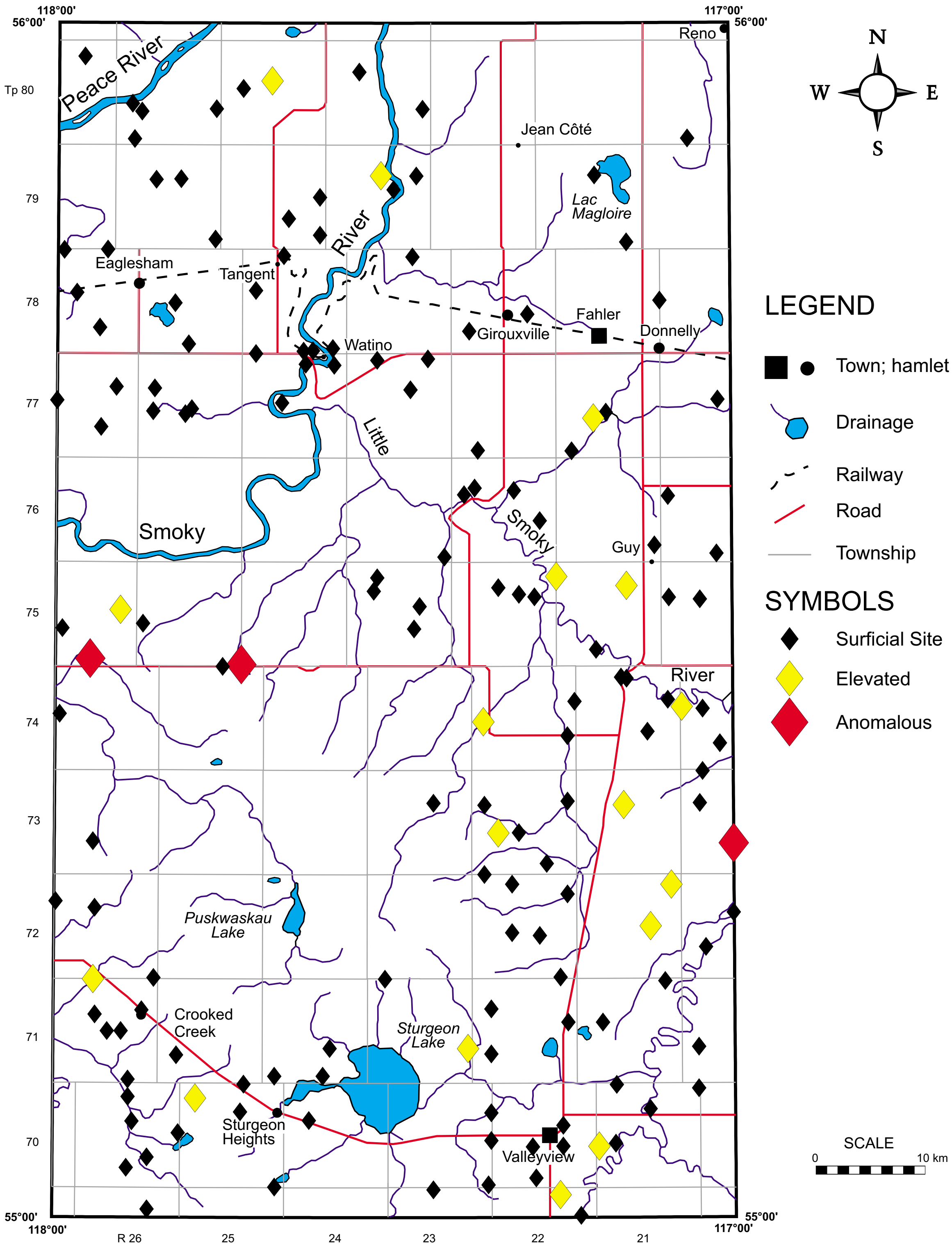
Br (INAA) concentration in surface samples.



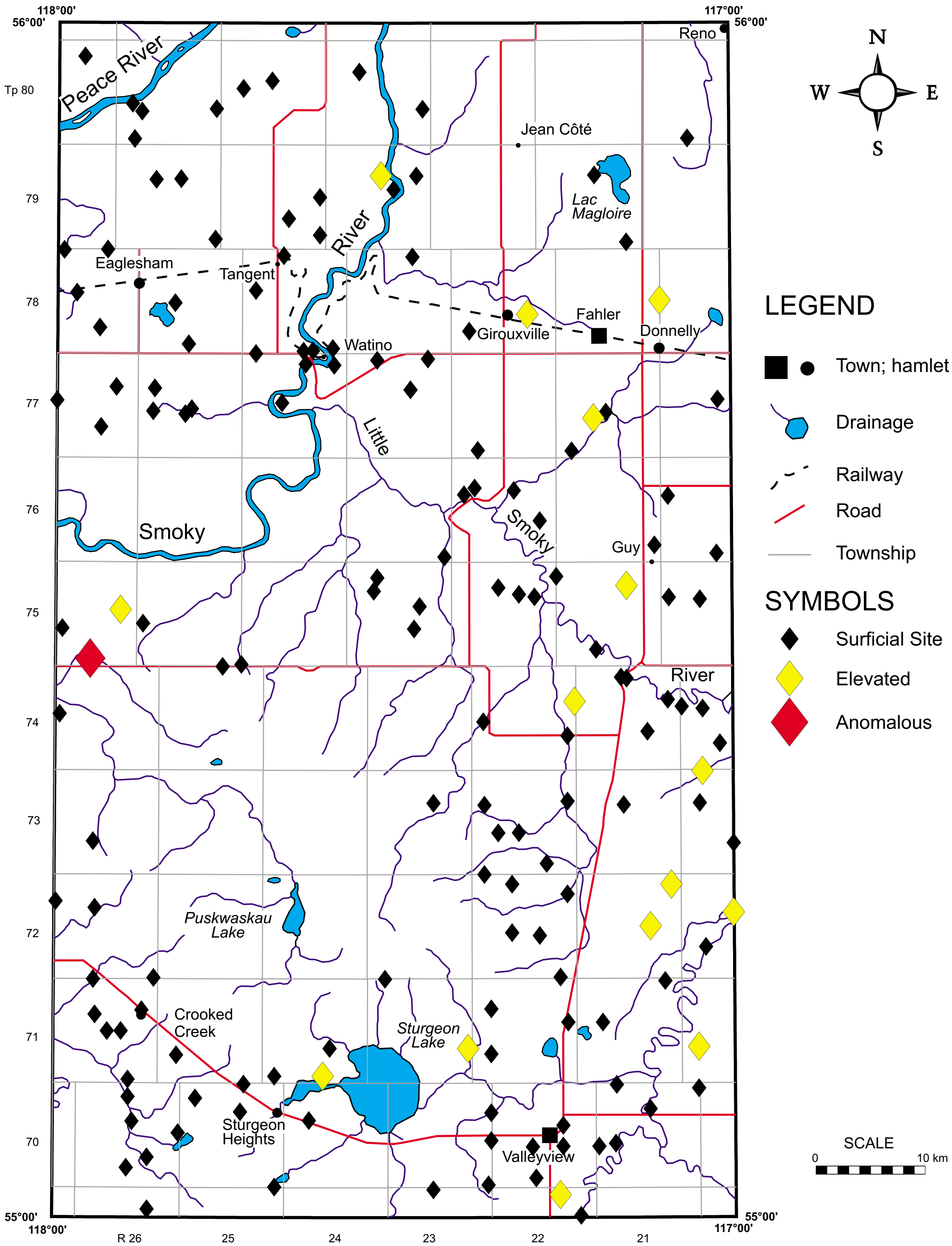
Ce (INAA) concentration in surface samples.



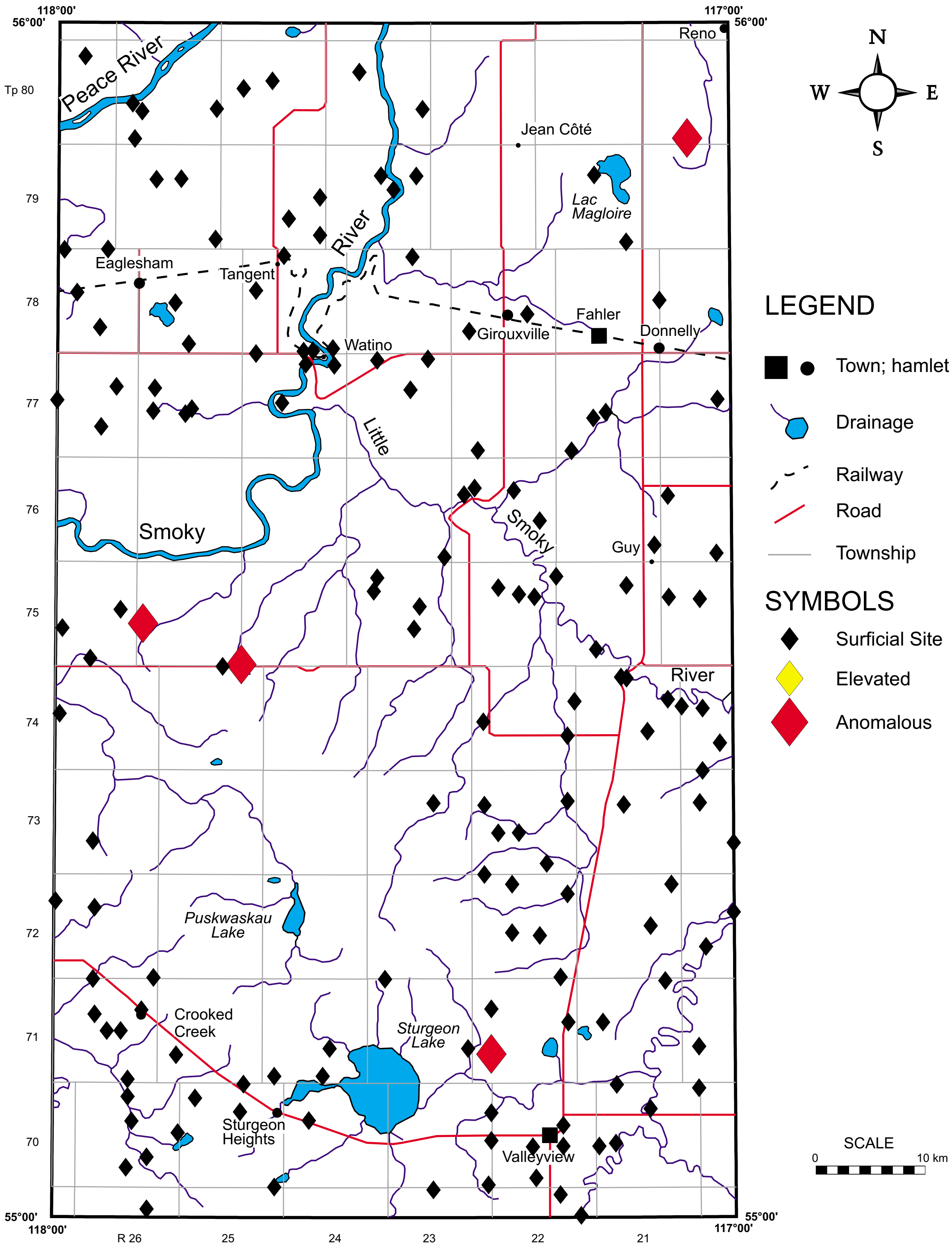
Co (INAA) concentration in surface samples.



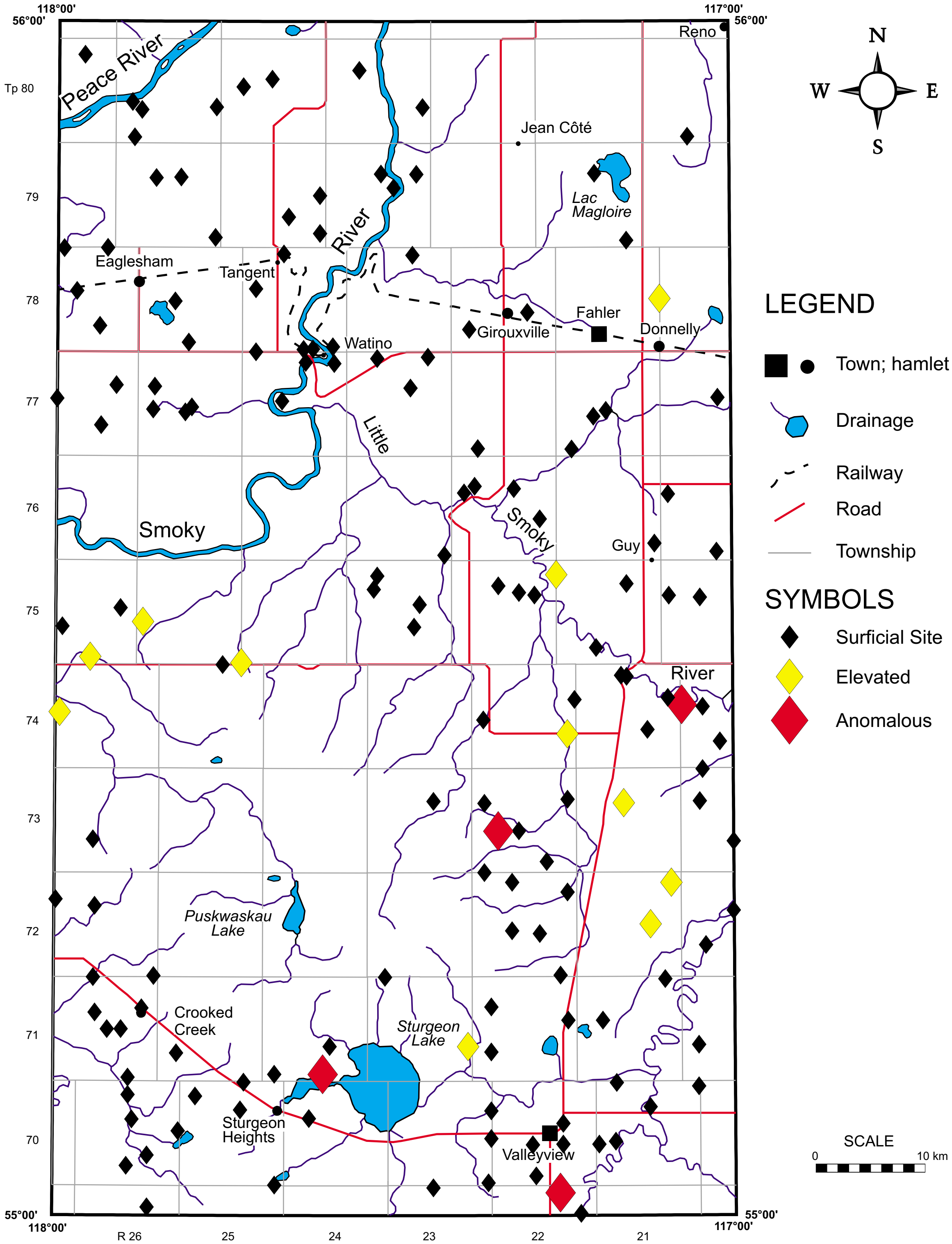
Cr (INAA) concentration in surface samples.



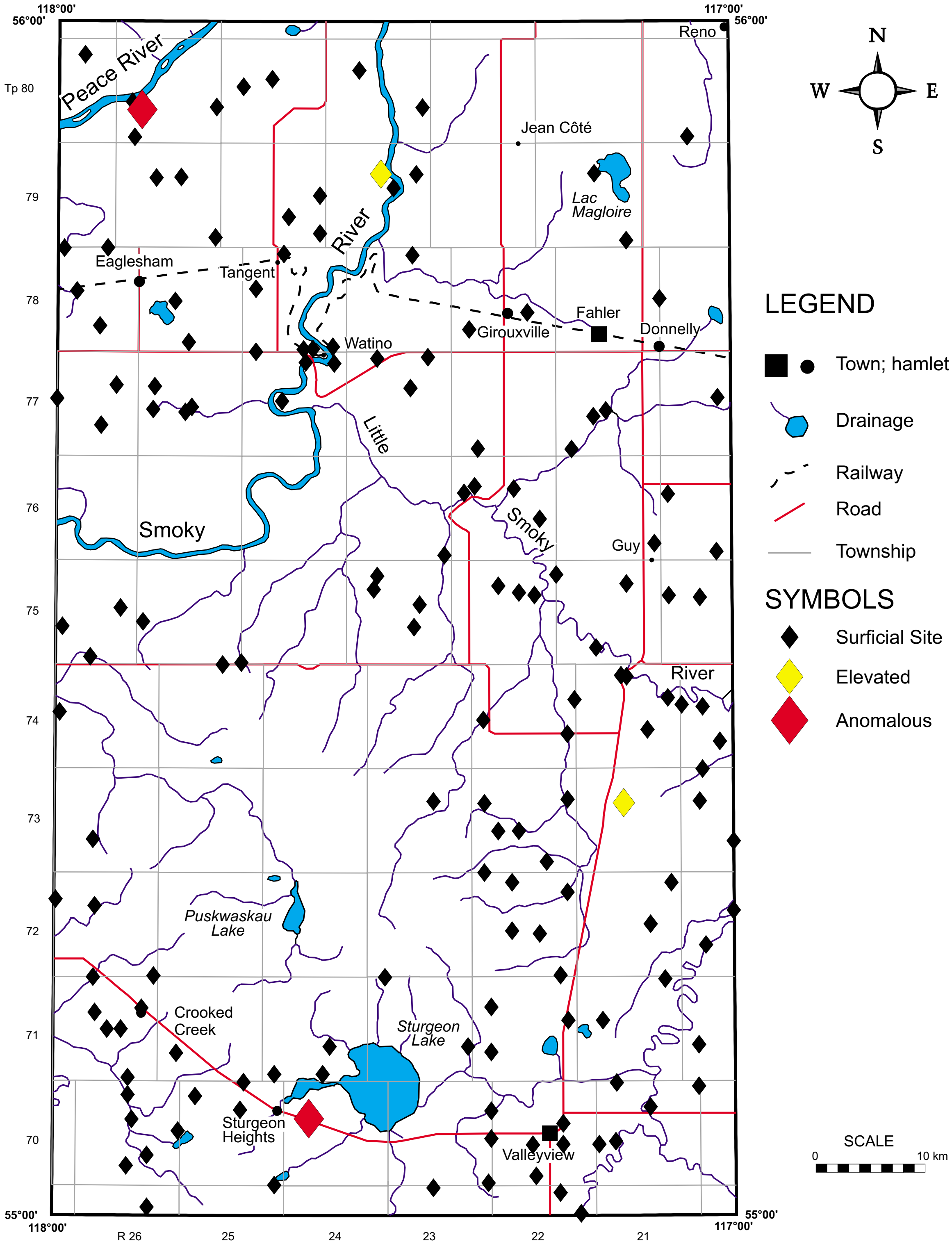
Cs (INAA) concentration in surface samples.



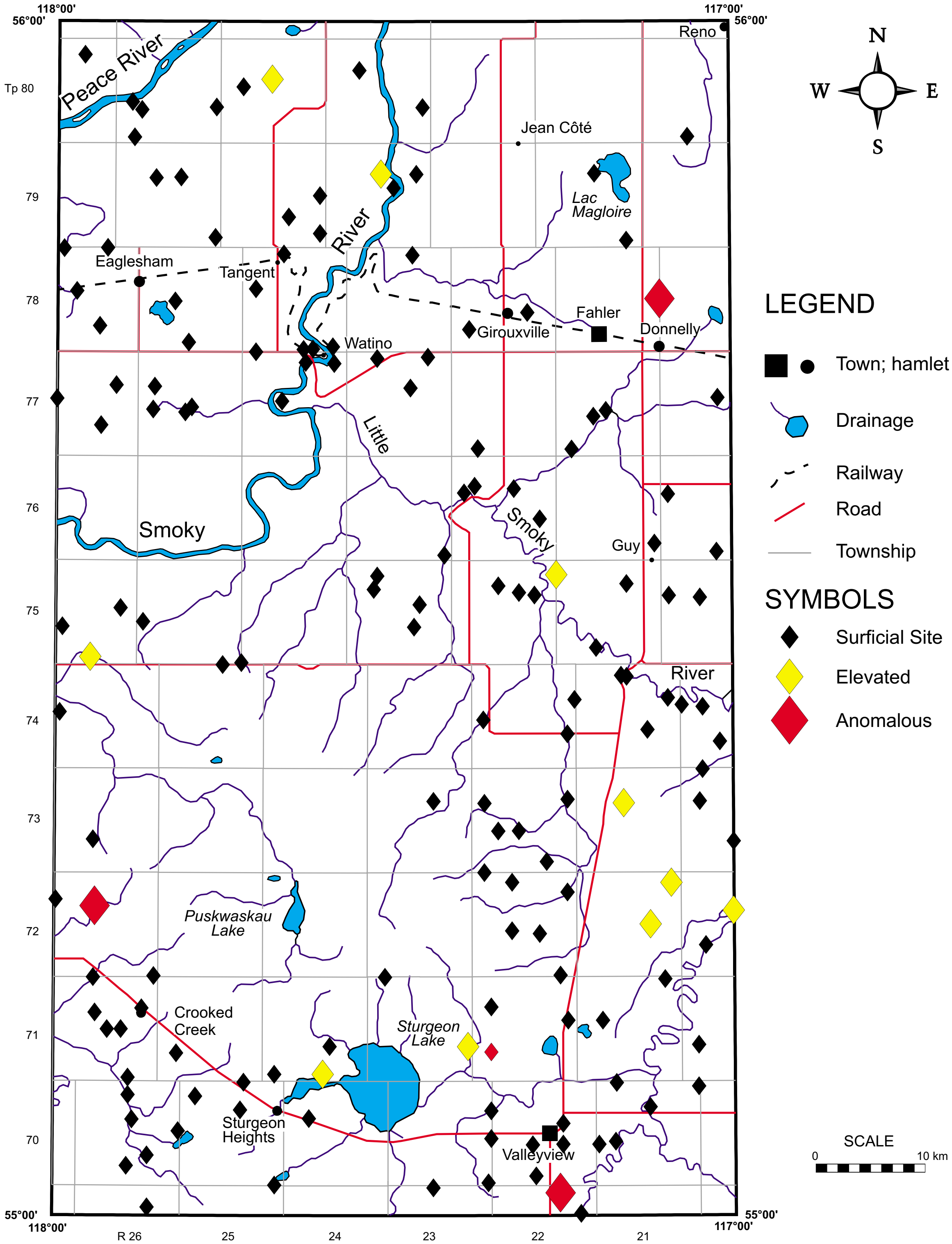
Eu (INAA) concentration in surface samples.



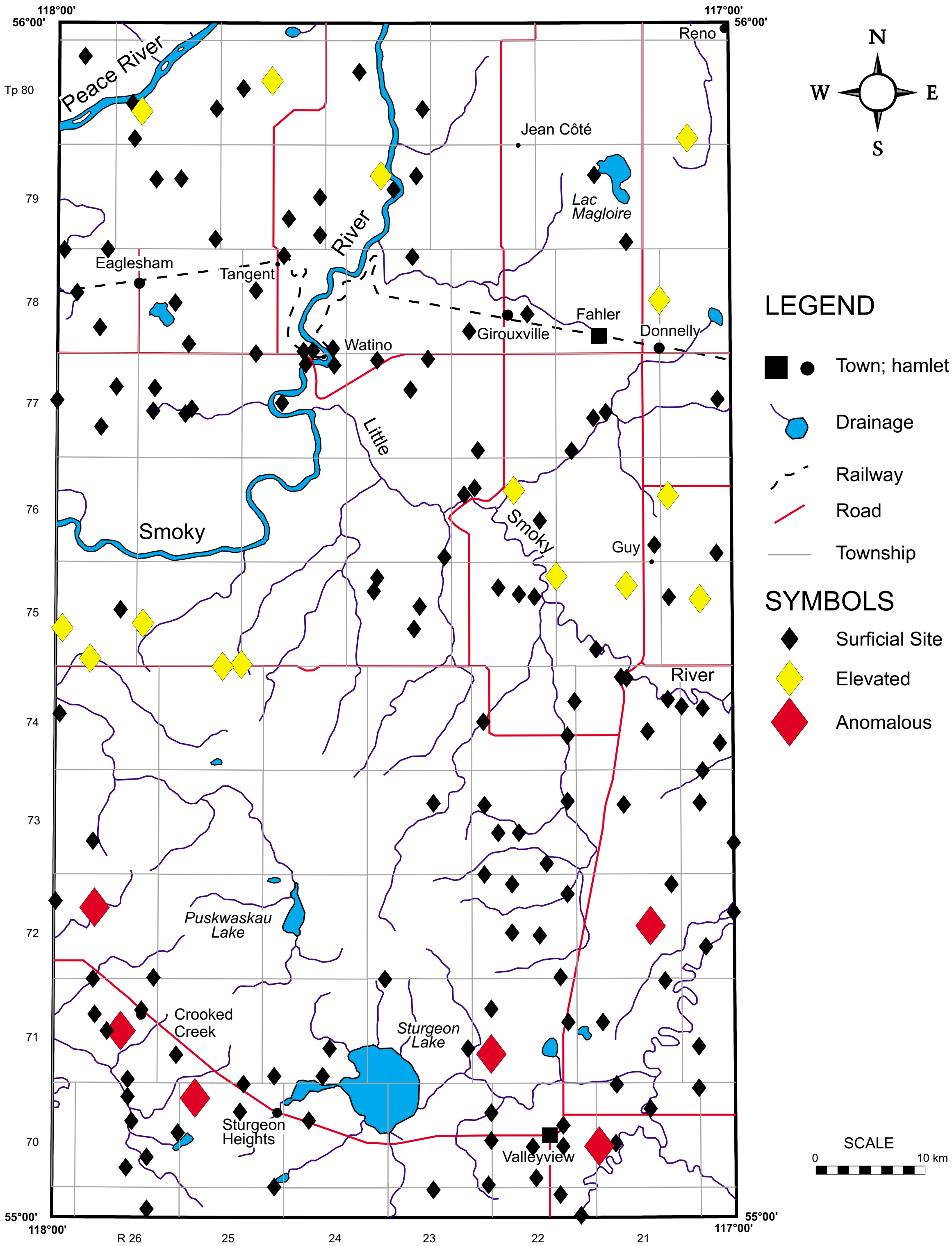
Fe (INAA) concentration in surface samples.



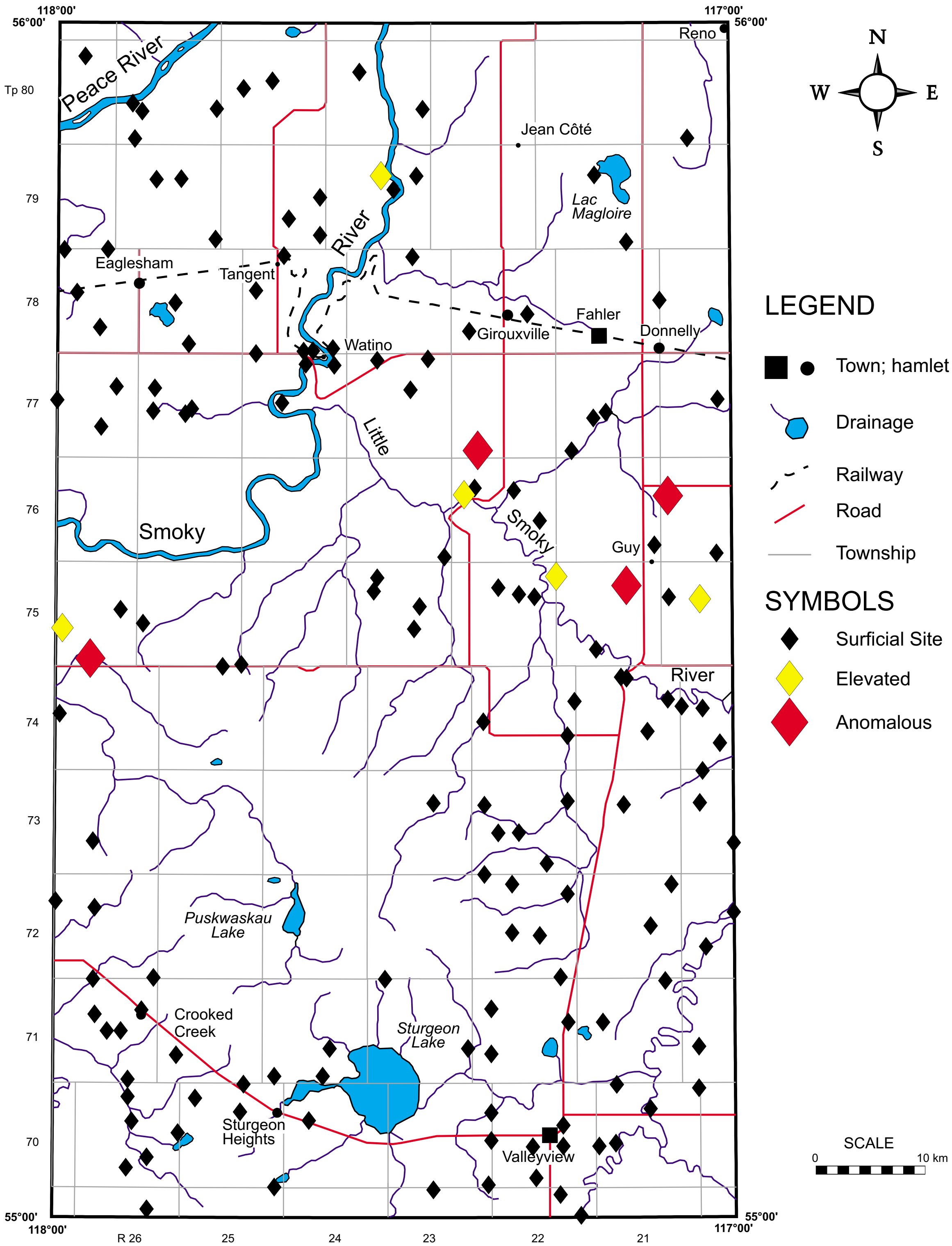
Hf (INAA) concentration in surface samples.



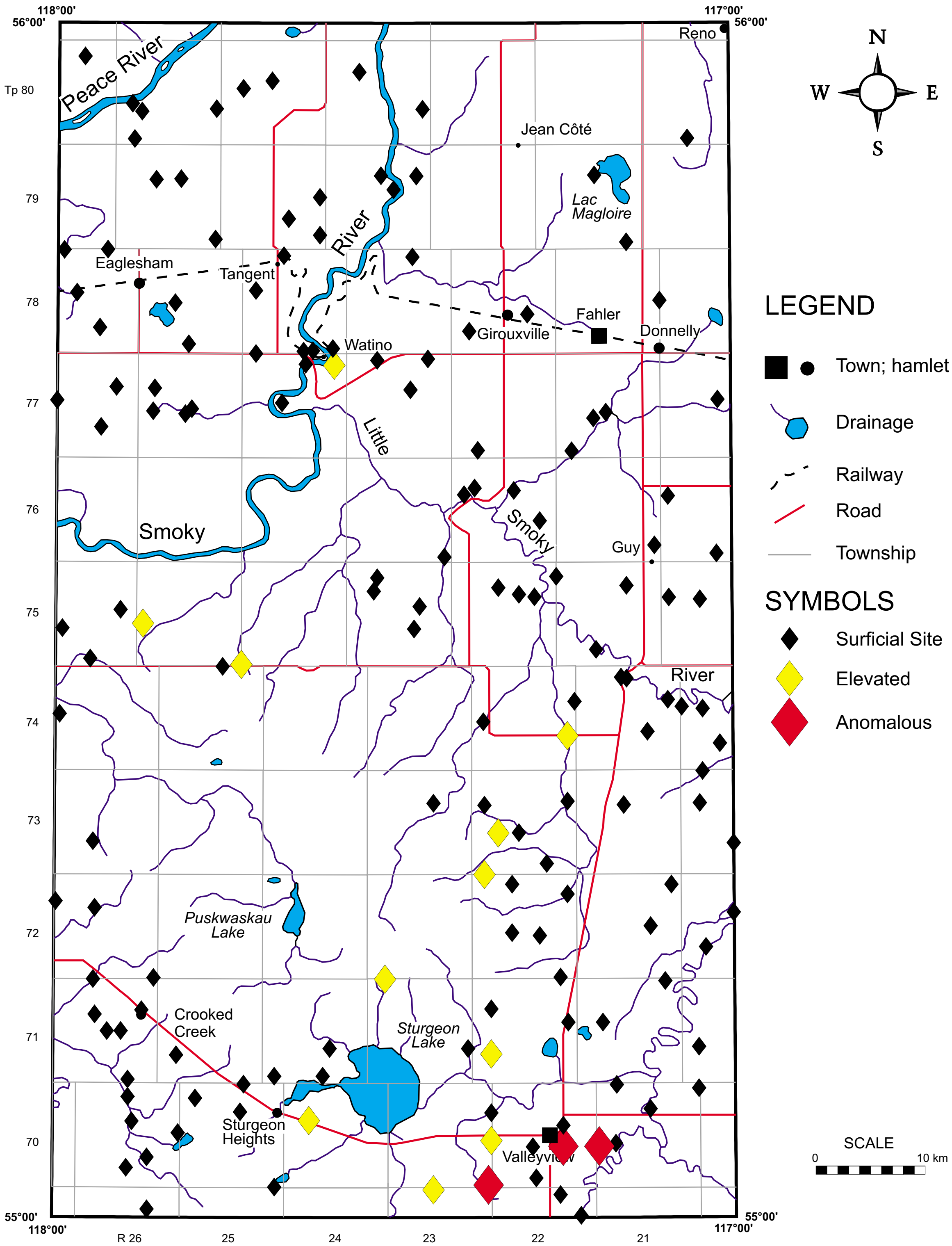
La (INAA) concentration in surface samples.



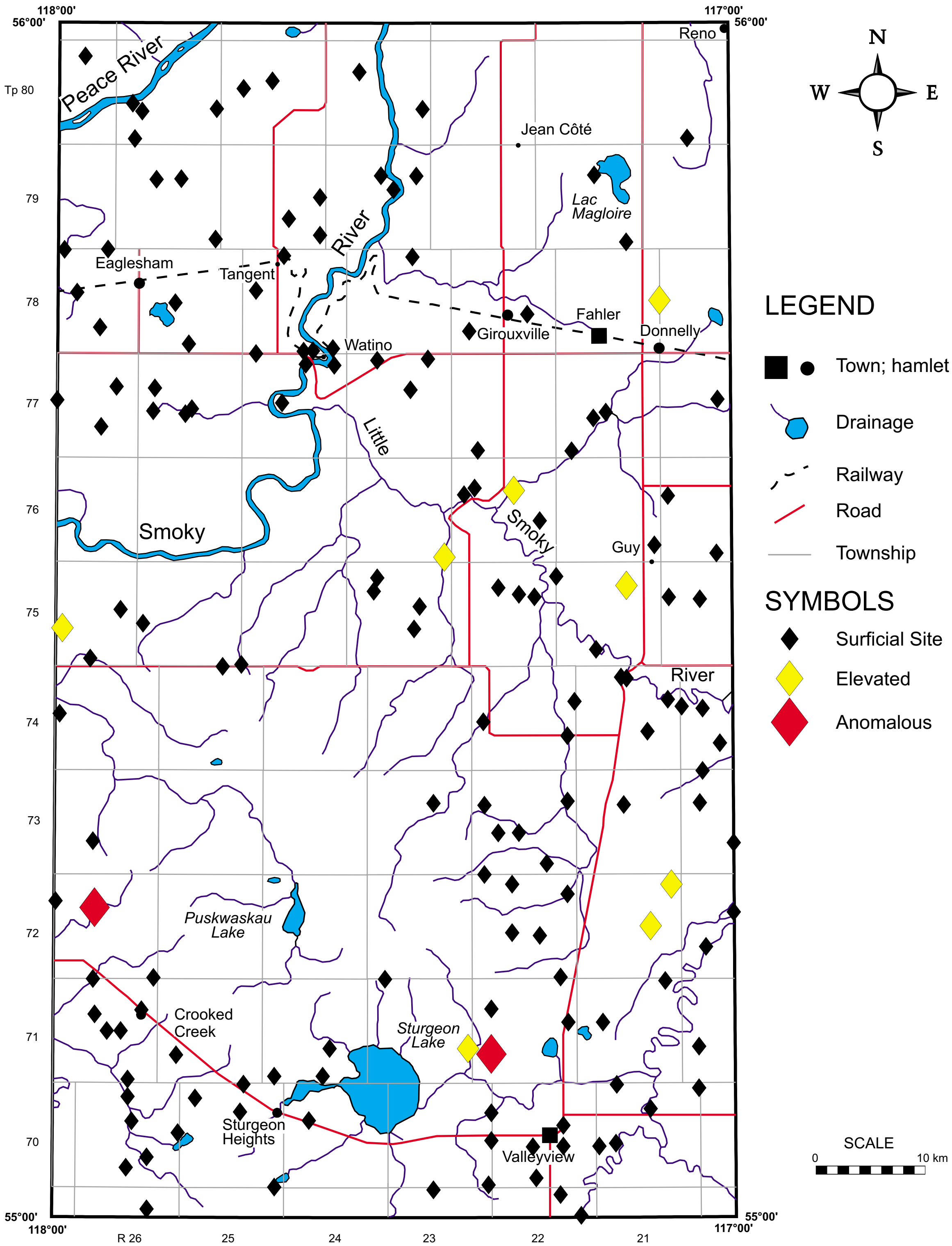
Lu (INAA) concentration in surface samples.



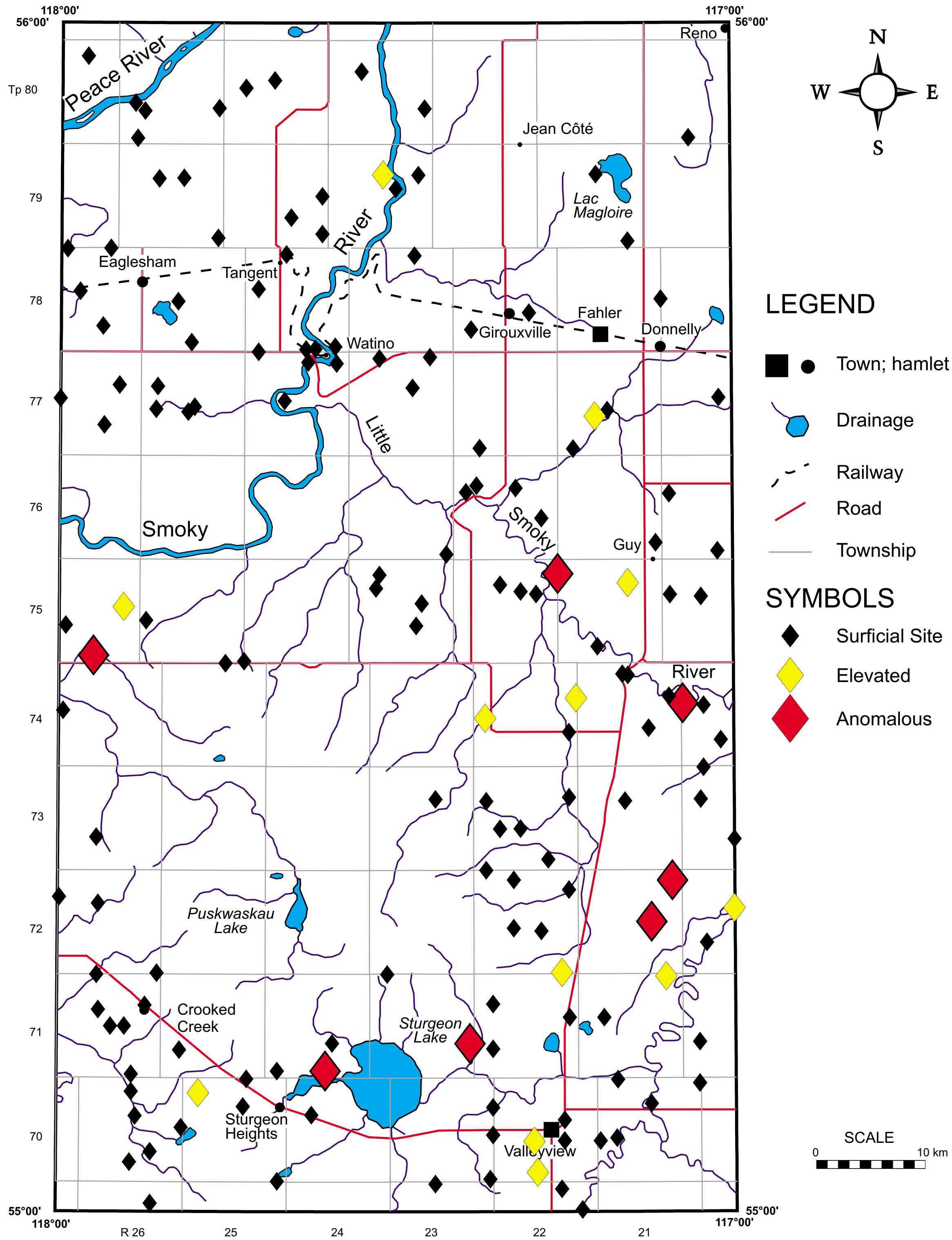
Mo (INAA) concentration in surface samples.



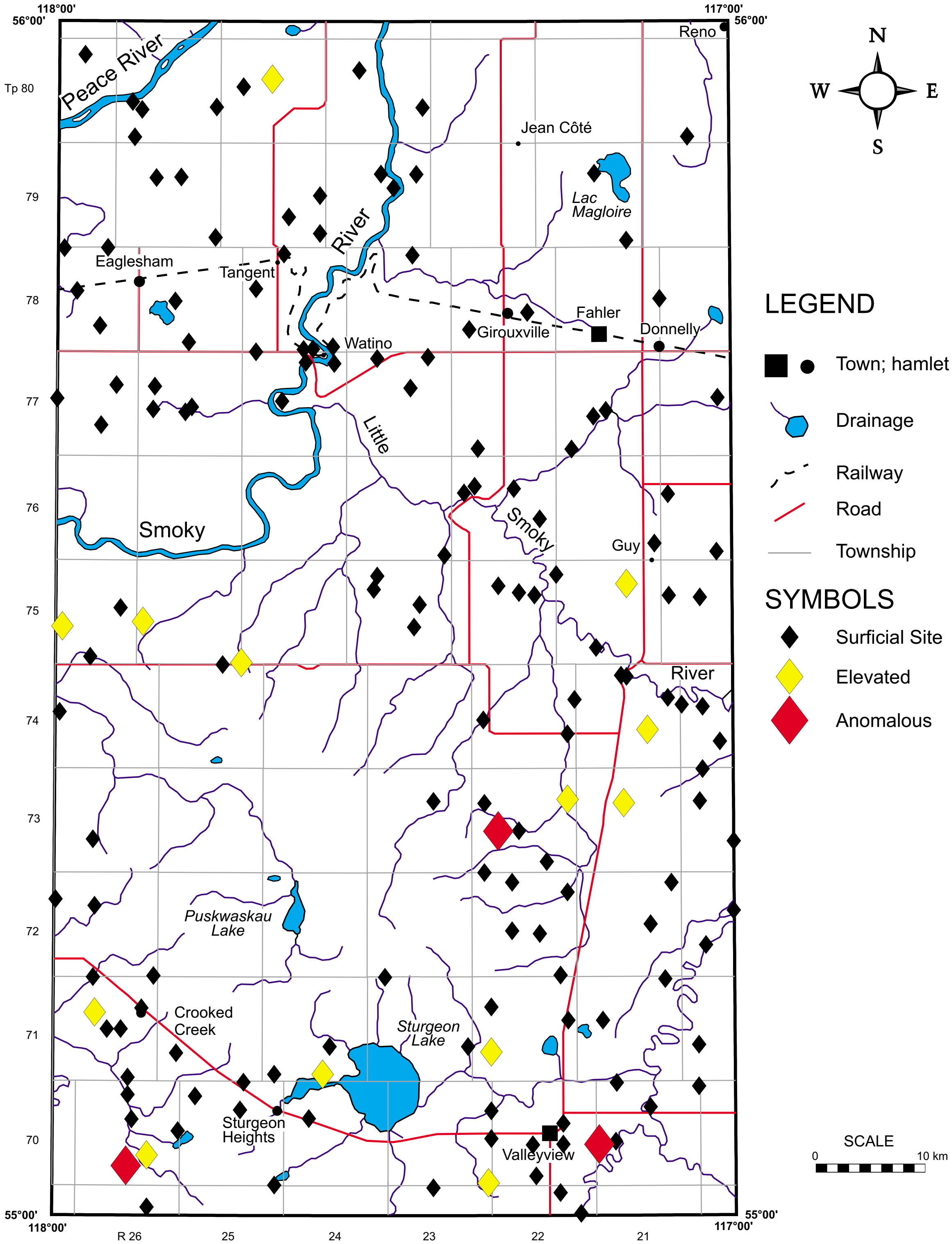
Na (INAA) concentration in surface samples.



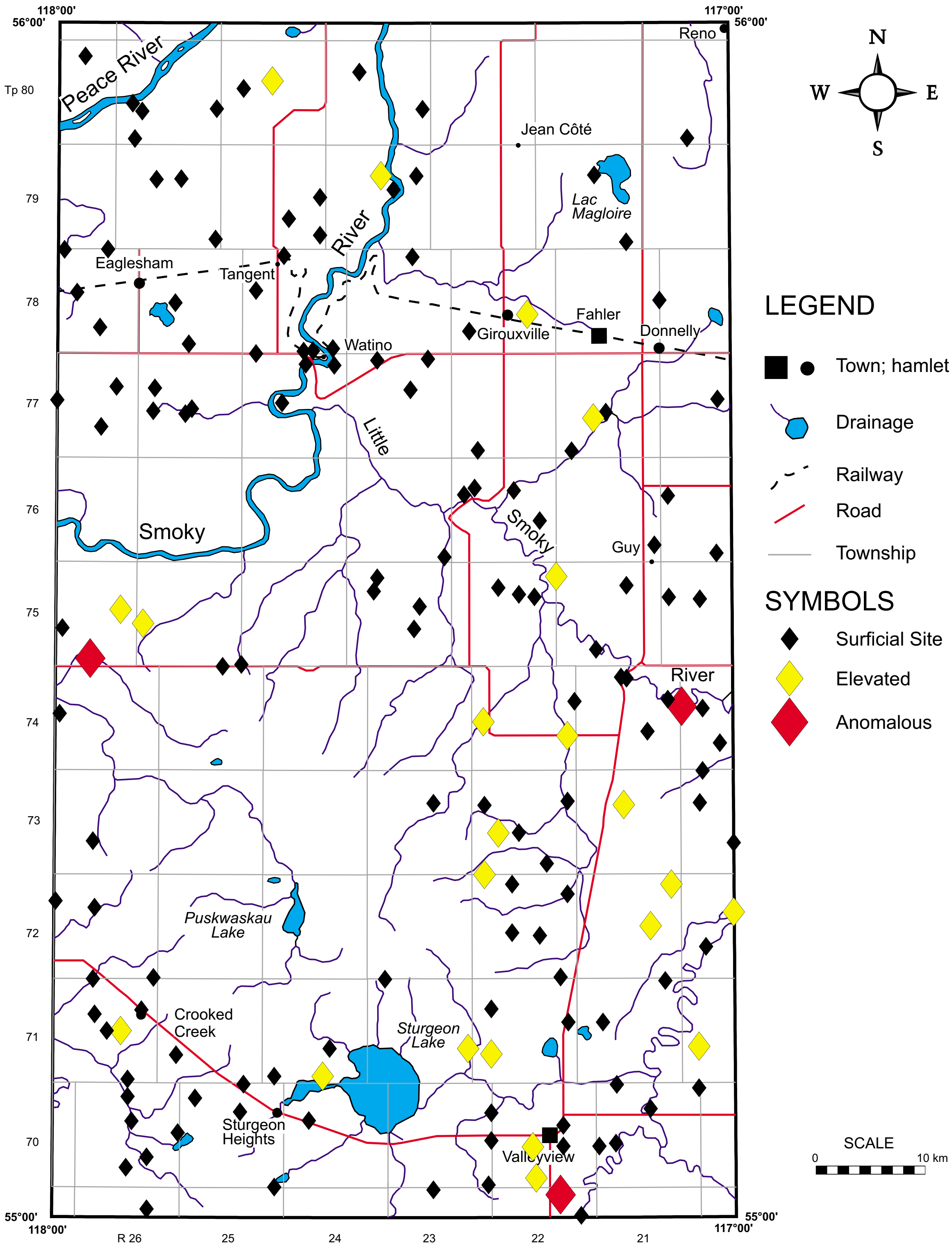
Ni (INAA) concentration in surface samples.



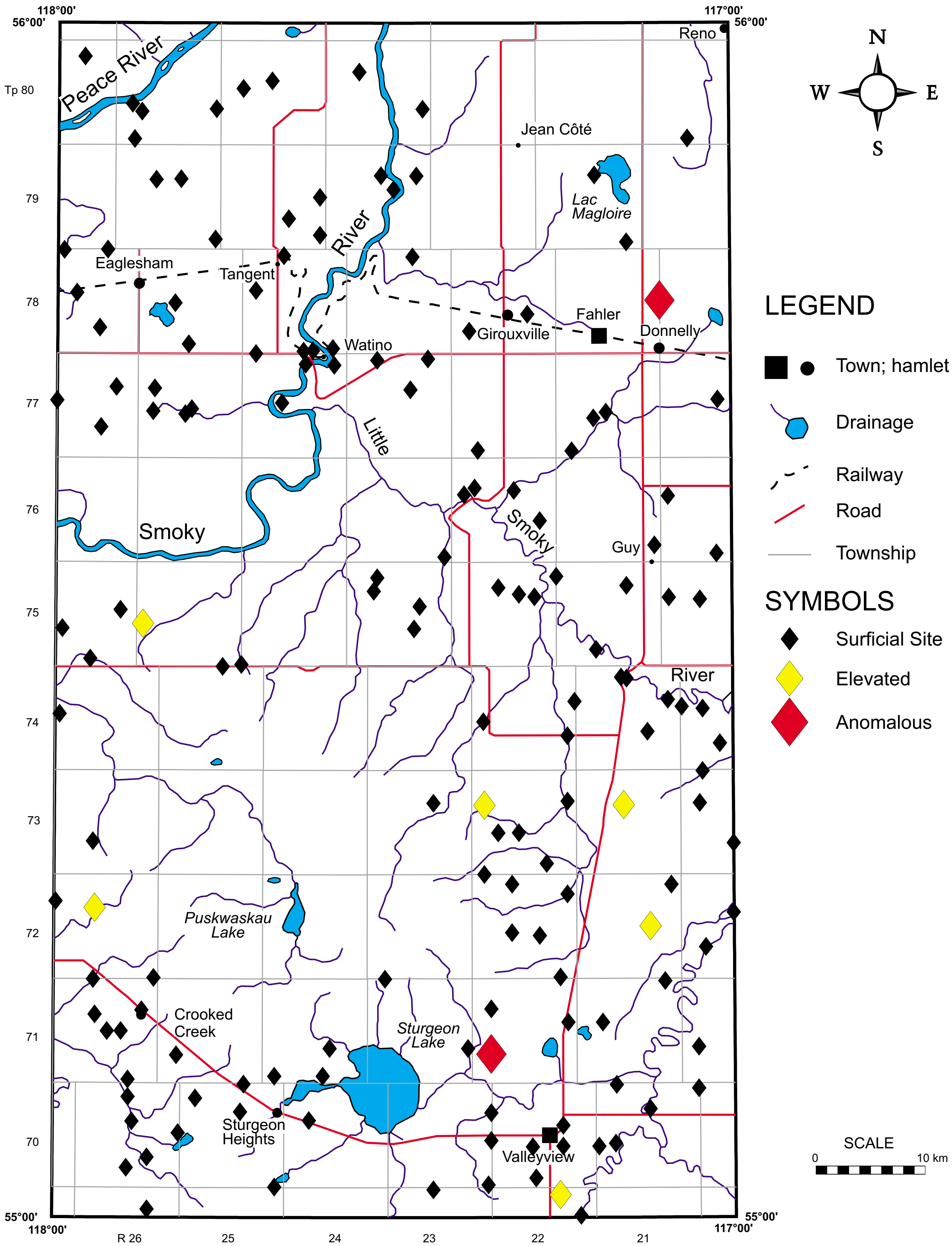
Rb (INAA) concentration in surface samples.



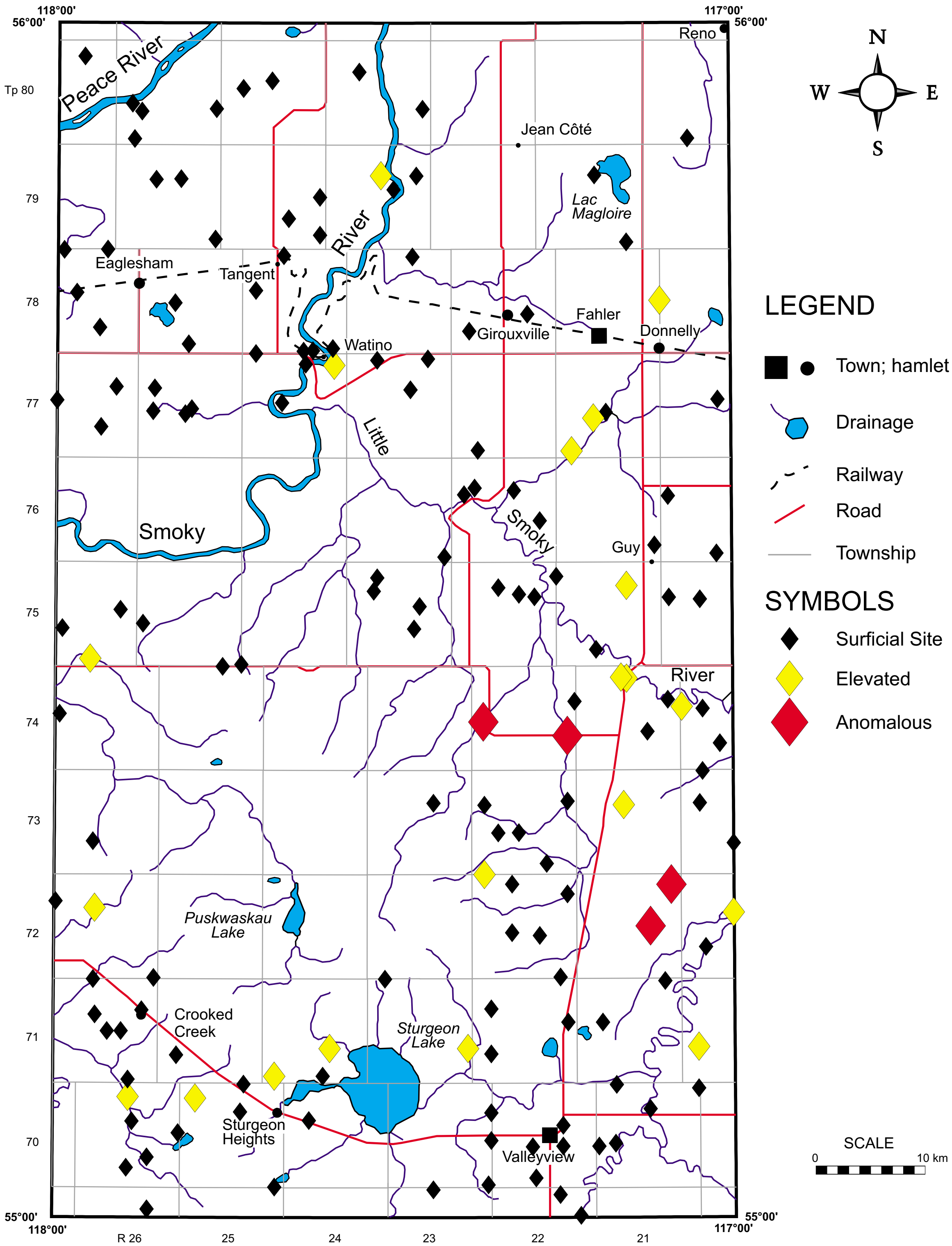
Sb (INAA) concentration in surface samples.



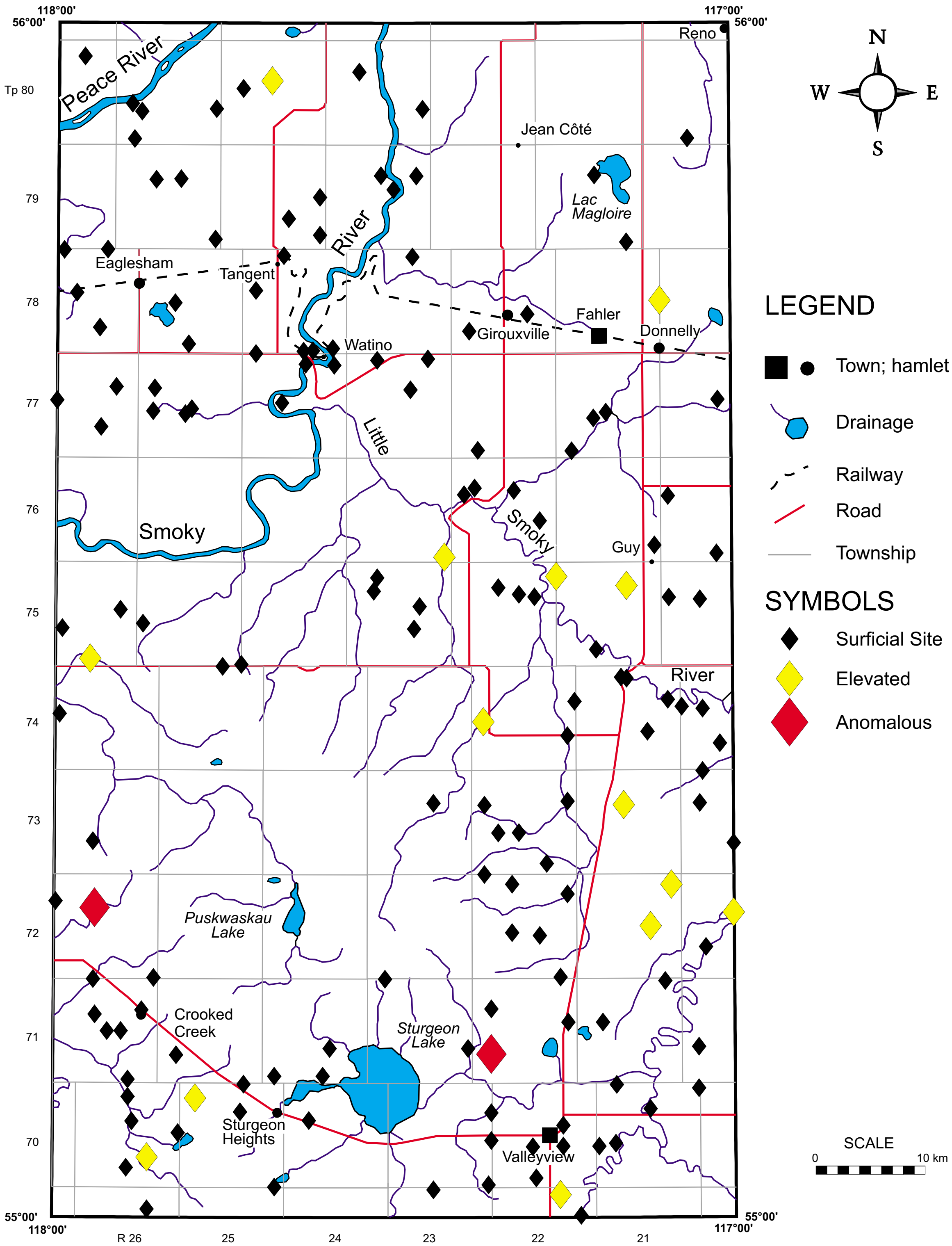
Sc (INAA) concentration in surface samples.



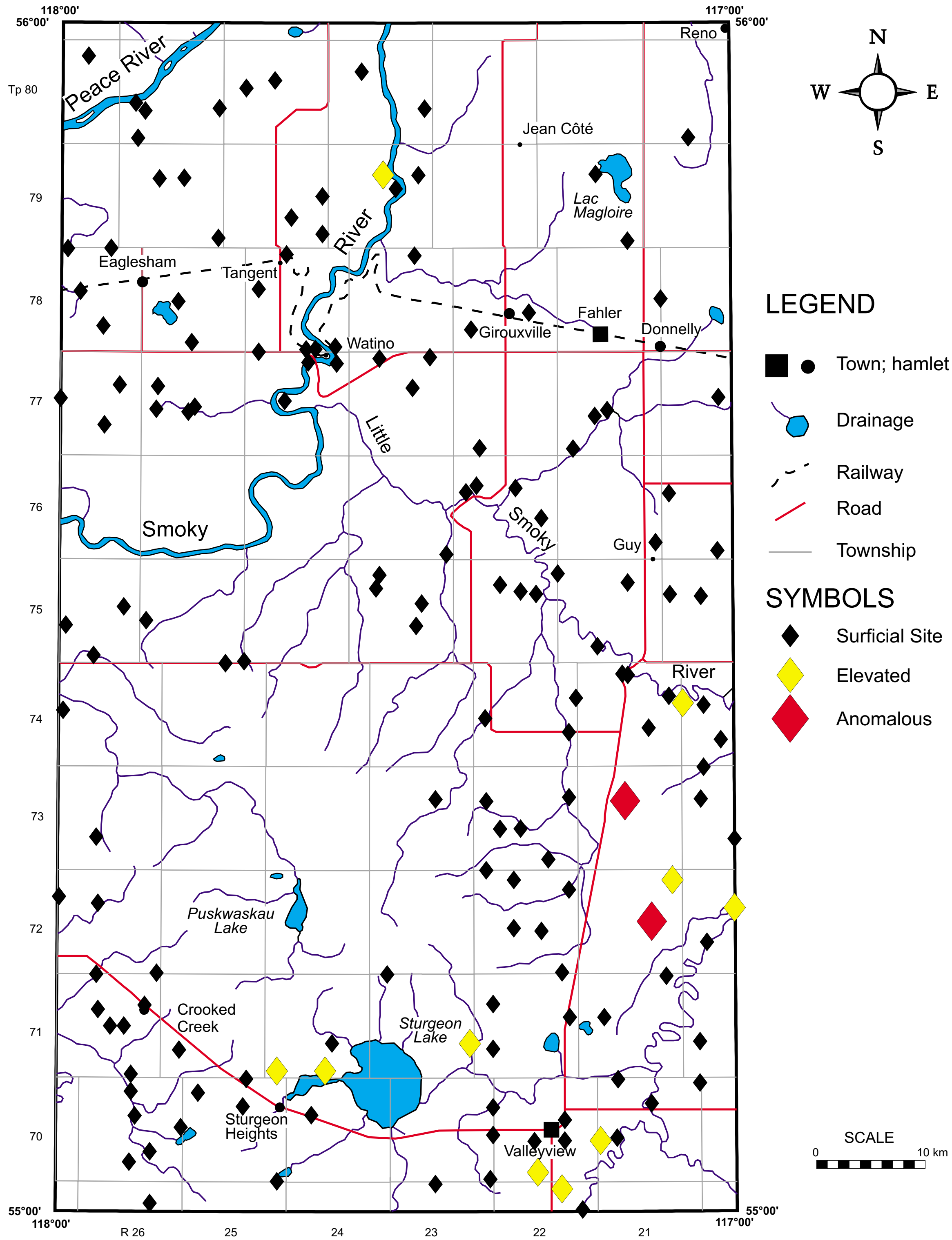
Sm (INAA) concentration in surface samples.



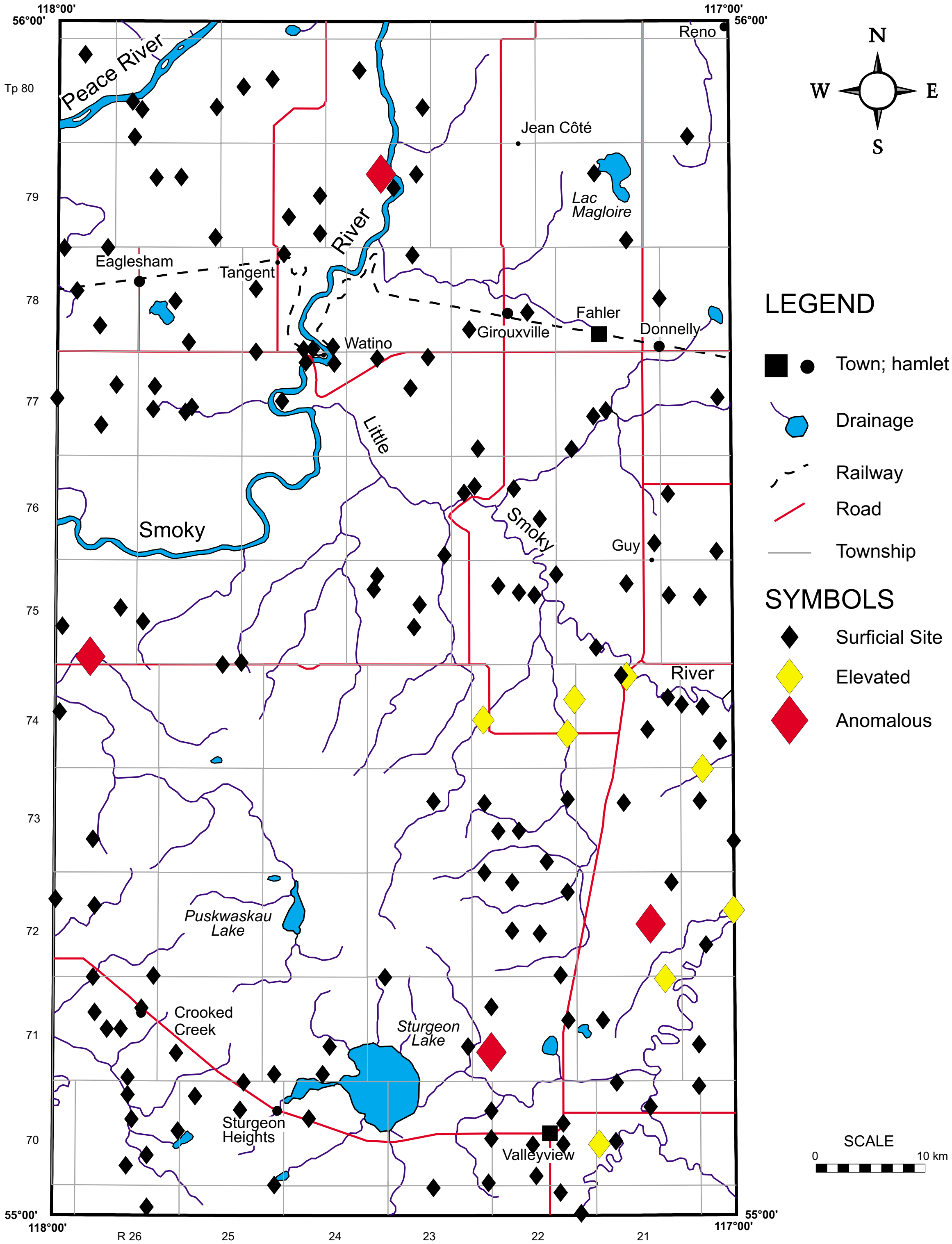
Ta (INAA) concentration in surface samples.



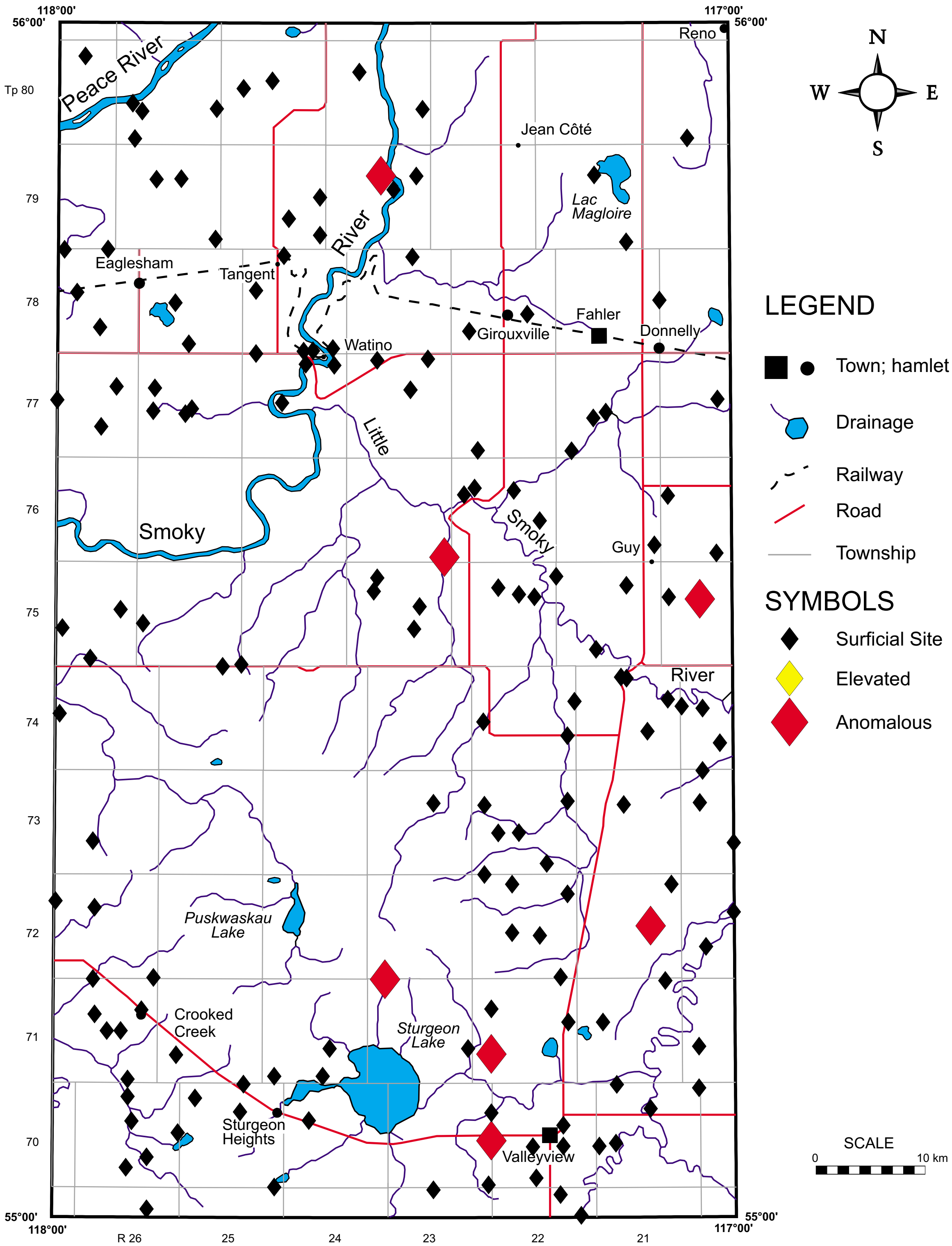
Tb (INAA) concentration in surface samples.



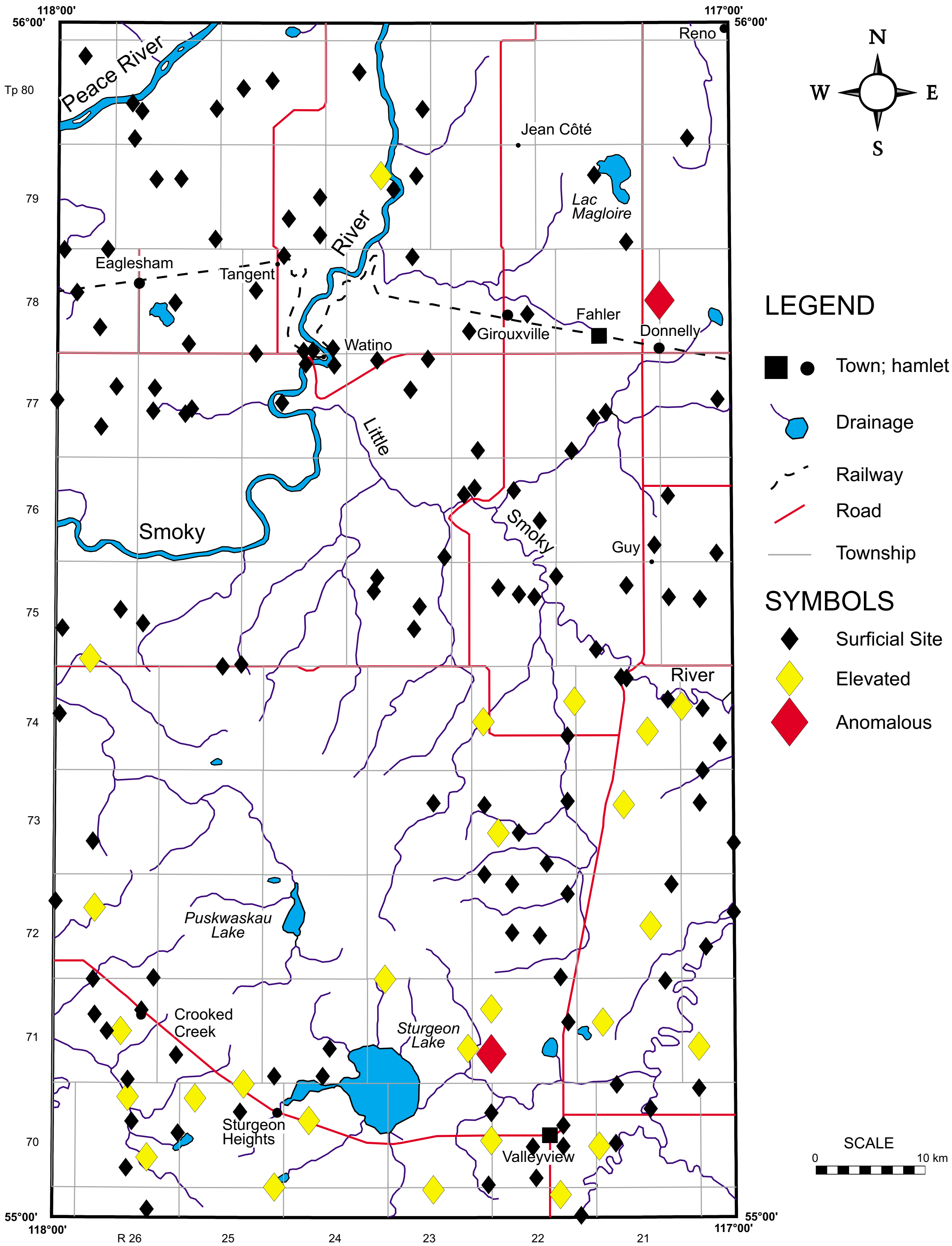
Th (INAA) concentration in surface samples.



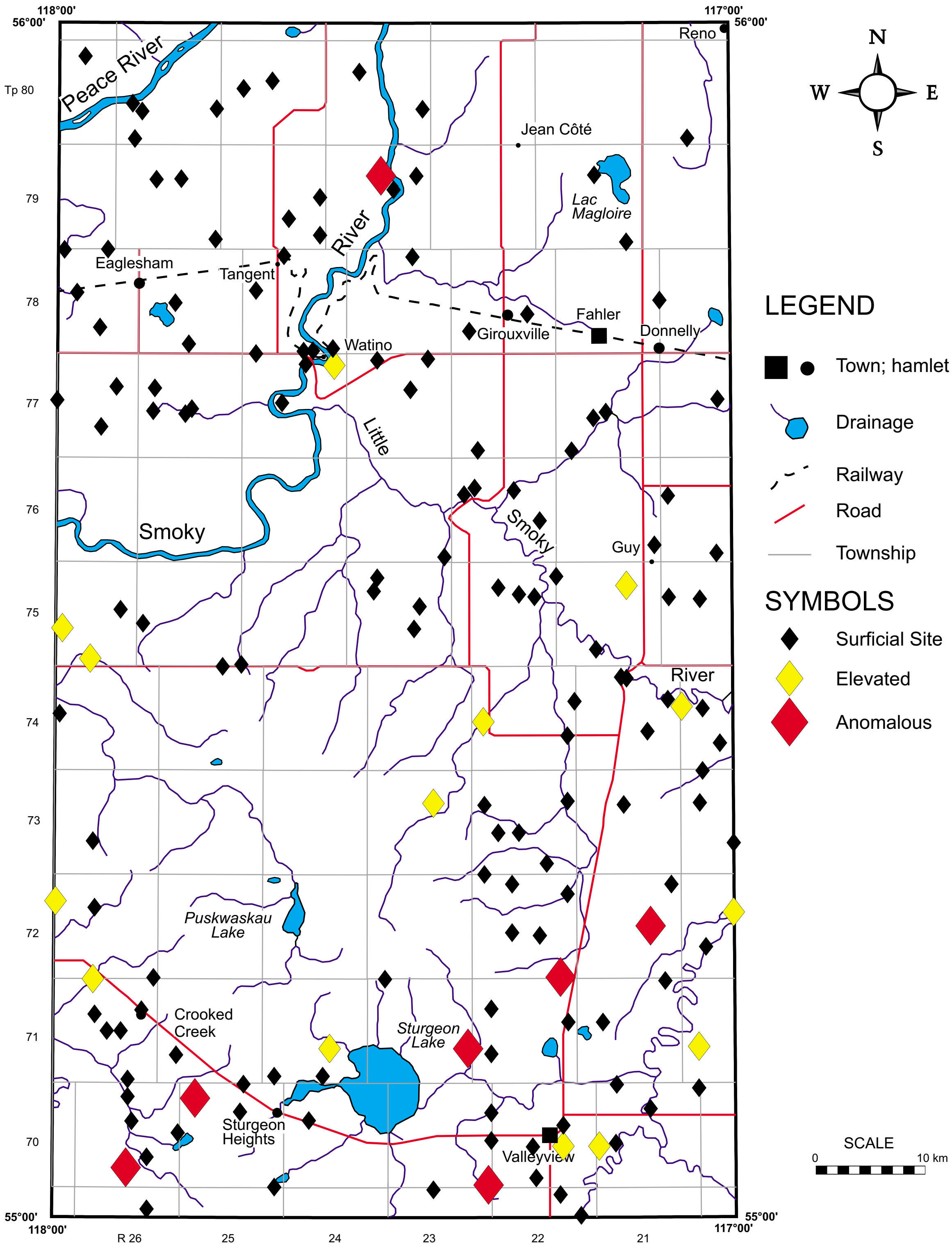
U (INAA) concentration in surface samples.



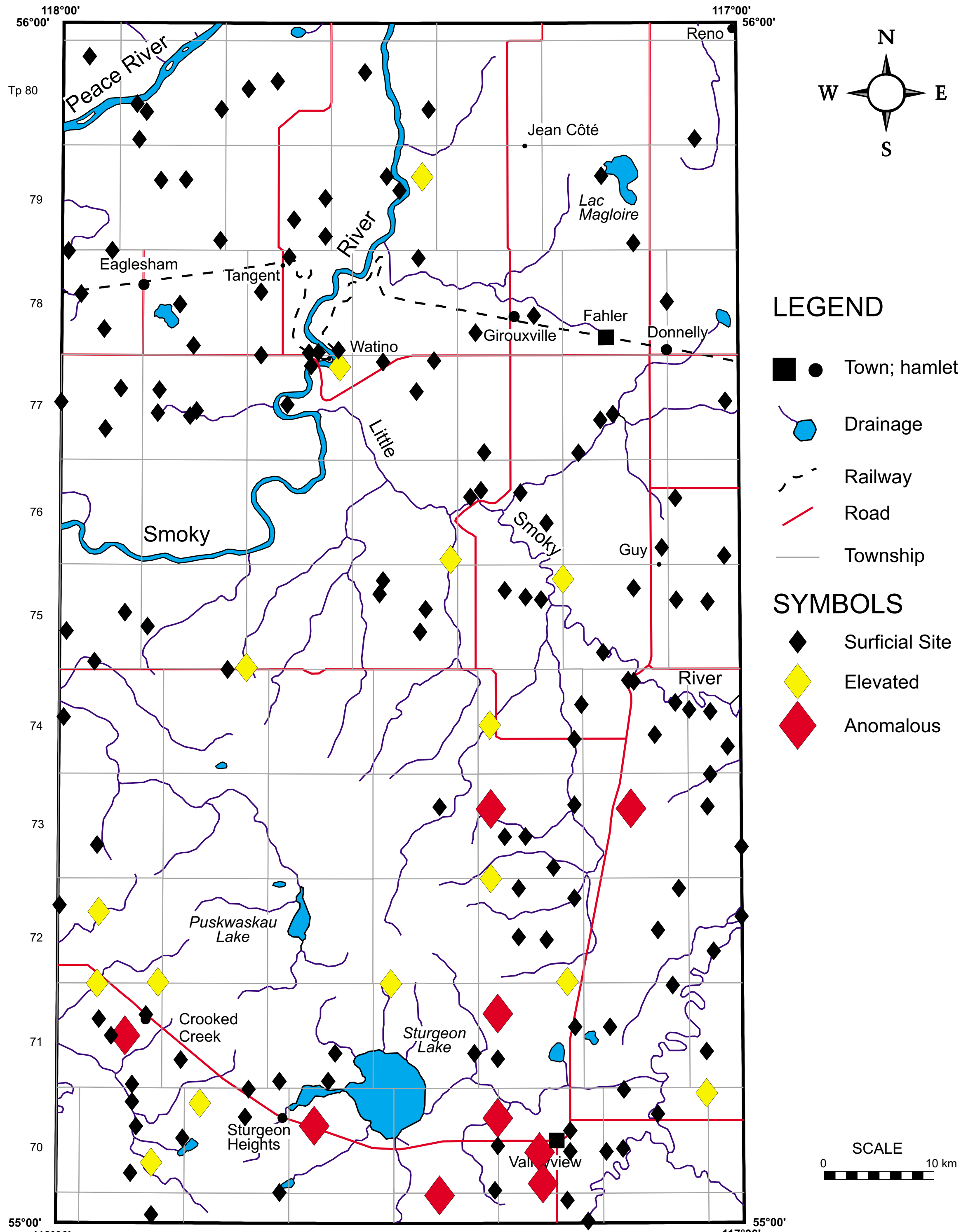
W (INAA) concentration in surface samples.



Yb (INAA) concentration in surface samples.



Zn (INAA) concentration in surface samples.



Zr (INAA) concentration in surface samples.

APPENDIX 7B

BOREHOLE SAMPLE DISPERSAL TRENDS

LEGEND

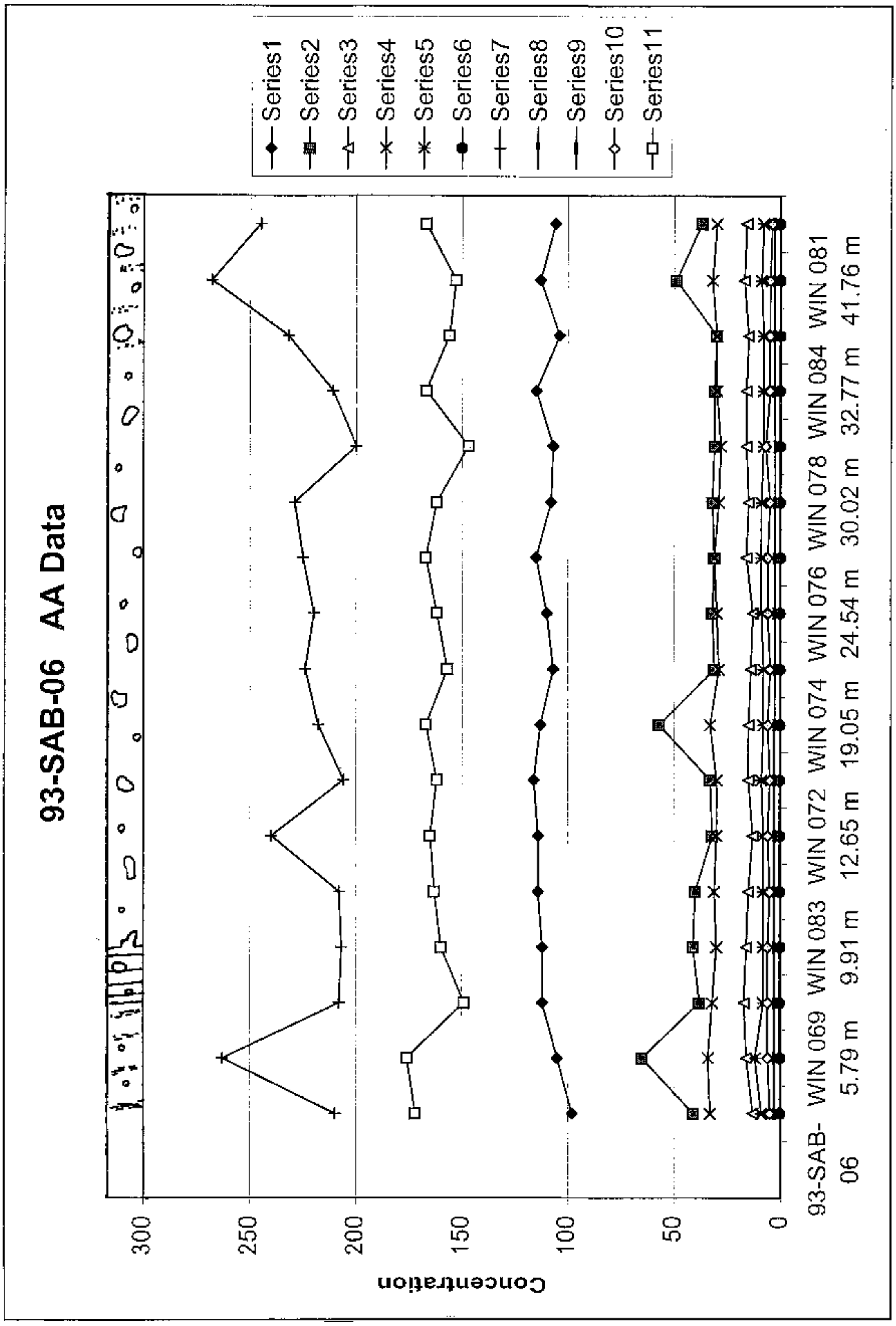
- Massive clay
- Massive silt
- Massive sand
- Silt lenses or laminae
- Sand lenses or laminae
- Laminated silt and clay
- Convoluted silt and clay
- Sand and gravel
- Clay diamict
- Silty clay diamict, massive
- Silty clay diamict, laminated
- Siltstone
- Sandstone
- Fractures

Note: legend is applicable to all of the boreholes on the following pages.

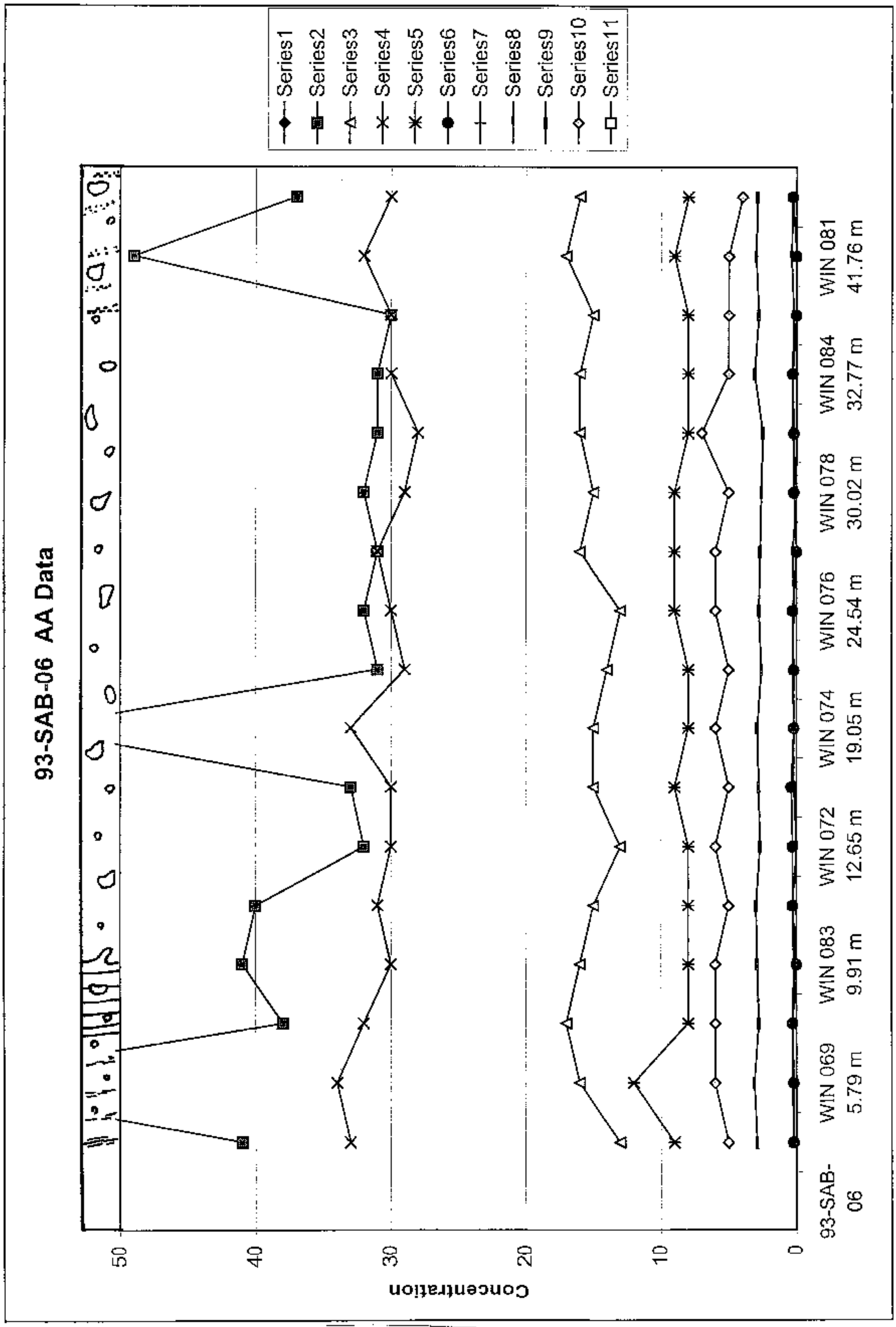
1993 AA DATA

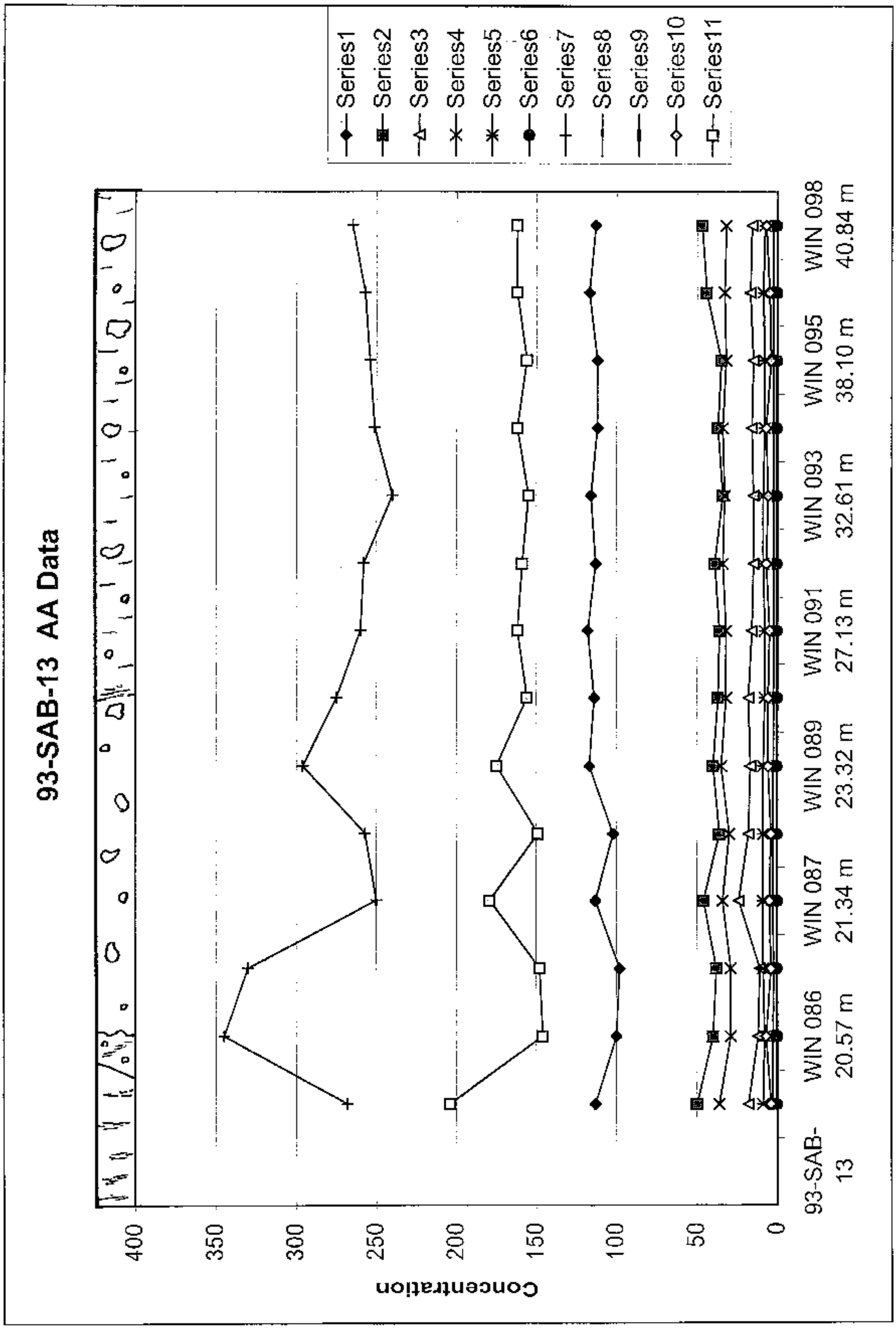
SERIES IDENTIFICATION CODE

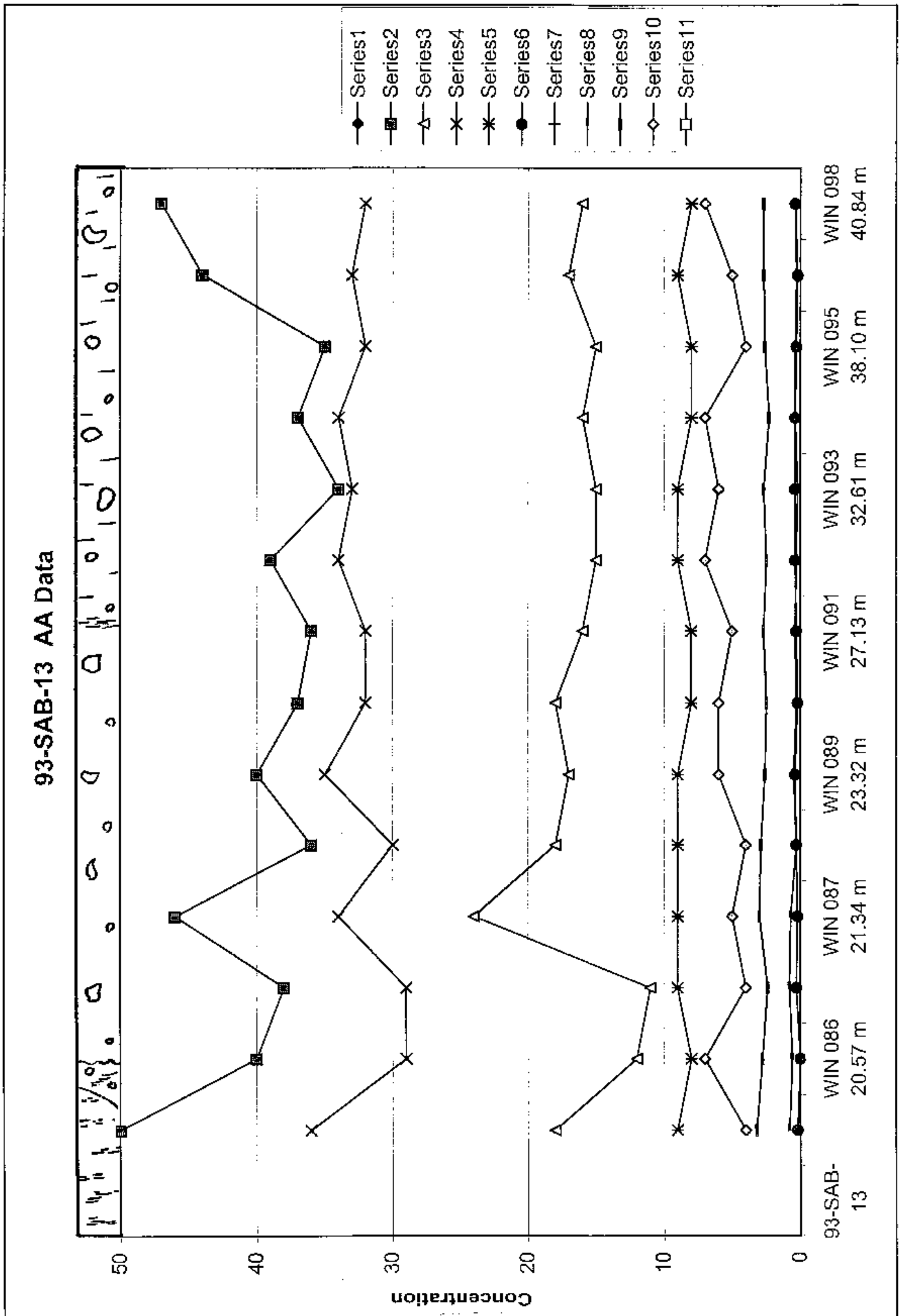
Series 1	Zn (ppm)
Series 2	Cu (ppm)
Series 3	Pb (ppm)
Series 4	Ni (ppm)
Series 5	Co (ppm)
Series 6	Ag (ppm)
Series 7	Mn (ppm)
Series 8	Cd (ppm)
Series 9	Fe (%)
Series 10	Mo (ppm)
Series 11	V (ppm)



93-SAB-06 AA Data
Concentration
300
250
200
150
100
50
0
93-SAB-06
WIN 069 5.79 m
WIN 083 9.91 m
WIN 072 12.65 m
WIN 074 19.05 m
WIN 076 24.54 m
WIN 078 30.02 m
WIN 084 32.77 m
WIN 081 41.76 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Series8
Series9
Series10
Series11


93-SAB-06 AA Data
Concentration
50
40
30
20
10
0
93-SAB-06
WIN 069 5.79 m
WIN 083 9.91 m
WIN 072 12.65 m
WIN 074 19.05 m
WIN 076 24.54 m
WIN 078 30.02 m
WIN 084 32.77 m
WIN 081 41.76 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Series8
Series9
Series10
Series11

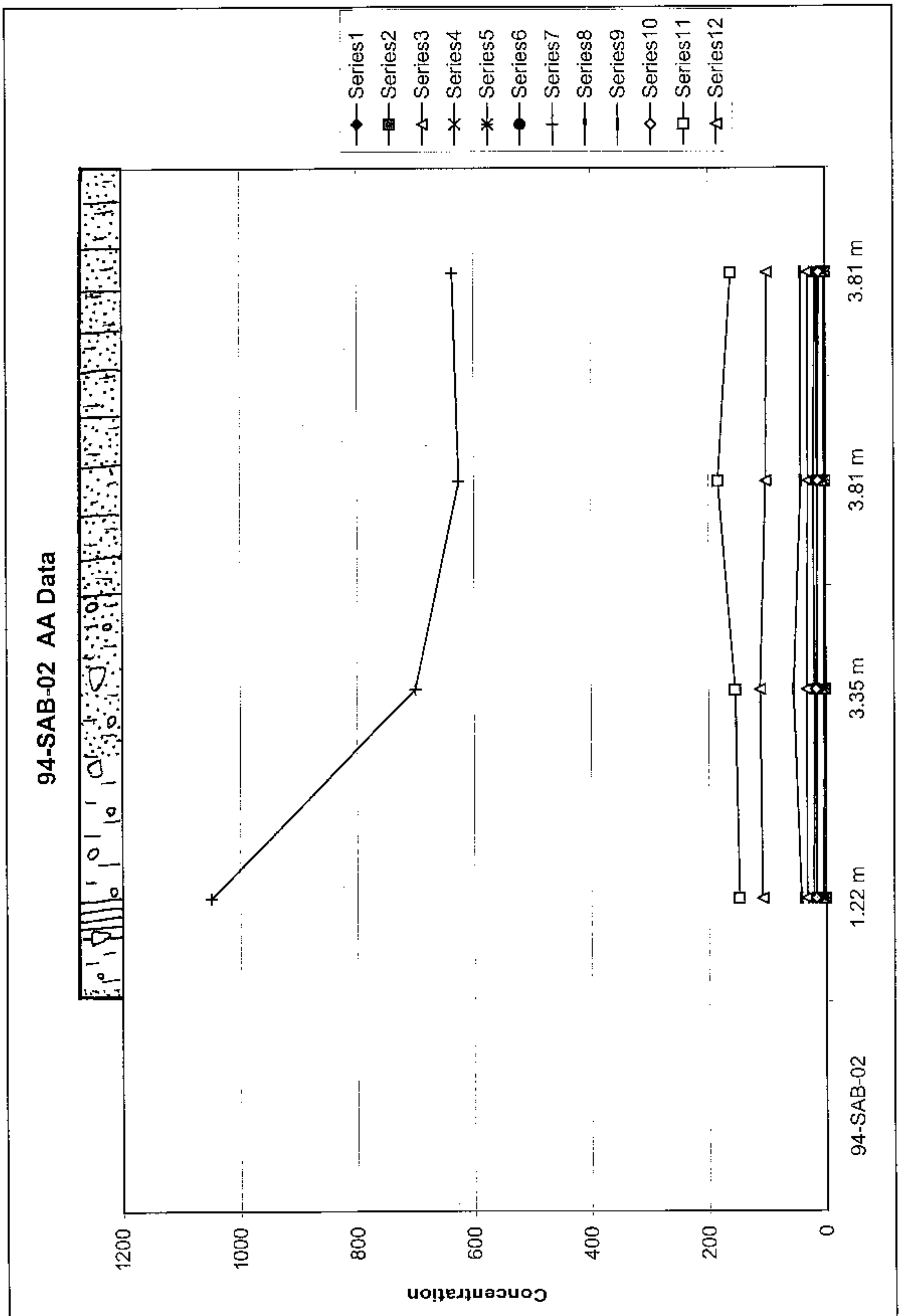

93-SAB-13 AA Data
Concentration
0
50
100
150
200
250
300
350
400
93-SAB-13
WIN 086 20.57 m
WIN 087 21.34 m
WIN 089 23.32 m
WIN 091 27.13 m
WIN 093 32.61 m
WIN 095 38.10 m
WIN 098 40.84 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Series8
Series9
Series10
Series11


93-SAB-13 AA Data
Concentration
0
10
20
30
40
50
93-SAB-13
WIN 086 20.57 m
WIN 087 21.34 m
WIN 089 23.32 m
WIN 091 27.13 m
WIN 093 32.61 m
WIN 095 38.10 m
WIN 098 40.84 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Series8
Series9
Series10
Series11

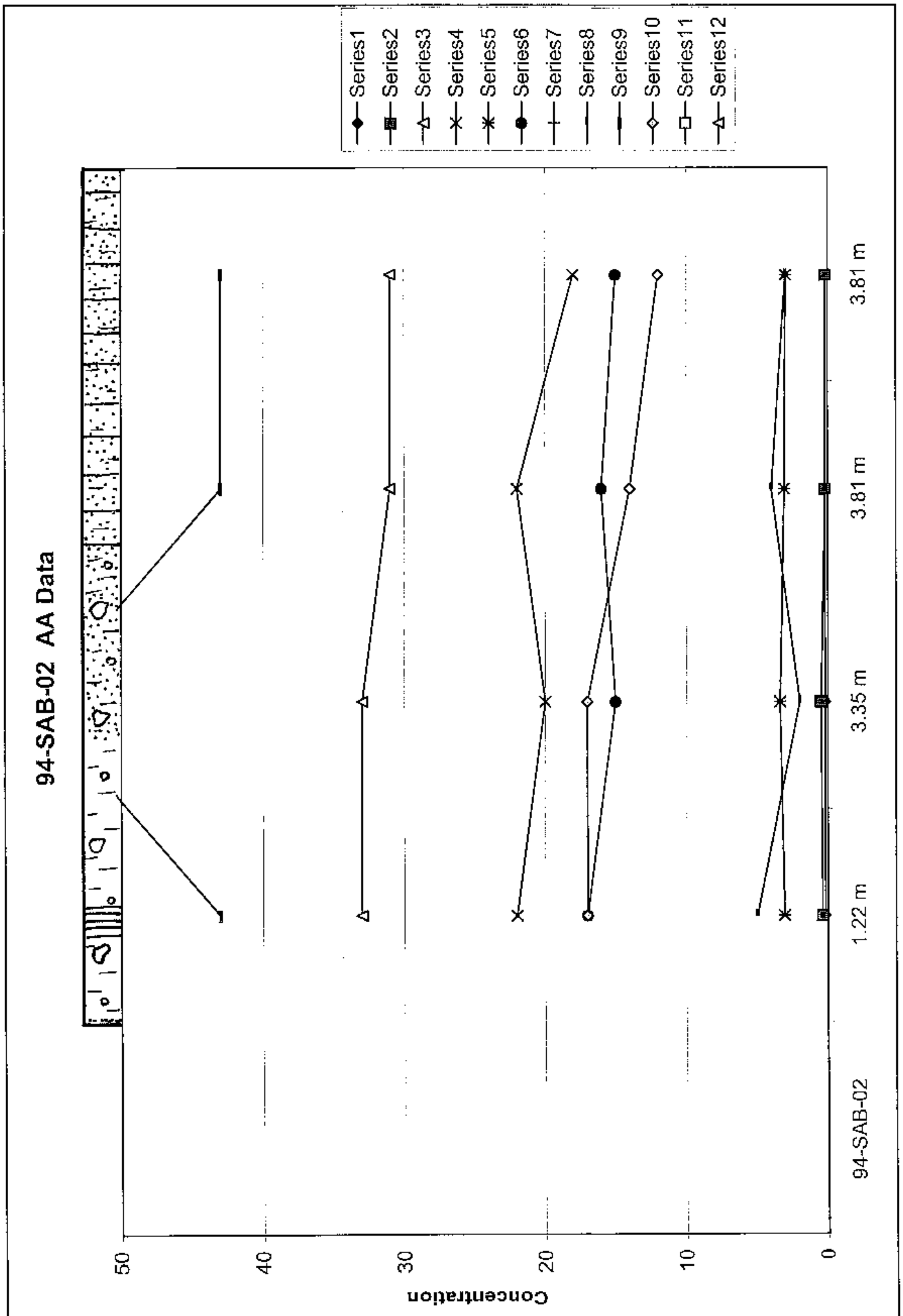
1994 AA DATA

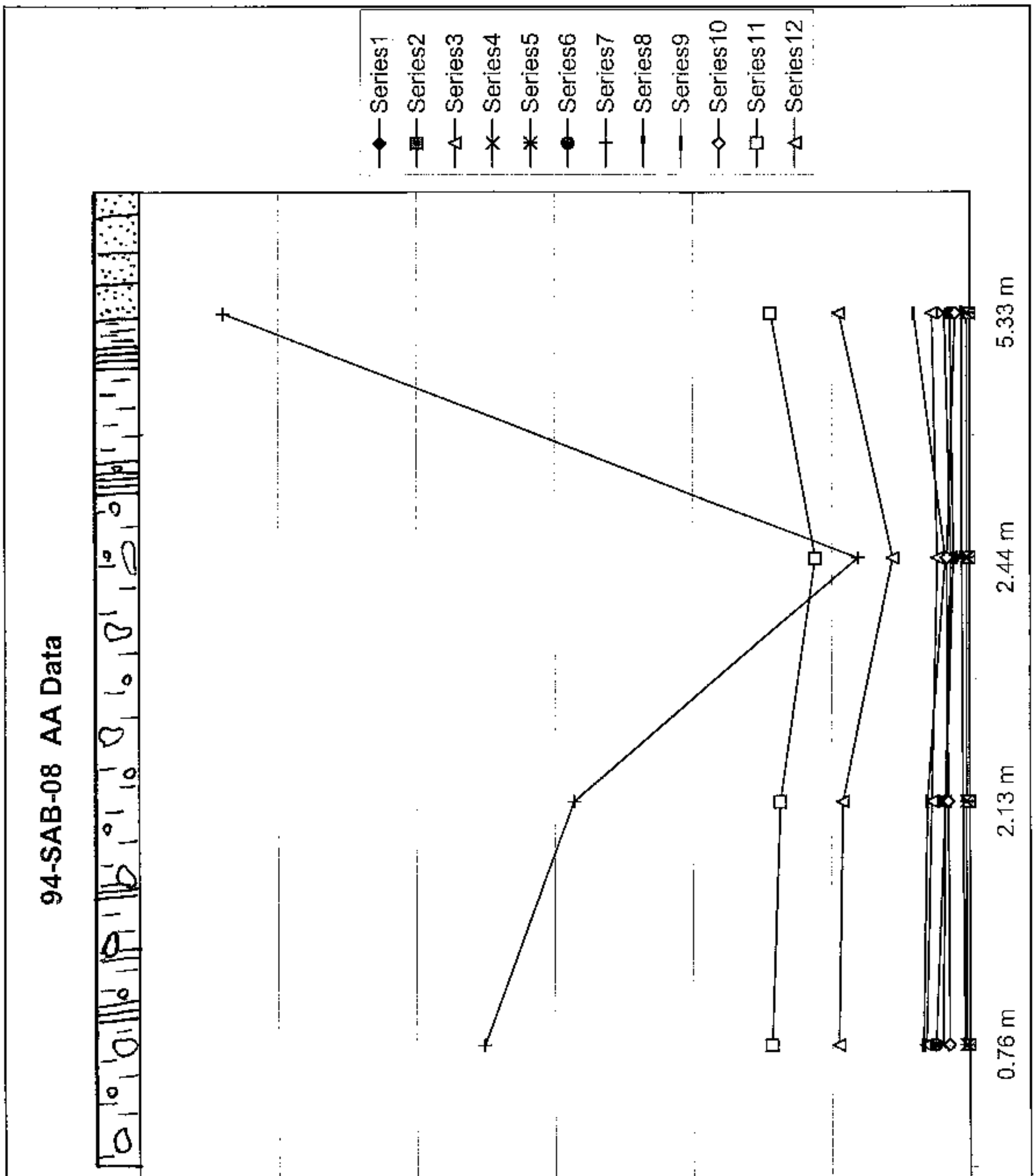
SERIES IDENTIFICATION CODE

Series 1	Ag (ppm)
Series 2	Cd (ppm)
Series 3	Cu (ppm)
Series 4	Co (ppm)
Series 5	Fe (%)
Series 6	Li (ppm)
Series 7	Mn (ppm)
Series 8	Mo (ppm)
Series 9	Ni (ppm)
Series 10	Pb (ppm)
Series 11	V (ppm)
Series 12	Zn (ppm)

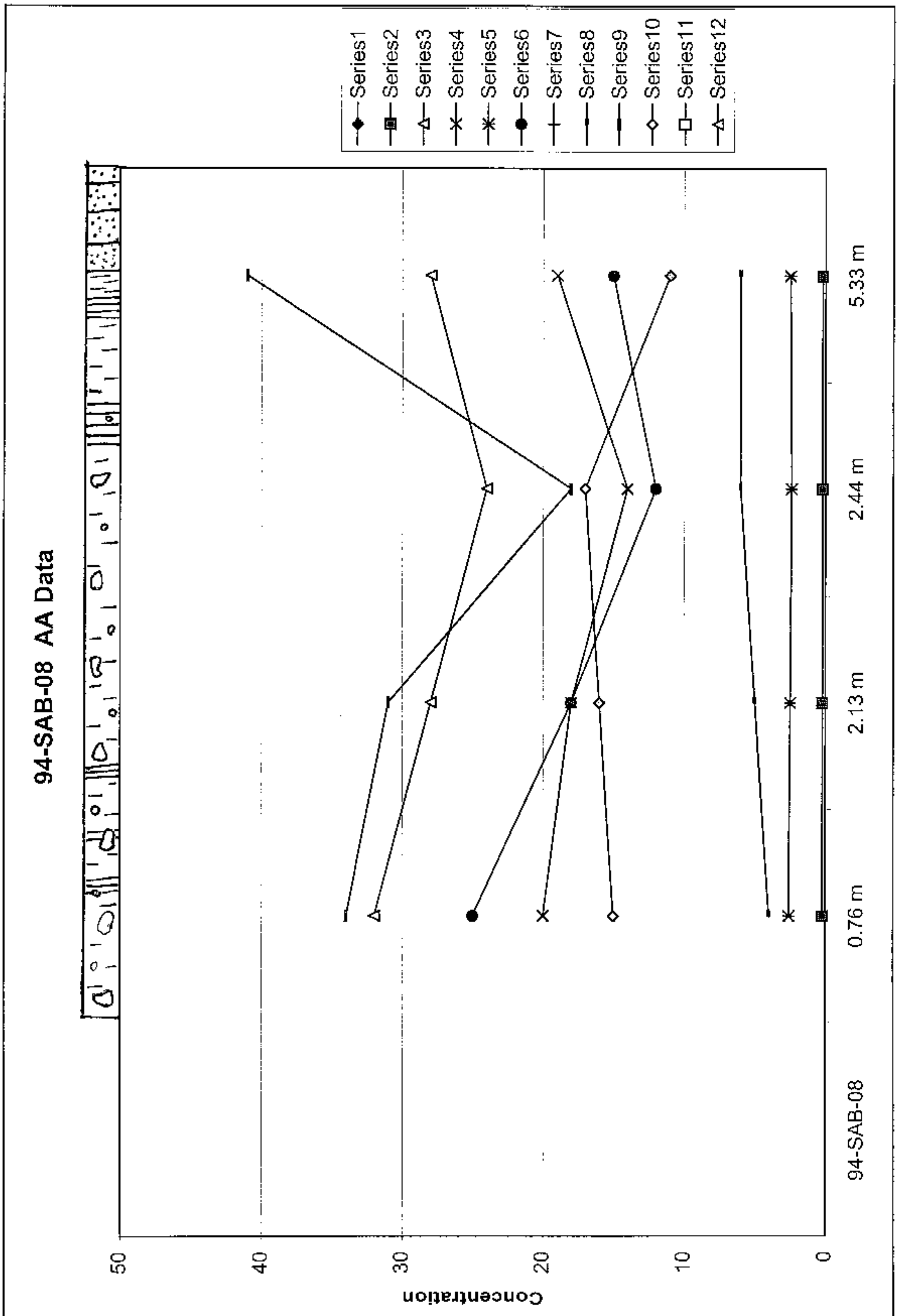


94-SAB-02 AA Data
Concentration
0
200
400
600
800
1000
1200
94-SAB-02
1.22 m
3.35 m
3.81 m
3.81 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Series8
Series9
Series10
Series11
Series12

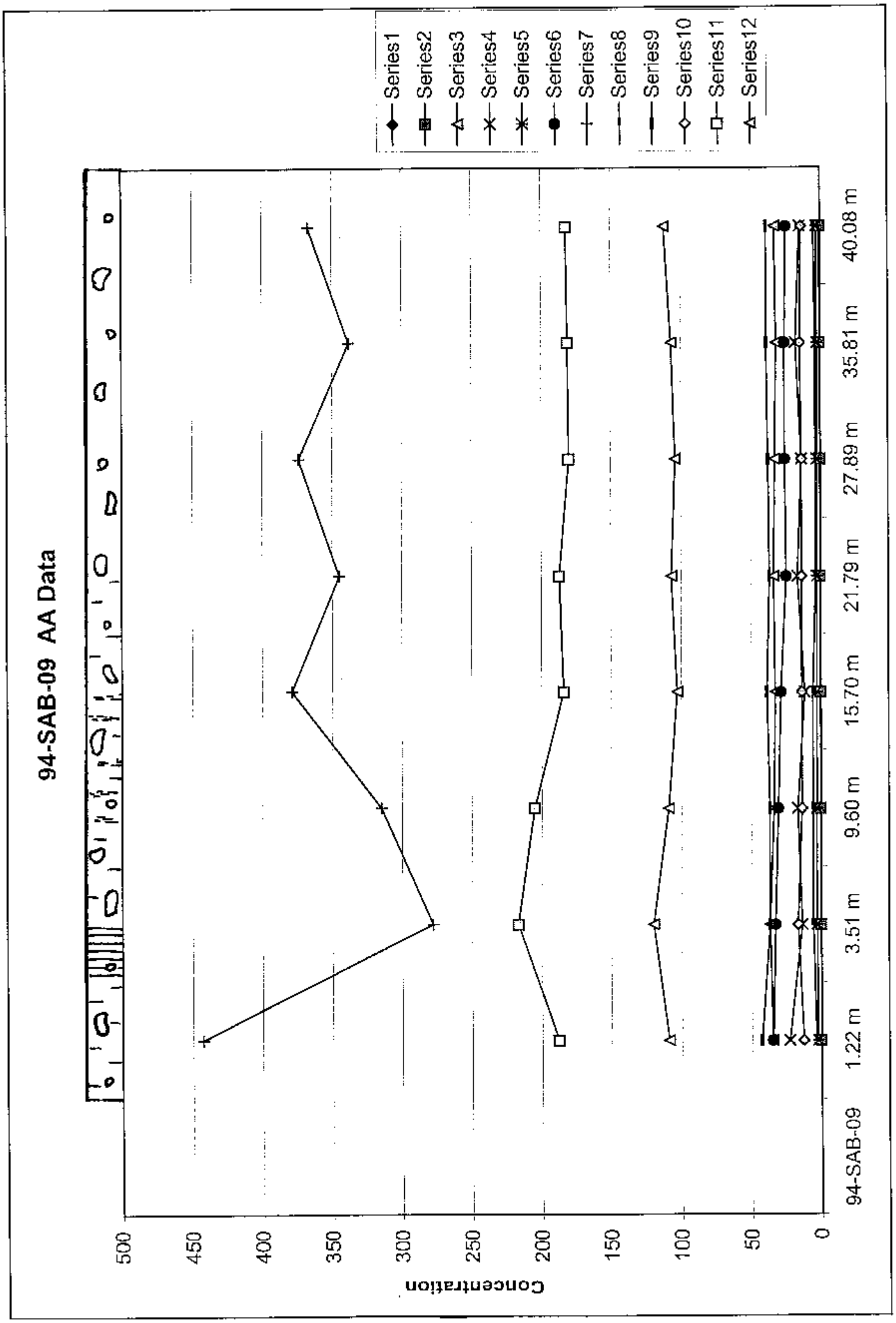

94-SAB-02 AA Data
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Series8
Series9
Series10
Series11
Series12
Concentration
0
10
20
30
40
50
94-SAB-02
1.22 m
3.35 m
3.81 m
3.81 m



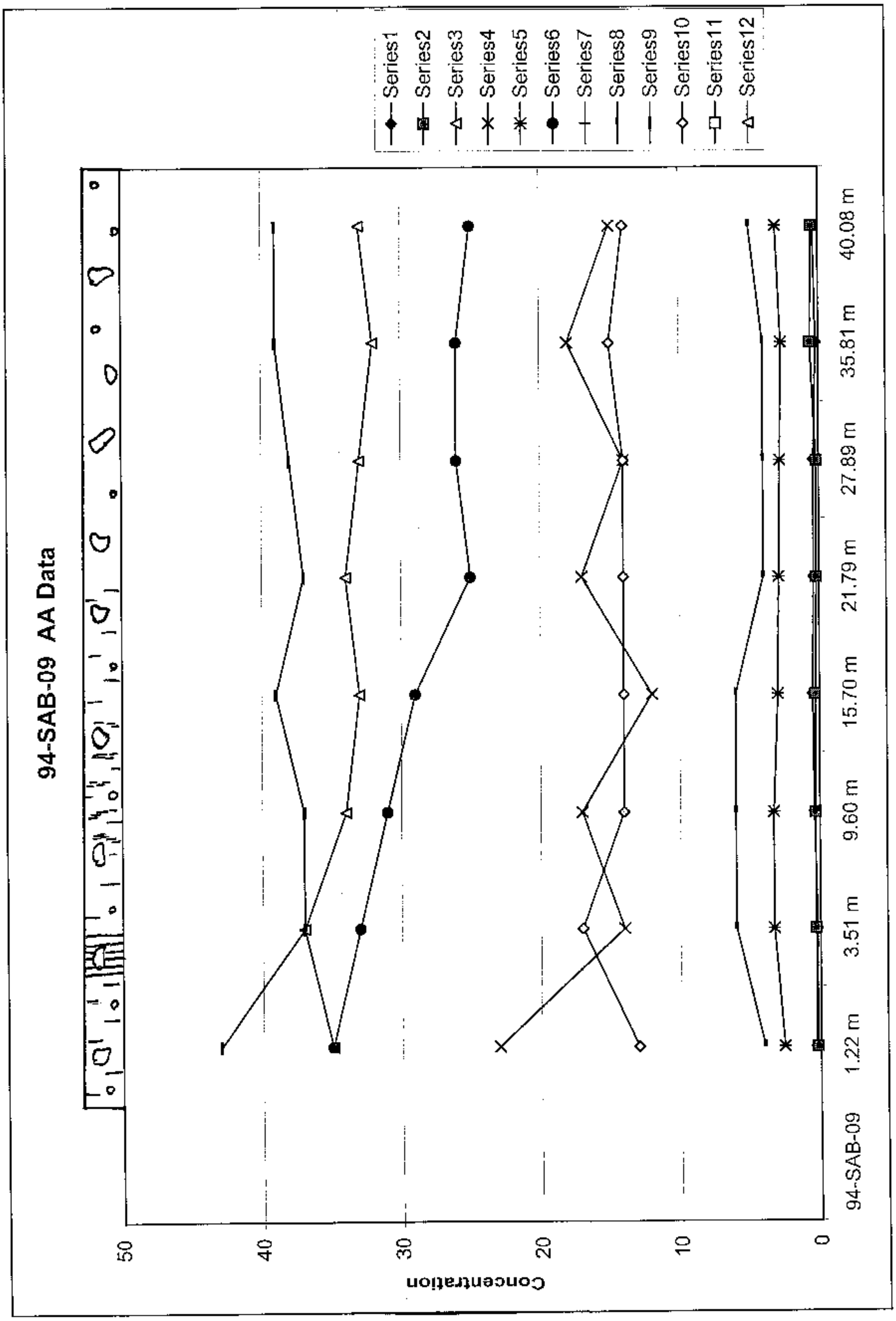
94-SAB-08 AA Data
Concentration
600
500
400
300
200
100
0
94-SAB-08
0.76 m
2.13 m
2.44 m
5.33 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Series8
Series9
Series10
Series11
Series12

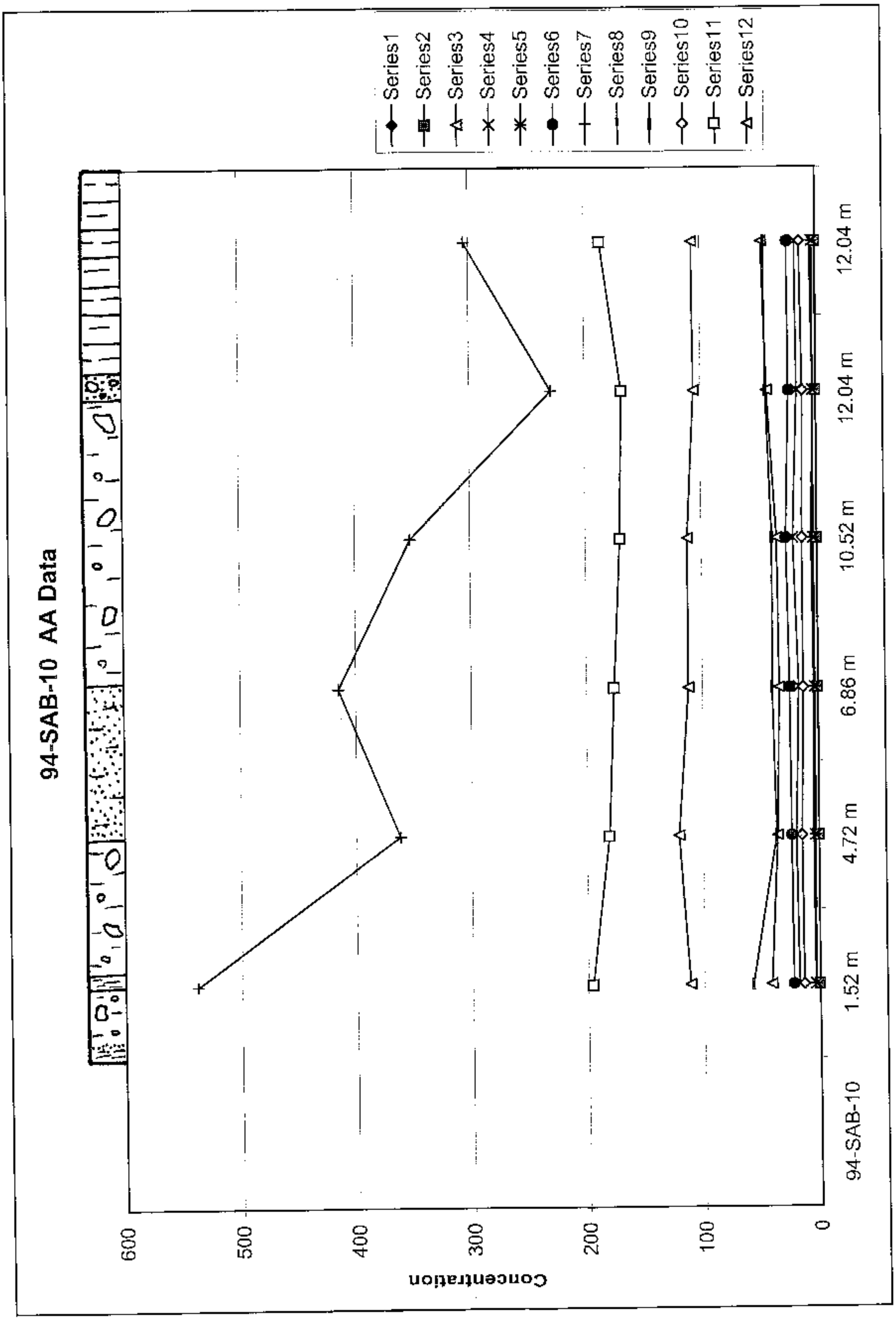


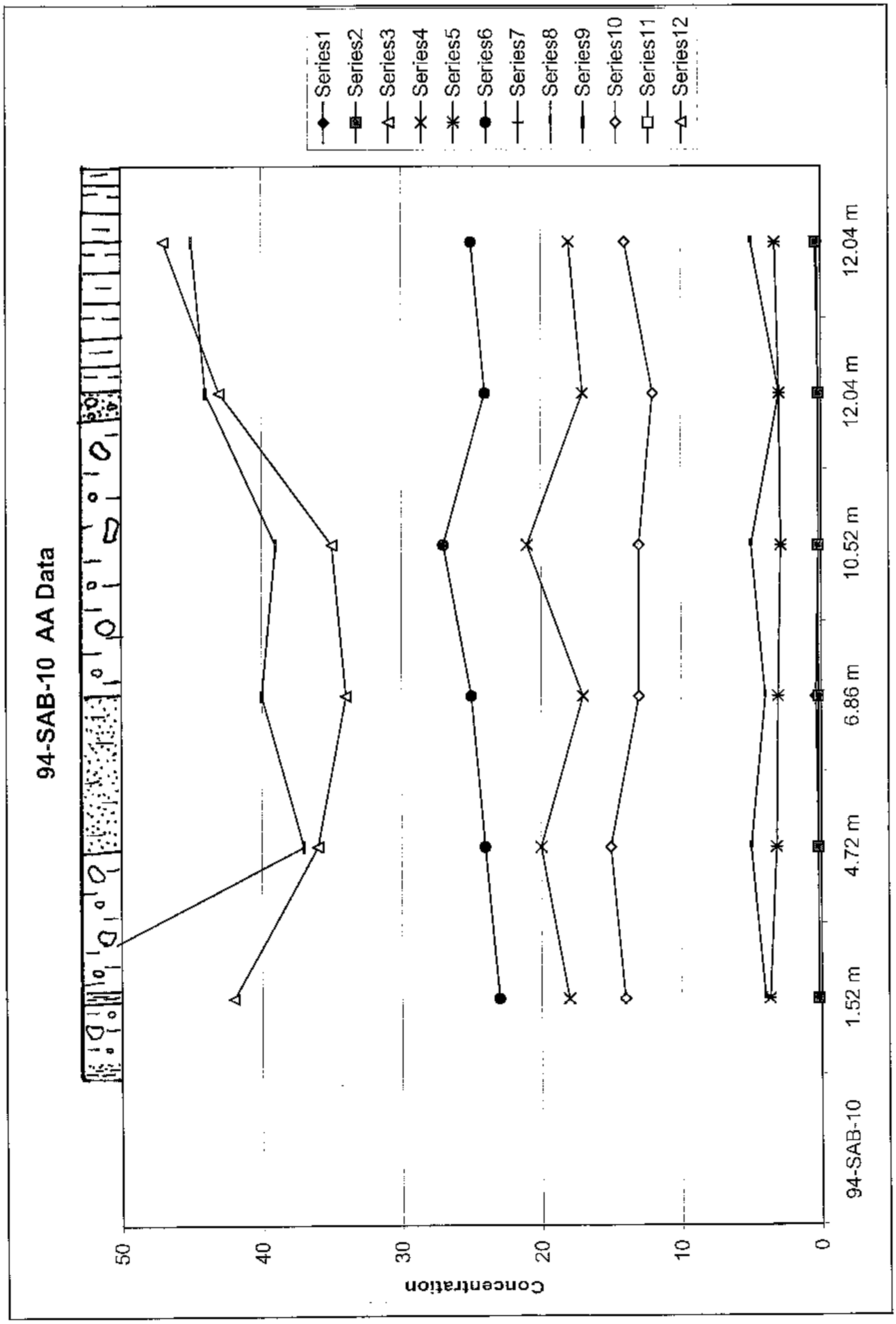
94-SAB-08 AA Data
Concentration
0
10
20
30
40
50
94-SAB-08
0.76 m
2.13 m
2.44 m
5.33 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Series8
Series9
Series10
Series11
Series12

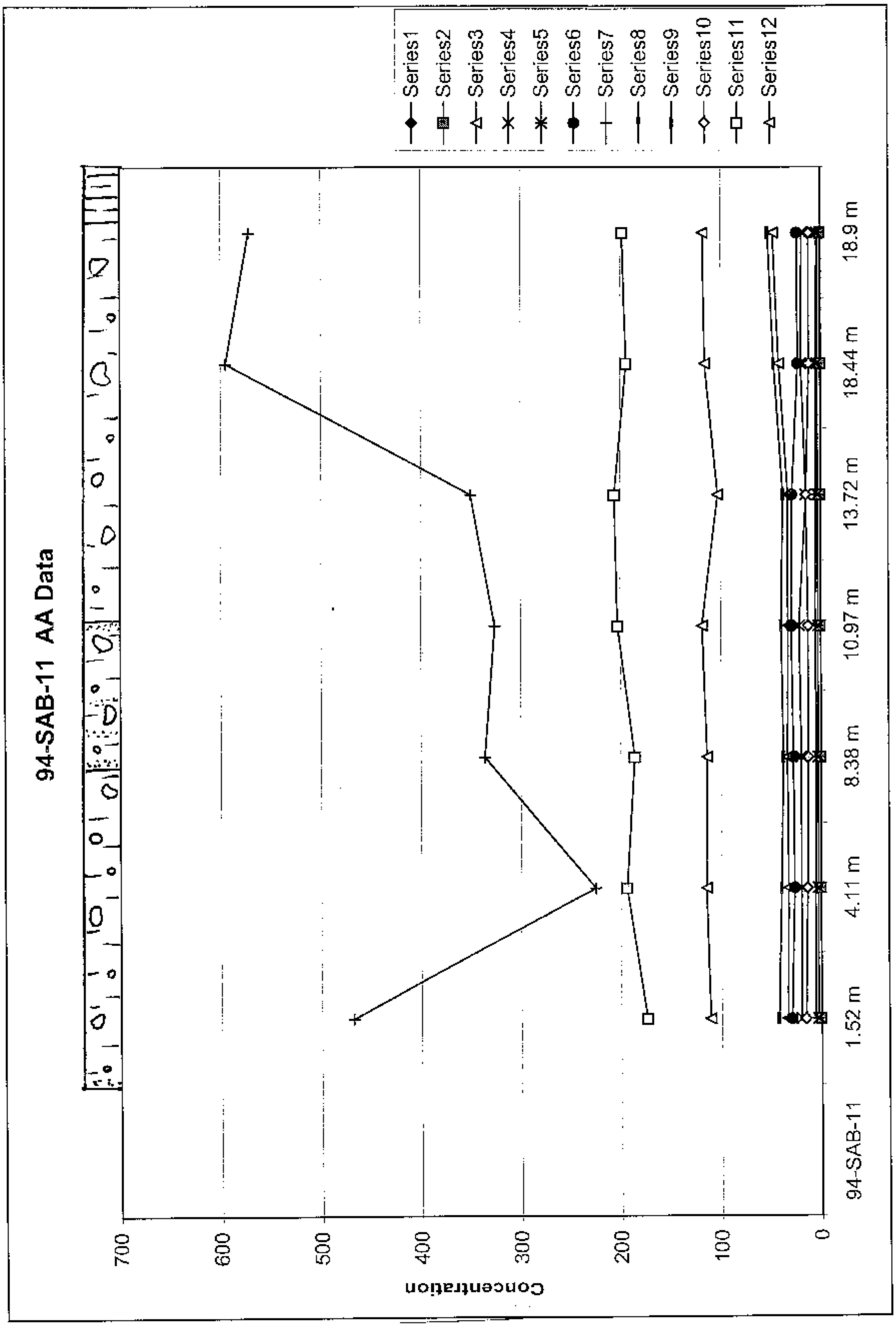


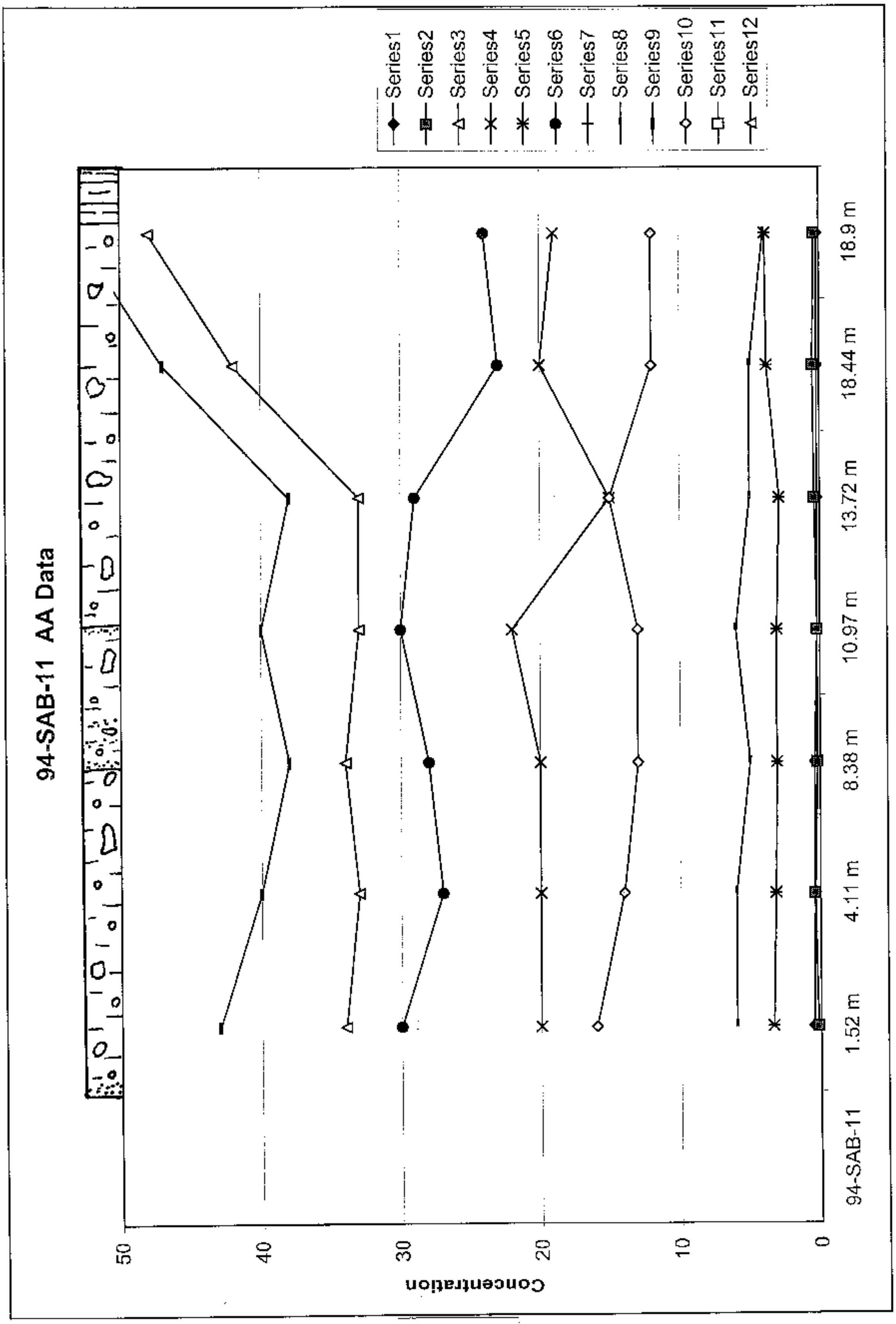
94-SAB-09 AA Data
Concentration
0
50
100
150
200
250
300
350
400
450
500
94-SAB-09
1.22 m
3.51 m
9.60 m
15.70 m
21.79 m
27.89 m
35.81 m
40.08 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Series8
Series9
Series10
Series11
Series12

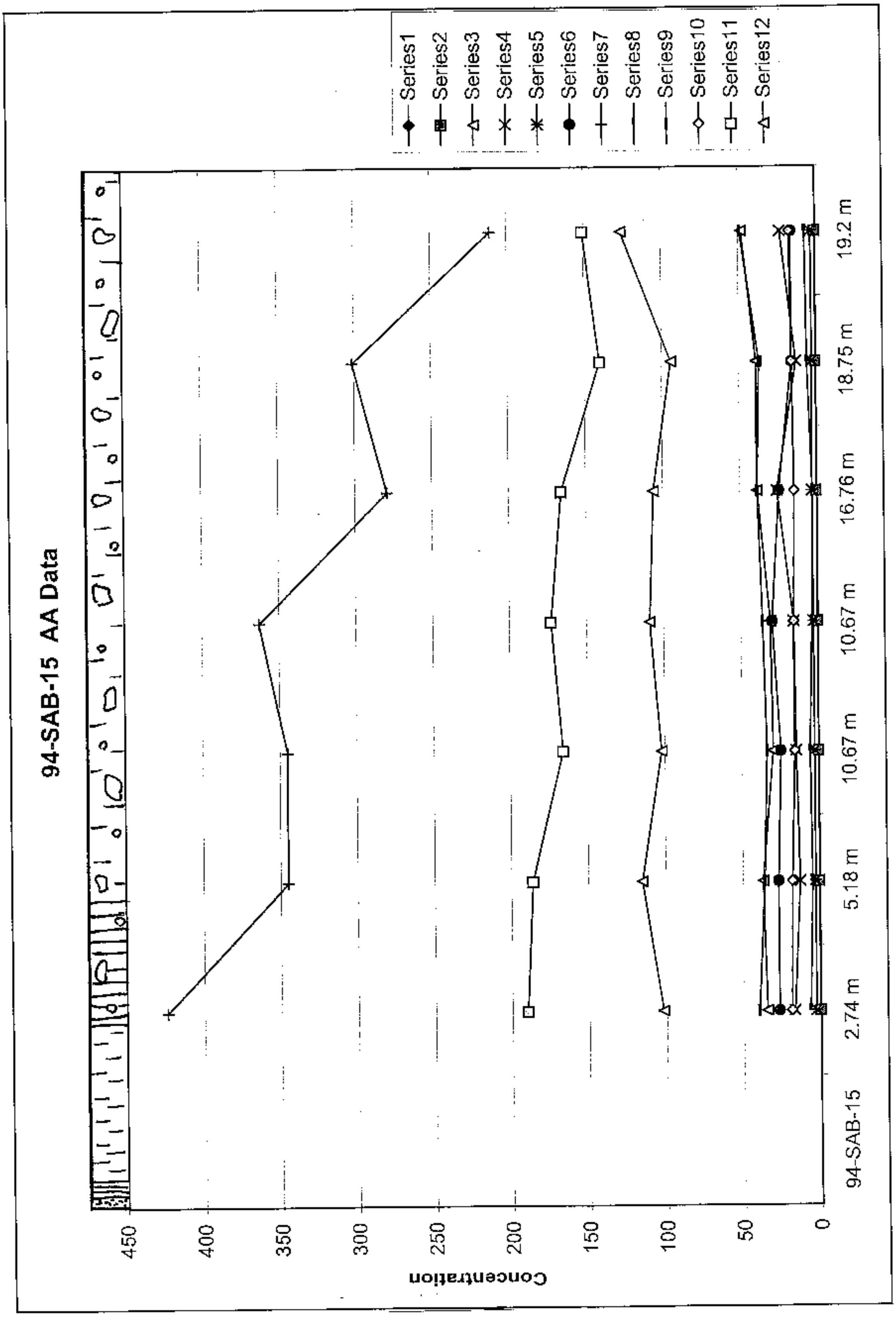

94-SAB-09 AA Data
Concentration
0
10
20
30
40
50
94-SAB-09
1.22 m
3.51 m
9.60 m
15.70 m
21.79 m
27.89 m
35.81 m
40.08 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Series8
Series9
Series10
Series11
Series12

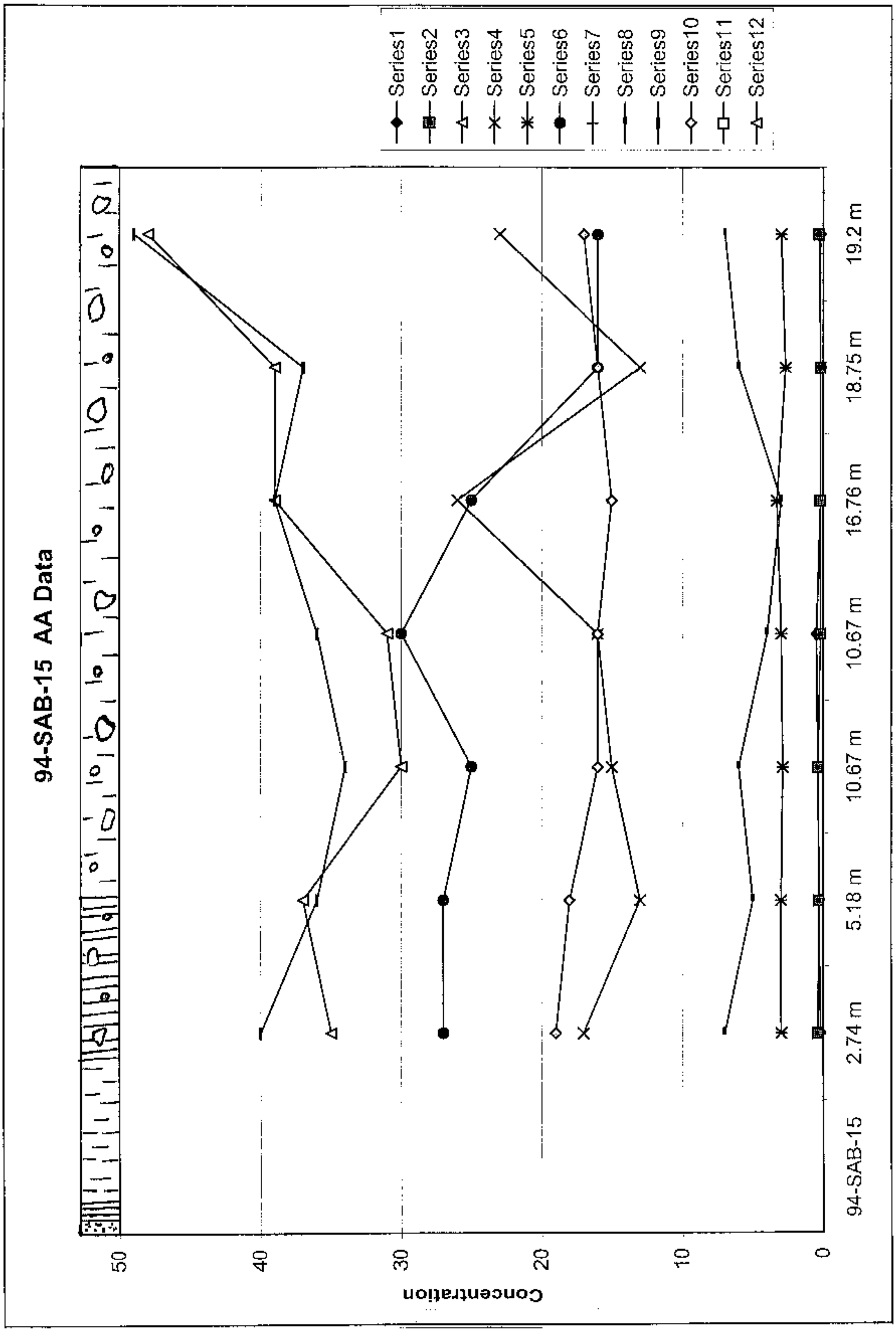

94-SAB-10 AA Data
Concentration
600
500
400
300
200
100
0
94-SAB-10
1.52 m
4.72 m
6.86 m
10.52 m
12.04 m
12.04 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Series8
Series9
Series10
Series11
Series12


94-SAB-10 AA Data
Concentration
0
10
20
30
40
50
94-SAB-10
1.52 m
4.72 m
6.86 m
10.52 m
12.04 m
12.04 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Series8
Series9
Series10
Series11
Series12


94-SAB-11 AA Data
Concentration
700
600
500
400
300
200
100
0
94-SAB-11
1.52 m
4.11 m
8.38 m
10.97 m
13.72 m
18.44 m
18.9 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Series8
Series9
Series10
Series11
Series12


94-SAB-11 AA Data
Concentration
0
10
20
30
40
50
94-SAB-11
1.52 m
4.11 m
8.38 m
10.97 m
13.72 m
18.44 m
18.9 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Series8
Series9
Series10
Series11
Series12


94-SAB-15 AA Data
Concentration
450
400
350
300
250
200
150
100
50
0
94-SAB-15
2.74 m
5.18 m
10.67 m
10.67 m
16.76 m
18.75 m
19.2 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Series8
Series9
Series10
Series11
Series12


94-SAB-15 AA Data
Concentration
0
10
20
30
40
50
94-SAB-15
2.74 m
5.18 m
10.67 m
10.67 m
16.76 m
18.75 m
19.2 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Series8
Series9
Series10
Series11
Series12

1993 INAA DATA

SERIES IDENTIFICATION CODE

GROUP A

Series 1	Au (ppb)
Series 2	Sb (ppm)
Series 3	As (ppm)
Series 4	Ba (ppm)
Series 5	Br (ppm)
Series 6	Ce (ppm)
Series 7	Cs (ppm)

GROUP B

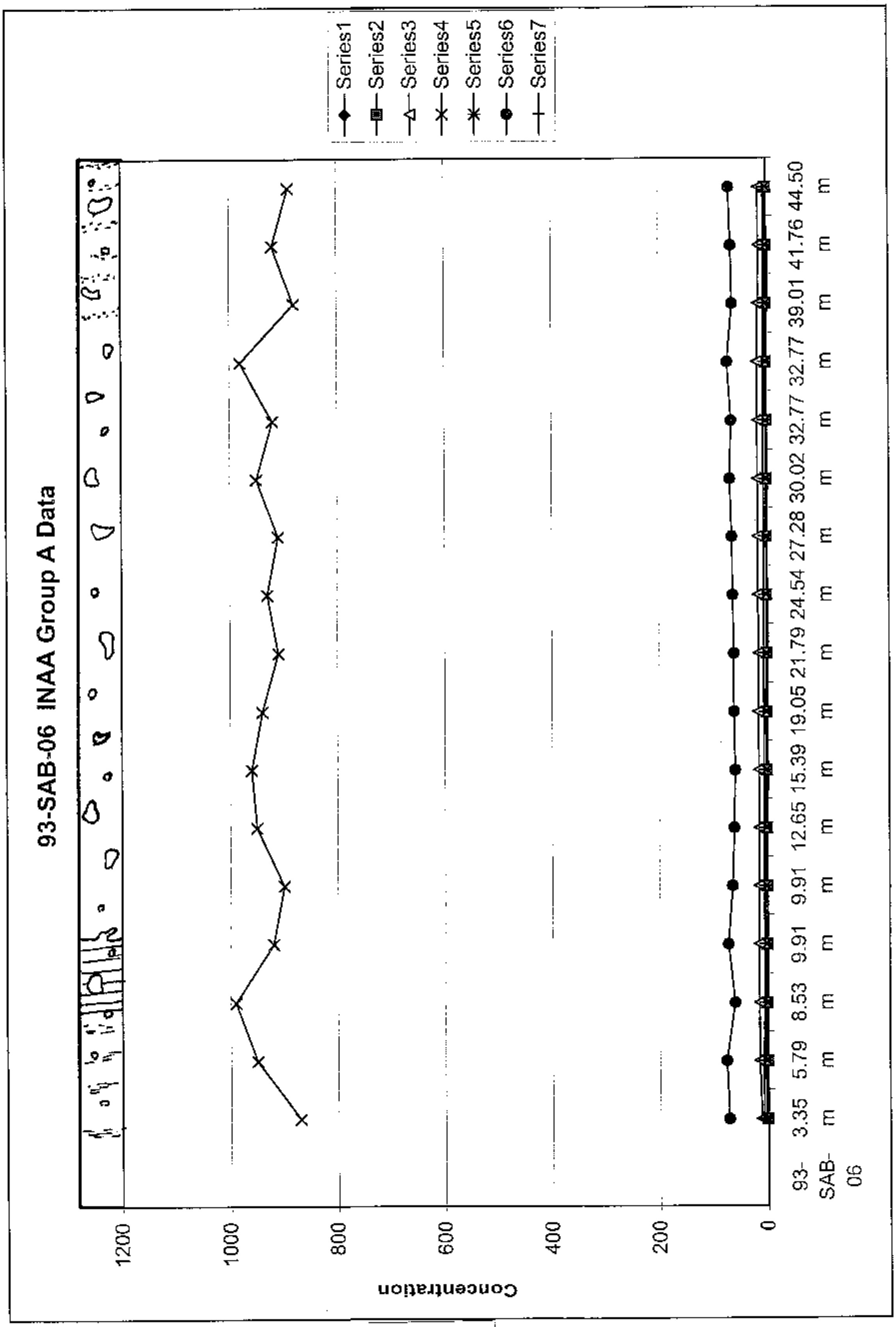
Series 1	Cr (ppm)
Series 2	Co (ppm)
Series 3	Eu (ppm)
Series 4	Hf (ppm)
Series 5	Fe (%)
Series 6	La (ppm)
Series 7	Lu (ppm)

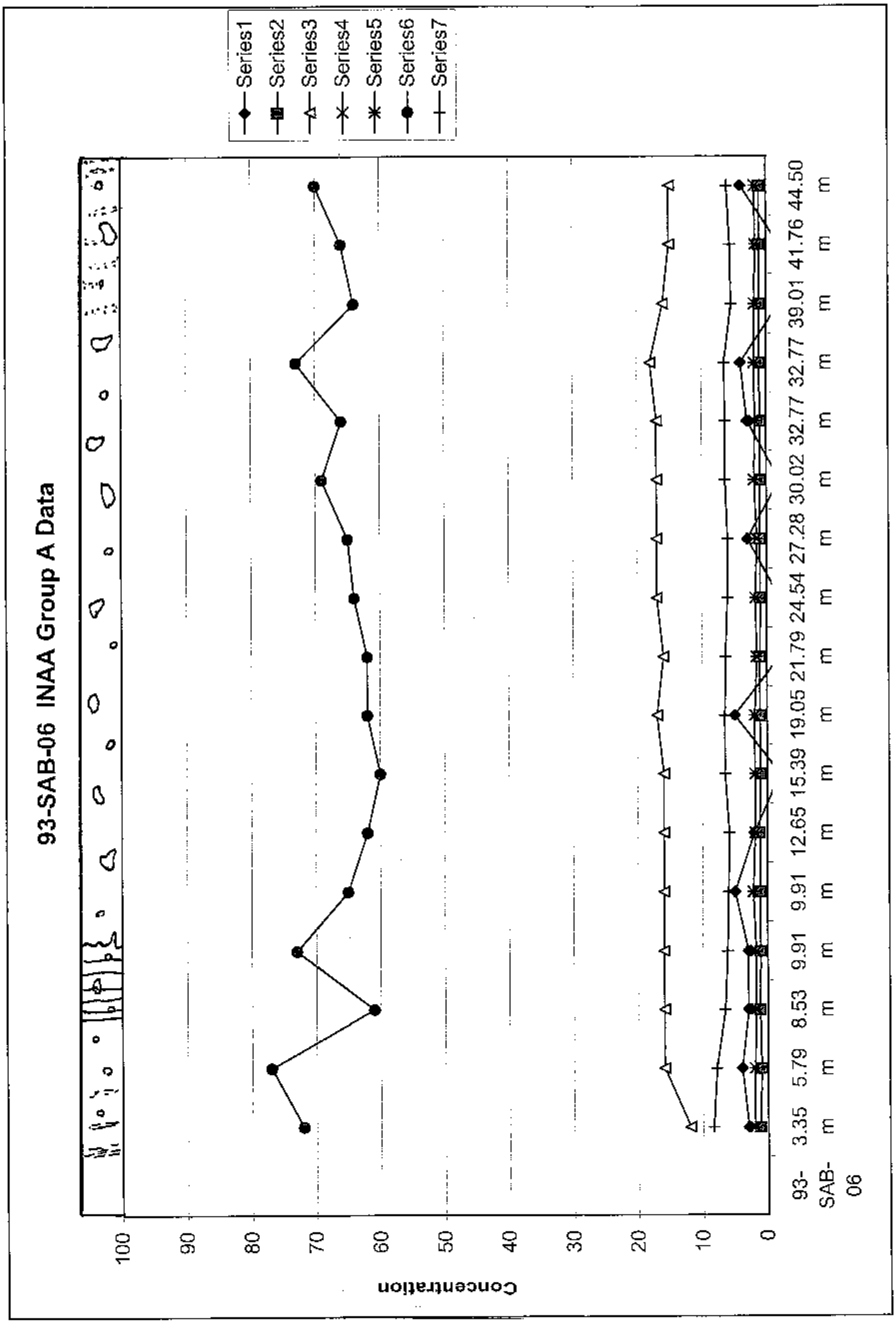
GROUP C

Series 1	Mo (ppm)
Series 2	Ni (ppm)
Series 3	Rb (ppm)
Series 4	Sm (ppm)
Series 5	Sc (ppm)
Series 6	Na (%)
Series 7	Ta (ppm)

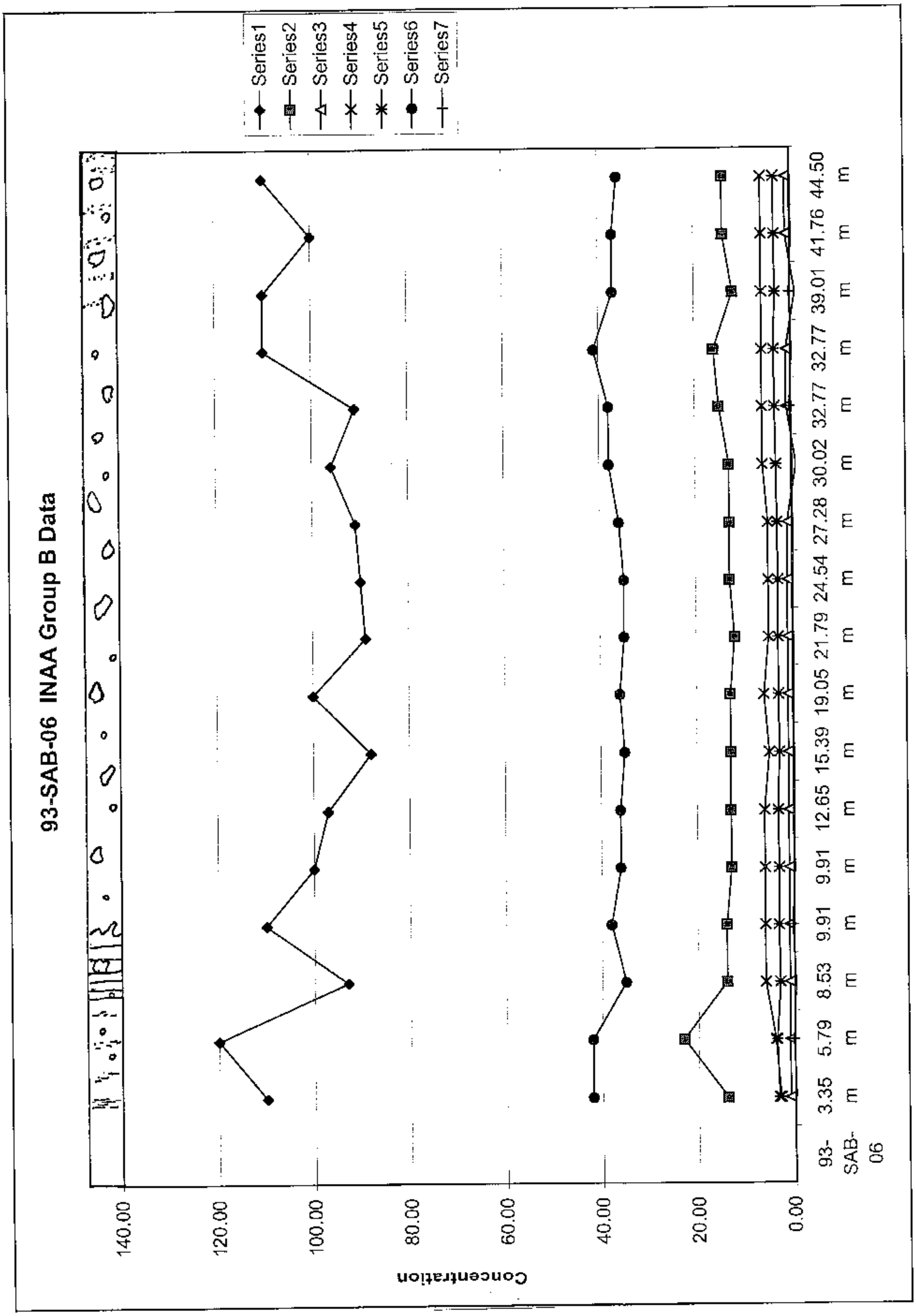
GROUP D

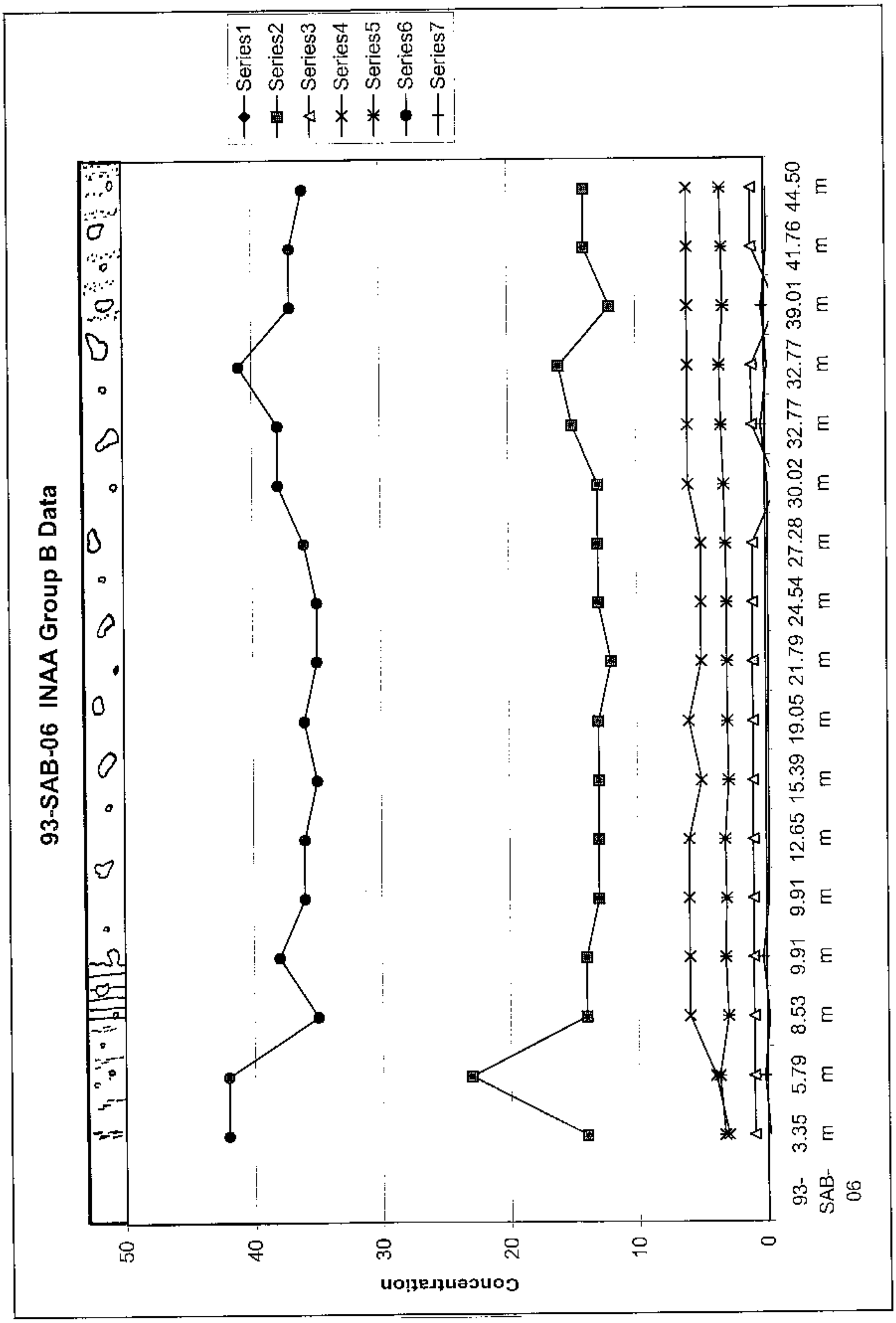
Series 1	Tb (ppm)
Series 2	Th (ppm)
Series 3	W (ppm)
Series 4	U (ppm)
Series 5	Yb (ppm)
Series 6	Zn (ppm)
Series 7	Zr (ppm)

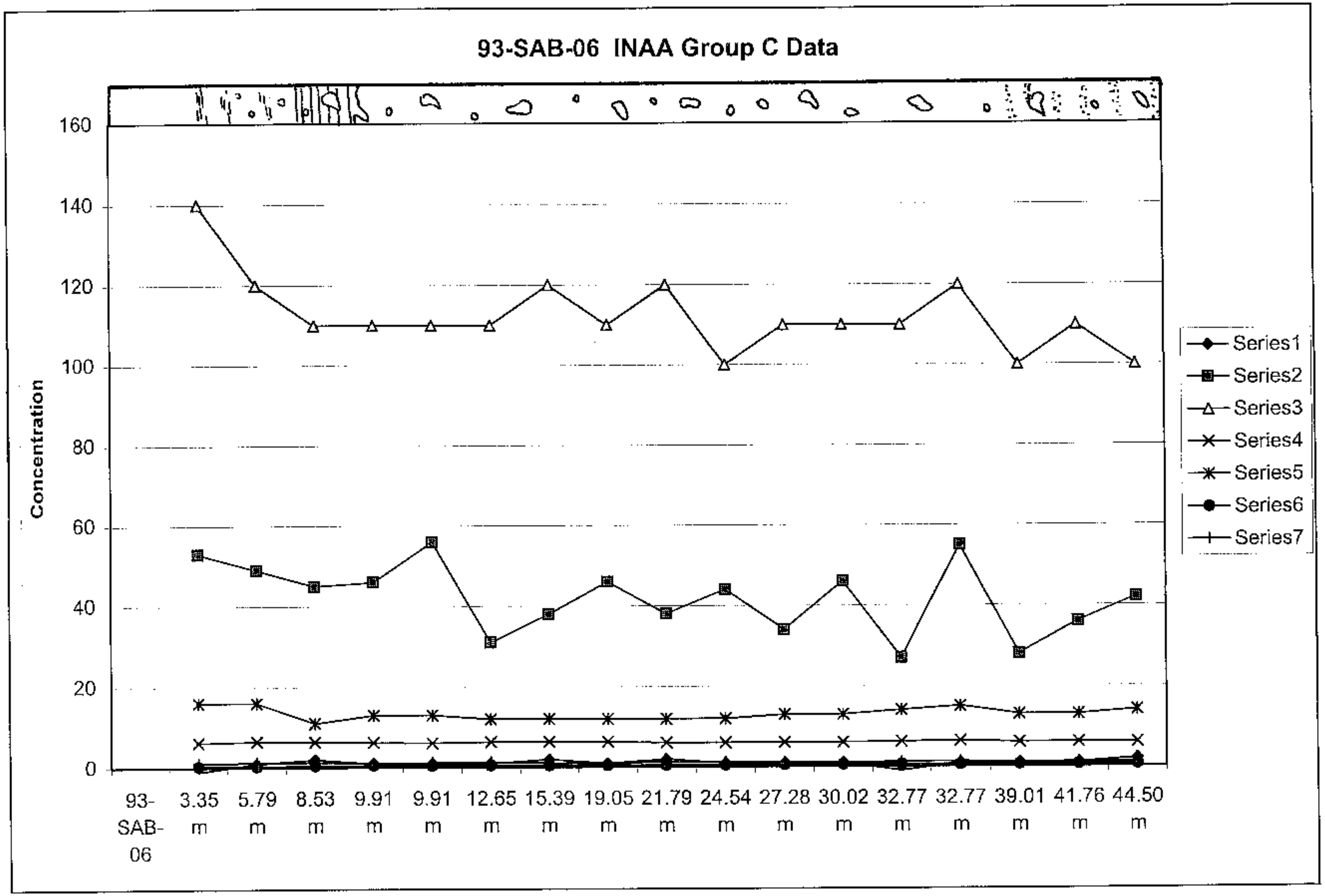

93-SAB-06 INAA Group A Data
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Concentration
0
200
400
600
800
1000
1200
93-SAB-06
3.35 m
5.79 m
8.53 m
9.91 m
9.91 m
12.65 m
15.39 m
19.05 m
21.79 m
24.54 m
27.28 m
30.02 m
32.77 m
32.77 m
39.01 m
41.76 m
44.50 m

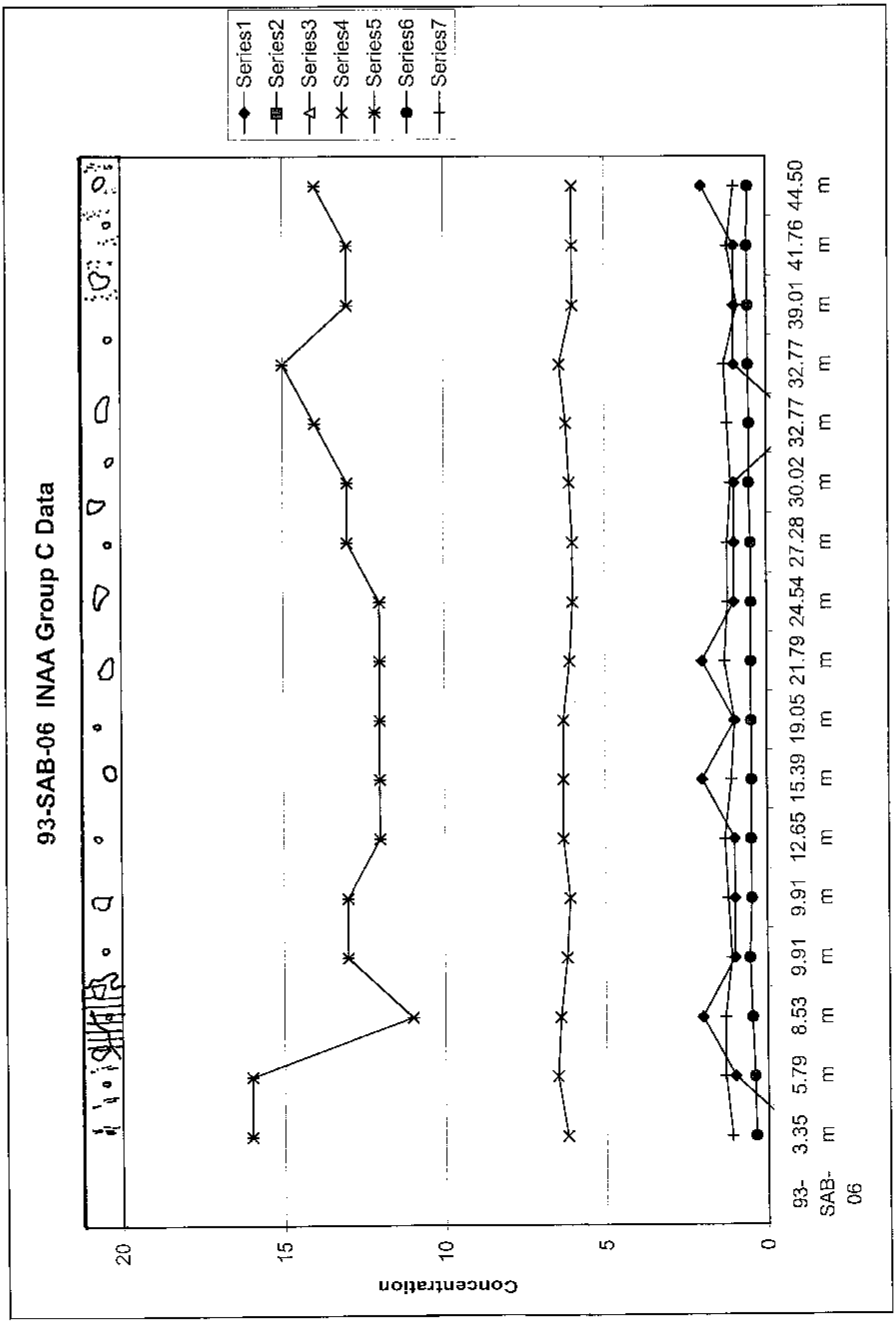


93-SAB-06 INAA Group A Data
Concentration
100
90
80
70
60
50
40
30
20
10
0
93-SAB-06
3.35 m
5.79 m
8.53 m
9.91 m
9.91 m
12.65 m
15.39 m
19.05 m
21.79 m
24.54 m
27.28 m
30.02 m
32.77 m
32.77 m
39.01 m
41.76 m
44.50 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7

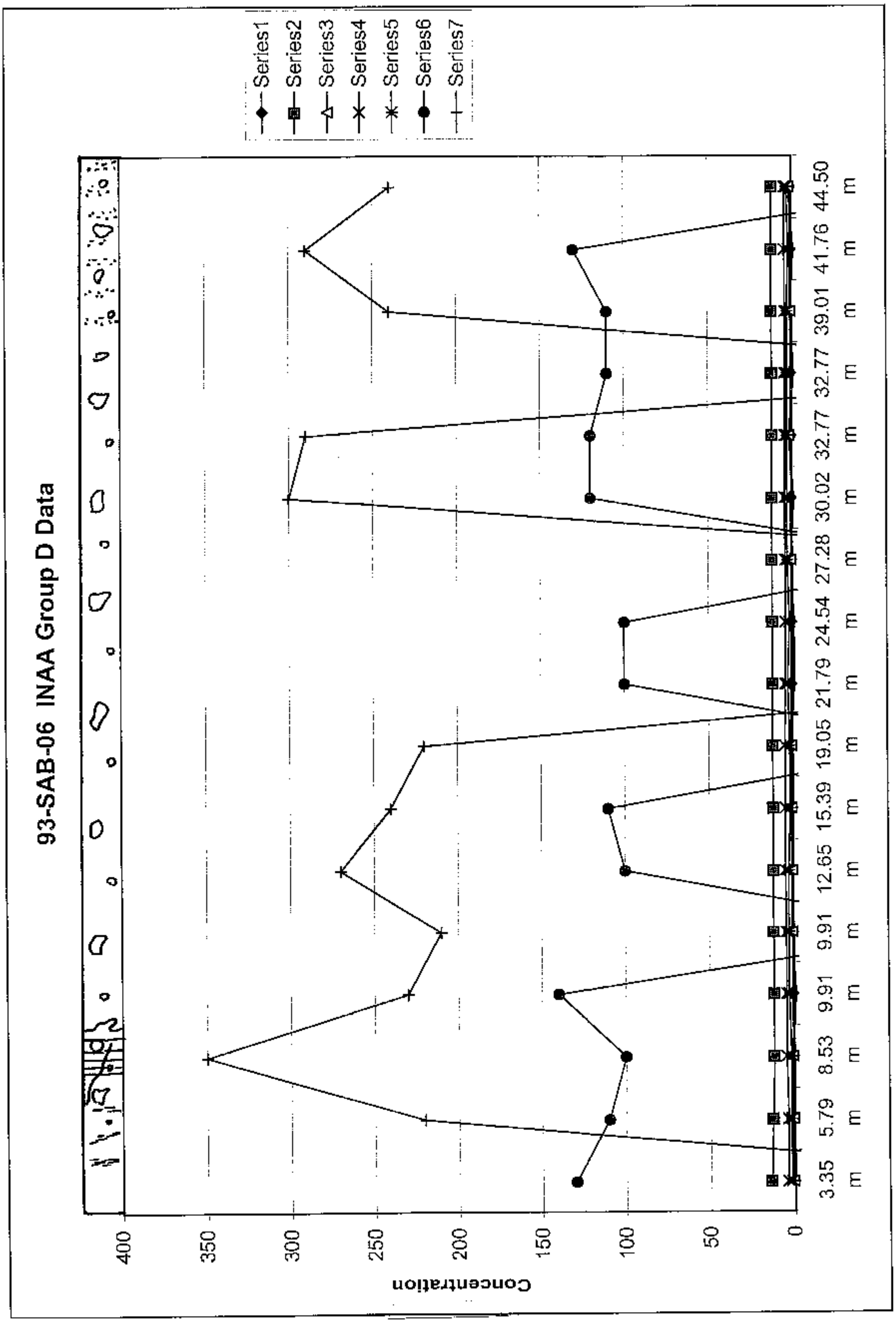

93-SAB-06 INAA Group B Data
Concentration
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
93-SAB-06
3.35 m
5.79 m
8.53 m
9.91 m
9.91 m
12.65 m
15.39 m
19.05 m
21.79 m
24.54 m
27.28 m
30.02 m
32.77 m
32.77 m
39.01 m
41.76 m
44.50 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7


93-SAB-06 INAA Group B Data
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Concentration
0
10
20
30
40
50
93-SAB-06
3.35 m
5.79 m
8.53 m
9.91 m
9.91 m
12.65 m
15.39 m
19.05 m
21.79 m
24.54 m
27.28 m
30.02 m
32.77 m
32.77 m
39.01 m
41.76 m
44.50 m

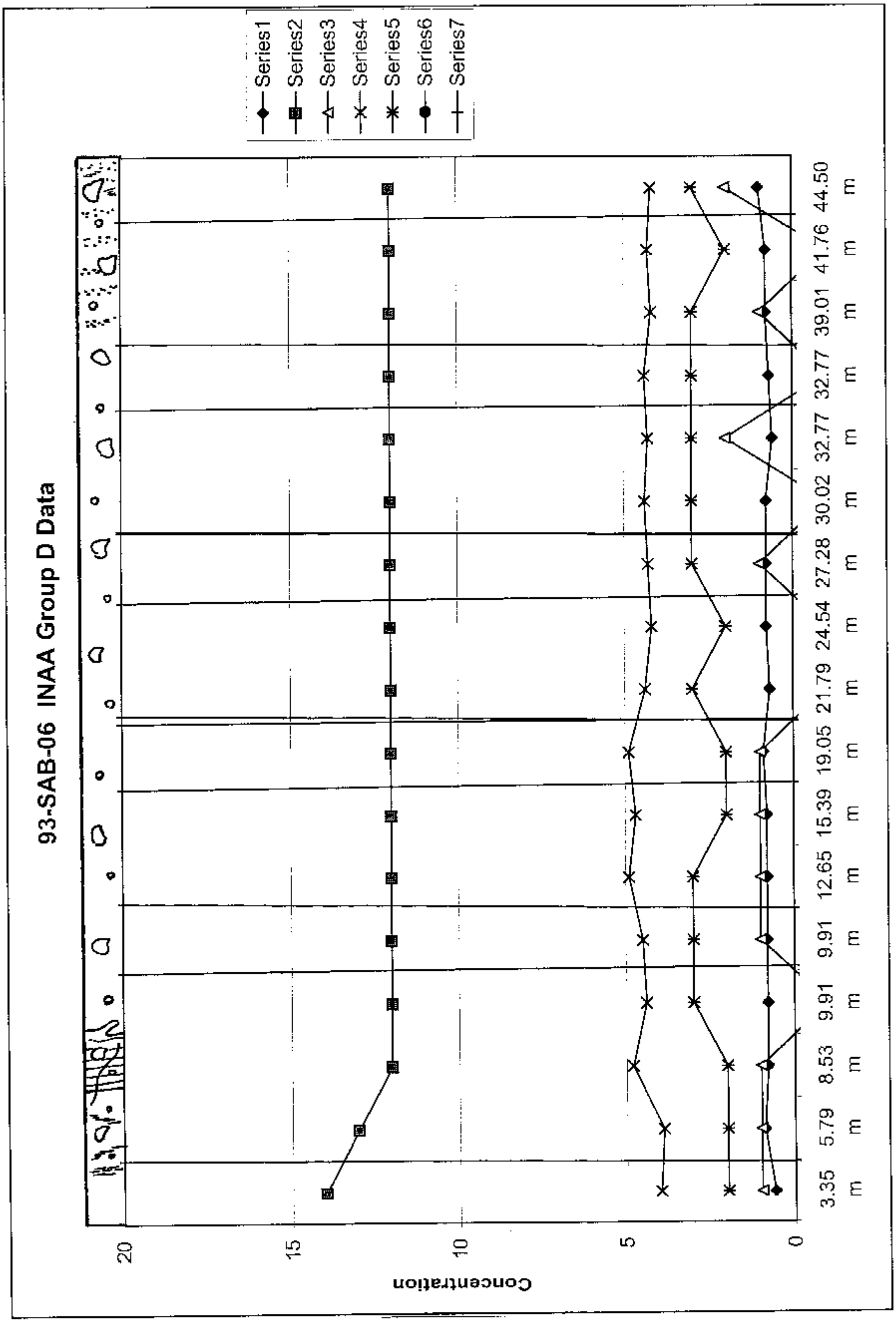

93-SAB-06 INAA Group C Data
Concentration
160
140
120
100
80
60
40
20
0
93-SAB-06
3.35 m
5.79 m
8.53 m
9.91 m
9.91 m
12.65 m
15.39 m
19.05 m
21.79 m
24.54 m
27.28 m
30.02 m
32.77 m
32.77 m
39.01 m
41.76 m
44.50 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7

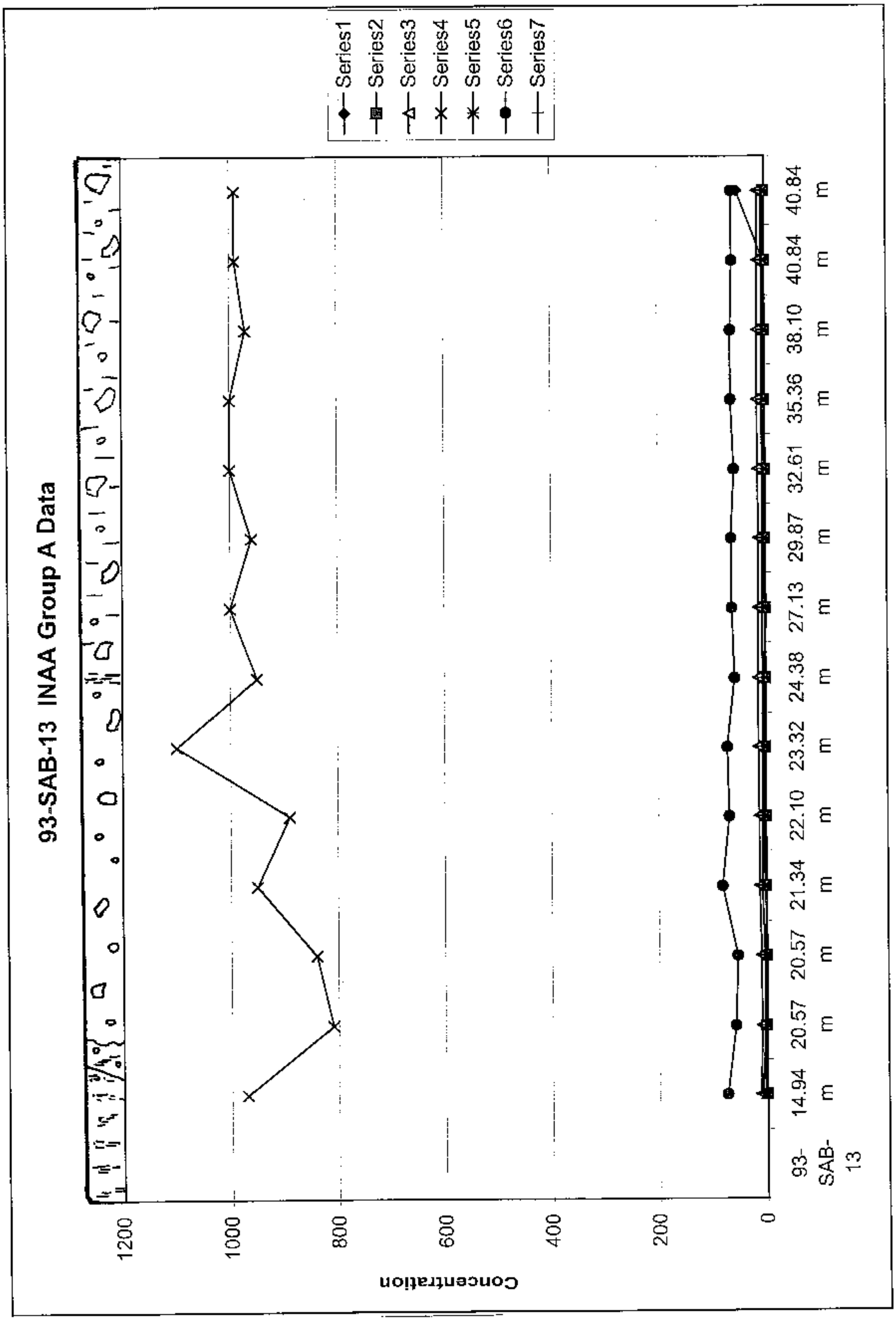


93-SAB-06 INAA Group C Data
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Concentration
0
5
10
15
20
93-SAB-06
3.35 m
5.79 m
8.53 m
9.91 m
9.91 m
12.65 m
15.39 m
19.05 m
21.79 m
24.54 m
27.28 m
30.02 m
32.77 m
32.77 m
39.01 m
41.76 m
44.50 m

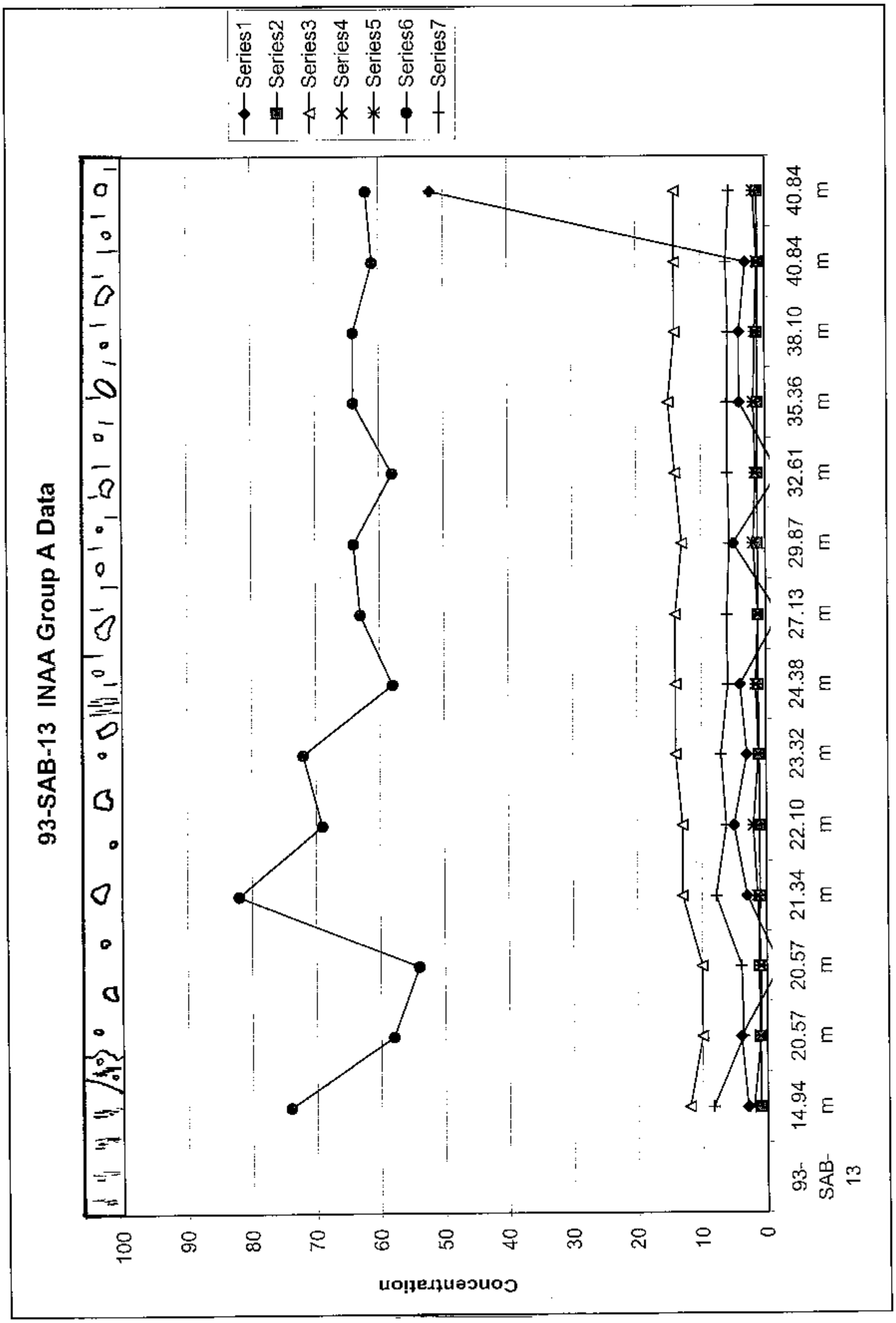


93-SAB-06 INAA Group D Data
Concentration
0
50
100
150
200
250
300
350
400
3.35 m
5.79 m
8.53 m
9.91 m
9.91 m
12.65 m
15.39 m
19.05 m
21.79 m
24.54 m
27.28 m
30.02 m
32.77 m
32.77 m
39.01 m
41.76 m
44.50 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7

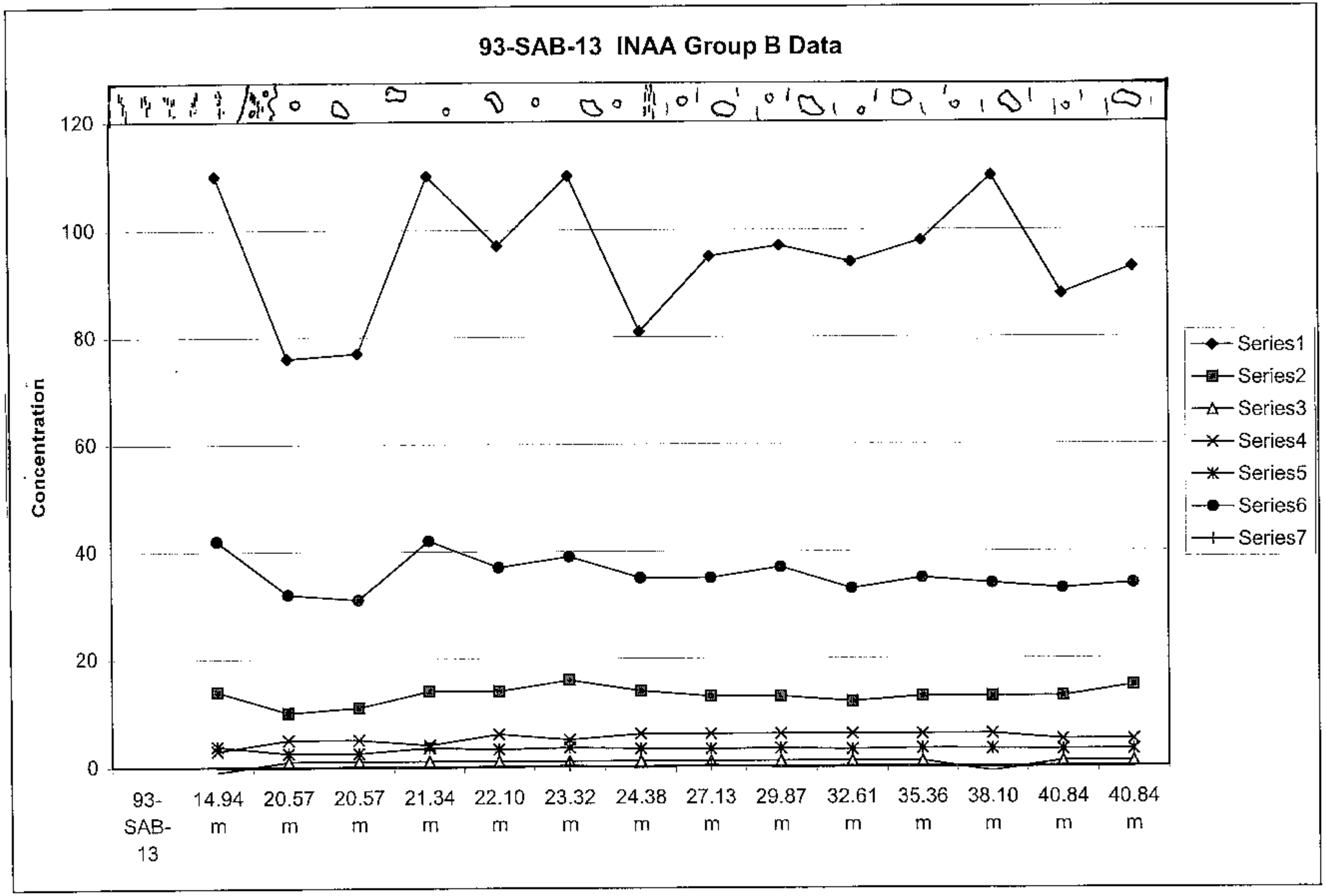

93-SAB-06 INAA Group D Data
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Concentration
20
15
10
5
0
3.35 m
5.79 m
8.53 m
9.91 m
9.91 m
12.65 m
15.39 m
19.05 m
21.79 m
24.54 m
27.28 m
30.02 m
32.77 m
32.77 m
39.01 m
41.76 m
44.50 m

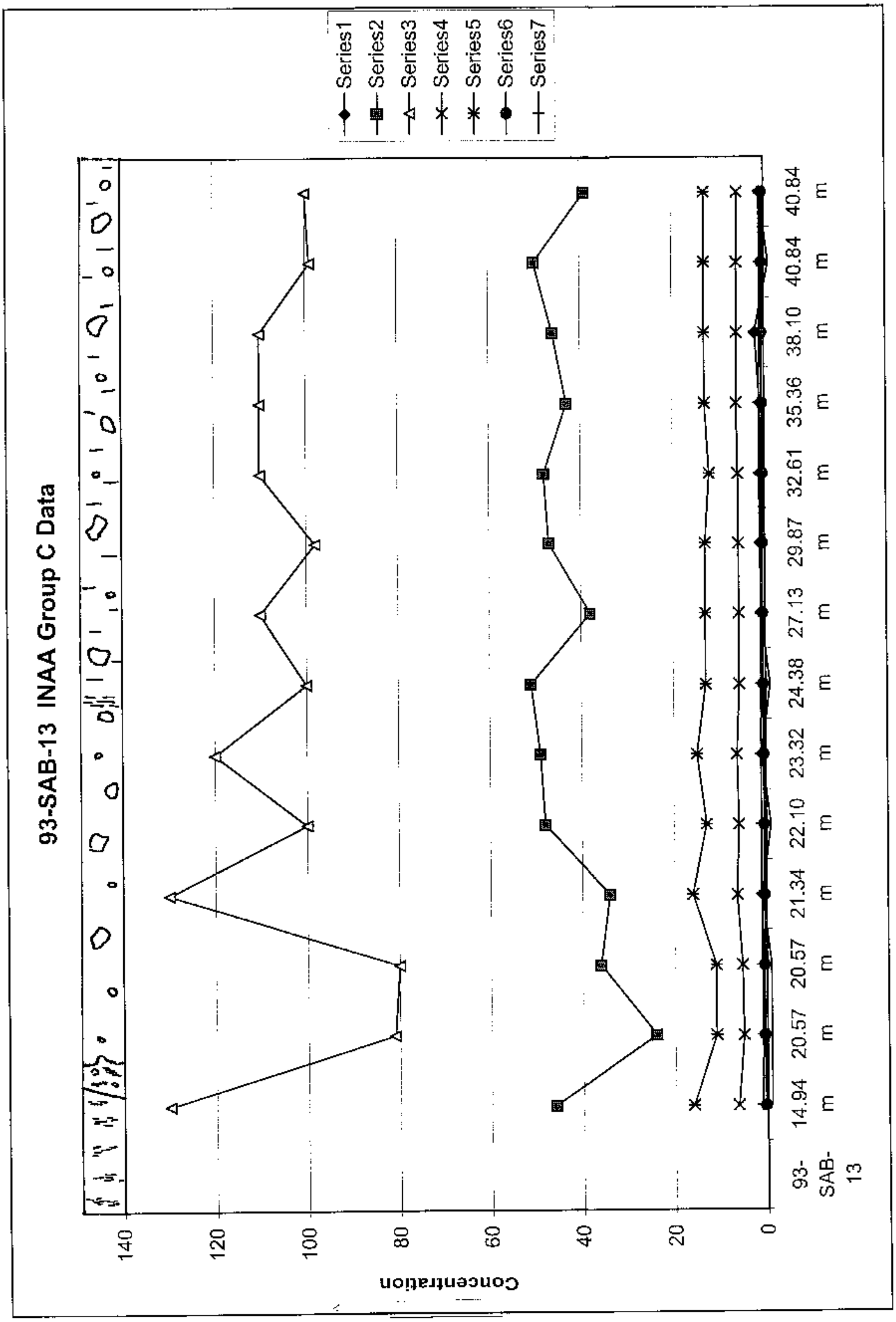


93-SAB-13 INAA Group A Data
Concentration
0
200
400
600
800
1000
1200
93-SAB-13
14.94 m
20.57 m
20.57 m
21.34 m
22.10 m
23.32 m
24.38 m
27.13 m
29.87 m
32.61 m
35.36 m
38.10 m
40.84 m
40.84 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7

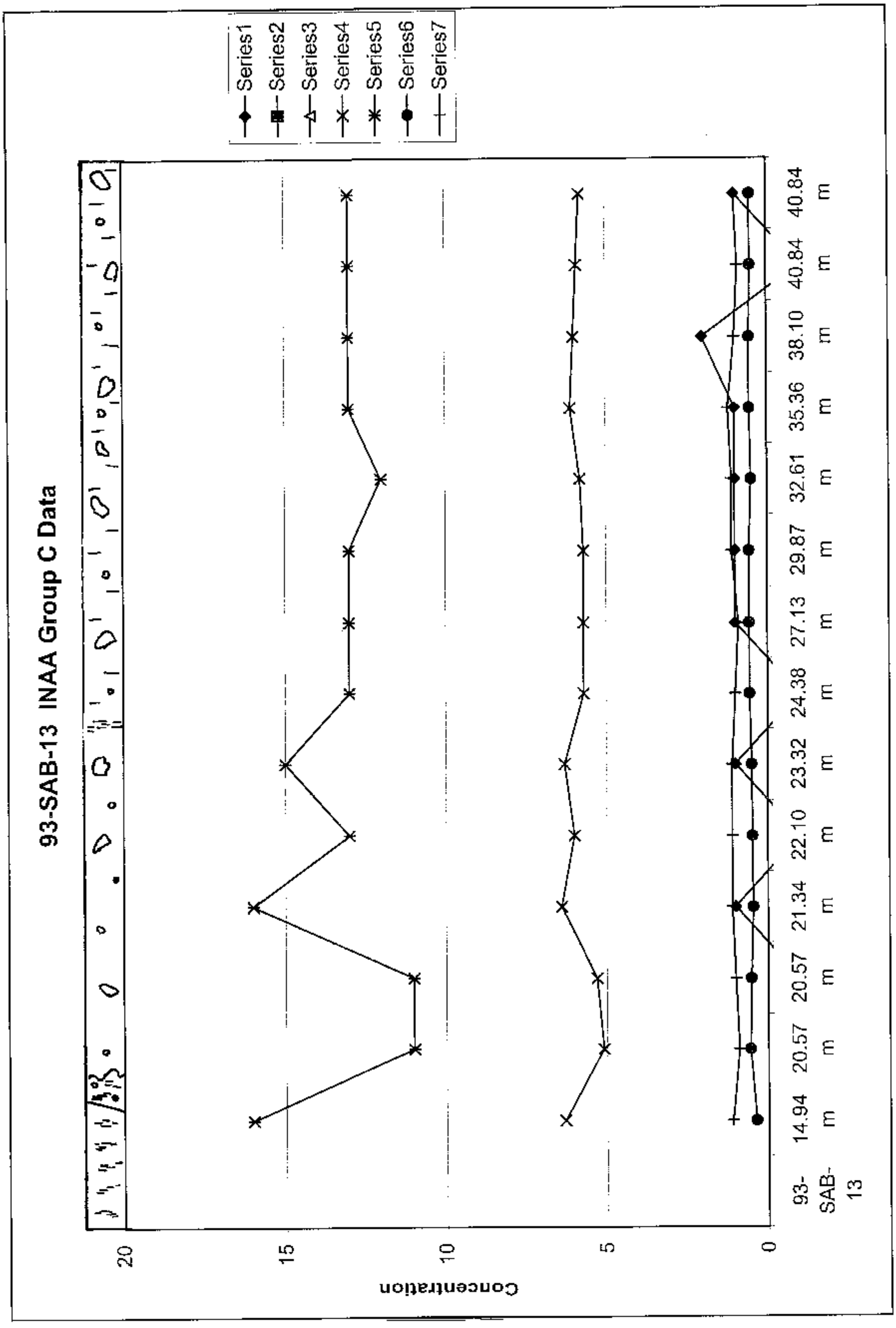


93-SAB-13 INAA Group A Data
Concentration
100
90
80
70
60
50
40
30
20
10
0
93-SAB-13
14.94 m
20.57 m
20.57 m
21.34 m
22.10 m
23.32 m
24.38 m
27.13 m
29.87 m
32.61 m
35.36 m
38.10 m
40.84 m
40.84 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7

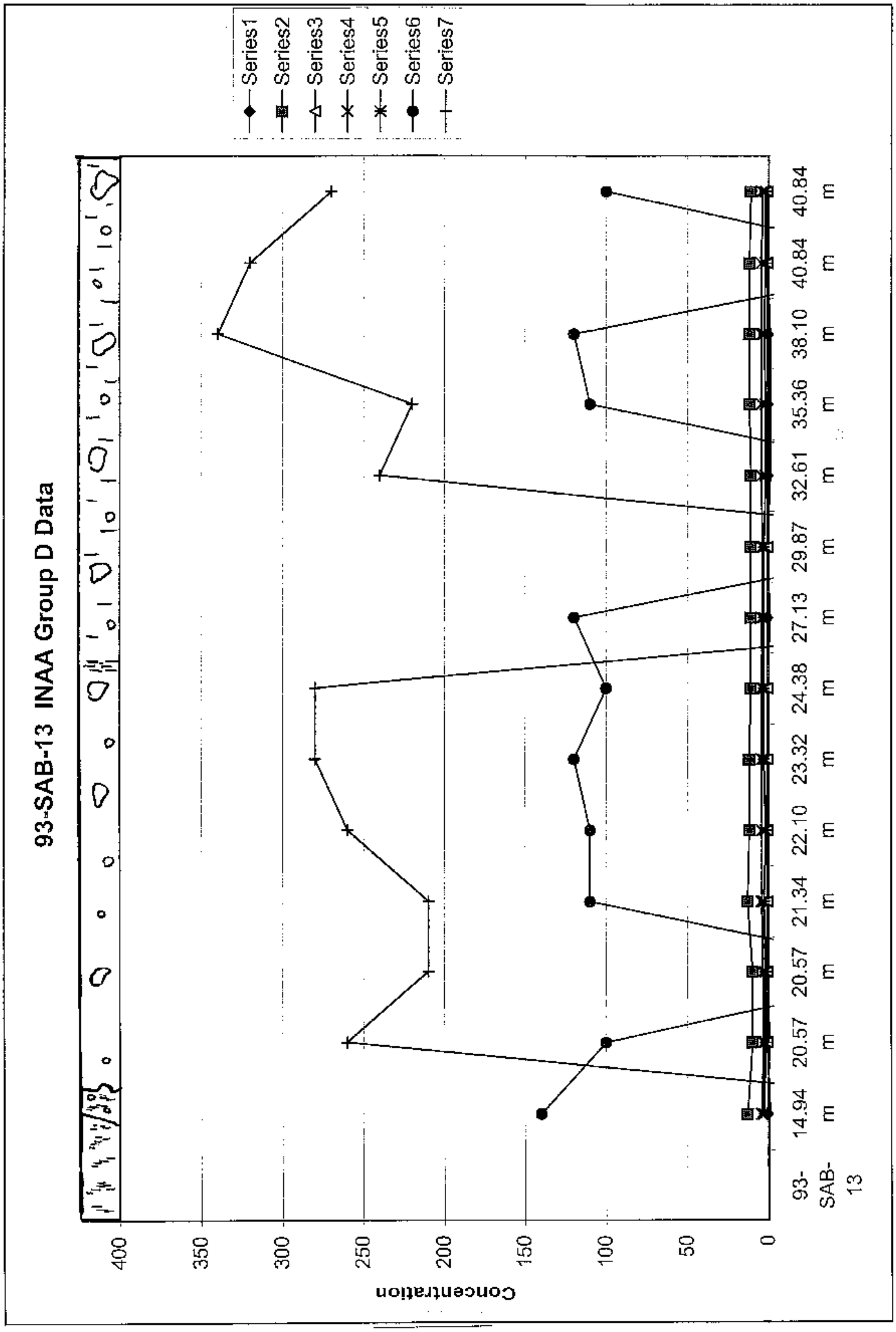

93-SAB-13 INAA Group B Data
Concentration
120
100
80
60
40
20
0
93-SAB-13
14.94 m
20.57 m
20.57 m
21.34 m
22.10 m
23.32 m
24.38 m
27.13 m
29.87 m
32.61 m
35.36 m
38.10 m
40.84 m
40.84 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7



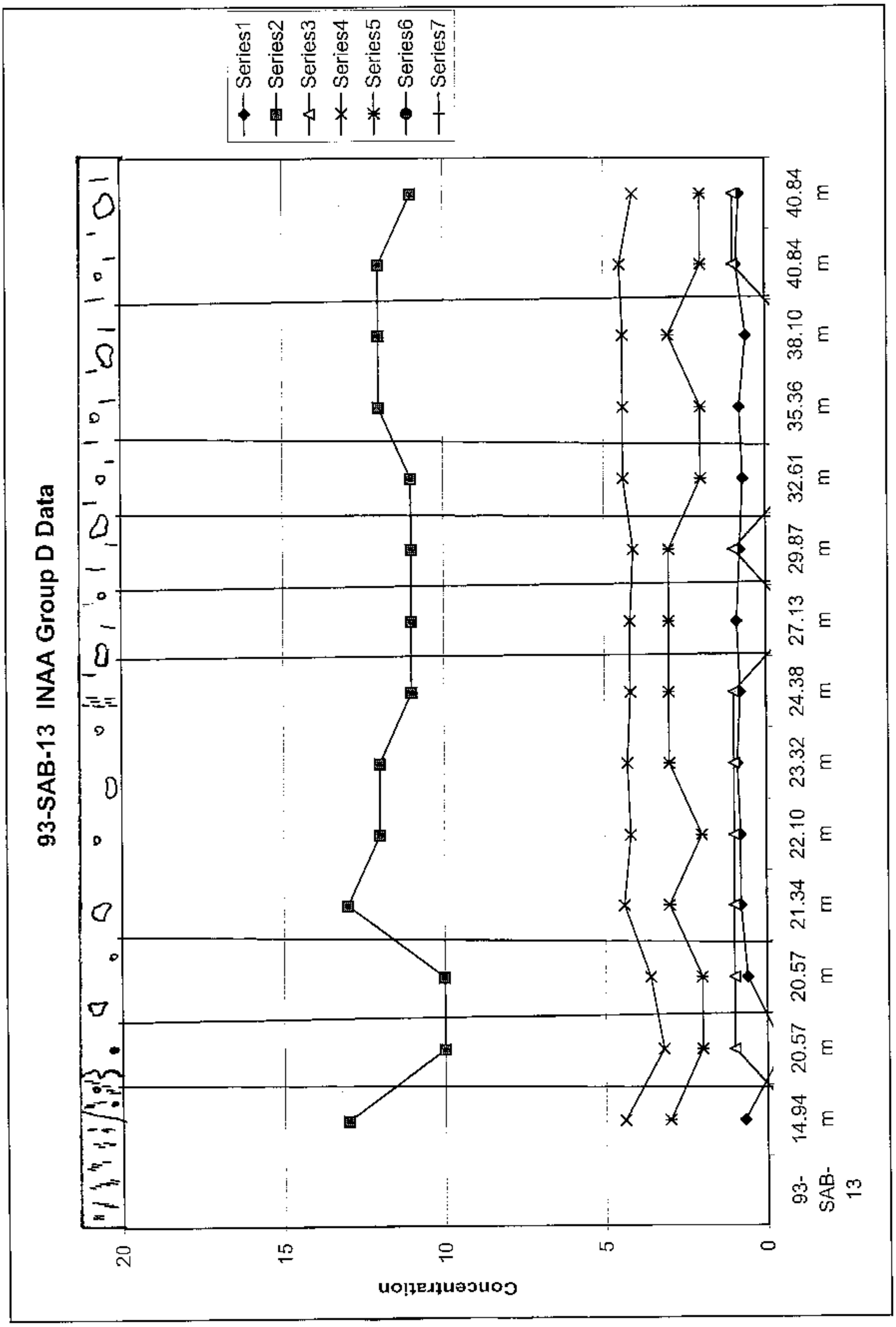
93-SAB-13 INAA Group C Data
Concentration
0
20
40
60
80
100
120
140
93-SAB-13
14.94 m
20.57 m
20.57 m
21.34 m
22.10 m
23.32 m
24.38 m
27.13 m
29.87 m
32.61 m
35.36 m
38.10 m
40.84 m
40.84 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7



93-SAB-13 INAA Group C Data
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Concentration
0
5
10
15
20
93-SAB-13
14.94 m
20.57 m
20.57 m
21.34 m
22.10 m
23.32 m
24.38 m
27.13 m
29.87 m
32.61 m
35.36 m
38.10 m
40.84 m
40.84 m



93-SAB-13 INAA Group D Data
Concentration
400
350
300
250
200
150
100
50
0
93-SAB-13
14.94 m
20.57 m
20.57 m
21.34 m
22.10 m
23.32 m
24.38 m
27.13 m
29.87 m
32.61 m
35.36 m
38.10 m
40.84 m
40.84 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7


93-SAB-13 INAA Group D Data
Concentration
20
15
10
5
0
93-SAB-13
14.94 m
20.57 m
20.57 m
21.34 m
22.10 m
23.32 m
24.38 m
27.13 m
29.87 m
32.61 m
35.36 m
38.10 m
40.84 m
40.84 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7

1994 INAA DATA

SERIES IDENTIFICATION CODE

GROUP A

Series 1	Au (ppb)
Series 2	Sb (ppm)
Series 3	As (ppm)
Series 4	Ba (ppm)
Series 5	Br (ppm)
Series 6	Ce (ppm)
Series 7	Cs (ppm)
Series 8	Cr (ppm)

GROUP B

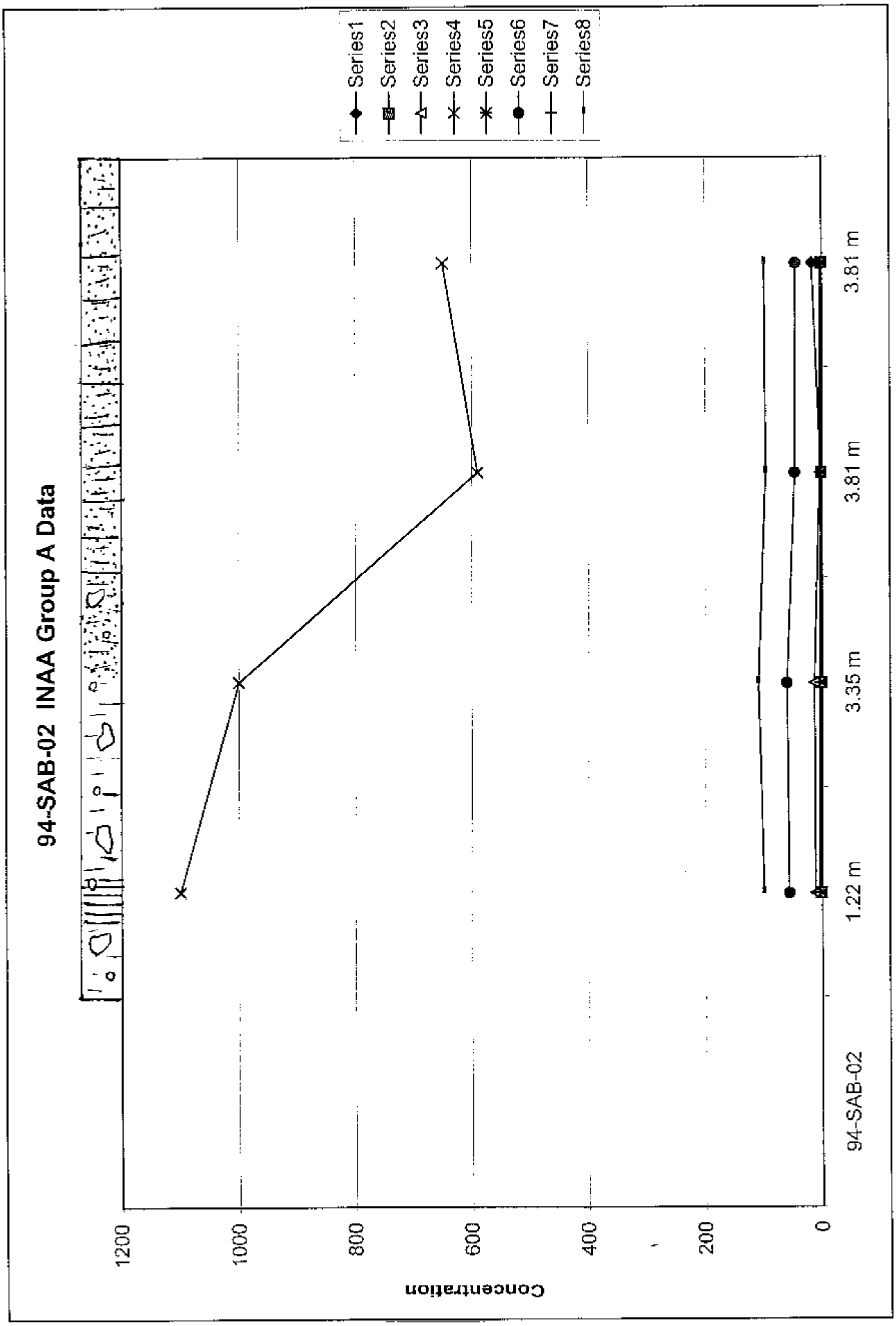
Series 1	Co (ppm)
Series 2	Eu (ppm)
Series 3	Hf (ppm)
Series 4	Fe (%)
Series 5	La (ppm)
Series 6	Lu (ppm)
Series 7	Mo (ppm)

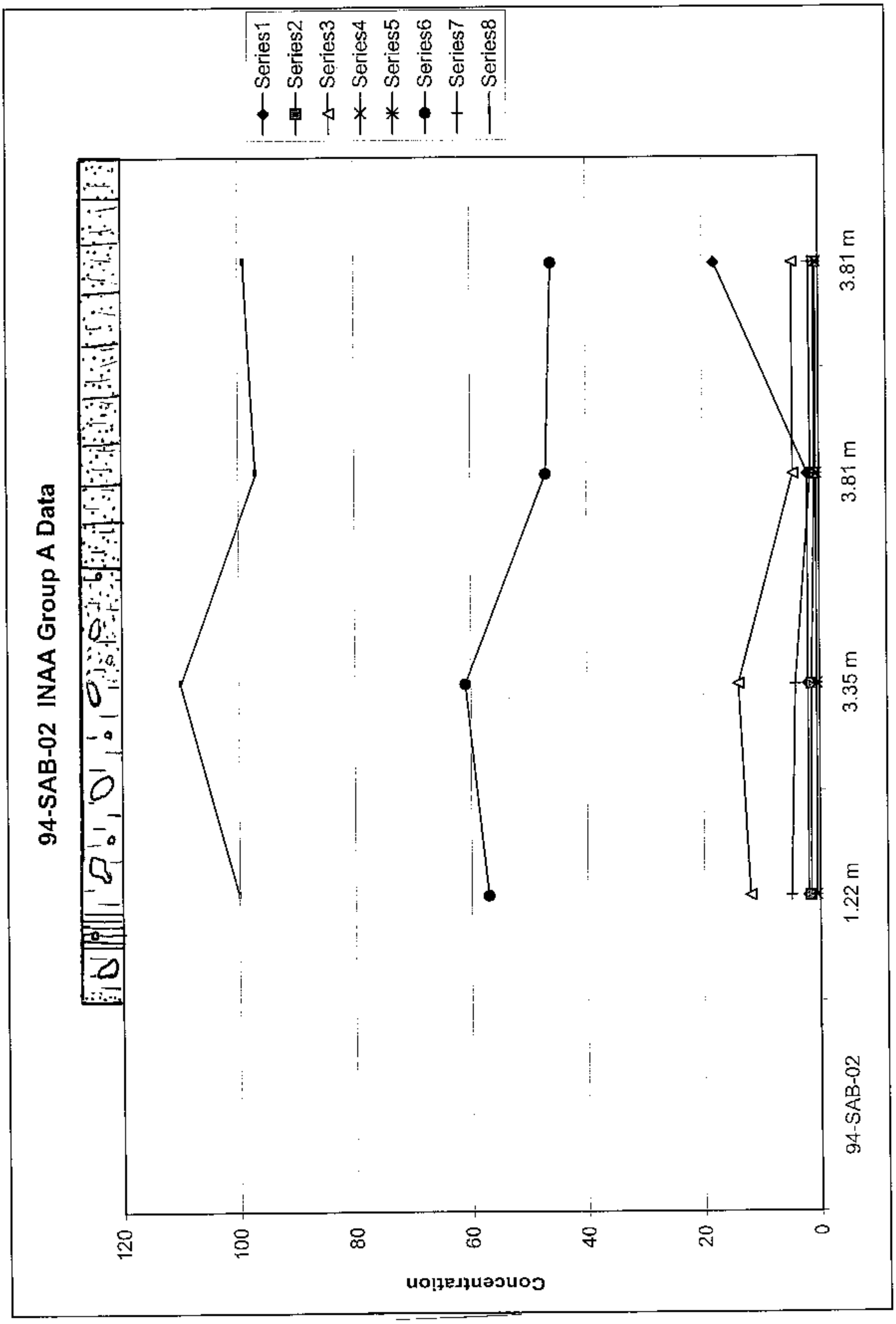
GROUP C

Series 1	Ni (ppm)
Series 2	Rb (ppm)
Series 3	Sm (ppm)
Series 4	Sc (ppm)
Series 5	Ag (ppm)
Series 6	Na (%)
Series 7	Ta (ppm)

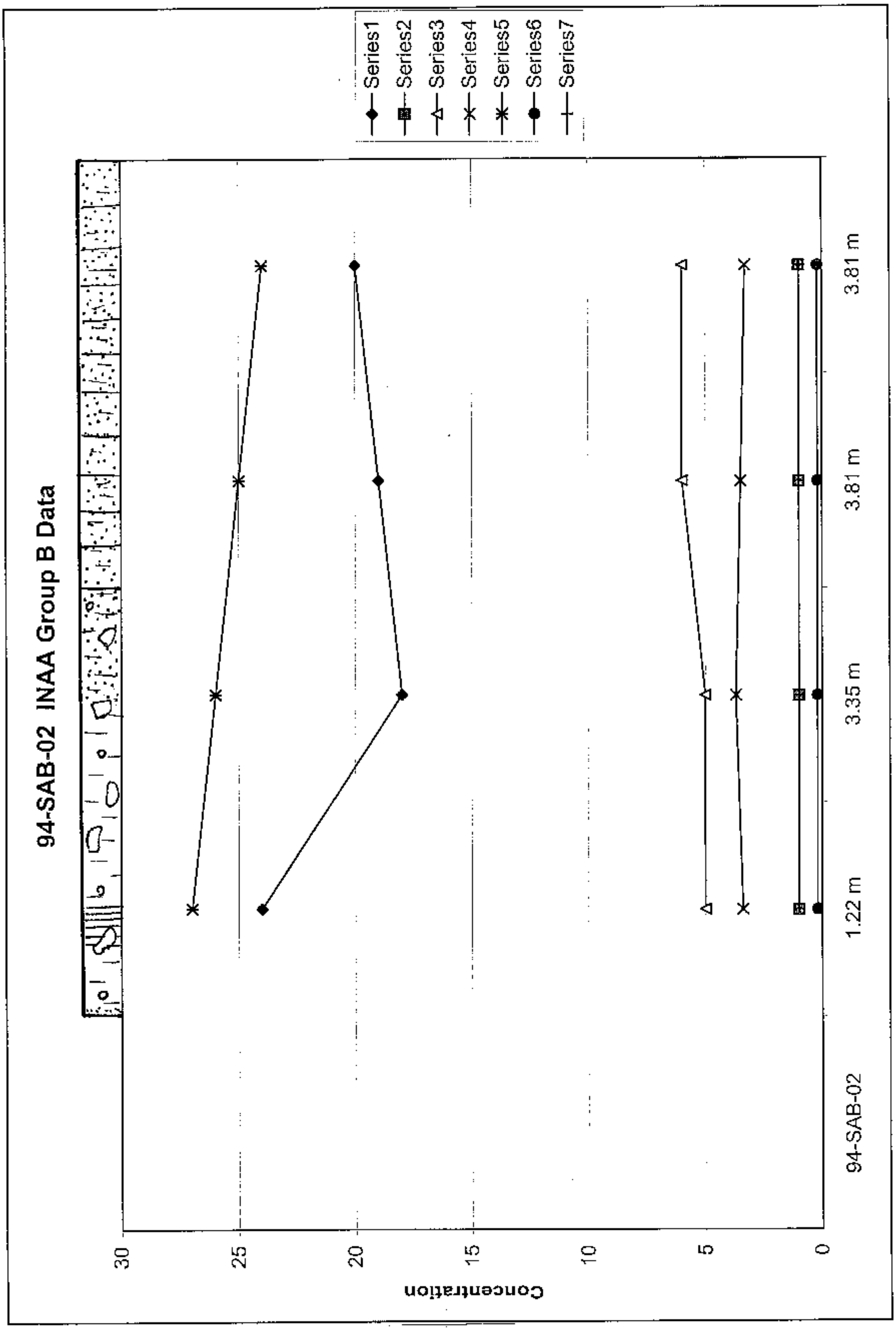
GROUP D

Series 1	Tb (ppm)
Series 2	Th (ppm)
Series 3	W (ppm)
Series 4	U (ppm)
Series 5	Yb (ppm)
Series 6	Zn (ppm)
Series 7	Zr (ppm)

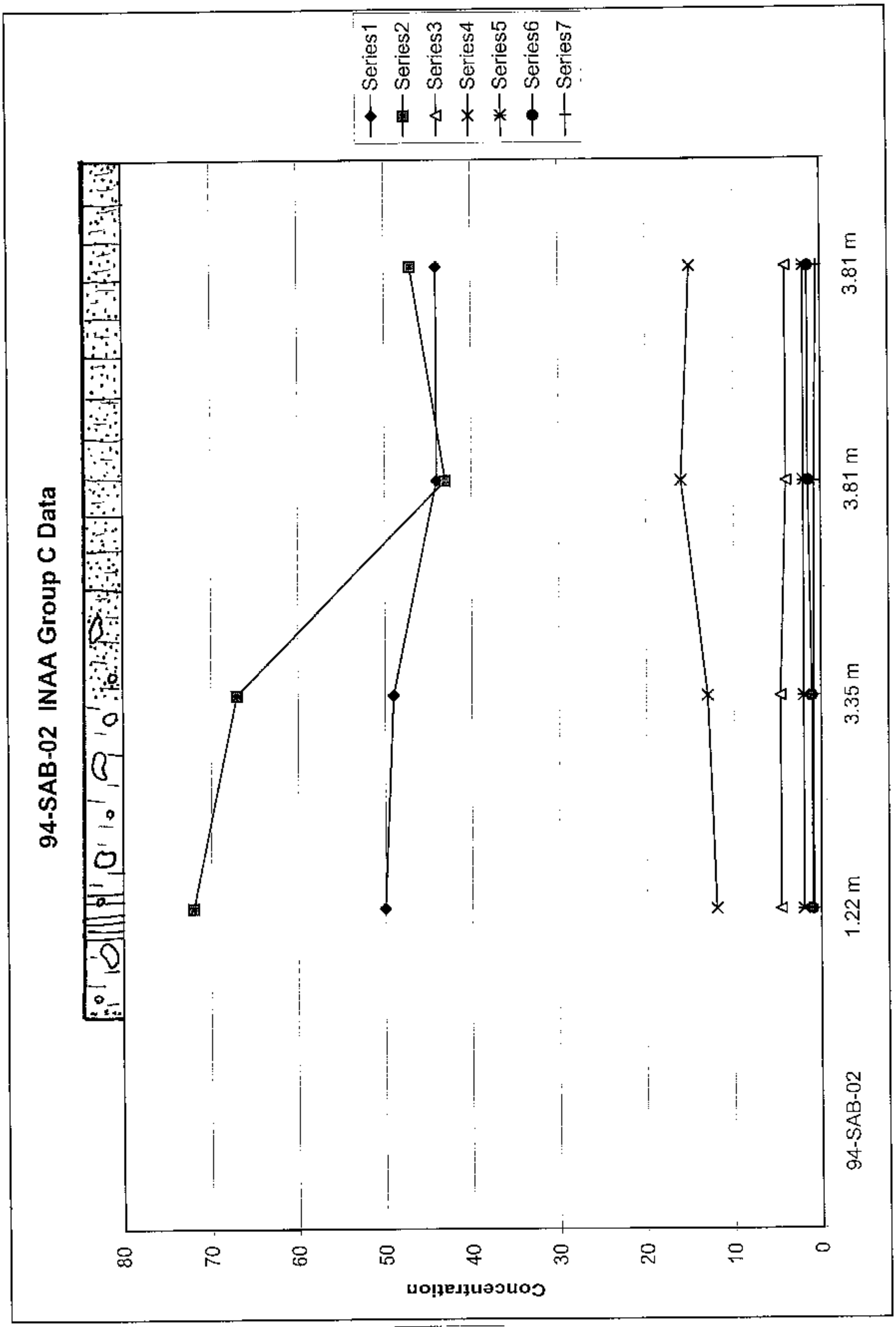

94-SAB-02 INAA Group A Data
Concentration
1200
1000
800
600
400
200
0
94-SAB-02
1.22 m
3.35 m
3.81 m
3.81 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Series8



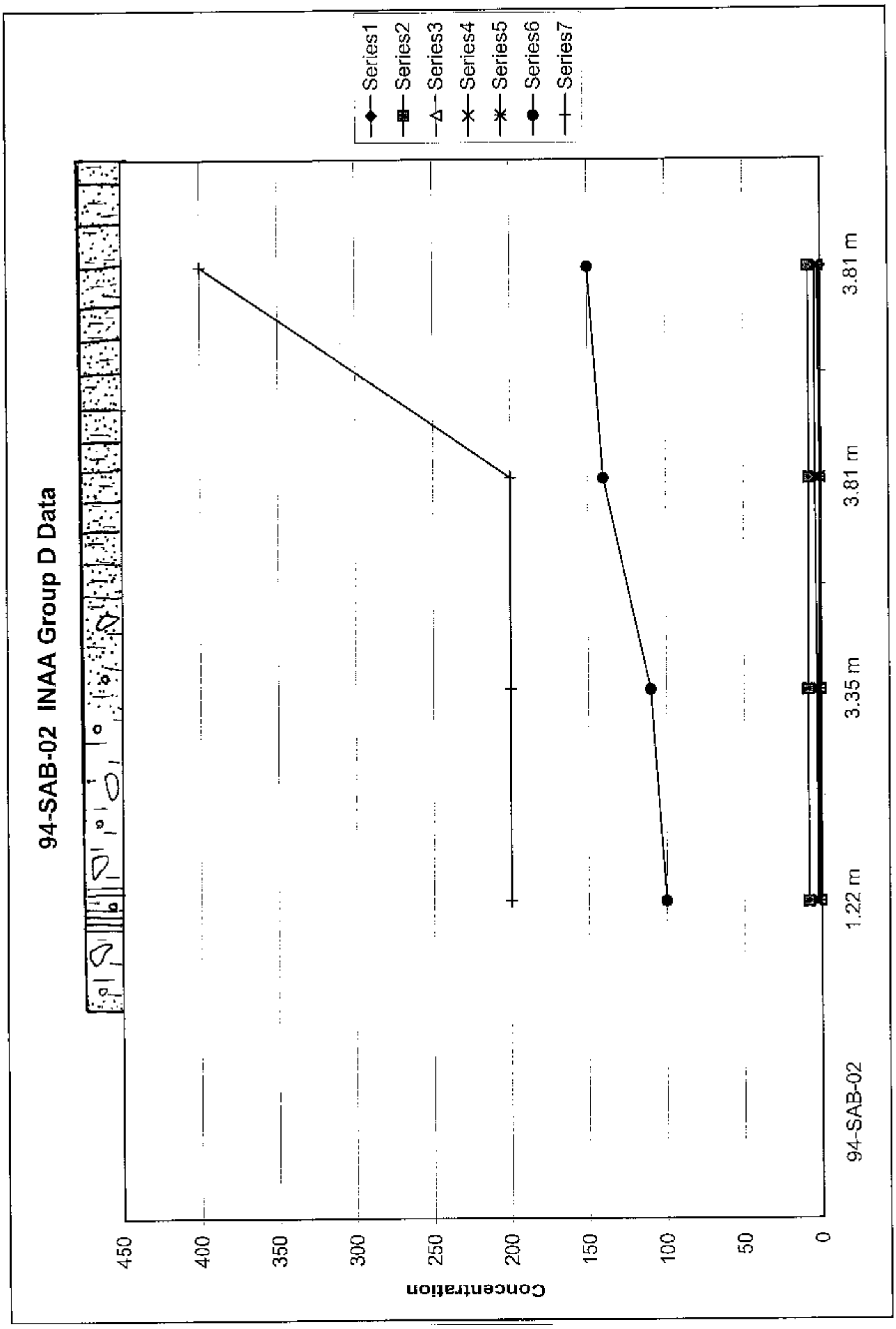
94-SAB-02 INAA Group A Data
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Series8
Concentration
120
100
80
60
40
20
0
94-SAB-02
1.22 m
3.35 m
3.81 m
3.81 m



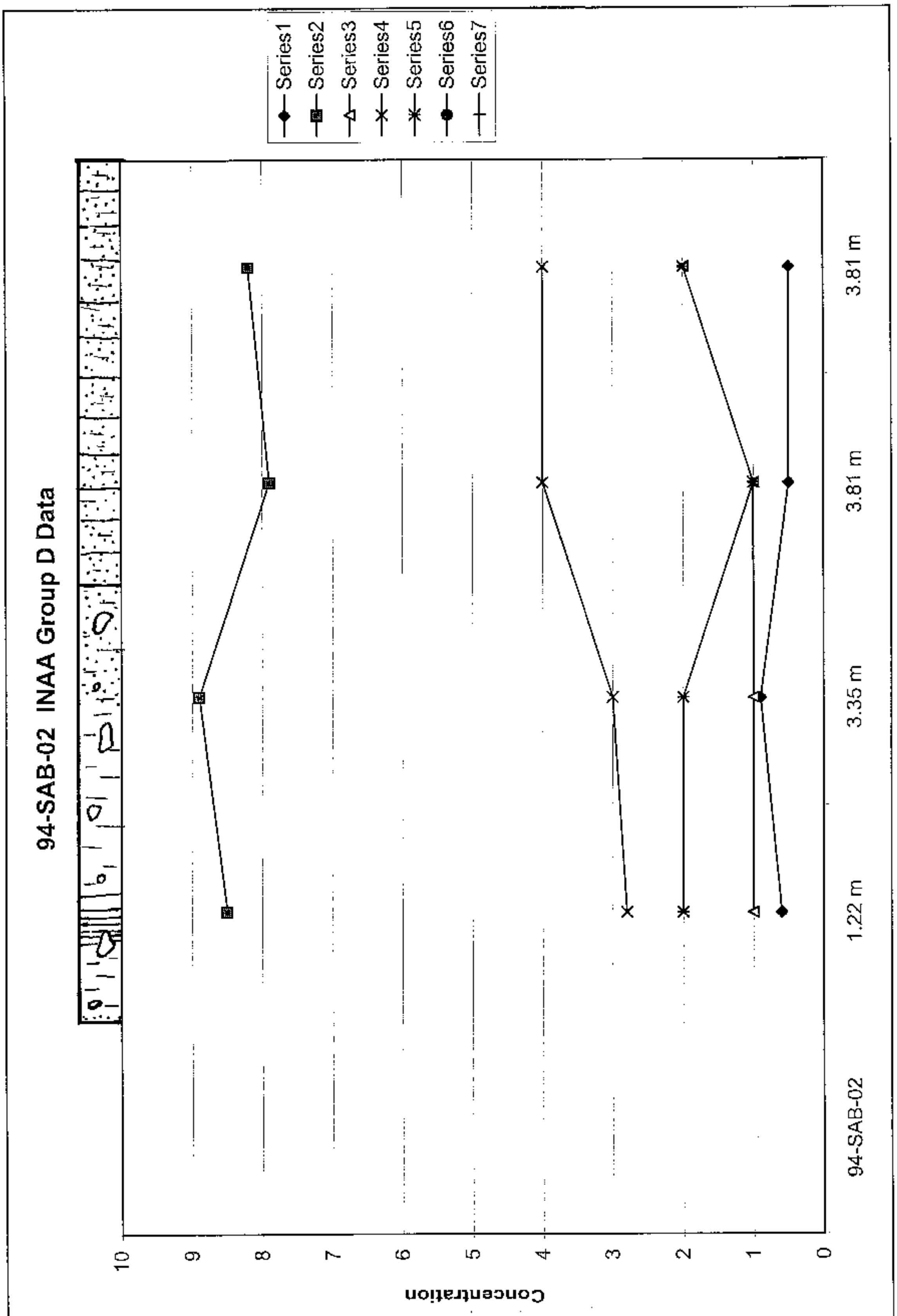
94-SAB-02 INAA Group B Data
Concentration
30
25
20
15
10
5
0
94-SAB-02
1.22 m
3.35 m
3.81 m
3.81 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7



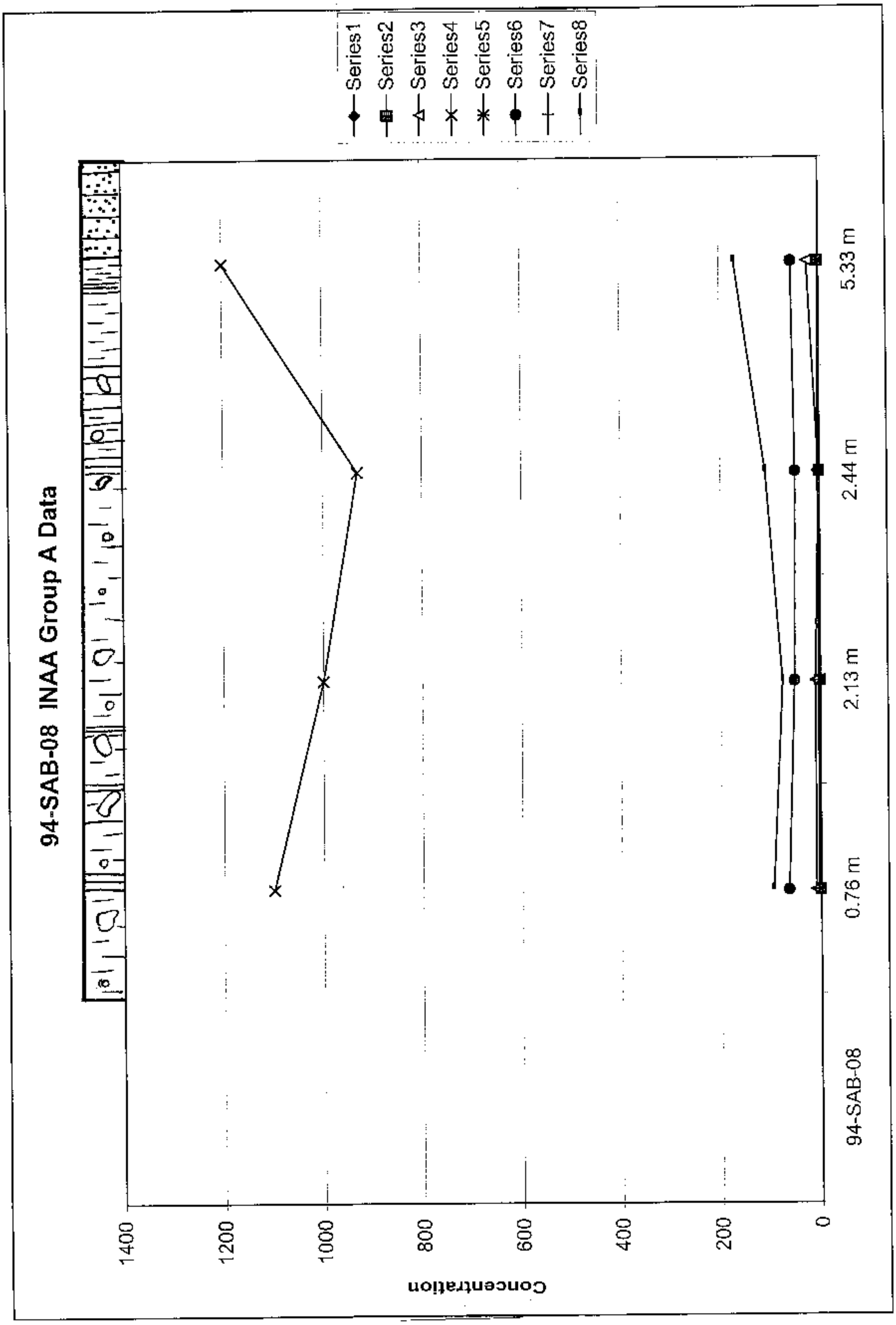
94-SAB-02 INAA Group C Data
Concentration
80
70
60
50
40
30
20
10
0
94-SAB-02
1.22 m
3.35 m
3.81 m
3.81 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7



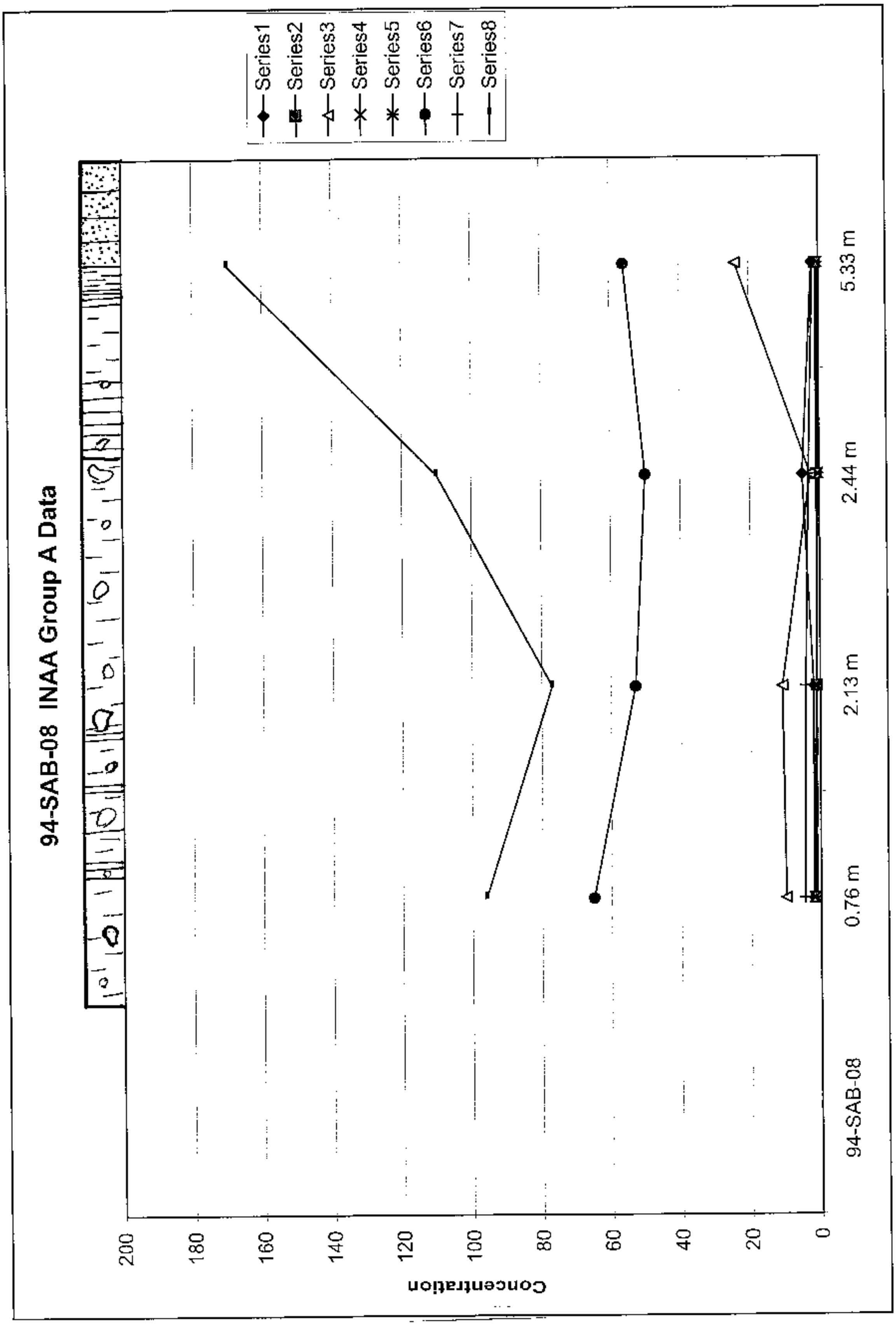
94-SAB-02 INAA Group D Data
Concentration
0
50
100
150
200
250
300
350
400
450
94-SAB-02
1.22 m
3.35 m
3.81 m
3.81 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7



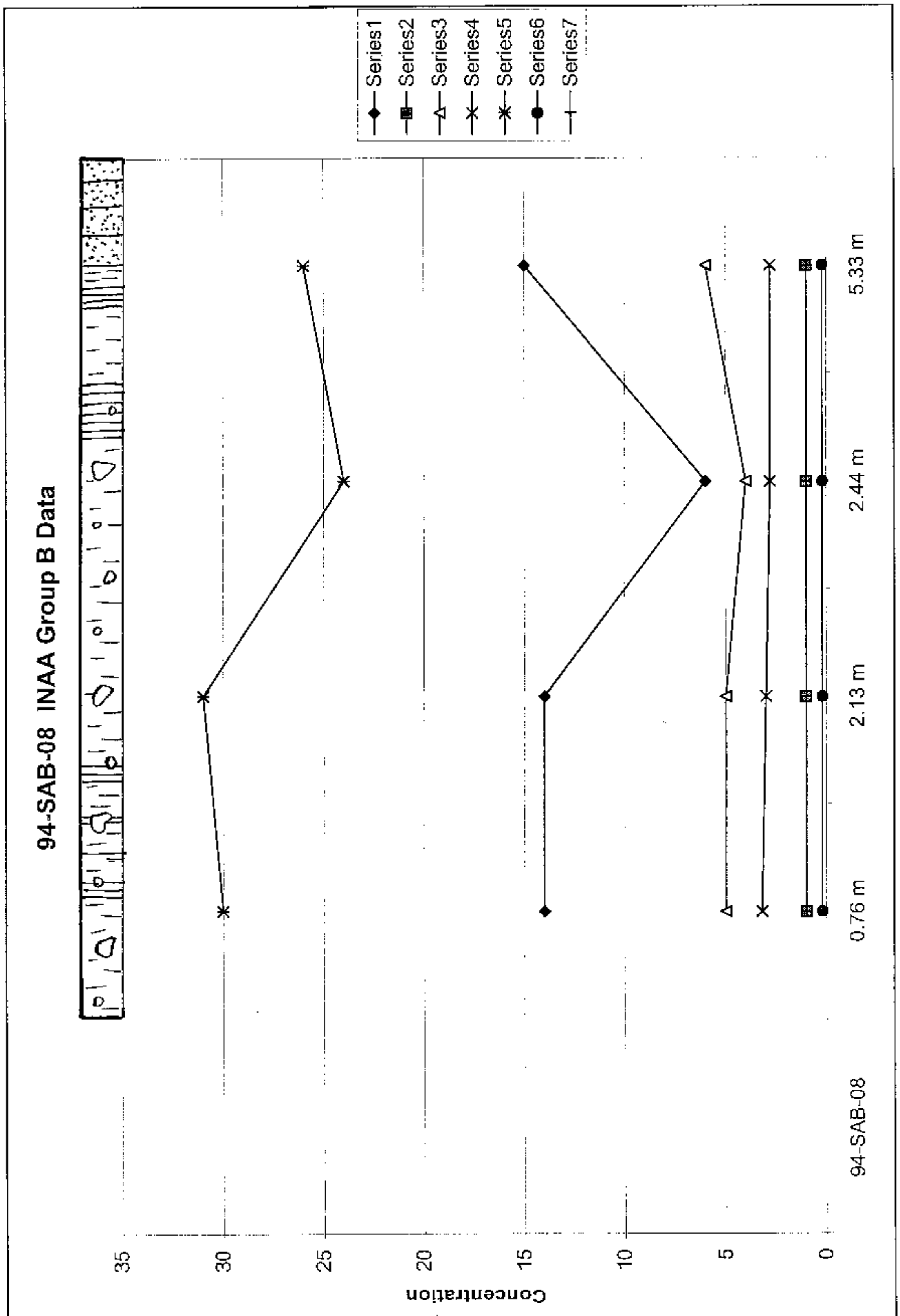
94-SAB-02 INAA Group D Data
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Concentration
0
1
2
3
4
5
6
7
8
9
10
94-SAB-02
1.22 m
3.35 m
3.81 m
3.81 m



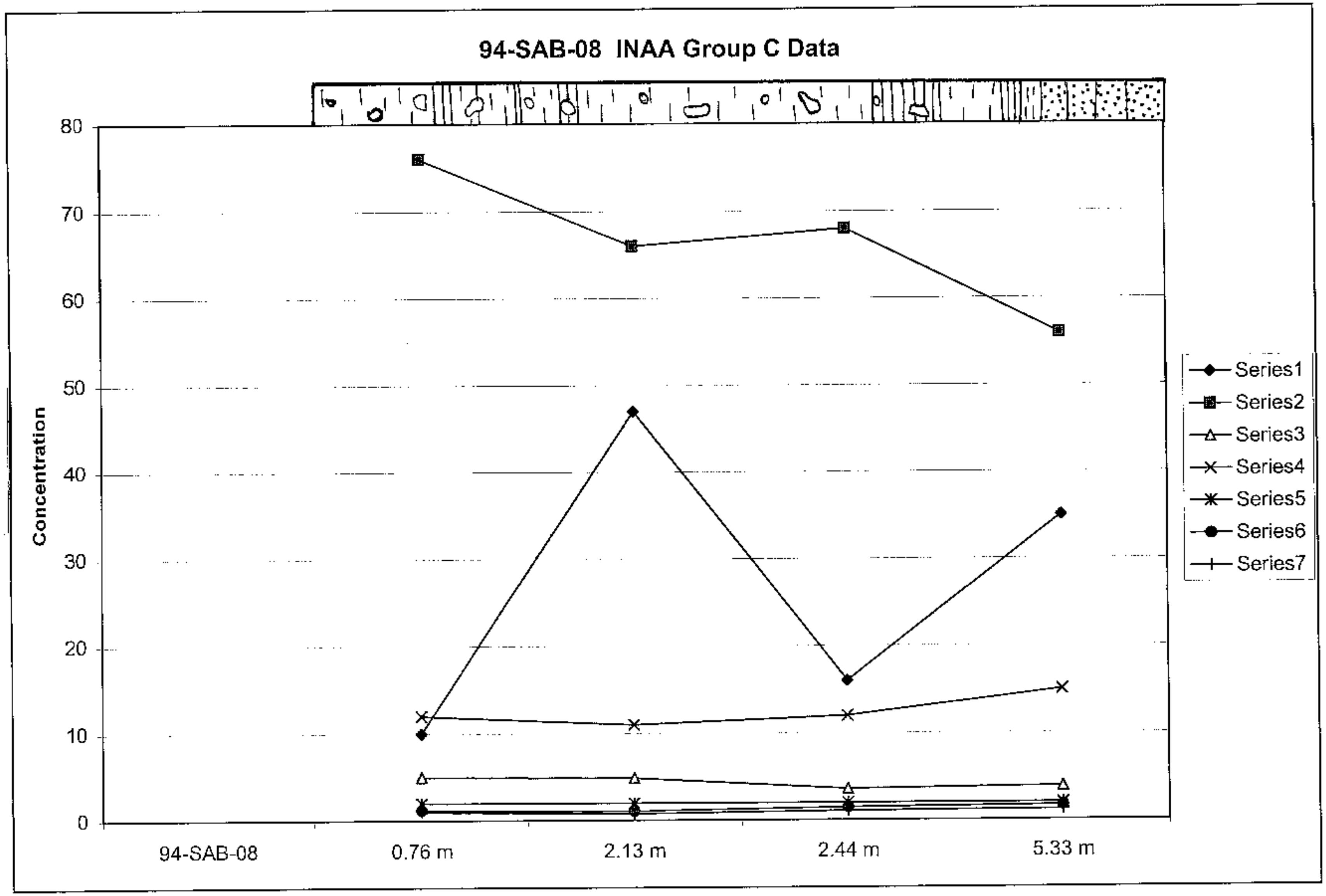
94-SAB-08 INAA Group A Data
Concentration
1400
1200
1000
800
600
400
200
0
94-SAB-08
0.76 m
2.13 m
2.44 m
5.33 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Series8

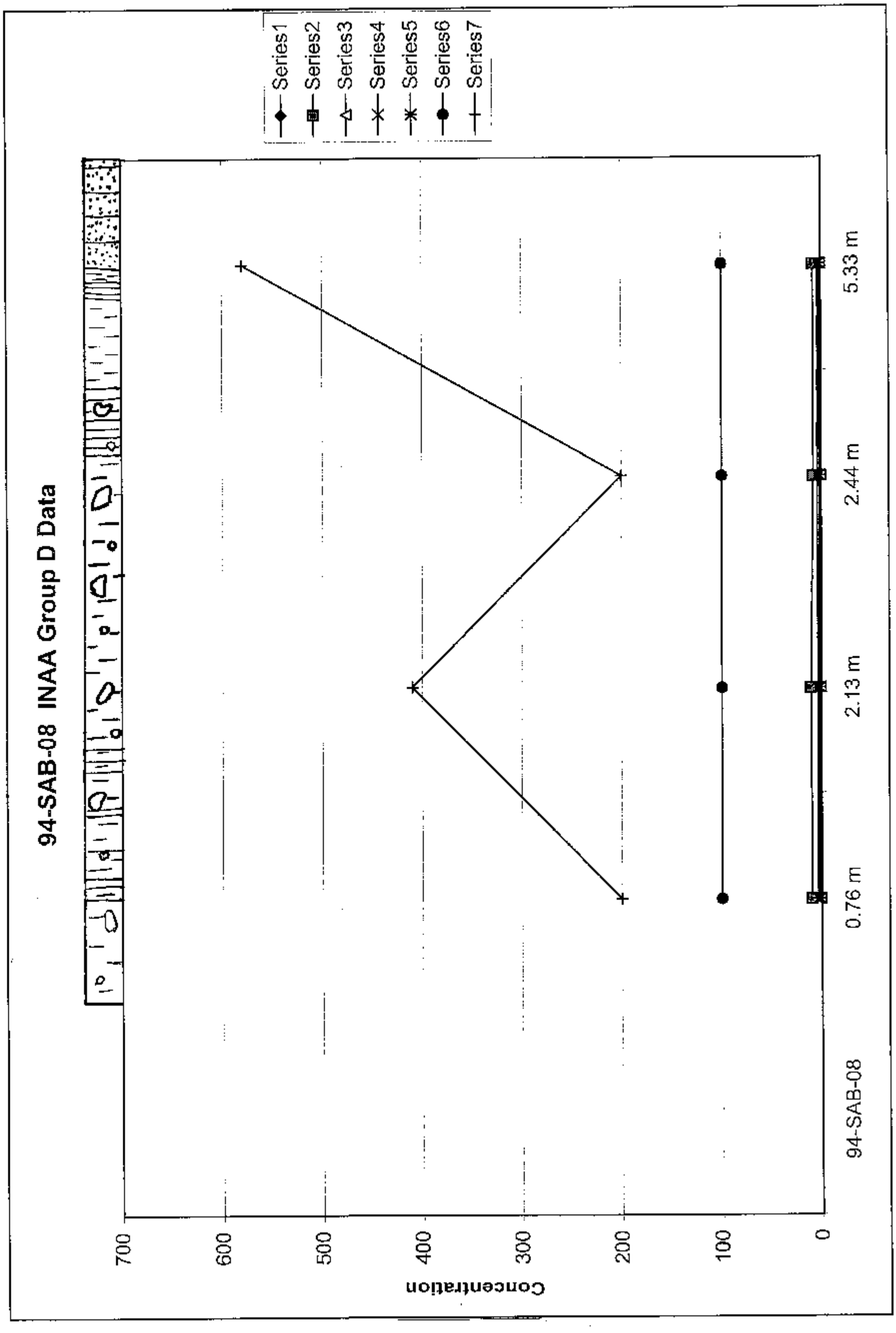


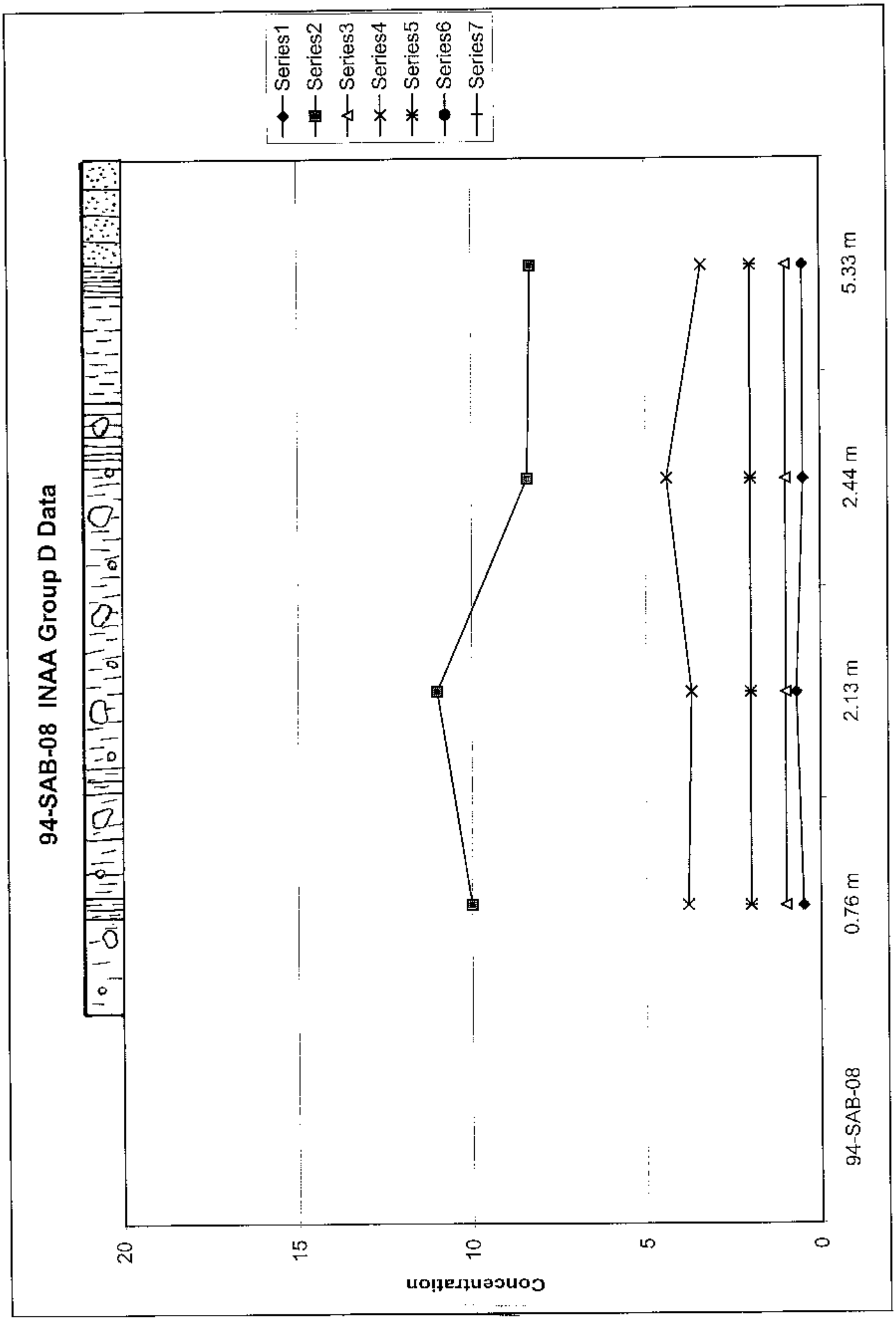
94-SAB-08 INAA Group A Data
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Series8
Concentration
200
180
160
140
120
100
80
60
40
20
0
94-SAB-08
0.76 m
2.13 m
2.44 m
5.33 m

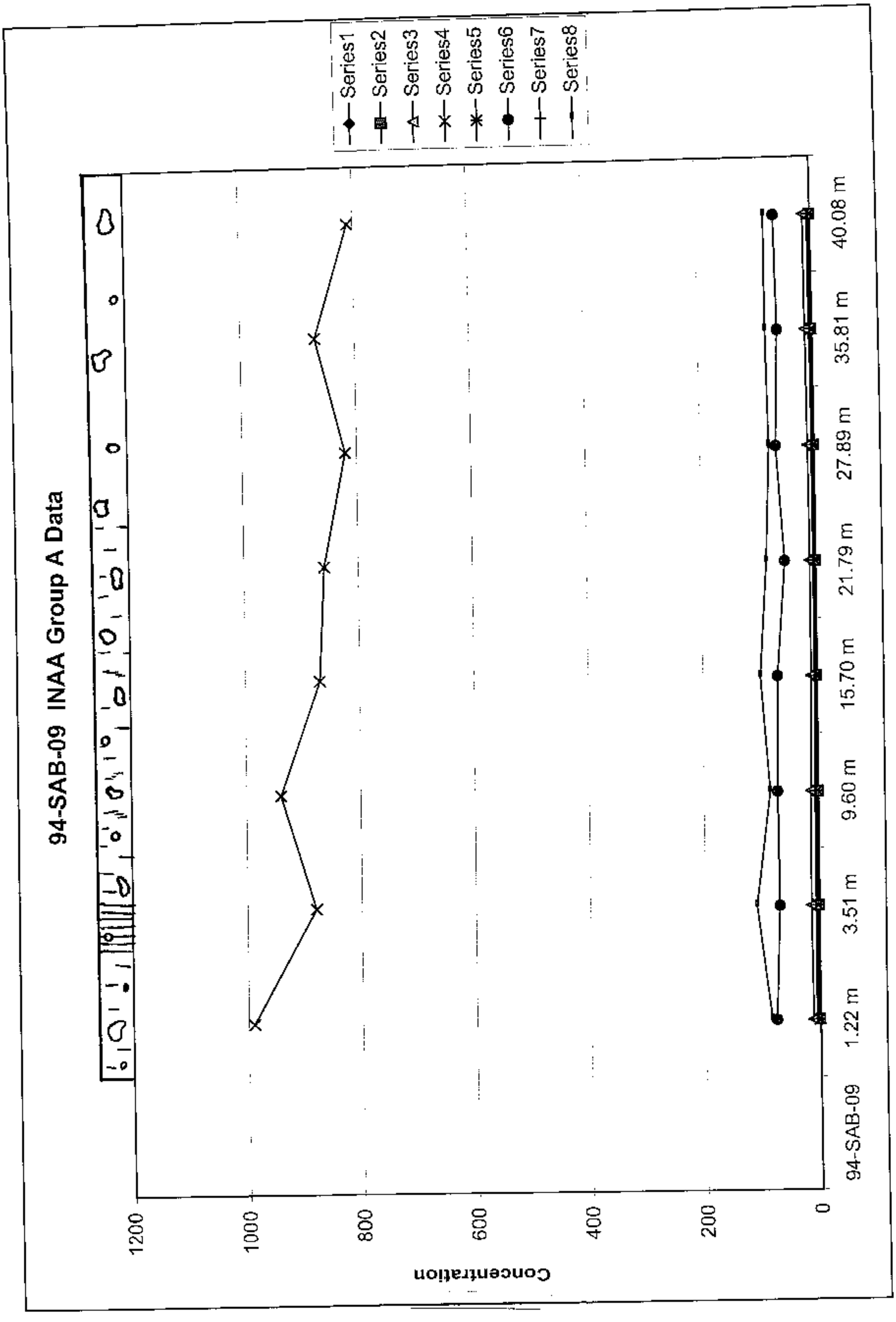


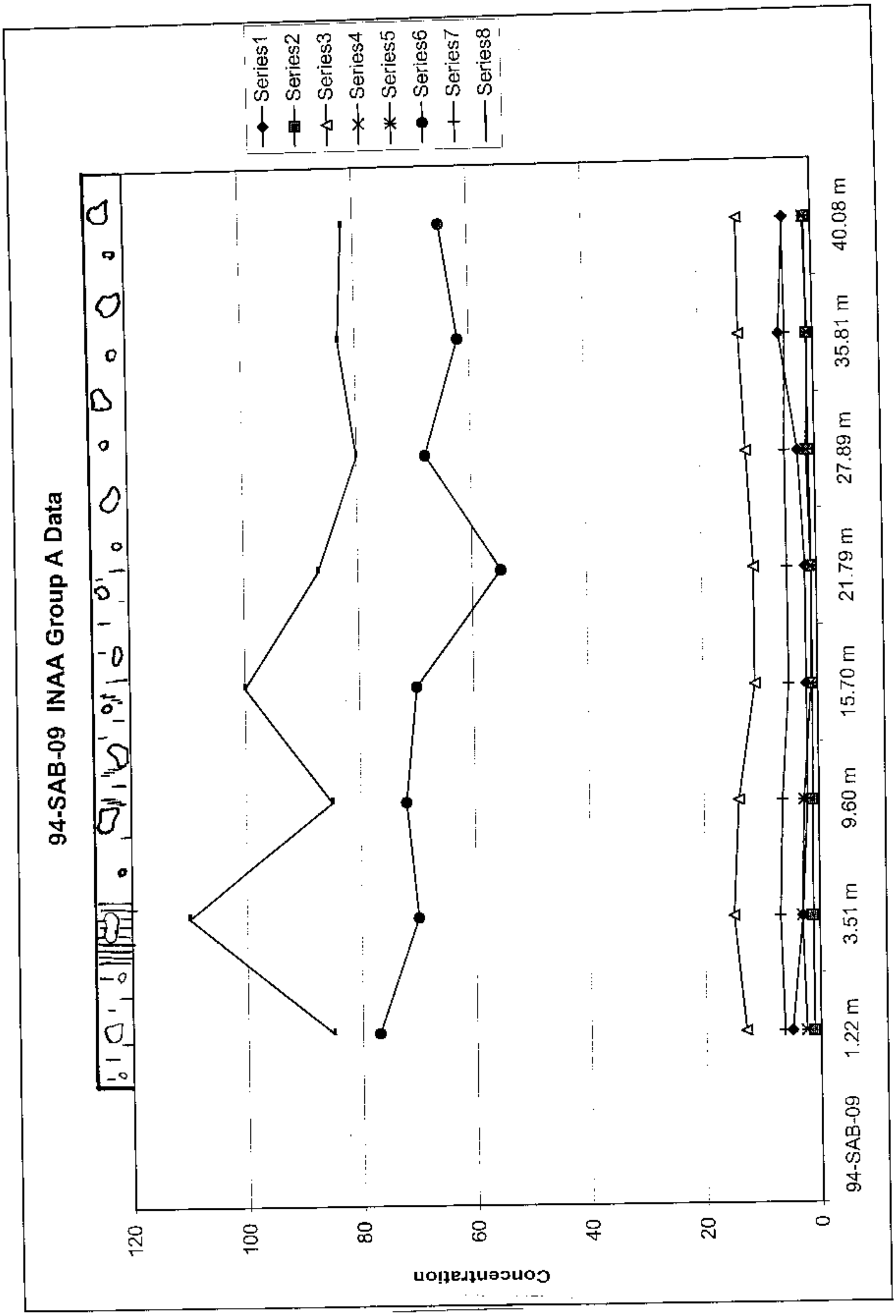
94-SAB-08 INAA Group B Data
Concentration
35
30
25
20
15
10
5
0
94-SAB-08
0.76 m
2.13 m
2.44 m
5.33 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7

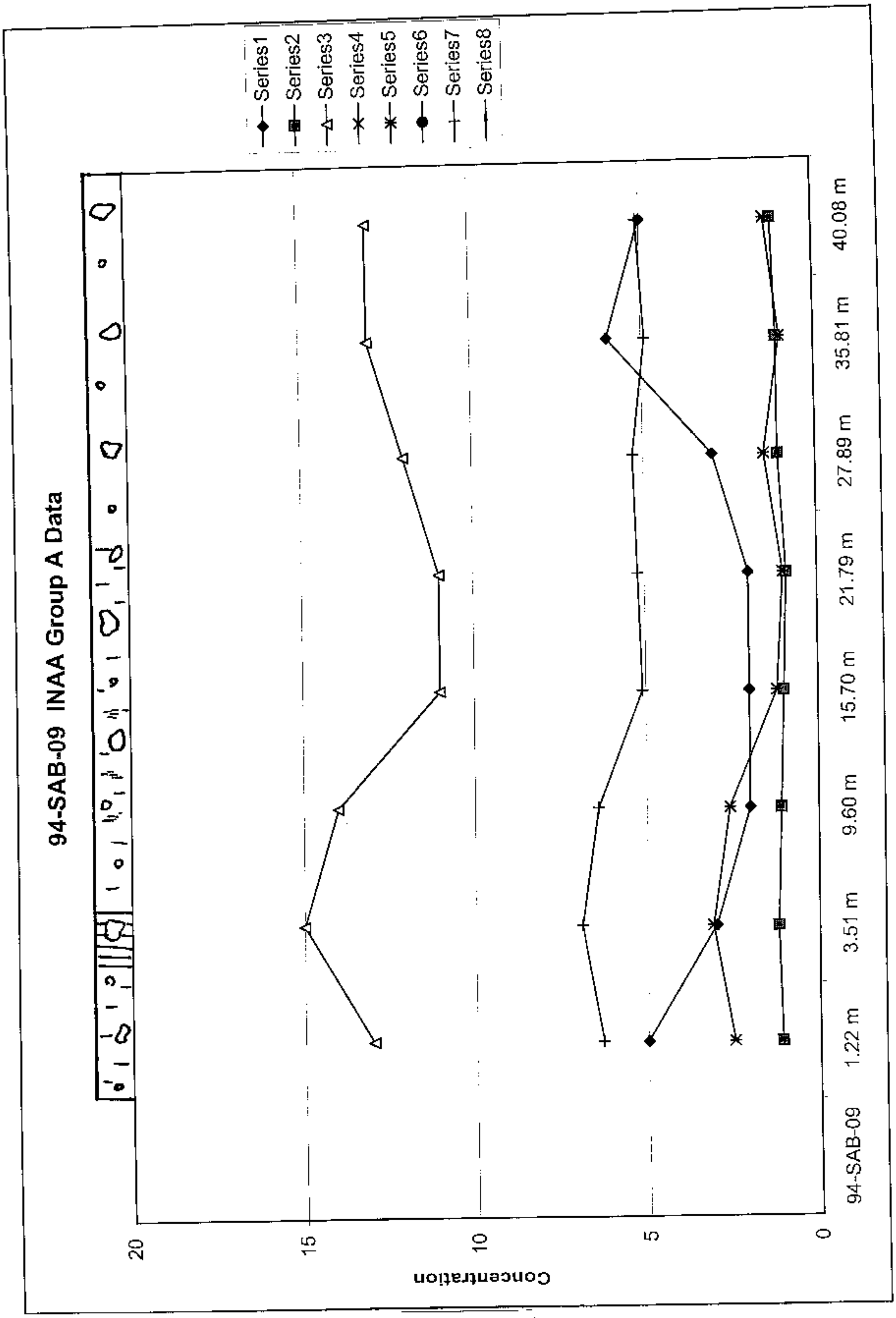

94-SAB-08 INAA Group C Data
Concentration
80
70
60
50
40
30
20
10
0
94-SAB-08
0.76 m
2.13 m
2.44 m
5.33 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7

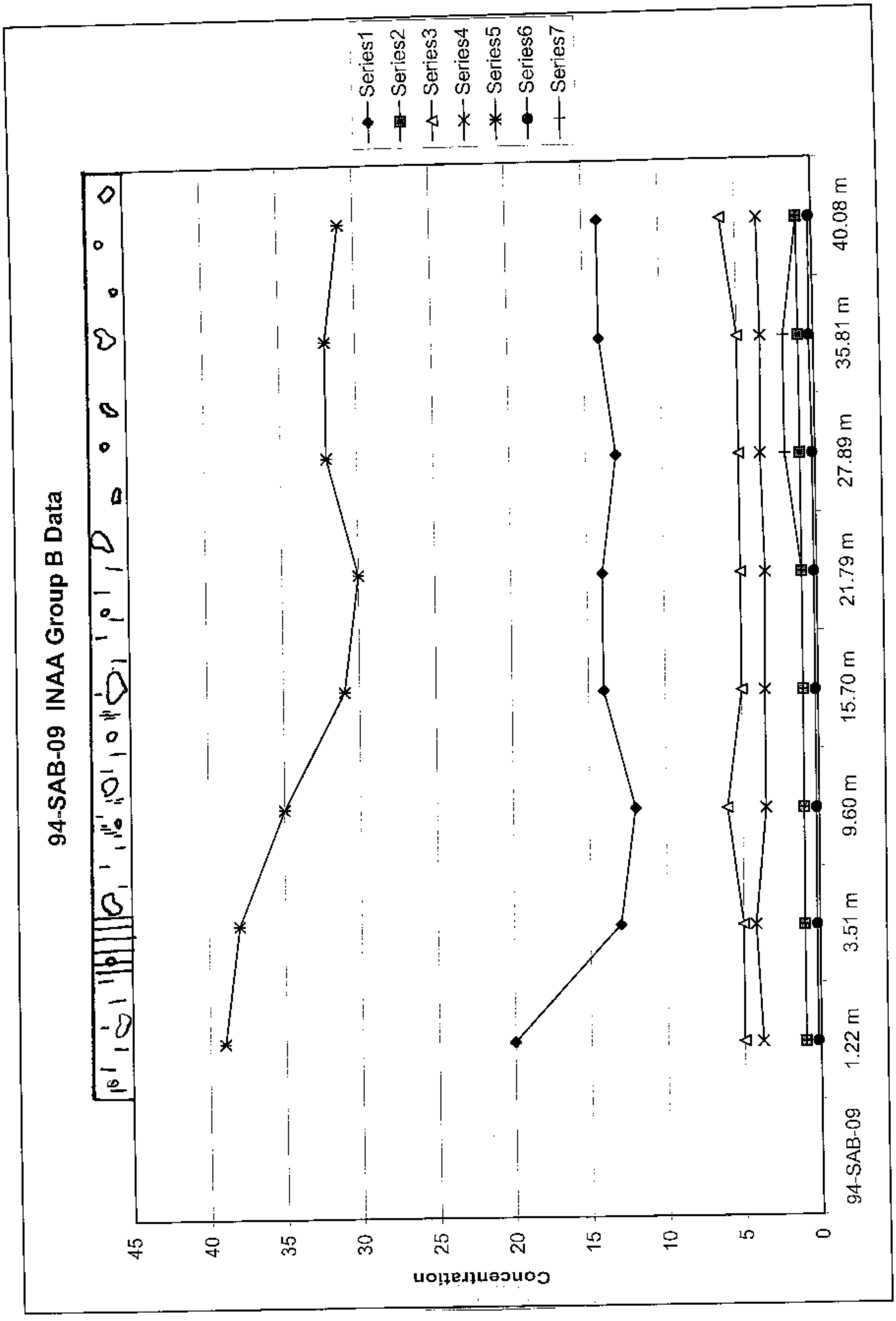

94-SAB-08 INAA Group D Data
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Concentration
700
600
500
400
300
200
100
0
94-SAB-08
0.76 m
2.13 m
2.44 m
5.33 m


94-SAB-08 INAA Group D Data
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Concentration
20
15
10
5
0
94-SAB-08
0.76 m
2.13 m
2.44 m
5.33 m

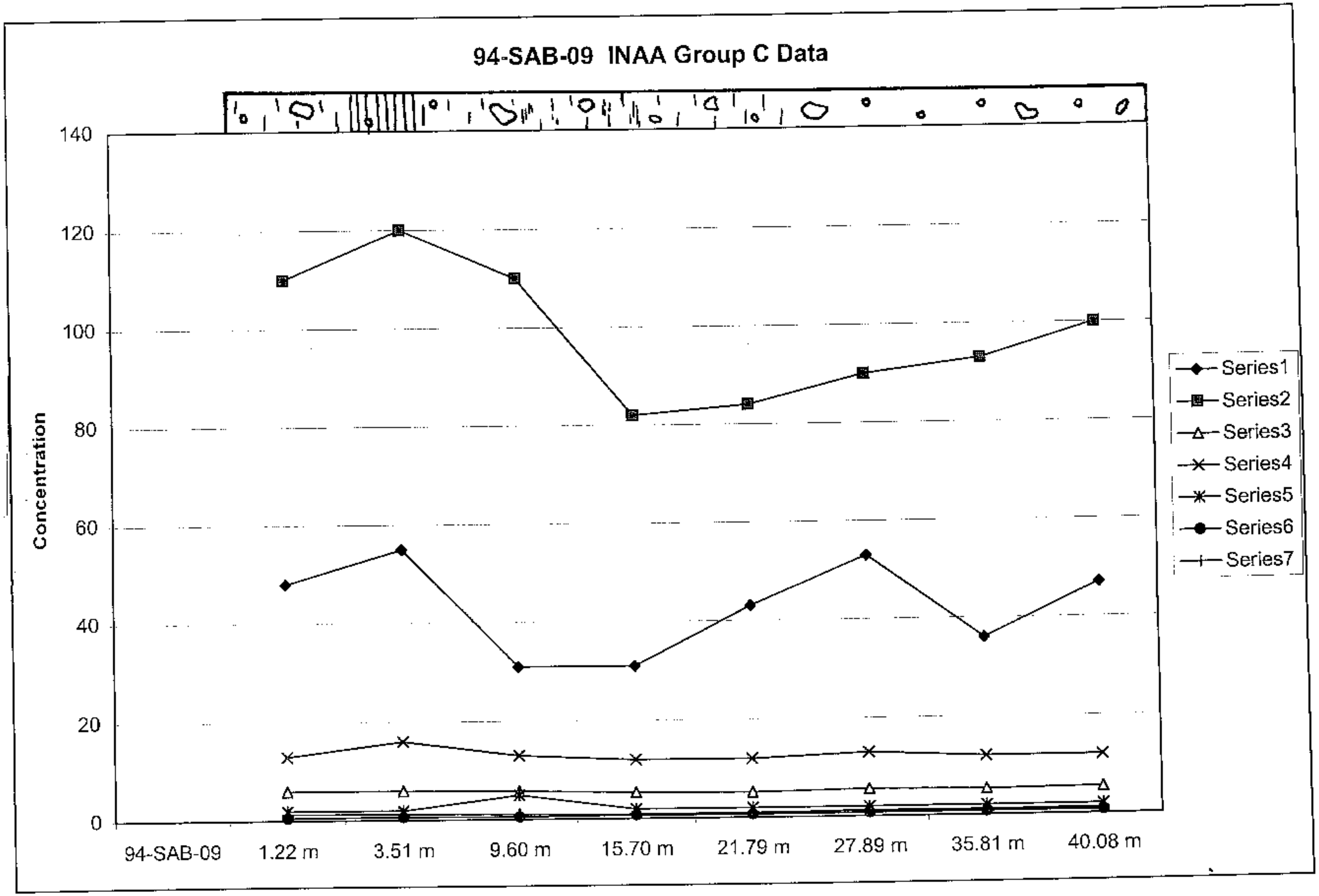

94-SAB-09 INAA Group A Data
Concentration
1200
1000
800
600
400
200
0
94-SAB-09
1.22 m
3.51 m
9.60 m
15.70 m
21.79 m
27.89 m
35.81 m
40.08 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Series8

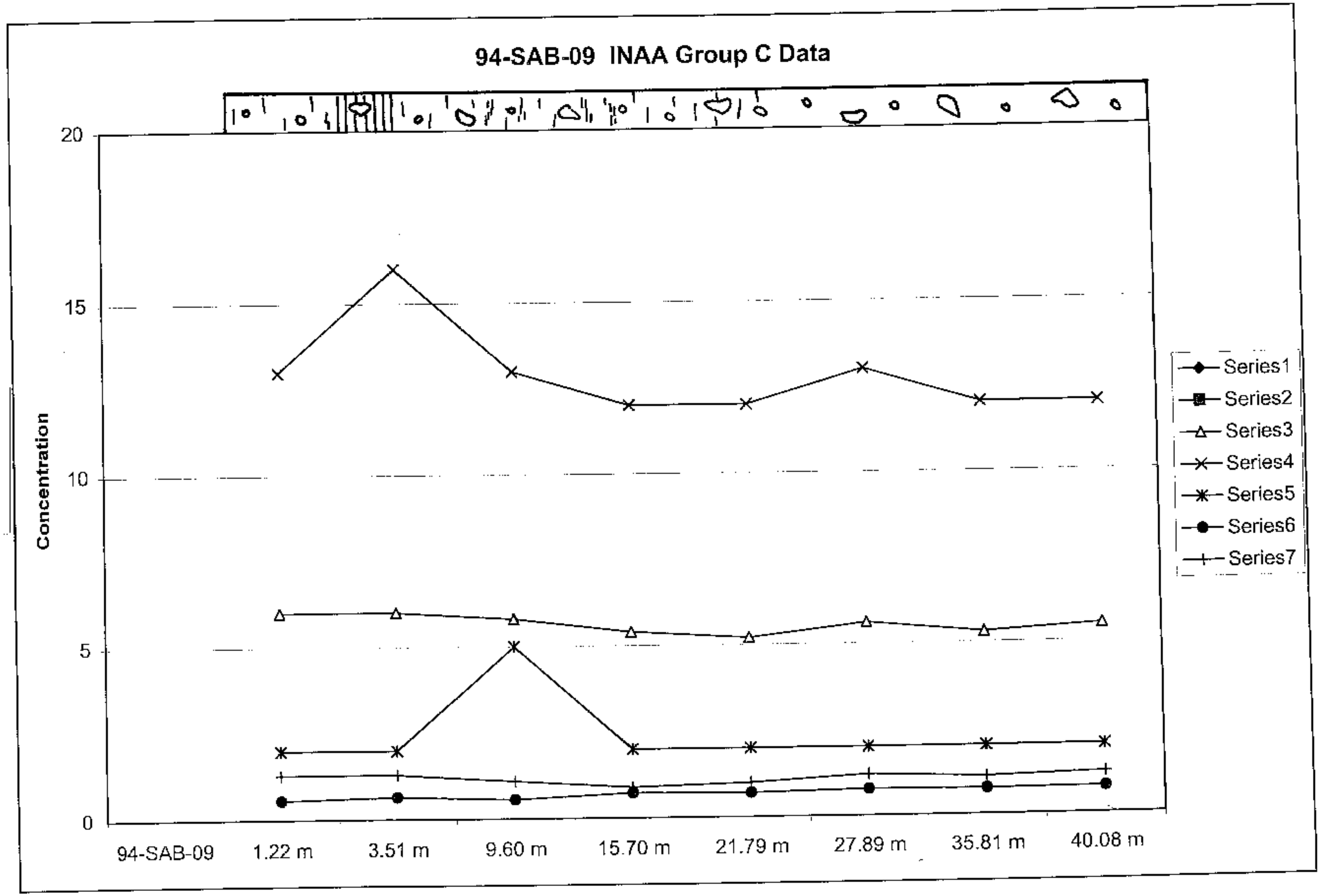

94-SAB-09 INAA Group A Data
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Series8
Concentration
0
20
40
60
80
100
120
94-SAB-09
1.22 m
3.51 m
9.60 m
15.70 m
21.79 m
27.89 m
35.81 m
40.08 m

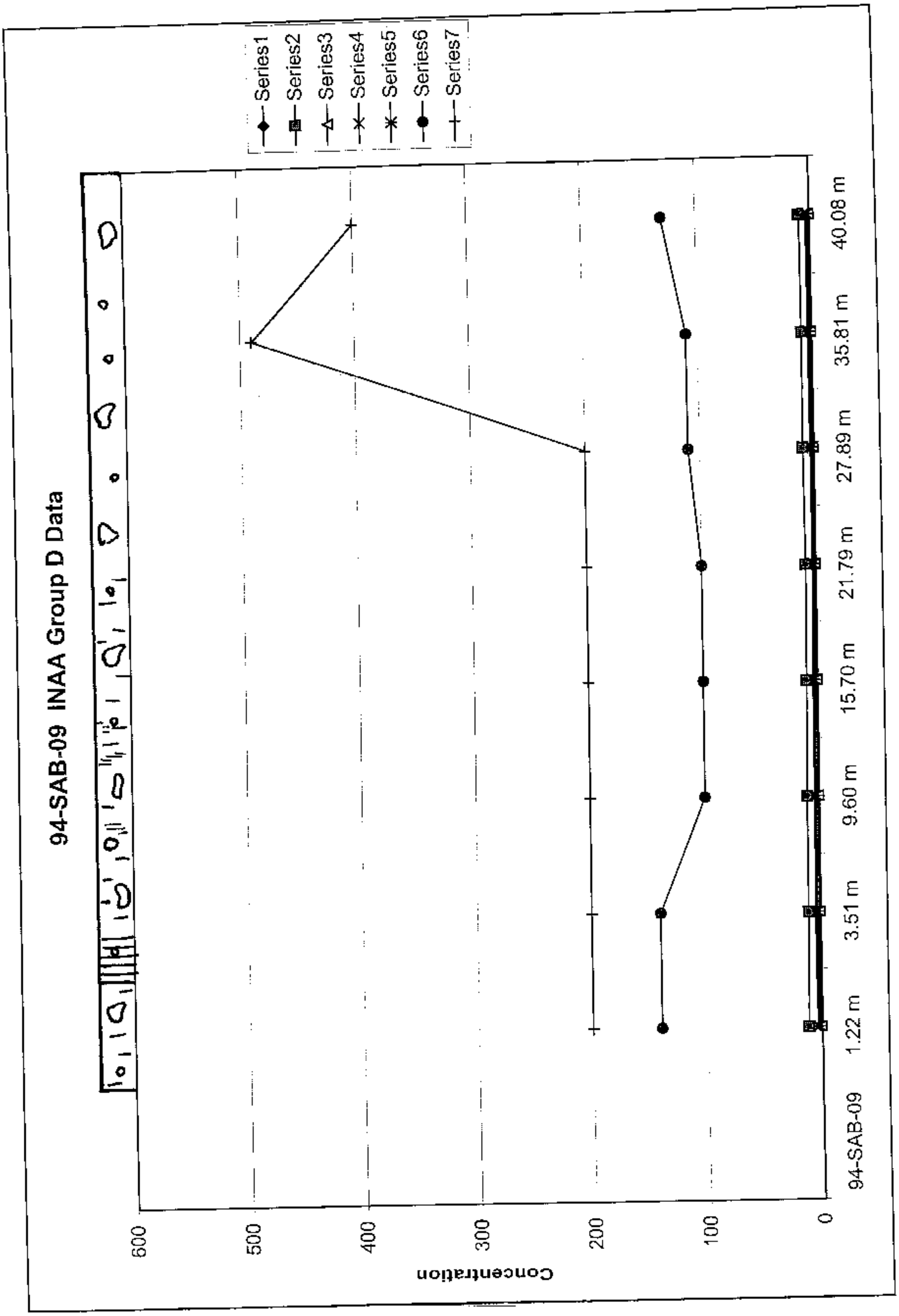

94-SAB-09 INAA Group A Data
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Series8
Concentration
0
5
10
15
20
94-SAB-09
1.22 m
3.51 m
9.60 m
15.70 m
21.79 m
27.89 m
35.81 m
40.08 m



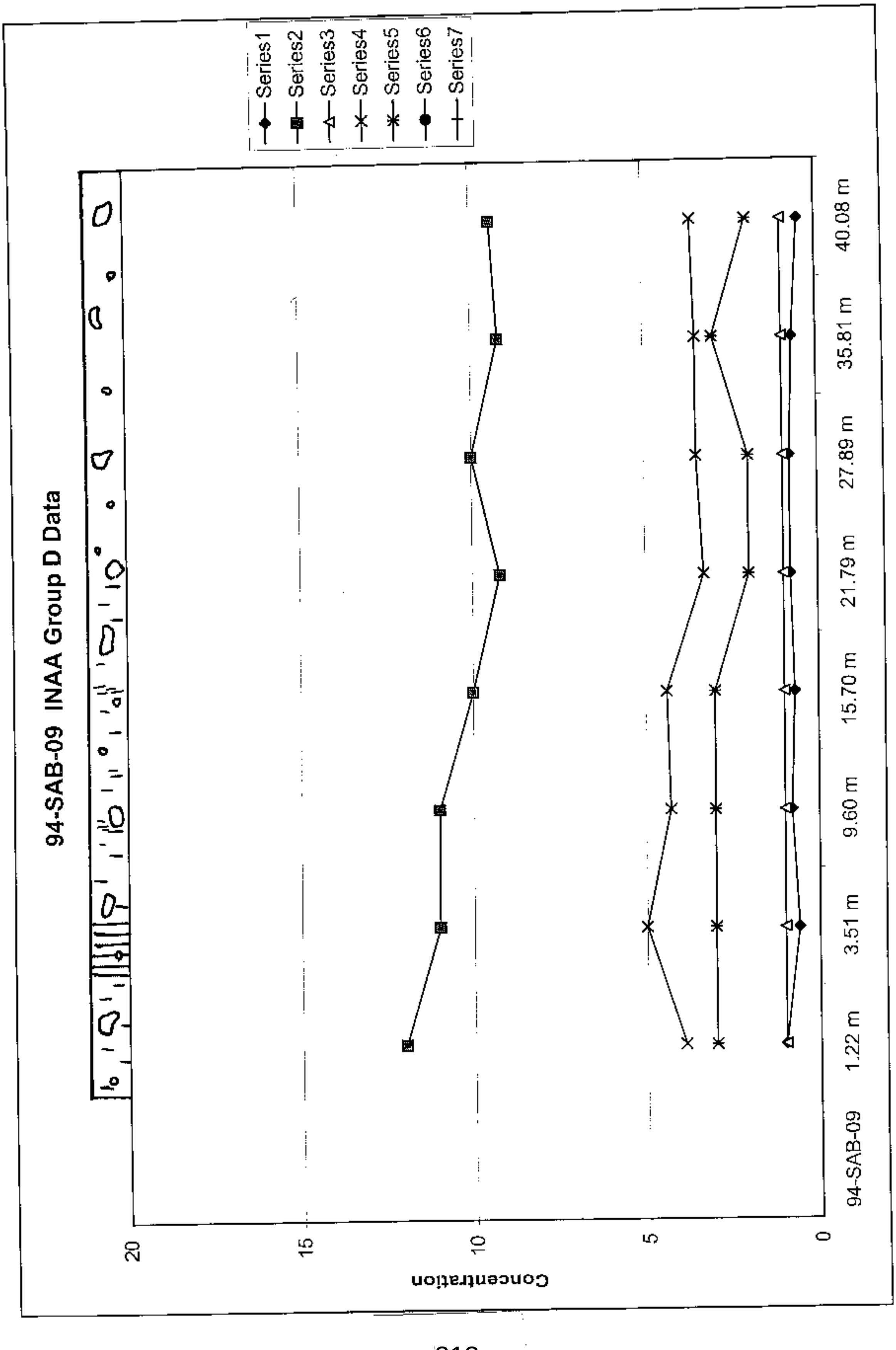
94-SAB-09 INAA Group B Data
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Concentration
45
40
35
30
25
20
15
10
5
0
94-SAB-09
1.22 m
3.51 m
9.60 m
15.70 m
21.79 m
27.89 m
35.81 m
40.08 m


94-SAB-09 INAA Group C Data
Concentration
140
120
100
80
60
40
20
0
94-SAB-09
1.22 m
3.51 m
9.60 m
15.70 m
21.79 m
27.89 m
35.81 m
40.08 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7


94-SAB-09 INAA Group C Data
Concentration
20
15
10
5
0
94-SAB-09
1.22 m
3.51 m
9.60 m
15.70 m
21.79 m
27.89 m
35.81 m
40.08 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7

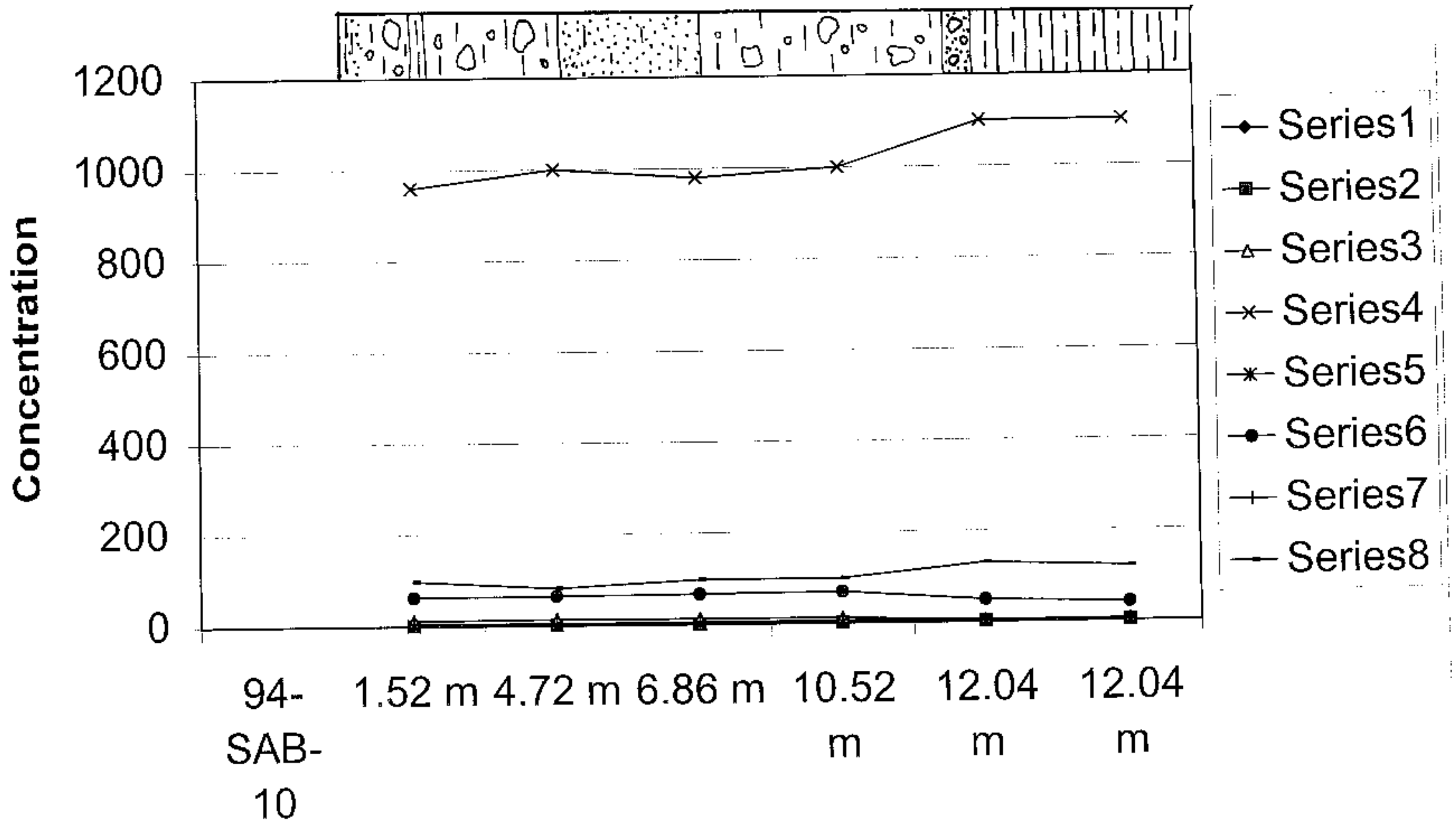


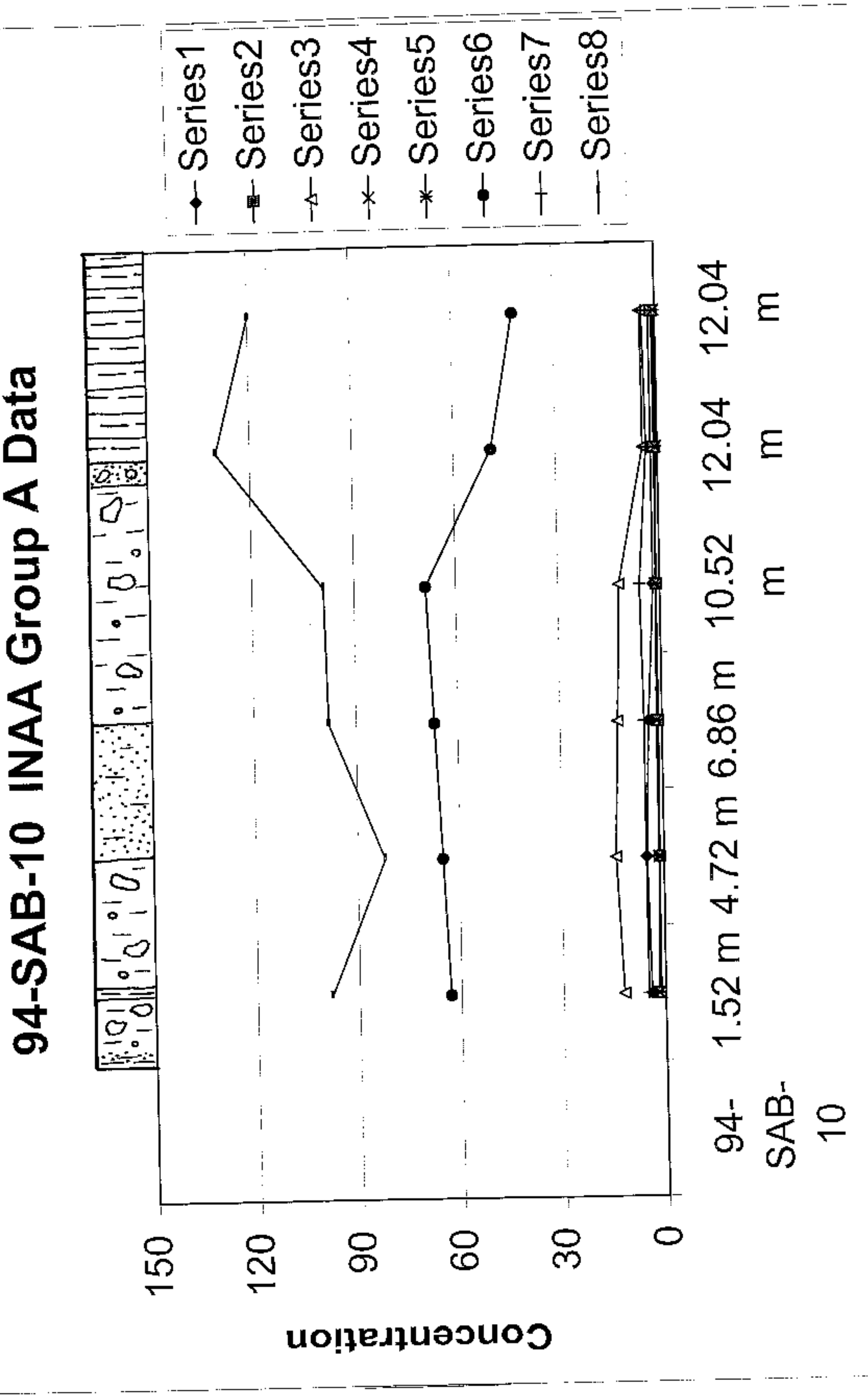
94-SAB-09 INAA Group D Data
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Concentration
600
500
400
300
200
100
0
94-SAB-09
1.22 m
3.51 m
9.60 m
15.70 m
21.79 m
27.89 m
35.81 m
40.08 m



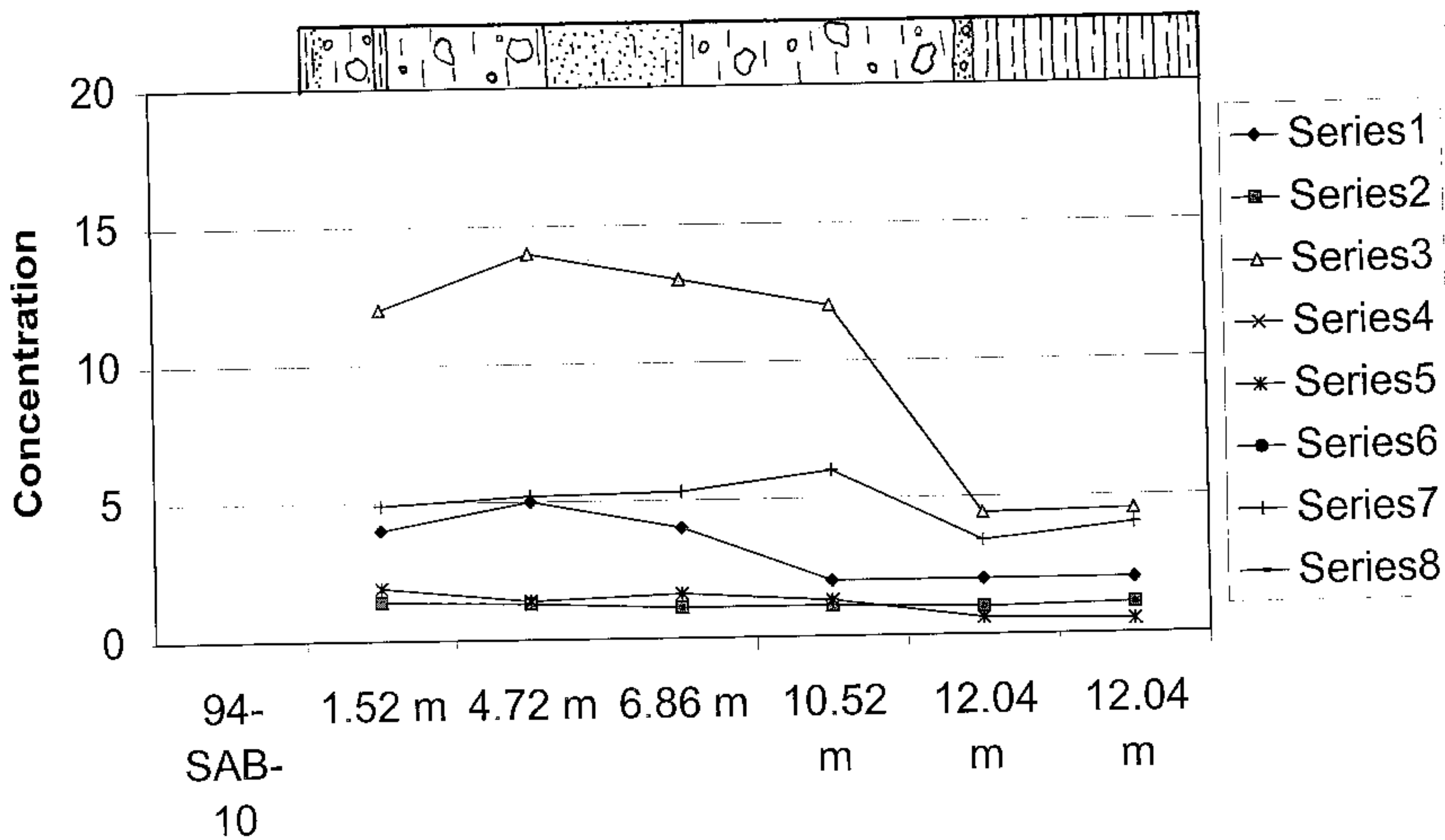
94-SAB-09 INAA Group D Data
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Concentration
0
5
10
15
20
94-SAB-09
1.22 m
3.51 m
9.60 m
15.70 m
21.79 m
27.89 m
35.81 m
40.08 m

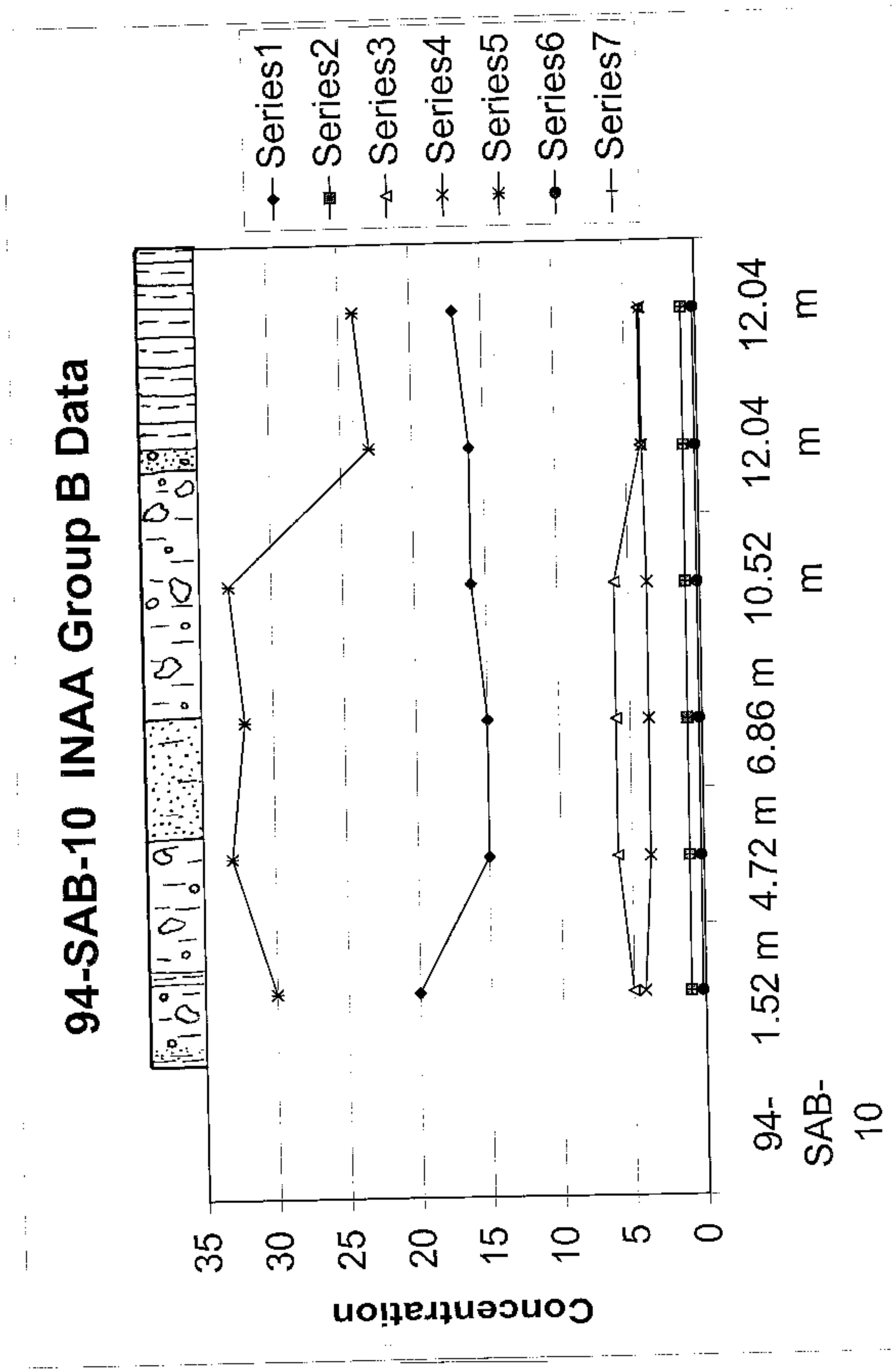
94-SAB-10 INAA Group A Data




94-SAB-10 INAA Group A Data
Concentration
150
120
90
60
30
0
94-SAB-10
1.52 m
4.72 m
6.86 m
10.52 m
12.04 m
12.04 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Series8

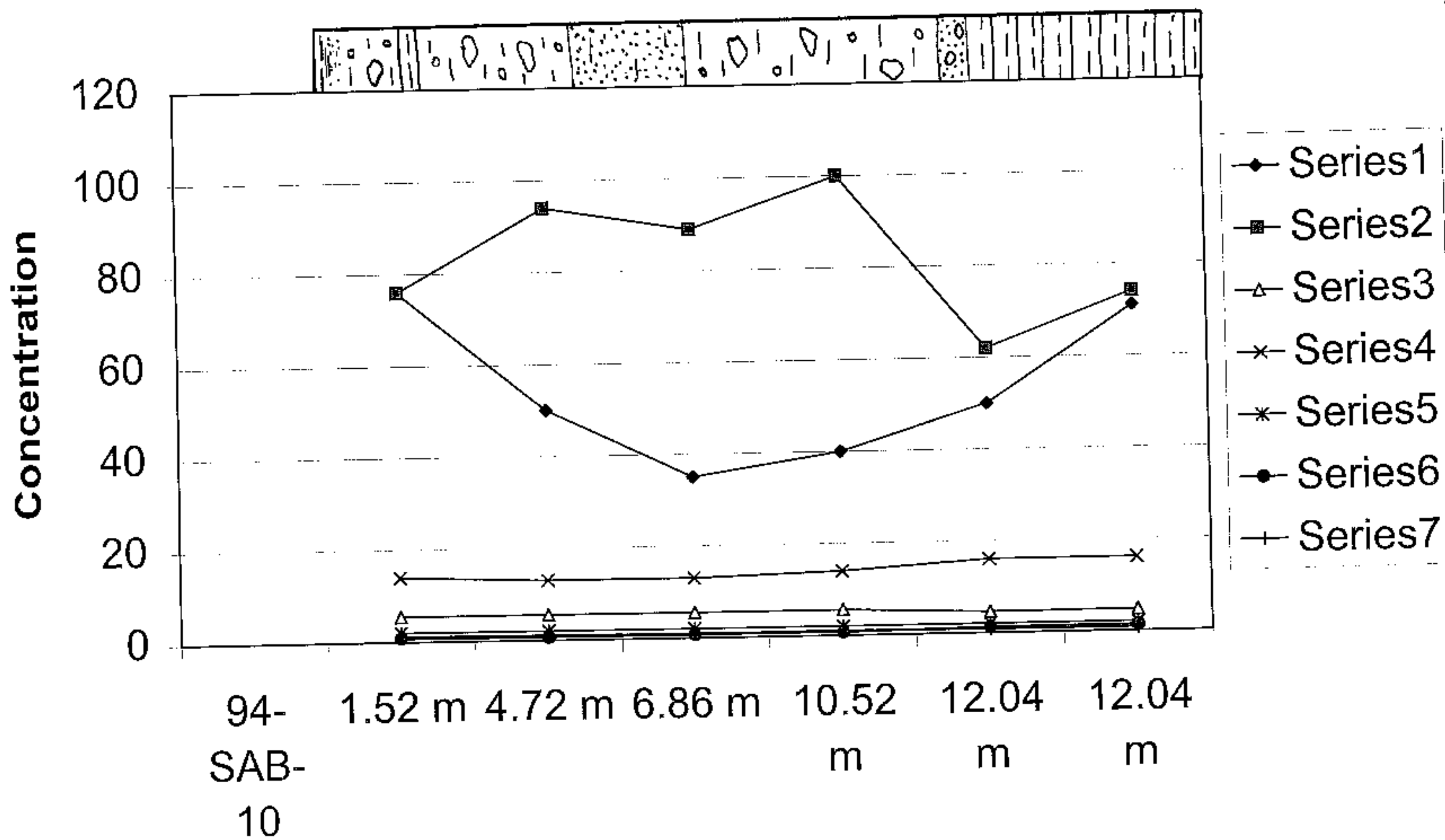
94-SAB-10 INAA Group A Data

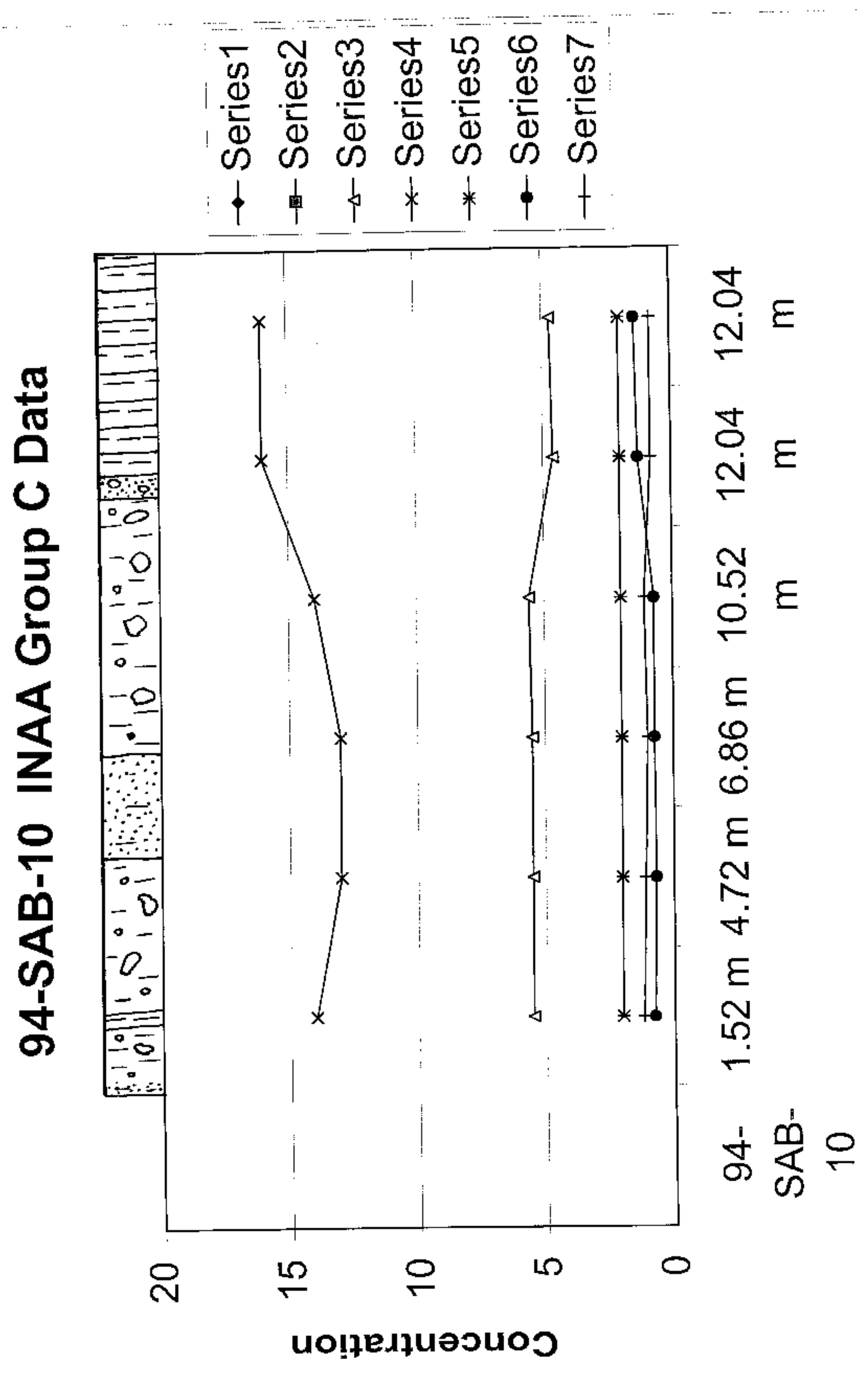


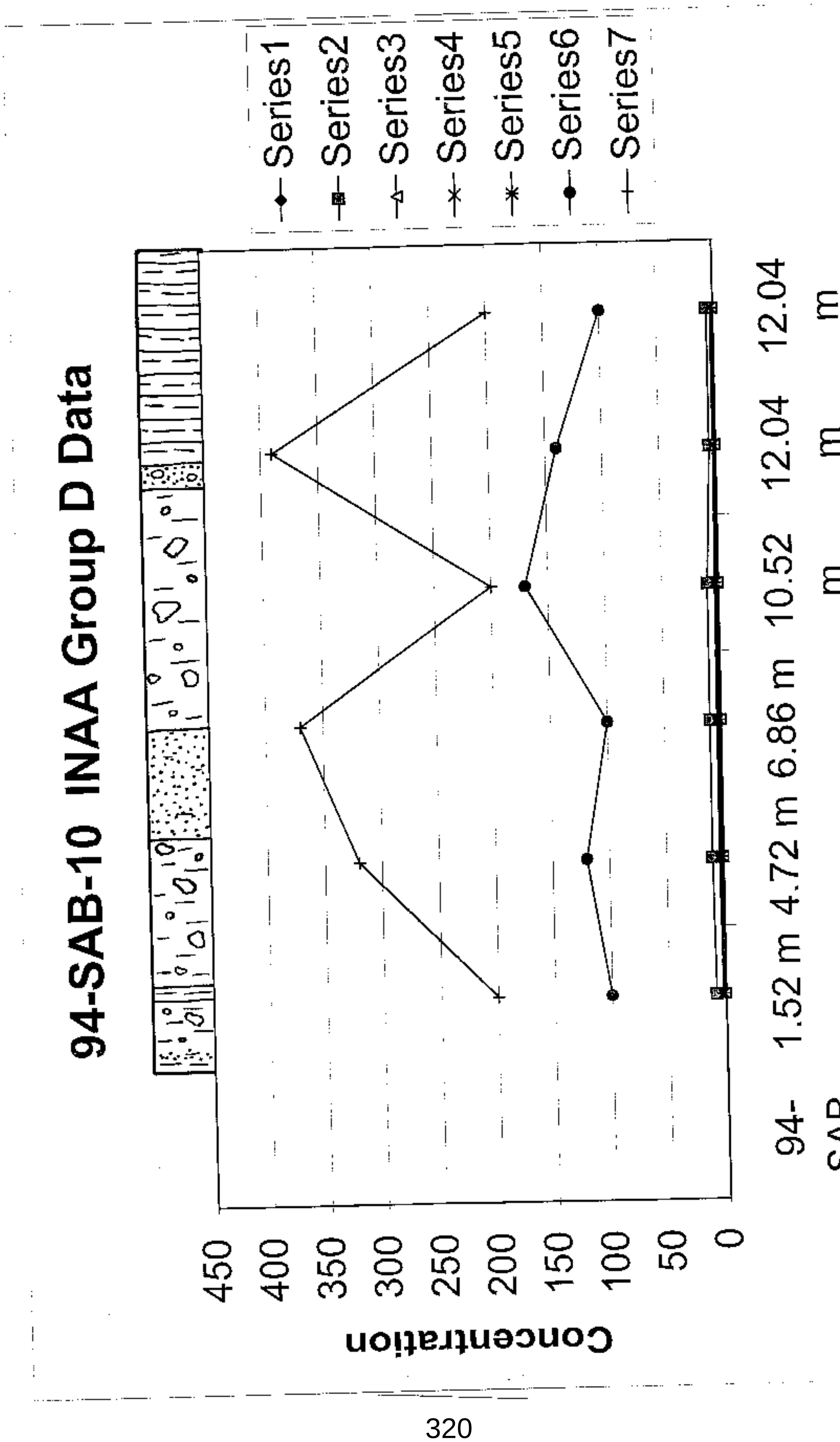


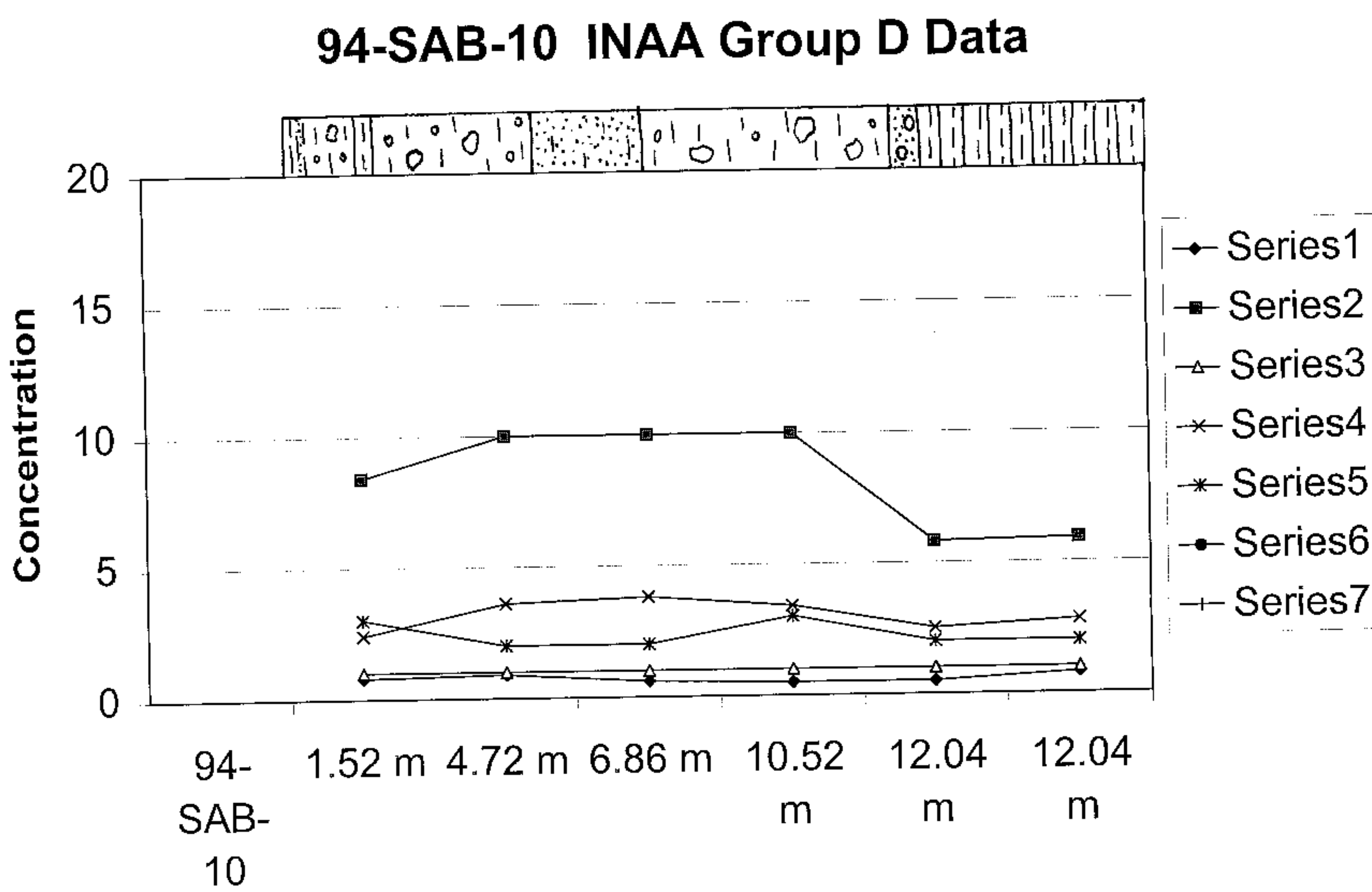
94-SAB-10 INAA Group B Data
Concentration
35
30
25
20
15
10
5
0
94-SAB-10
1.52 m
4.72 m
6.86 m
10.52 m
12.04 m
12.04 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7

94-SAB-10 INAA Group C Data

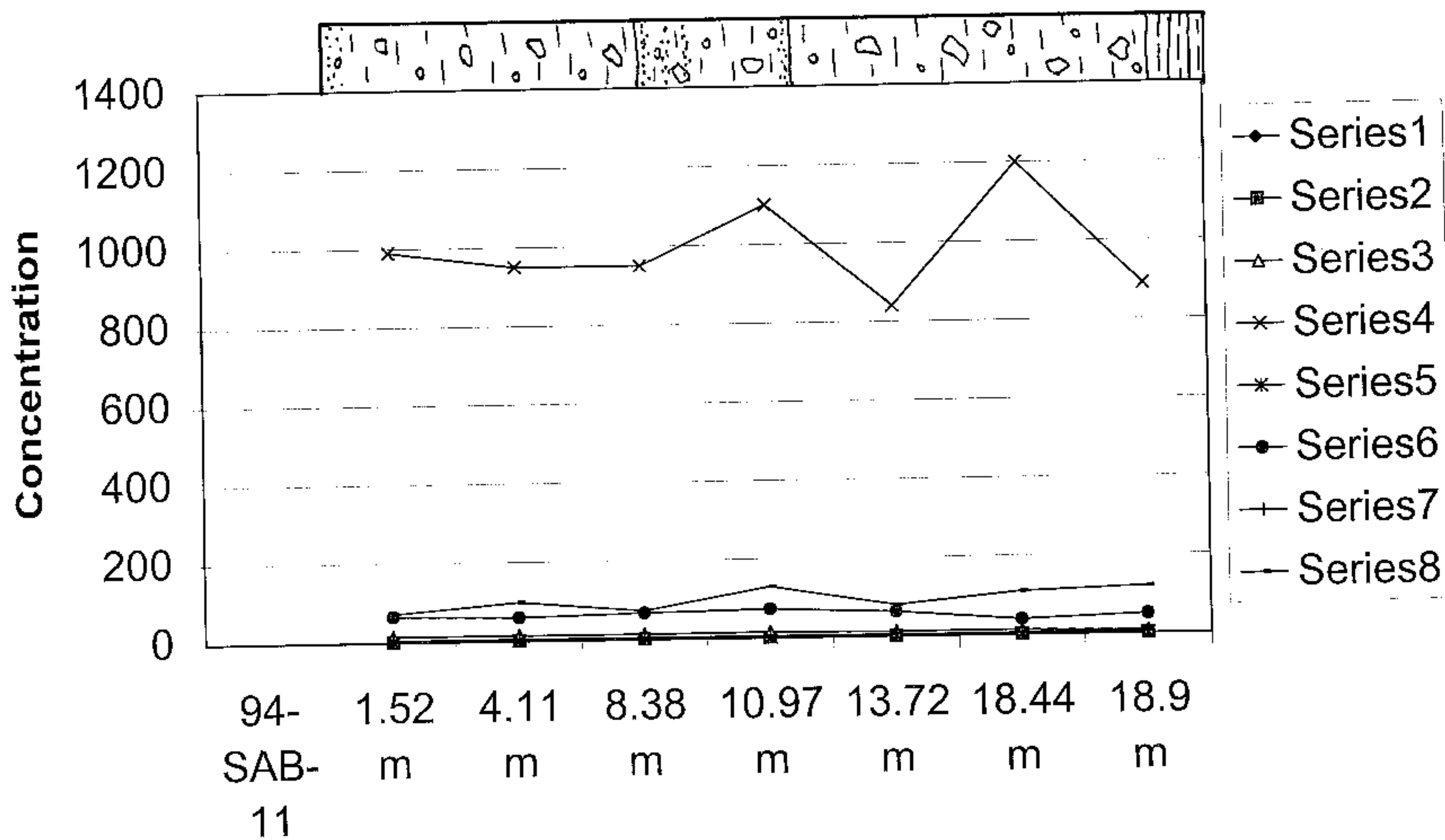


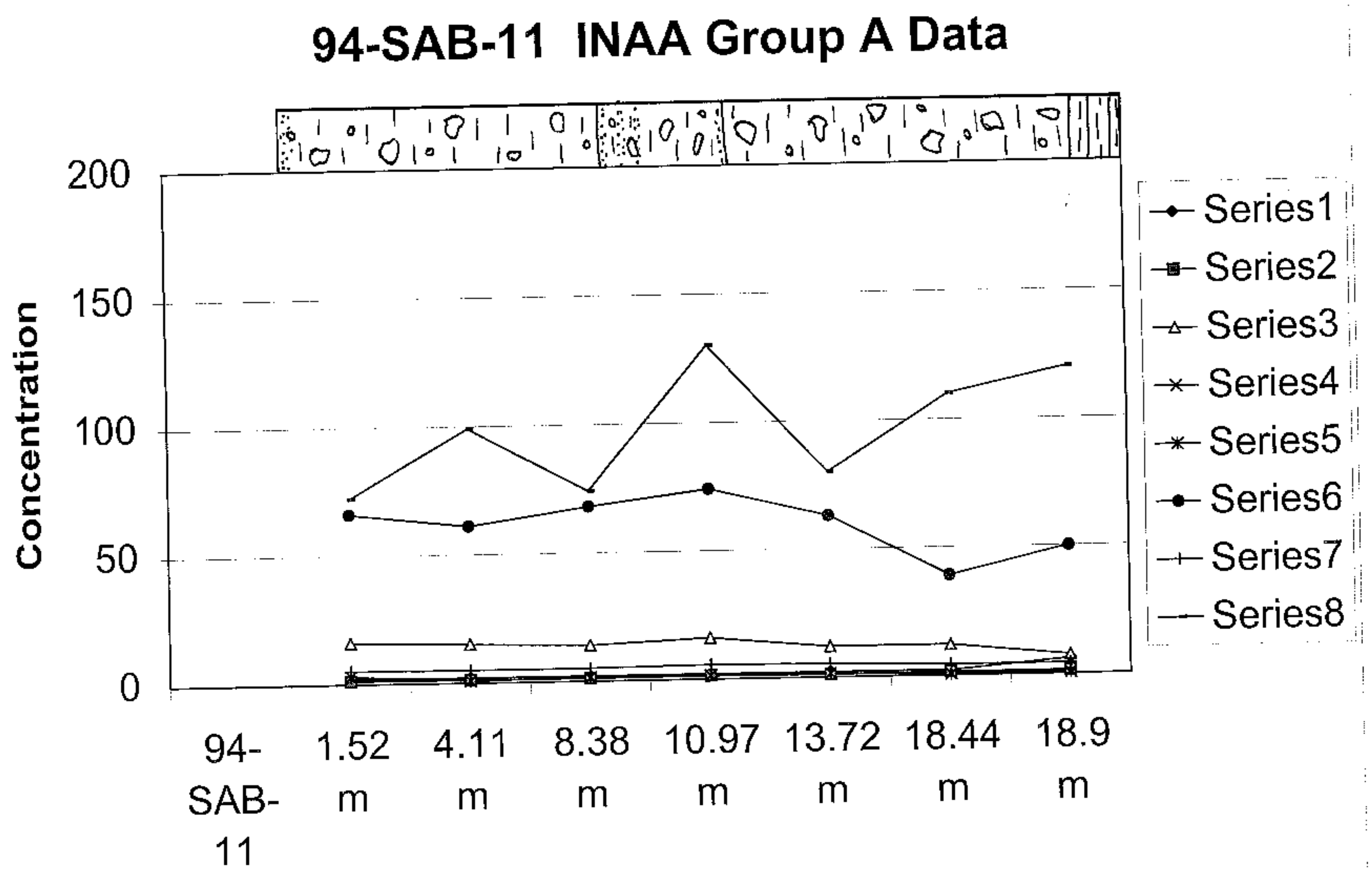

94-SAB-10 INAA Group C Data
Concentration
0
5
10
15
20
94-SAB-10
1.52 m
4.72 m
6.86 m
10.52 m
12.04 m
12.04 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7

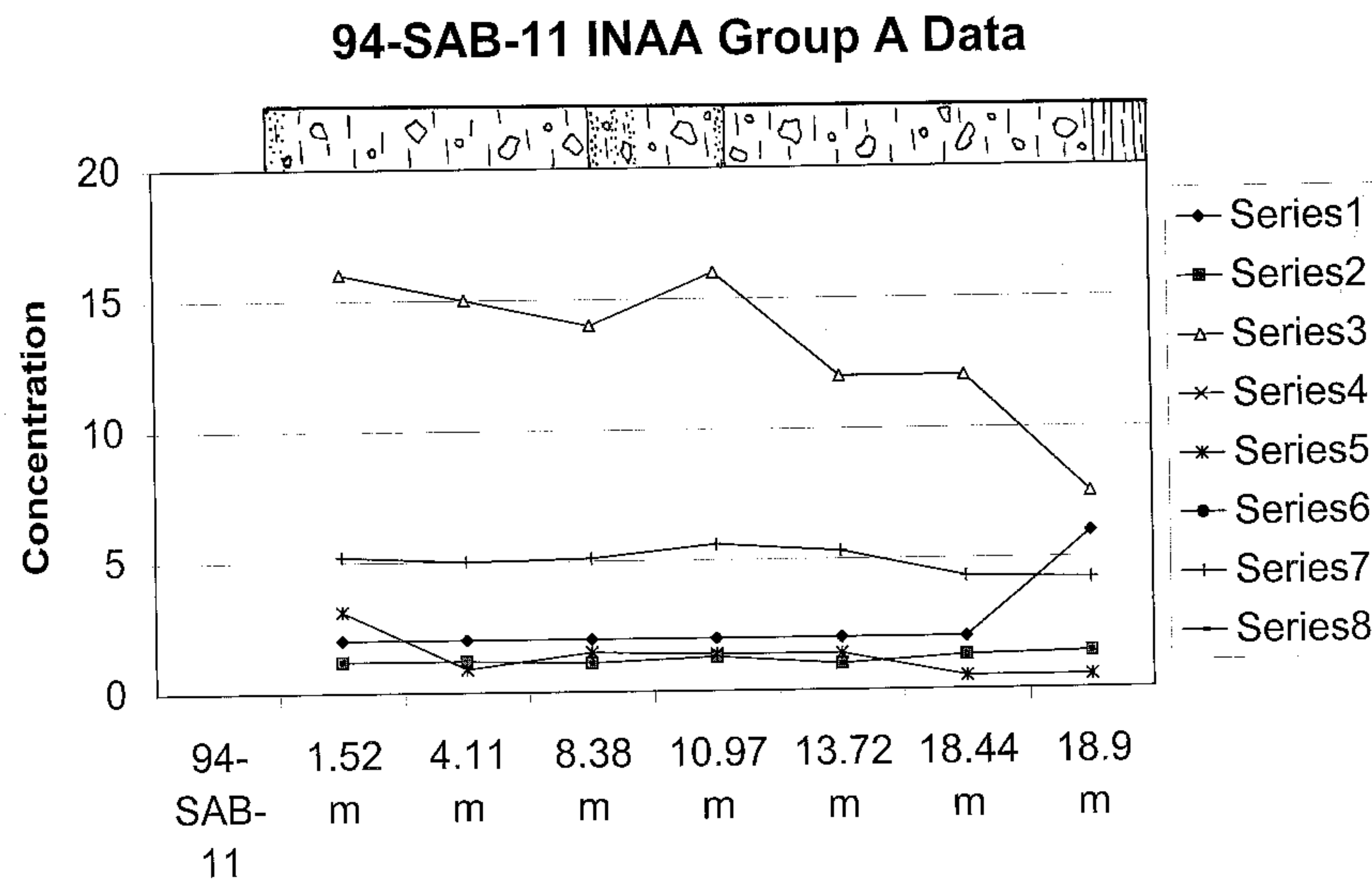

94-SAB-10 INAA Group D Data
Concentration
450
400
350
300
250
200
150
100
50
0
94-SAB-10
1.52 m
4.72 m
6.86 m
10.52 m
12.04 m
12.04 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7


94-SAB-10 INAA Group D Data
Concentration
20
15
10
5
0
94-SAB-10
1.52 m
4.72 m
6.86 m
10.52 m
12.04 m
12.04 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7

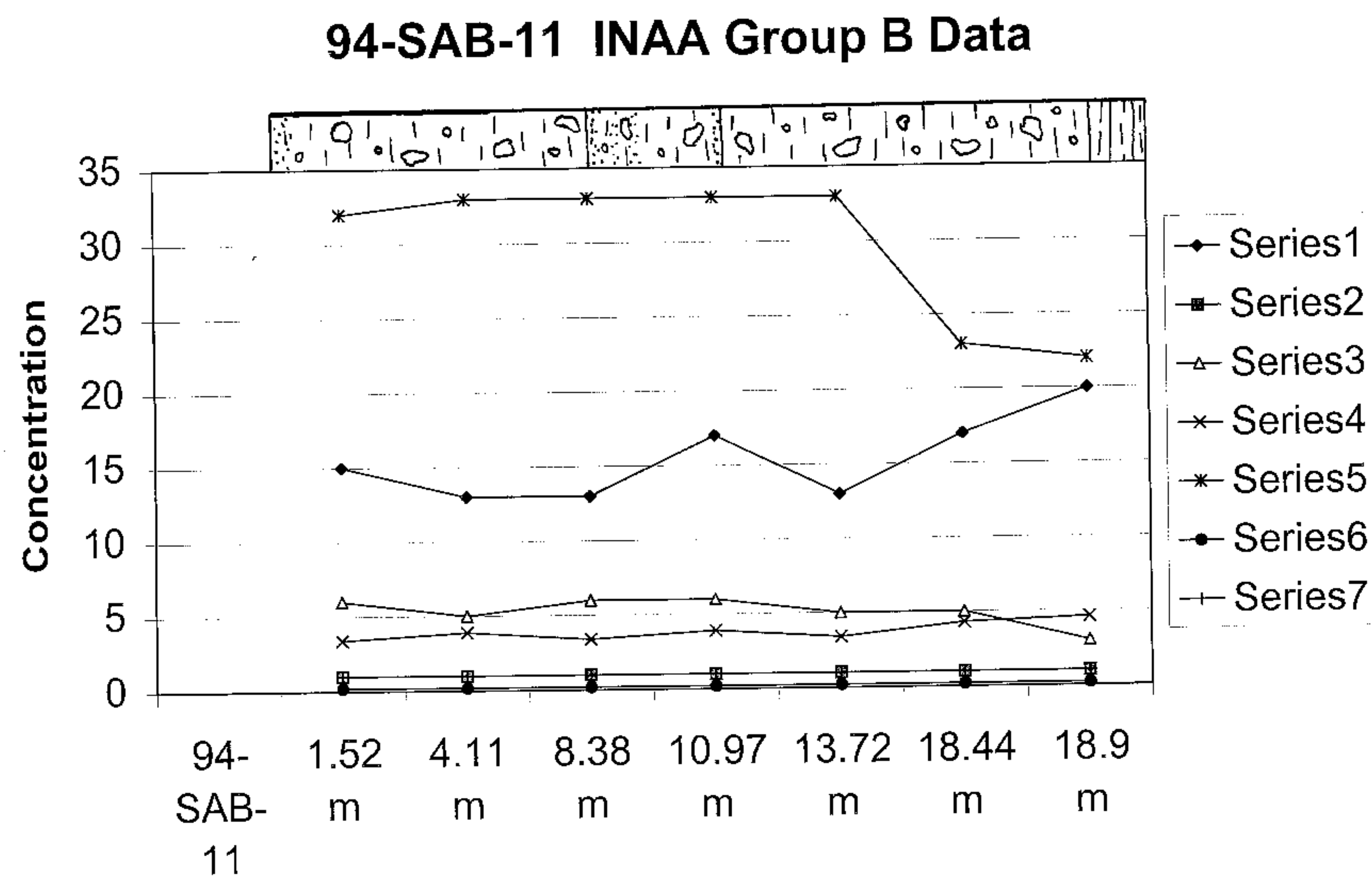
94-SAB-11 INAA Group A Data



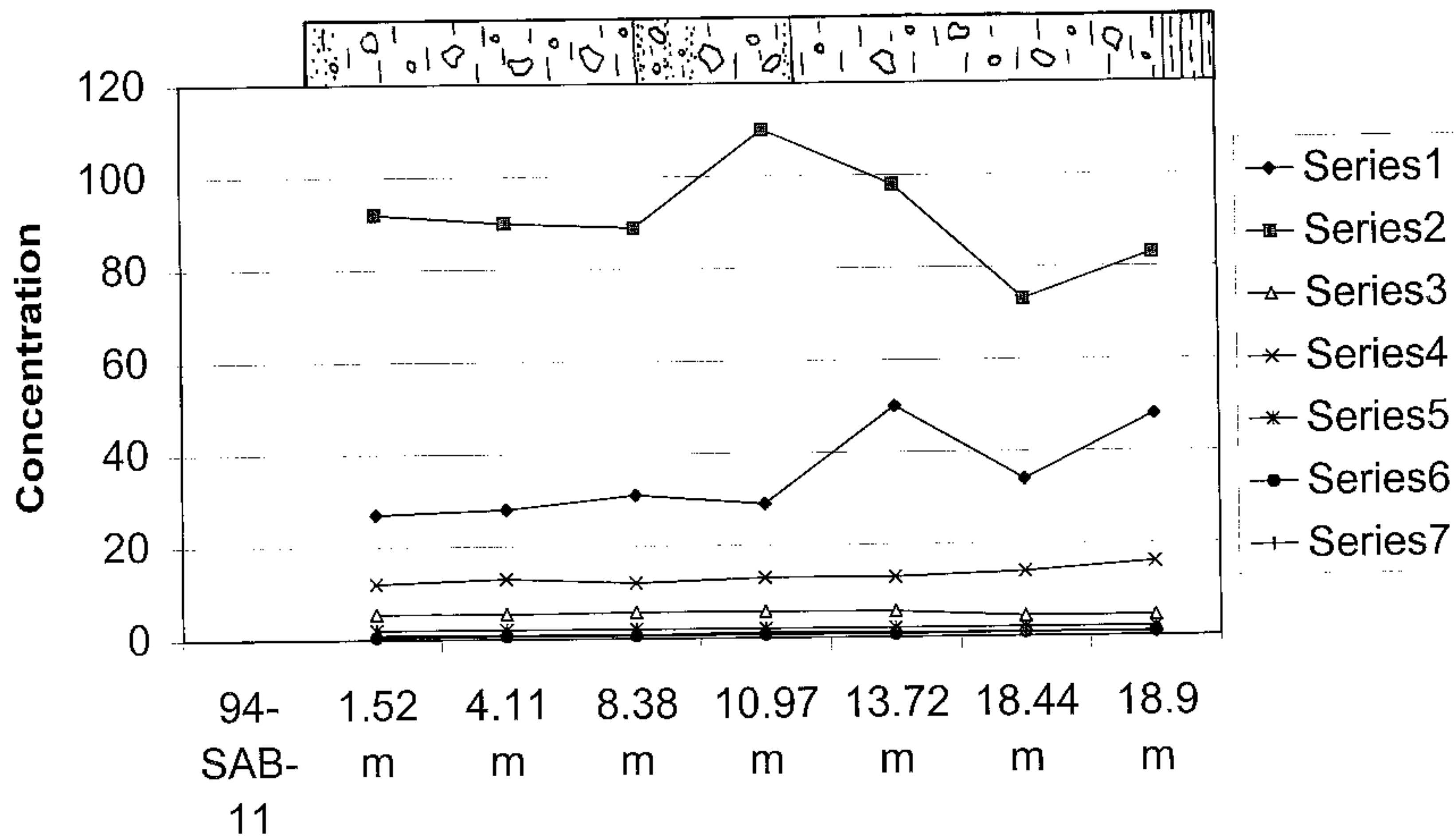

94-SAB-11 INAA Group A Data
Concentration
200
150
100
50
0
94-SAB-11
1.52 m
4.11 m
8.38 m
10.97 m
13.72 m
18.44 m
18.9 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Series8

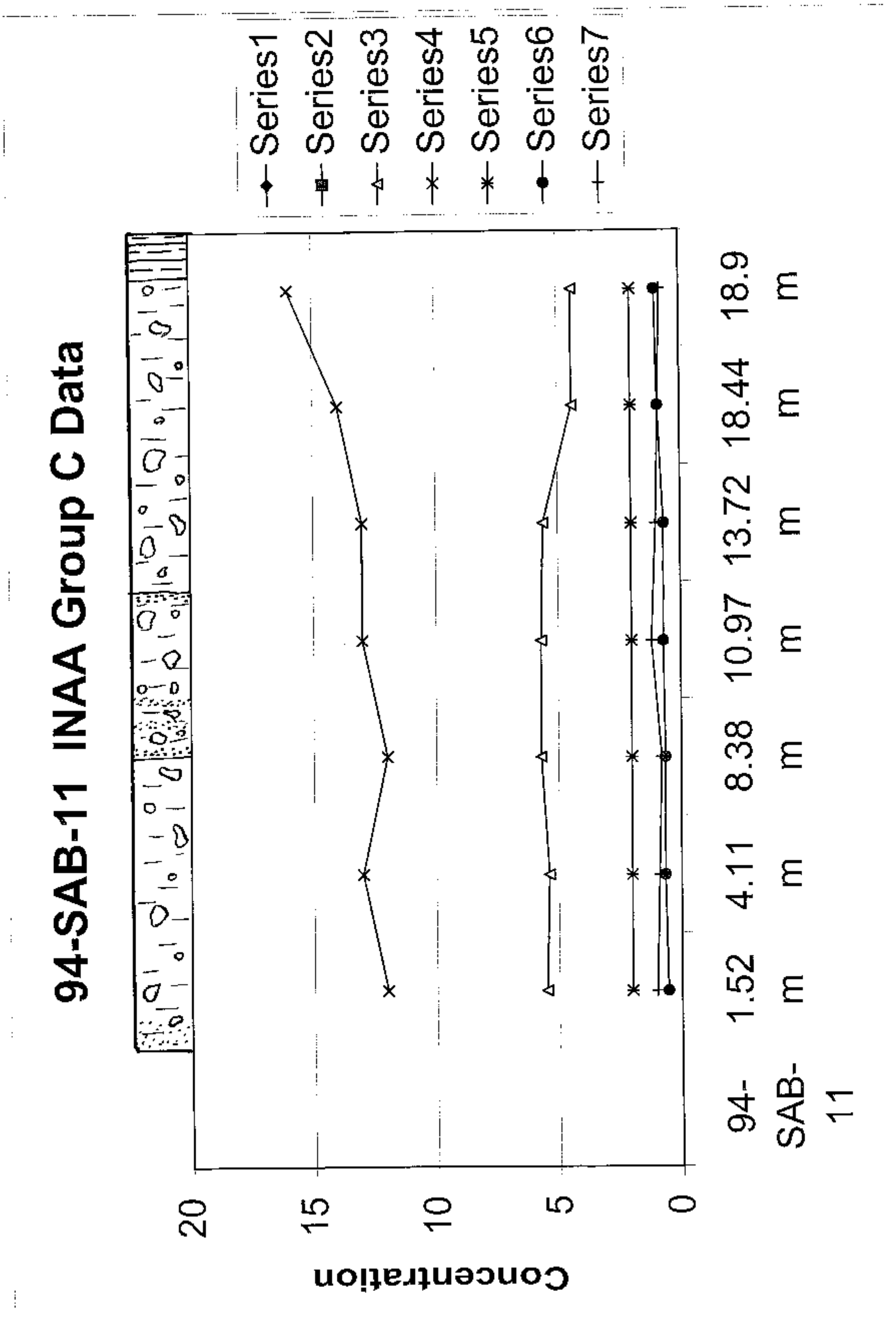


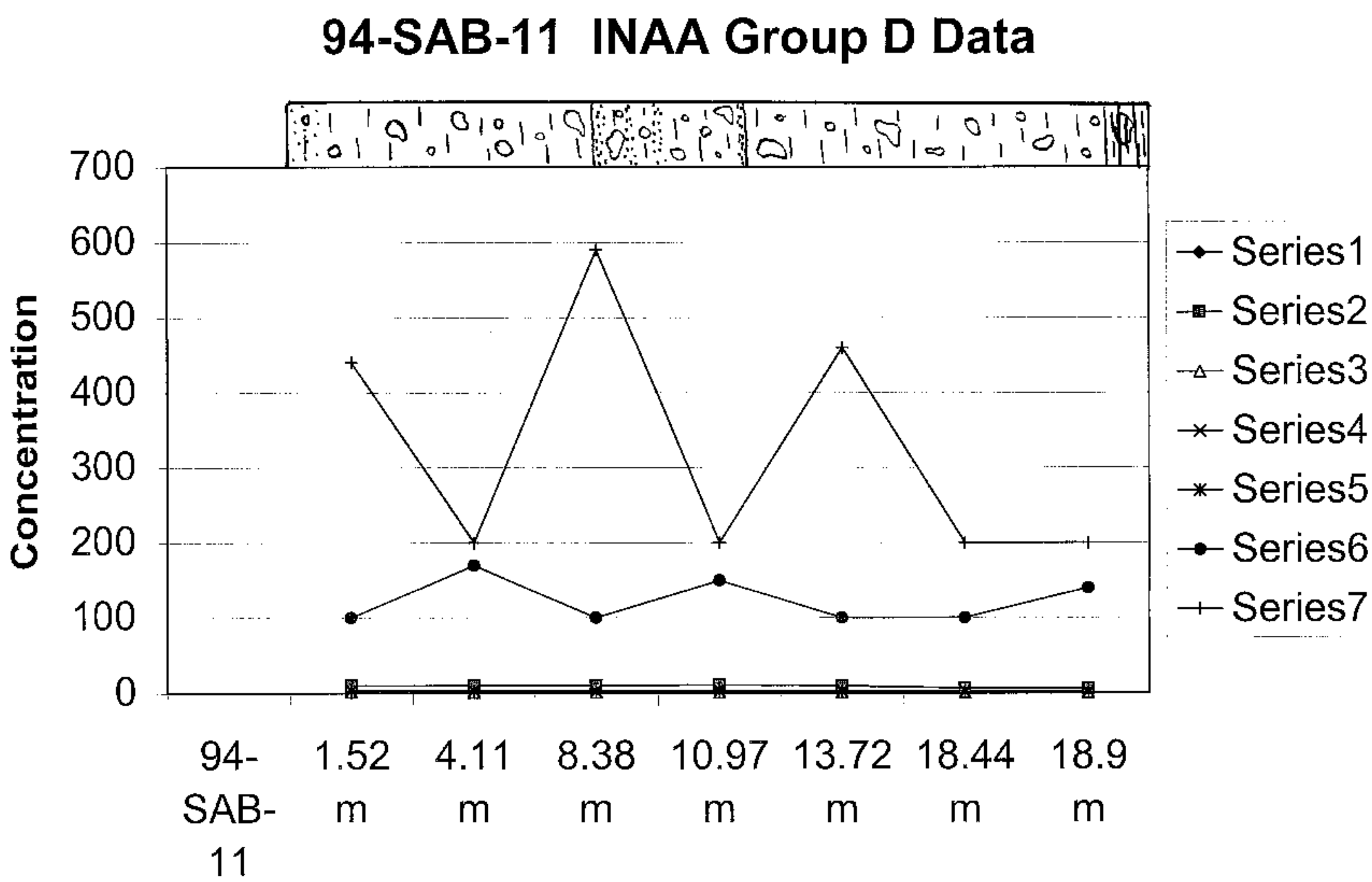
94-SAB-11 INAA Group A Data
Concentration
20
15
10
5
0
94-SAB-11
1.52 m
4.11 m
8.38 m
10.97 m
13.72 m
18.44 m
18.9 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Series8


94-SAB-11 INAA Group B Data
Concentration
35
30
25
20
15
10
5
0
94-SAB-11
1.52 m
4.11 m
8.38 m
10.97 m
13.72 m
18.44 m
18.9 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7

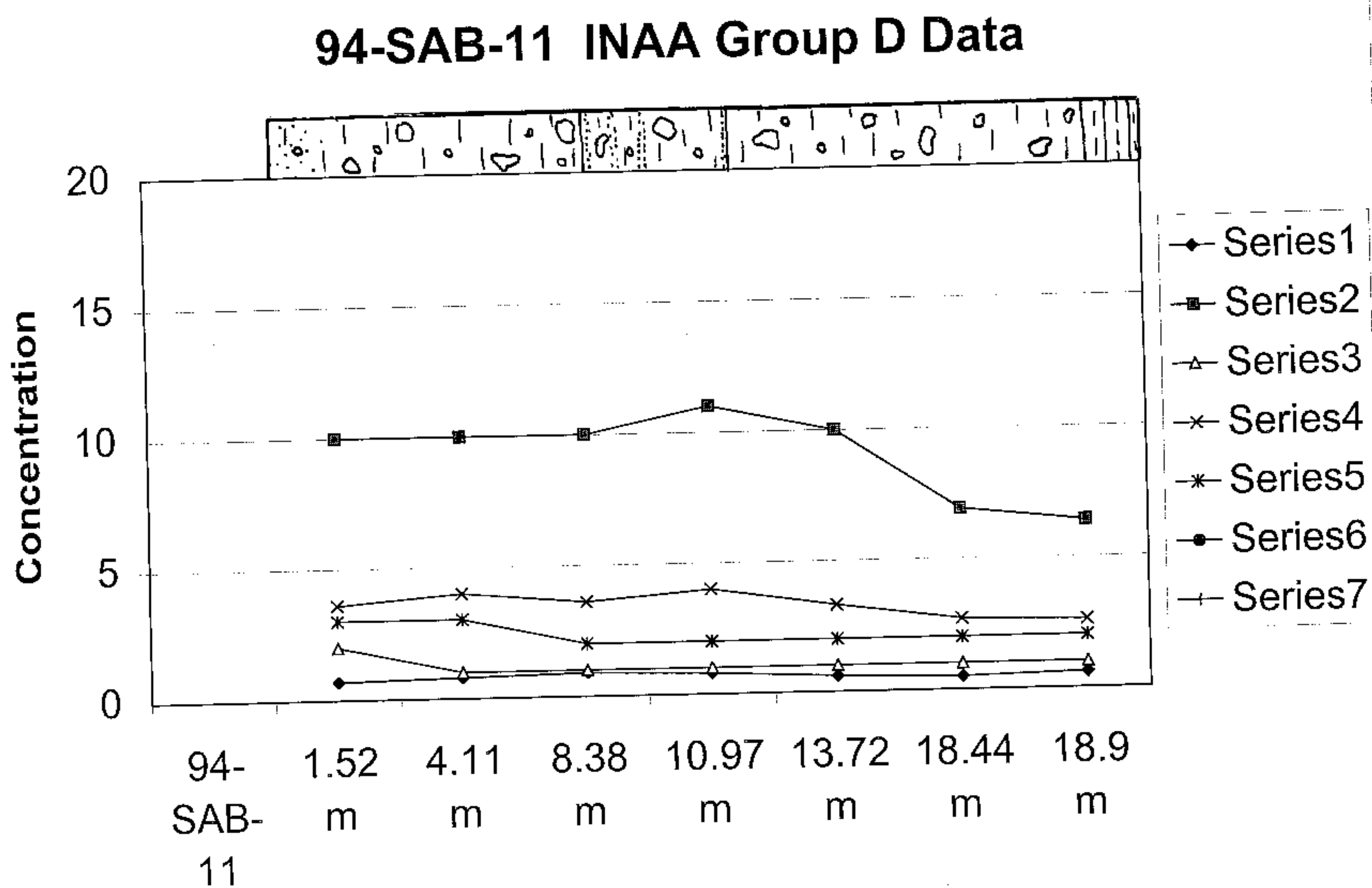
94-SAB-11 INAA Group C Data



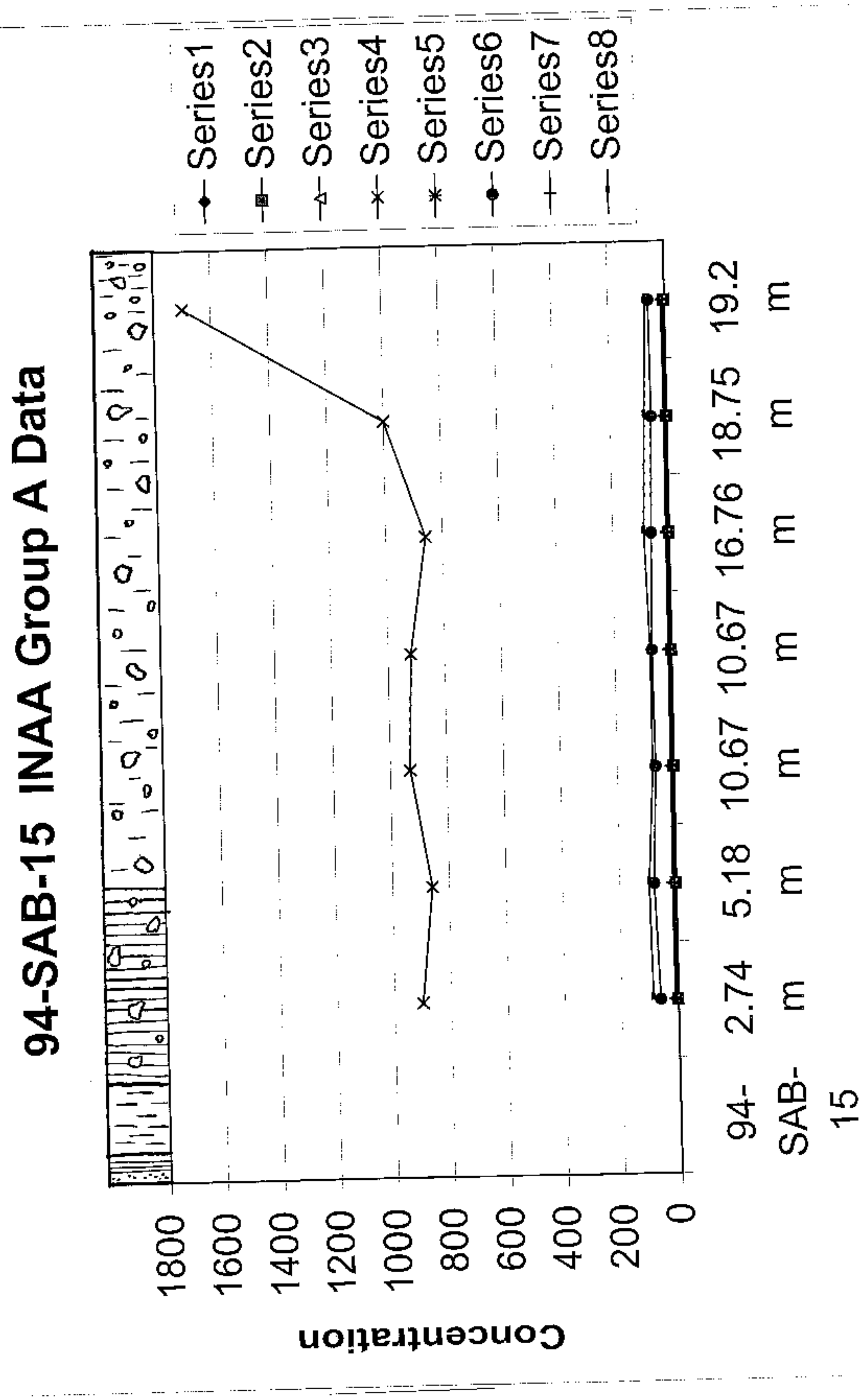

94-SAB-11 INAA Group C Data
Concentration
0
5
10
15
20
94-SAB-11
1.52 m
4.11 m
8.38 m
10.97 m
13.72 m
18.44 m
18.9 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7



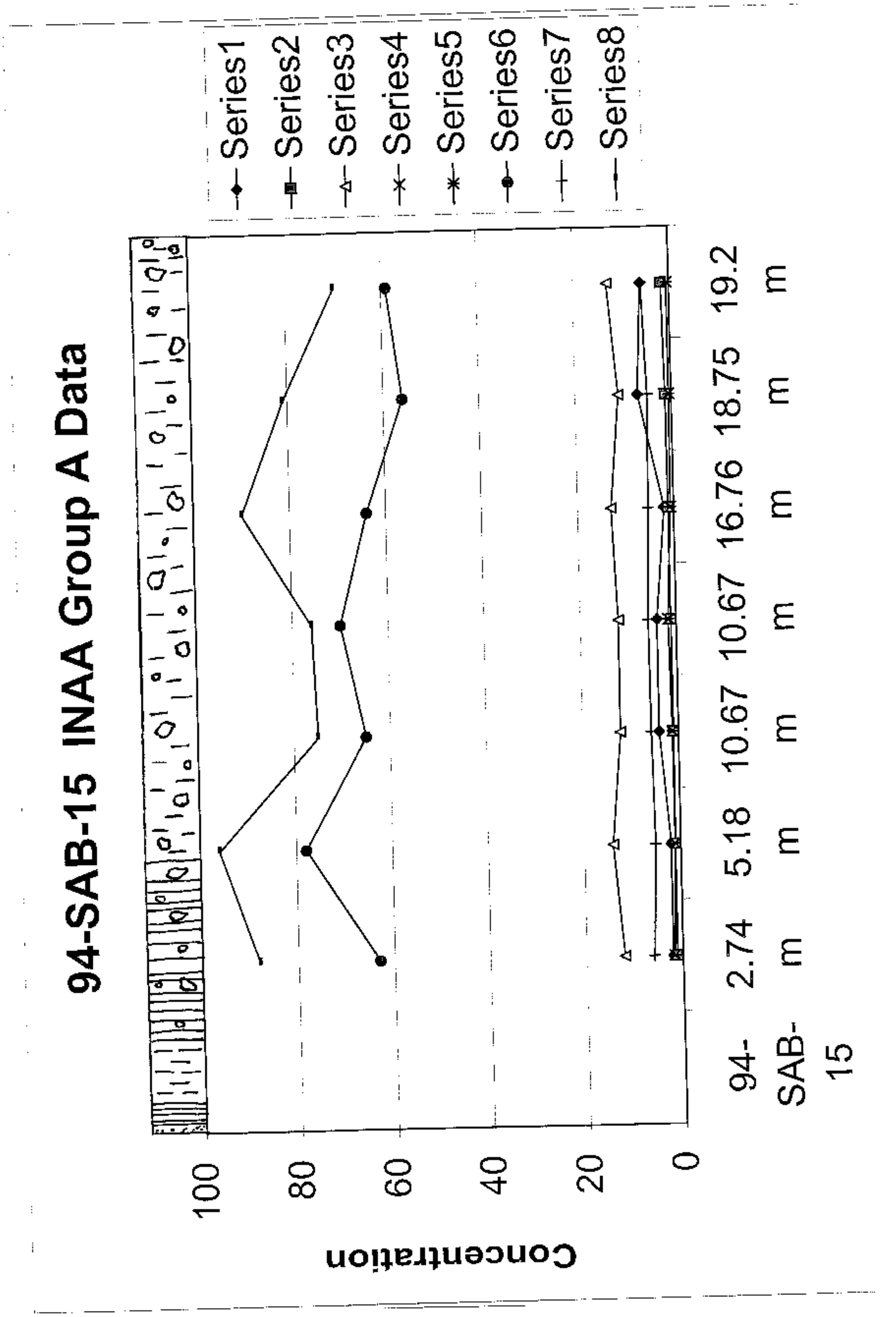
94-SAB-11 INAA Group D Data
Concentration
700
600
500
400
300
200
100
0
94-SAB-11
1.52 m
4.11 m
8.38 m
10.97 m
13.72 m
18.44 m
18.9 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7



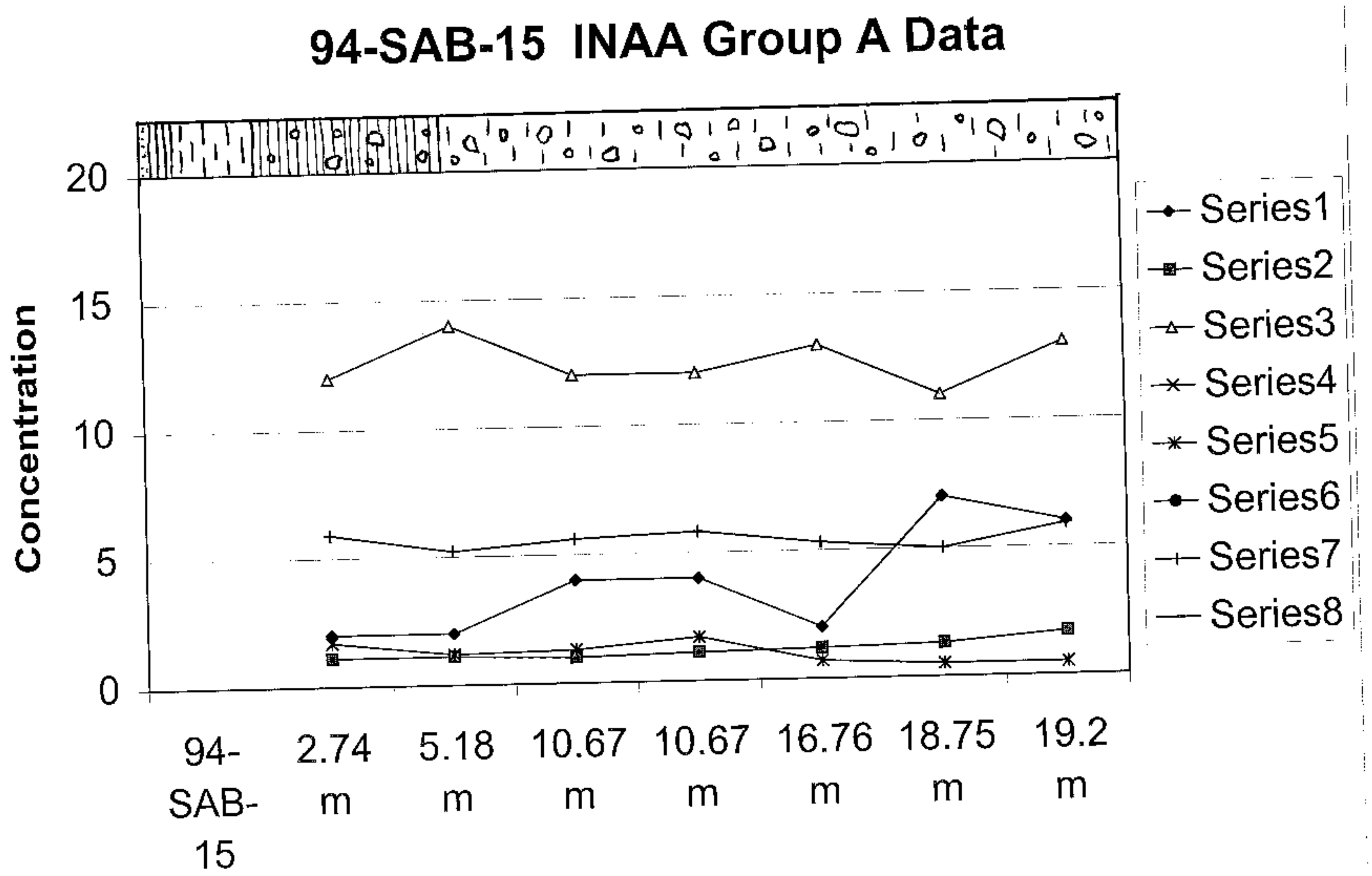
94-SAB-11 INAA Group D Data
Concentration
20
15
10
5
0
94-SAB-11
1.52 m
4.11 m
8.38 m
10.97 m
13.72 m
18.44 m
18.9 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7

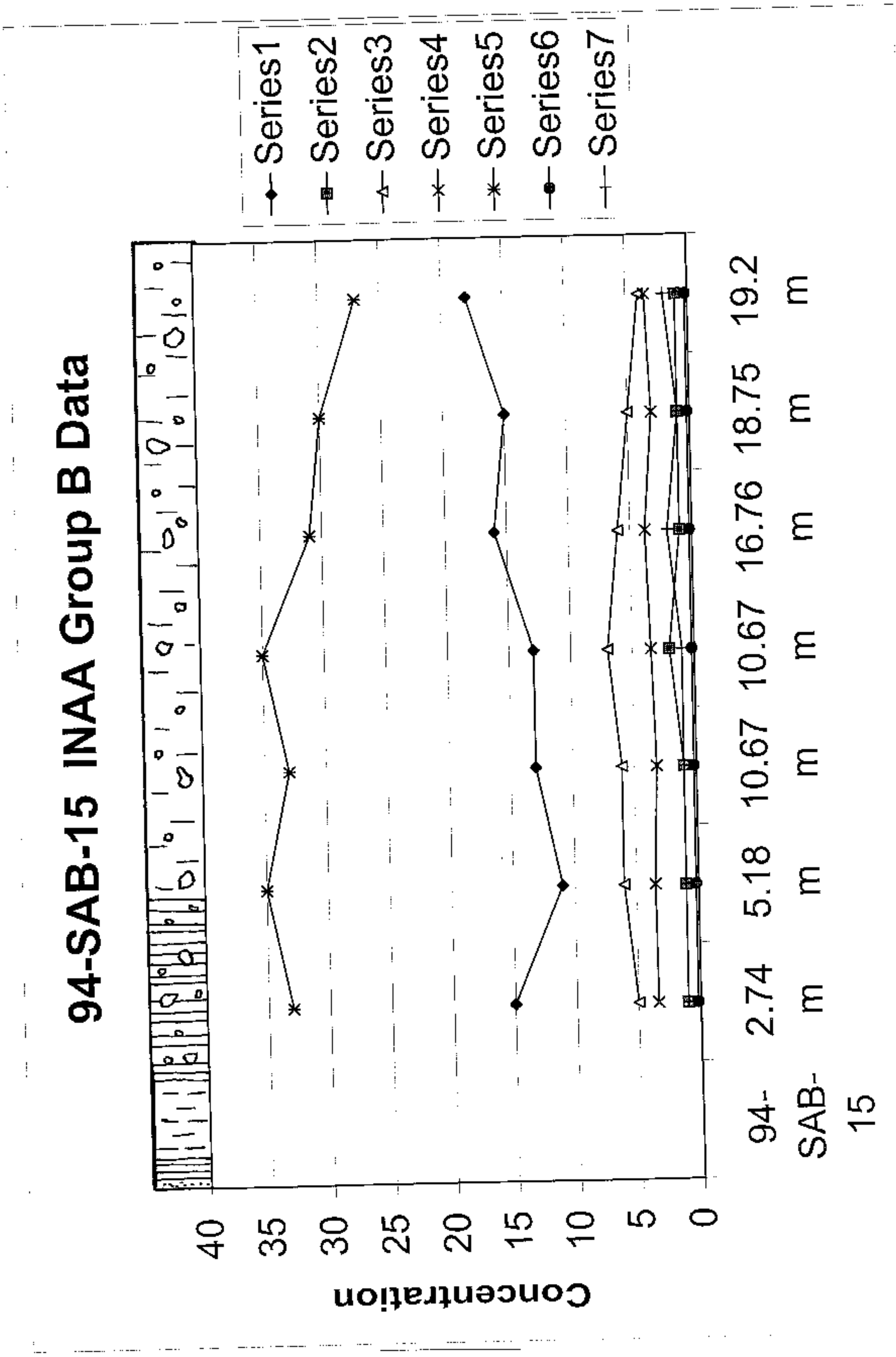


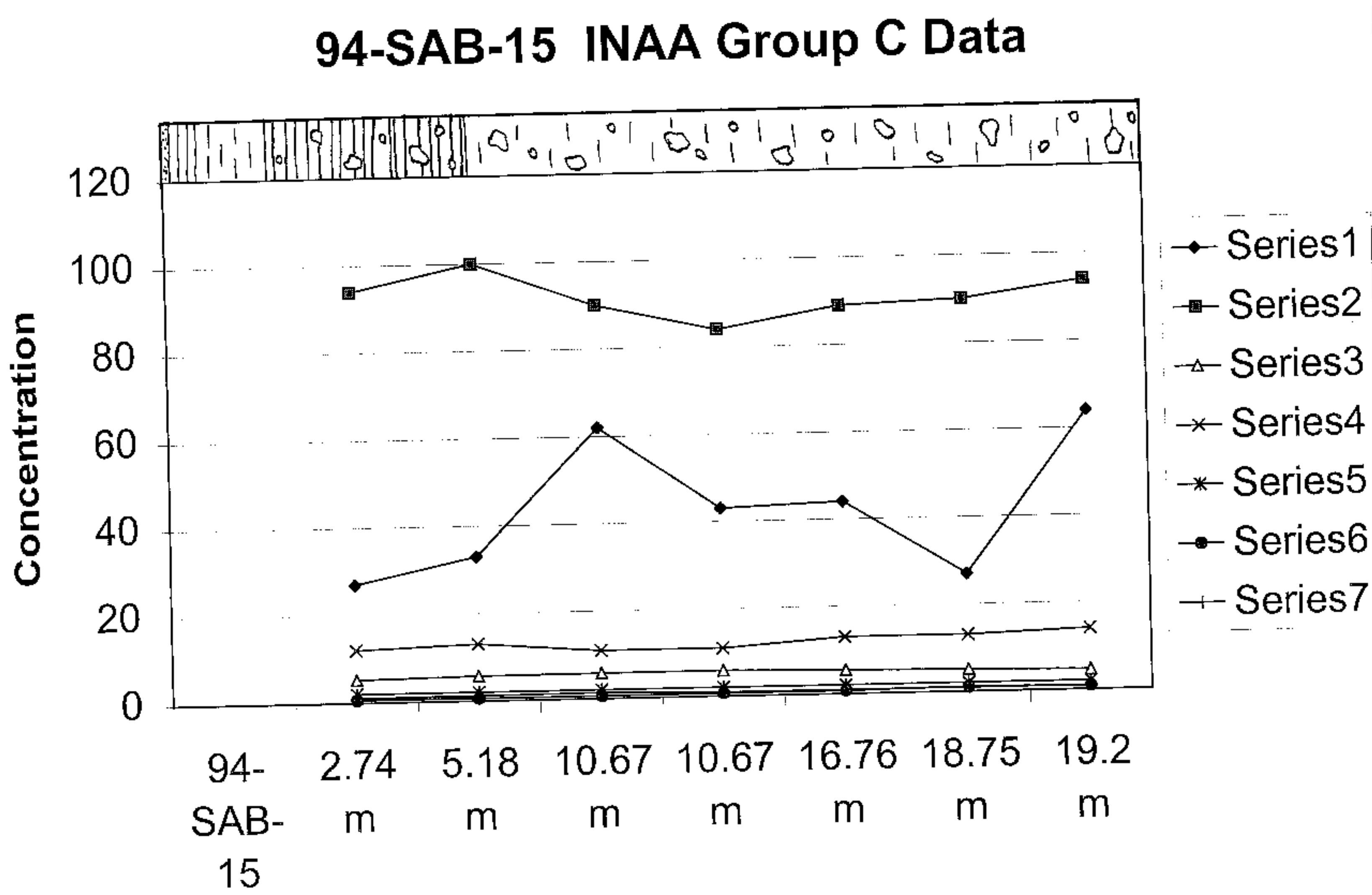
94-SAB-15 INAA Group A Data
Concentration
1800
1600
1400
1200
1000
800
600
400
200
0
94-SAB-15
2.74 m
5.18 m
10.67 m
10.67 m
16.76 m
18.75 m
19.2 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Series8

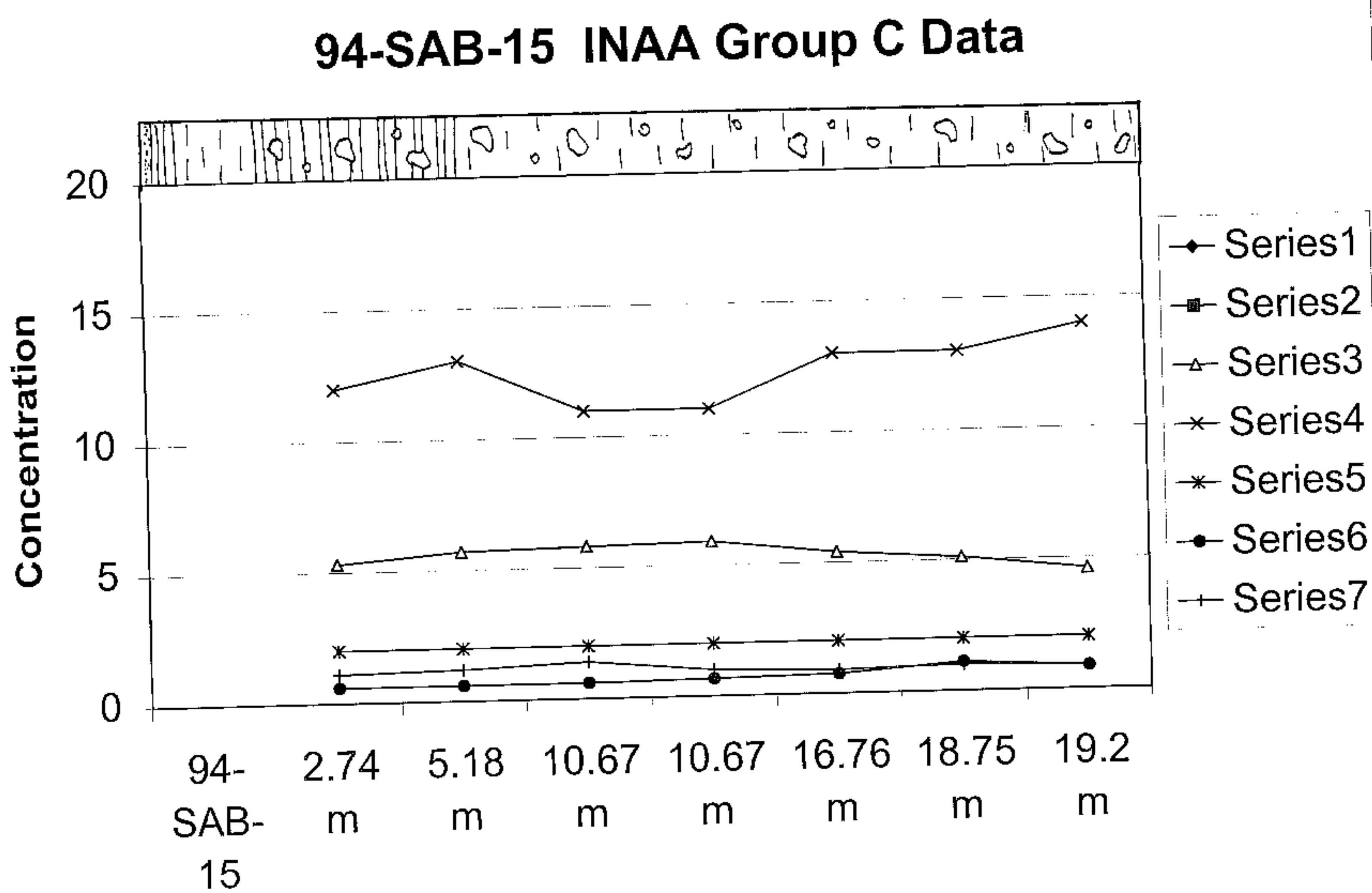


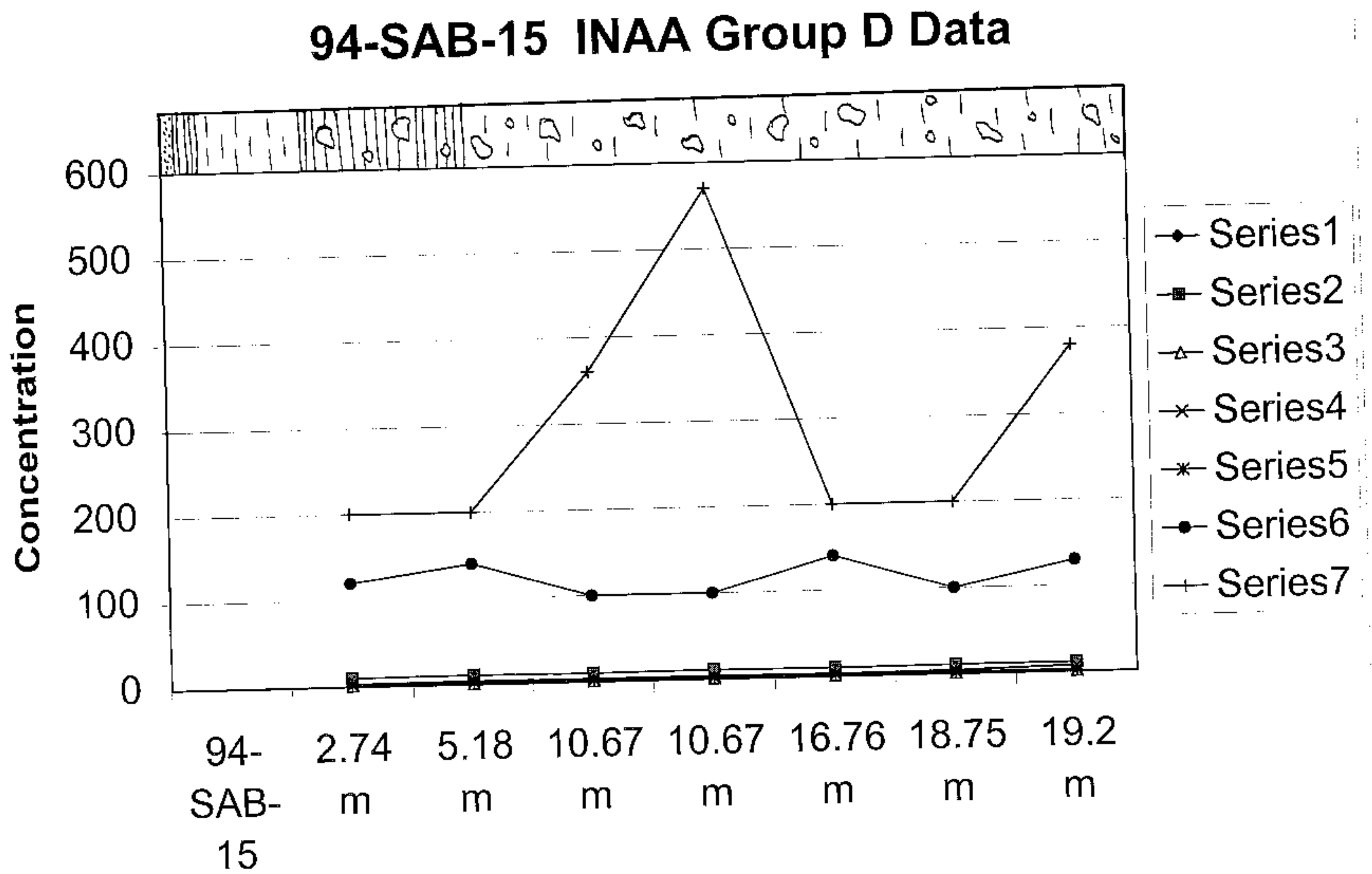
94-SAB-15 INAA Group A Data
Concentration
0
20
40
60
80
100
94-SAB-15
2.74 m
5.18 m
10.67 m
10.67 m
16.76 m
18.75 m
19.2 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Series8

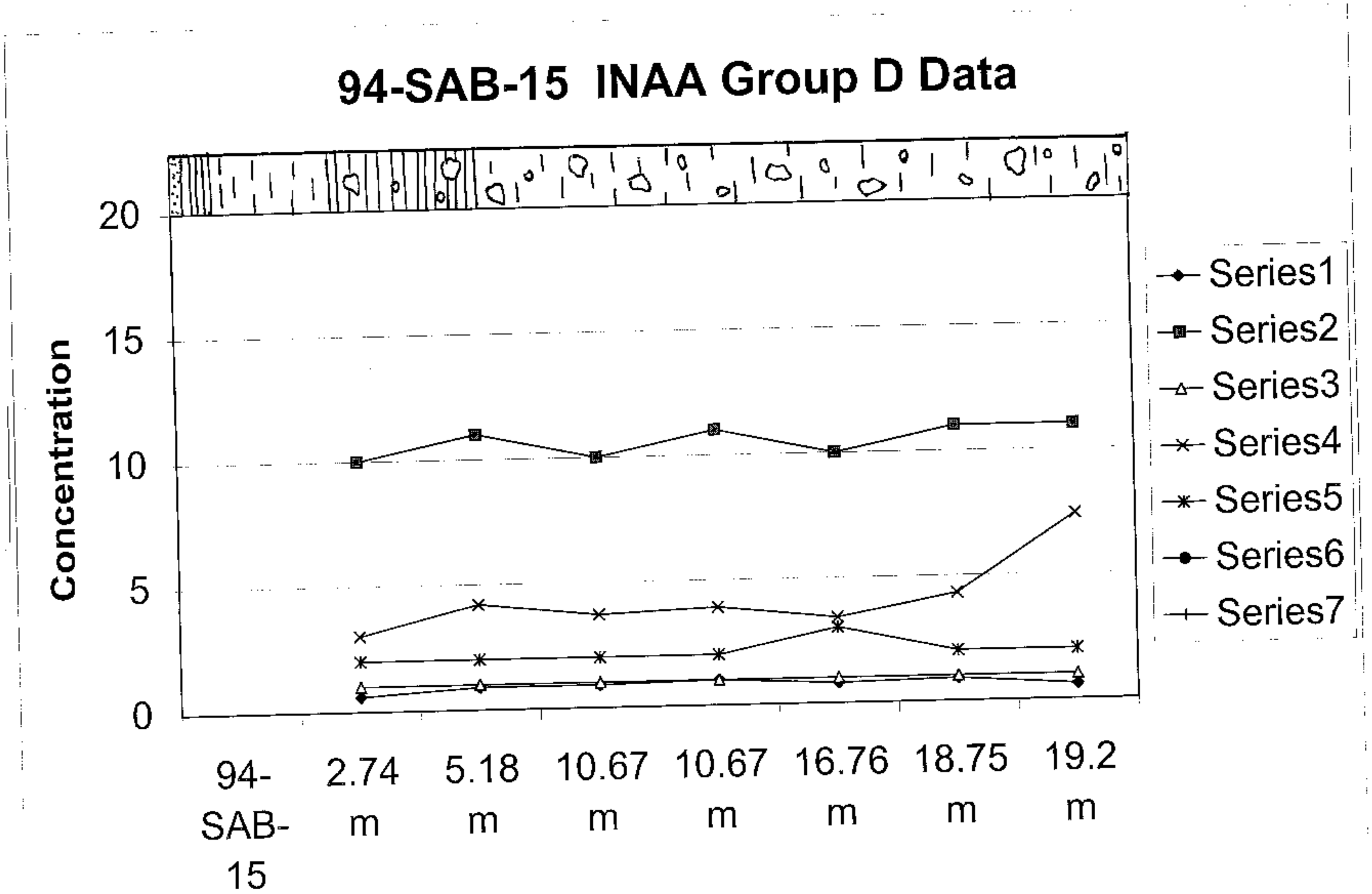

94-SAB-15 INAA Group A Data
Concentration
20
15
10
5
0
94-SAB-15
2.74 m
5.18 m
10.67 m
10.67 m
16.76 m
18.75 m
19.2 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Series8


94-SAB-15 INAA Group B Data
Concentration
0
5
10
15
20
25
30
35
40
94-SAB-15
2.74 m
5.18 m
10.67 m
10.67 m
16.76 m
18.75 m
19.2 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7

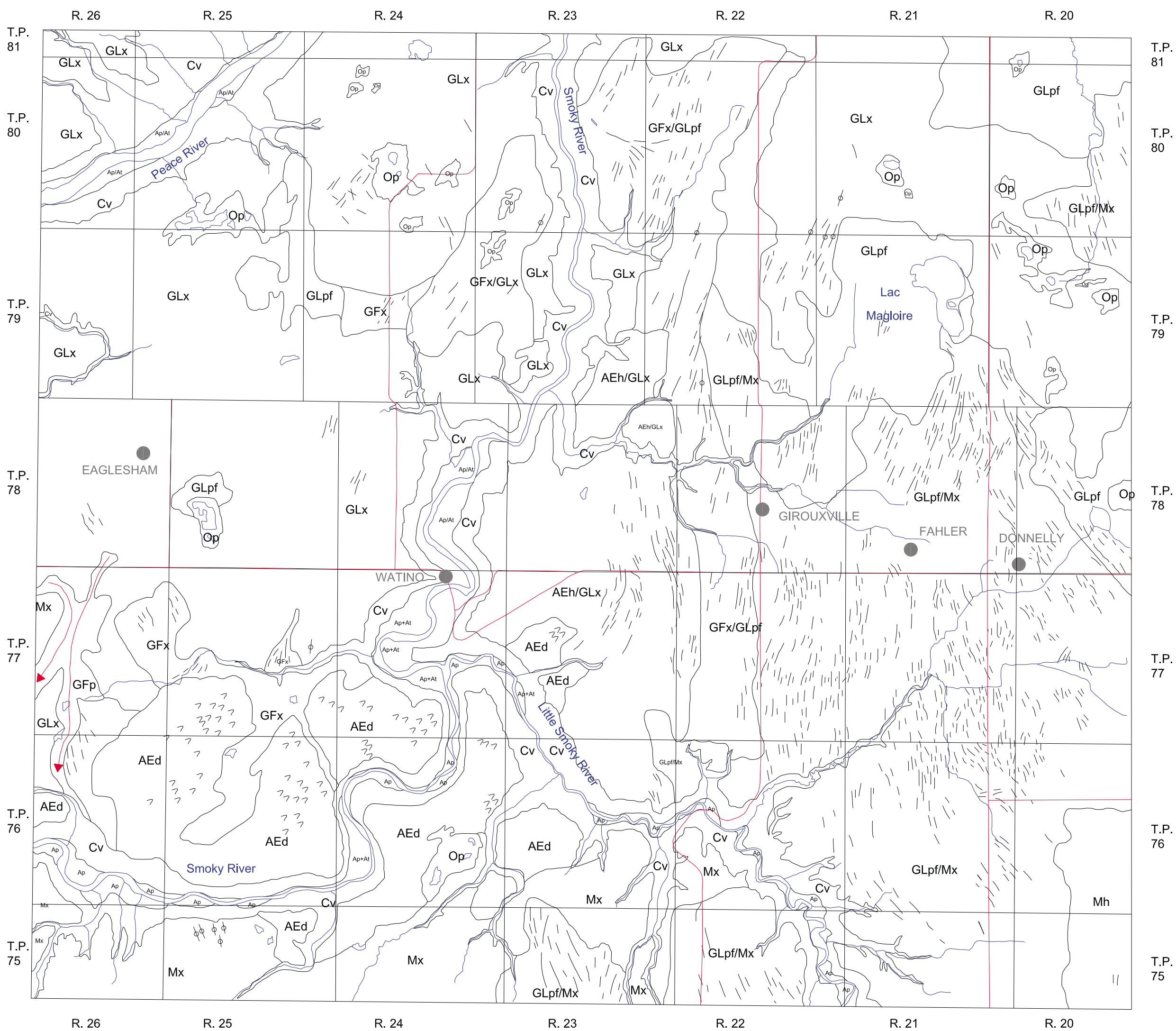

94-SAB-15 INAA Group C Data
Concentration
120
100
80
60
40
20
0
94-SAB-15
2.74 m
5.18 m
10.67 m
10.67 m
16.76 m
18.75 m
19.2 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7


94-SAB-15 INAA Group C Data
Concentration
20
15
10
5
0
94-SAB-15
2.74 m
5.18 m
10.67 m
10.67 m
16.76 m
18.75 m
19.2 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7


94-SAB-15 INAA Group D Data
Concentration
600
500
400
300
200
100
0
94-SAB-15
2.74 m
5.18 m
10.67 m
10.67 m
16.76 m
18.75 m
19.2 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7


94-SAB-15 INAA Group D Data
Concentration
20
15
10
5
0
94-SAB-15
2.74 m
5.18 m
10.67 m
10.67 m
16.76 m
18.75 m
19.2 m
Series1
Series2
Series3
Series4
Series5
Series6
Series7

N



LEGEND

Op — ORGANIC DEPOSITS: Swamps, fens, sedge marshes and peat bogs deposited in shallow depressions and poorly drained areas.

A — ALLUVIAL DEPOSITS: Predominantly moderately sorted sand, silt and gravel deposited as channel fill bars and floodplains along present river level (Ap); terraces, paired and unpaired may be present (At); includes reworked material from slump faces.

Cv — COLLUVIAL DEPOSITS: Silt, clay, sand, gravel, till and bedrock deposited along steep valley flanks as slumps, gently undulating, scalloped hummocks and ridges.

AE — AEOLIAN DEPOSITS: Moderately to well-sorted sand, minor silt; form parabolic to irregular dune fields and hummocks; variable in thickness from <2m to >10m.

- AEd — Forested dune fields with abundant organics; parabolic to irregular in shape; relief up to 7.5m.
- AEh — Primarily fine sand and silt; irregular dunes and modified ice-contact stagnation ridges and hummocks; kettled, relief up to 3m.

GL — GLACIOLACUSTRINE DEPOSITS: Massive to laminated silt and clay, minor sands; occasional dropstones; generally flat, fluted, ridged or hummocky; relief up to 2.5m.

- GLpf — Flat plains with flutes and ridges; relief generally <2m; poorly drained; numerous ponds.
- GLx — Varies between flat, fluted, ridged to hummocky; relief up to 2m; poorly drained; many ponds.

GF — GLACIOFLUVIAL DEPOSITS: Sand, gravel and silt; minor clay and till; depositedd at the margin of, within or under glacial ice; kames, streamlined ridges, hummocks, eskers and outwash plains; variable in thickness.

- GFp — Outwash and meltwater channels; moderately sorted sand, minor clay and silt; relief generally flat; moderately to well drained; thickness may exceed 30m.
- GFx — Ice-contact landforms; eskers, kames, streamlined ridges and hummocks; relief up to 5m; thickness variable.

M — MORAINAL DEPOSITS: Predominantly ablation with some basal till; local pockets of glaciolacustrine, aeolian, alluvial and organic deposits; subdued to ridged and hummocky; relief up to 10m; thickness varies from <2.5m to >43m; moderate to poor drainage; ponding common.

- Mx — Ranges from flat to ridged to hummocky; mixed basal, englacial and ablation till; relief up to 10m.
- Mh — Hummocky to kettled; predominantly ablation till, some basal; relief up to 10m; ponding common.
- Mpd — Prairie mounds/doughnuts; relief up to 10m; predominantly ablation, some englacial till; ponding around and in centres of mounds.

R — BEDROCK: Exposed in river cuts and as thrusted slabs. Lithology dependent upon location.

SYMBOLS

- Geological boundary
- Dunes
- Drumlinoids
- Flutes, ridges, elongated hummocks
- Meltwater channel
- Fahler — Town, hamlet; identifier
- Provincial highway
- Drainage

S.A. BALZER, P.GEOL.

WINAGAMI 83N NORTHWEST QUARTER

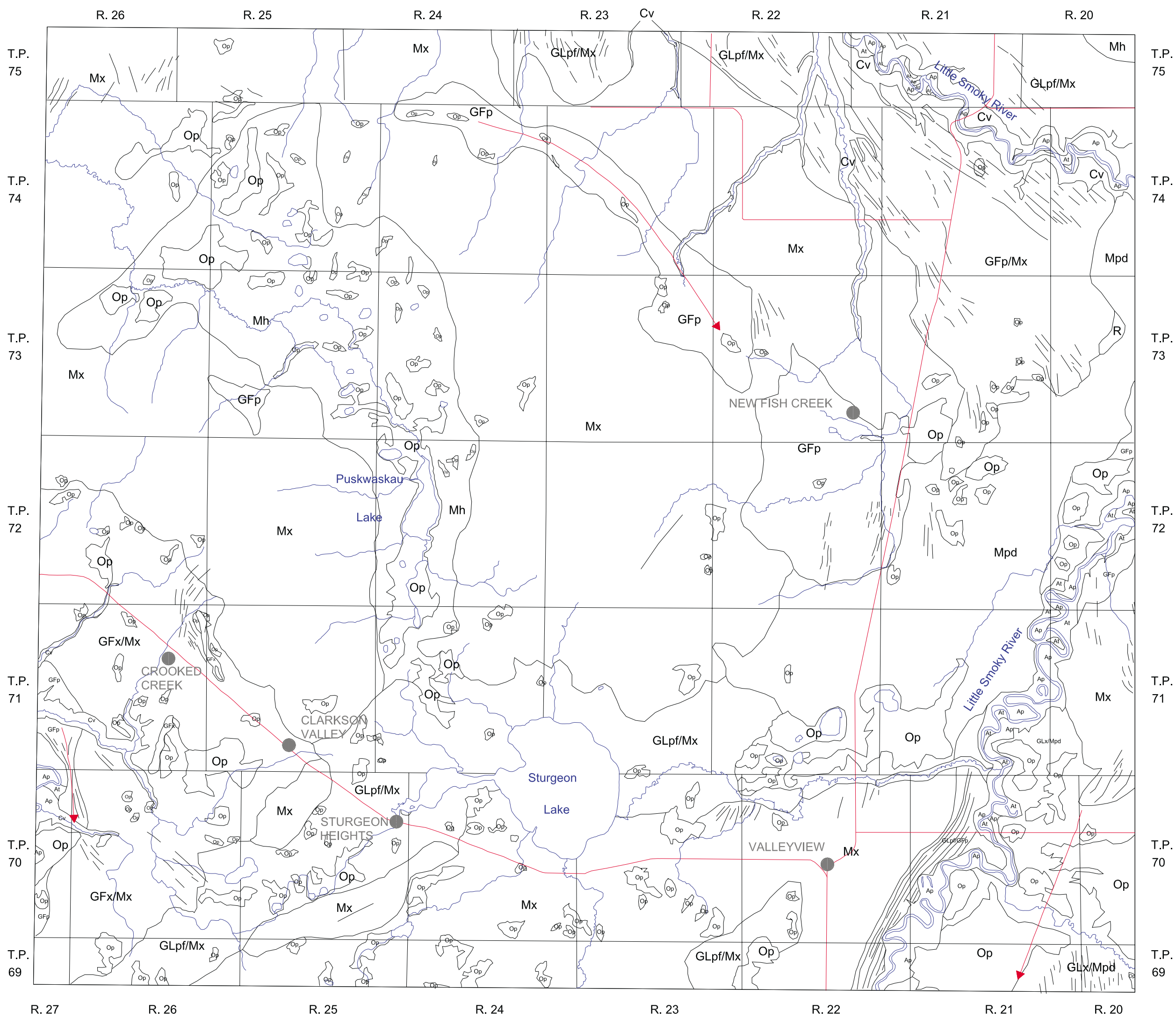
SURFICIAL GEOLOGY

SCALE 0 — 5 KILOMETRES

1:100,000

EDMONTON, ALBERTA MARCH, 1999

MAP 1



LEGEND

Op	ORGANIC DEPOSITS: Swamps, fens, sedge marshes and peat bogs deposited in shallow depressions and poorly drained areas.
A	ALLUVIAL DEPOSITS: Predominantly moderately sorted sand, silt and gravel deposited as channel fill bars and floodplains along present river level (Ap); terraces, paired and unpaired may be present (At); includes reworked material from slump faces.
Cv	COLLUVIAL DEPOSITS: Silt, clay, sand, gravel, till and bedrock deposited along steep valley flanks as slumps, gently undulating, scalloped hummocks and ridges.
AE	AEOLIAN DEPOSITS: Moderately to well-sorted sand, minor silt; form parabolic to irregular dune fields and hummocks; variable in thickness from <2m to >10m.
AEd	Forested dune fields with abundant organics; parabolic to irregular in shape; relief up to 7.5m.
AEh	Primarily fine sand and silt; irregular dunes and modified ice-contact stagnation ridges and hummocks; kettled, relief up to 3m.
GL	GLACIOLACUSTRINE DEPOSITS: Massive to laminated silt and clay, minor sands; occasional dropstones; generally flat, fluted, ridged or hummocky; relief up to 2.5m.
GLpf	Flat plains with flutes and ridges; relief generally <2m; poorly drained; numerous ponds.
GLx	Varies between flat, fluted, ridged to hummocky; relief up to 2m; poorly drained; many ponds.
GF	GLACIOFLUVIAL DEPOSITS: Sand, gravel and silt; minor clay and till; depositedd at the margin of, within or under glacial ice; kames, streamlined ridges, hummocks, eskers and outwash plains; variable in thickness.
GFp	Outwash and meltwater channels; moderately sorted sand, minor clay and silt; relief generally flat; moderately to well drained; thickness may exceed 30m.
GFx	Ice-contact landforms; eskers, kames, streamlined ridges and hummocks; relief up to 5m; thickness variable.
M	MORAINAL DEPOSITS: Predominantly ablation with some basal till; local pockets of glaciolacustrine, aeolian, alluvial and organic deposits; subdued to ridged and hummocky; relief up to 10m; thickness varies from <2.5m to >43m; moderate to poor drainage; ponding common.
Mx	Ranges from flat to ridged to hummocky; mixed basal, englacial and ablation till; relief up to 10m.
Mh	Hummocky to kettled; predominantly ablation till, some basal; relief up to 10m; ponding common.
Mpd	Prairie mounds/doughnuts; relief up to 10m; predominantly ablation, some englacial till; ponding around and in centres of mounds.
R	BEDROCK: Exposed in river cuts and as thrusted slabs. Lithology dependent upon location.

SYMBOLS

- Geological boundary
- Dunes
- Drumlinoids
- Flutes, ridges, elongated hummocks
- Meltwater channel
- Fahler — Town, hamlet; identifier
- Provincial highway
- Drainage

S.A. BALZER, P.GEOL.

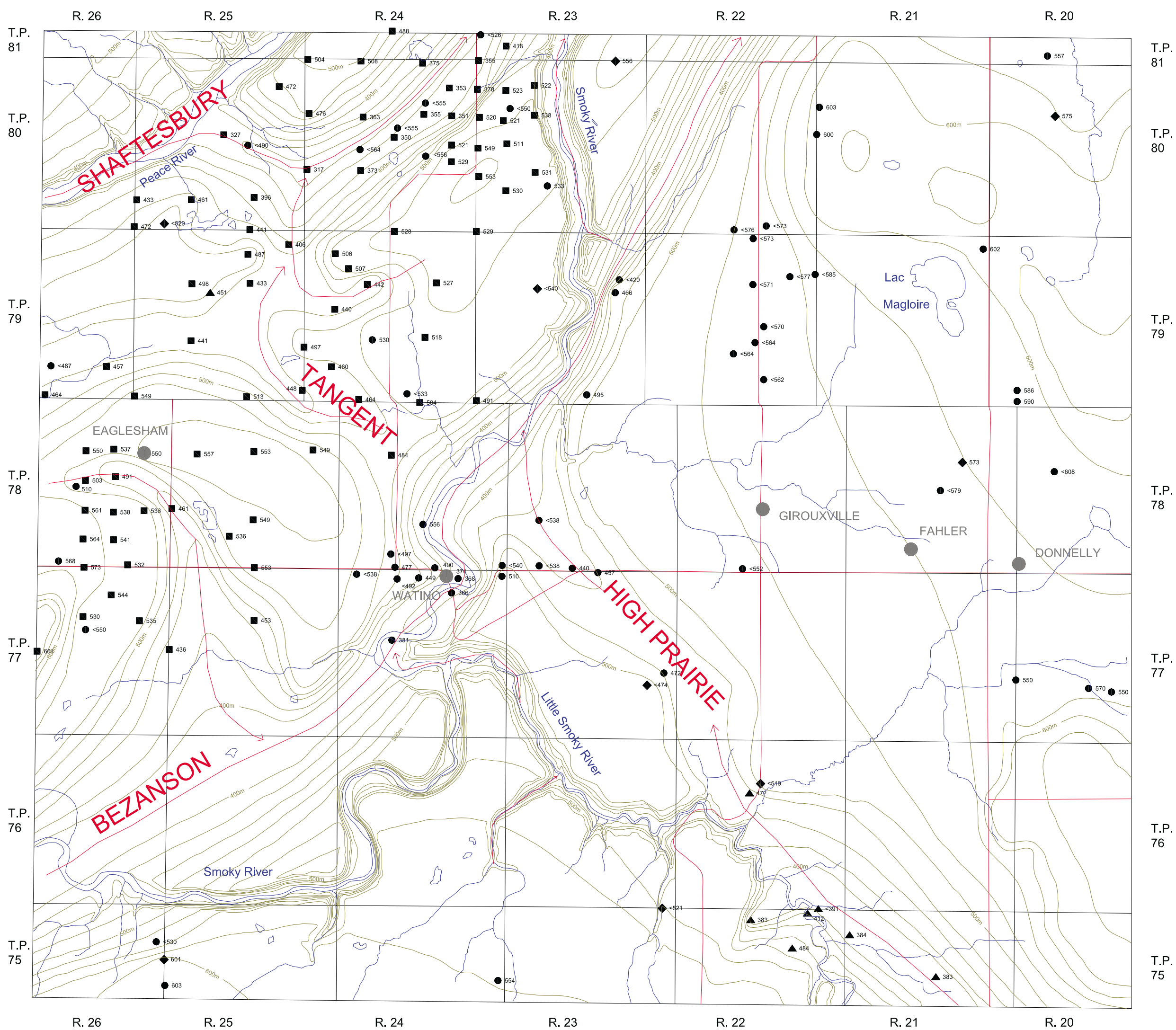
WINAGAMI 83N SOUTHWEST QUARTER

SURFICIAL GEOLOGY

SCALE 0 — 5 KILOMETRES
1:100,000

EDMONTON, ALBERTA — MARCH, 1999

MAP 2



N

LEGEND

Data source; elevation in metres

- ◆ 217 MDA drillhole
- ▲ 354 PFRA-CAESA drillhole
- ● 433 Water well
- ■ 728 Oil/Gas well

Thalweg

BEZANSON Paleochannel Identifier

DONNELLY Town or hamlet; identifier

Drainage

Provincial highway

Contour; interval = 25m

S.A. BALZER, P.GEOL.

WINAGAMI 83N NORTHWEST QUARTER

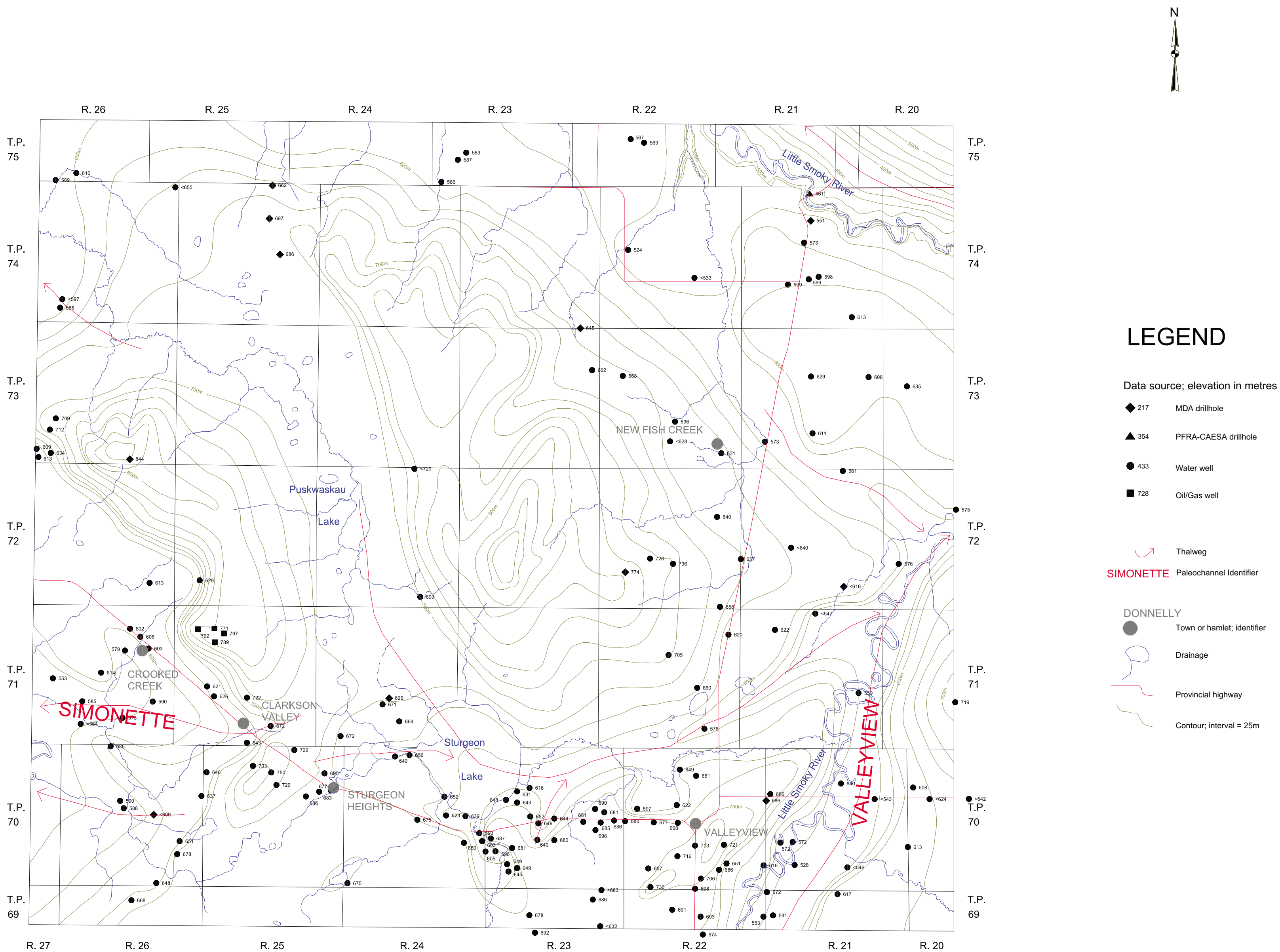
BEDROCK TOPOGRAPHY

SCALE 0 — 5 KILOMETRES

1:100,000

EDMONTON, ALBERTA MARCH, 1999

MAP 3



S.A. BALZER, P.GEOL.

WINAGAMI 83N SOUTHWEST QUARTER

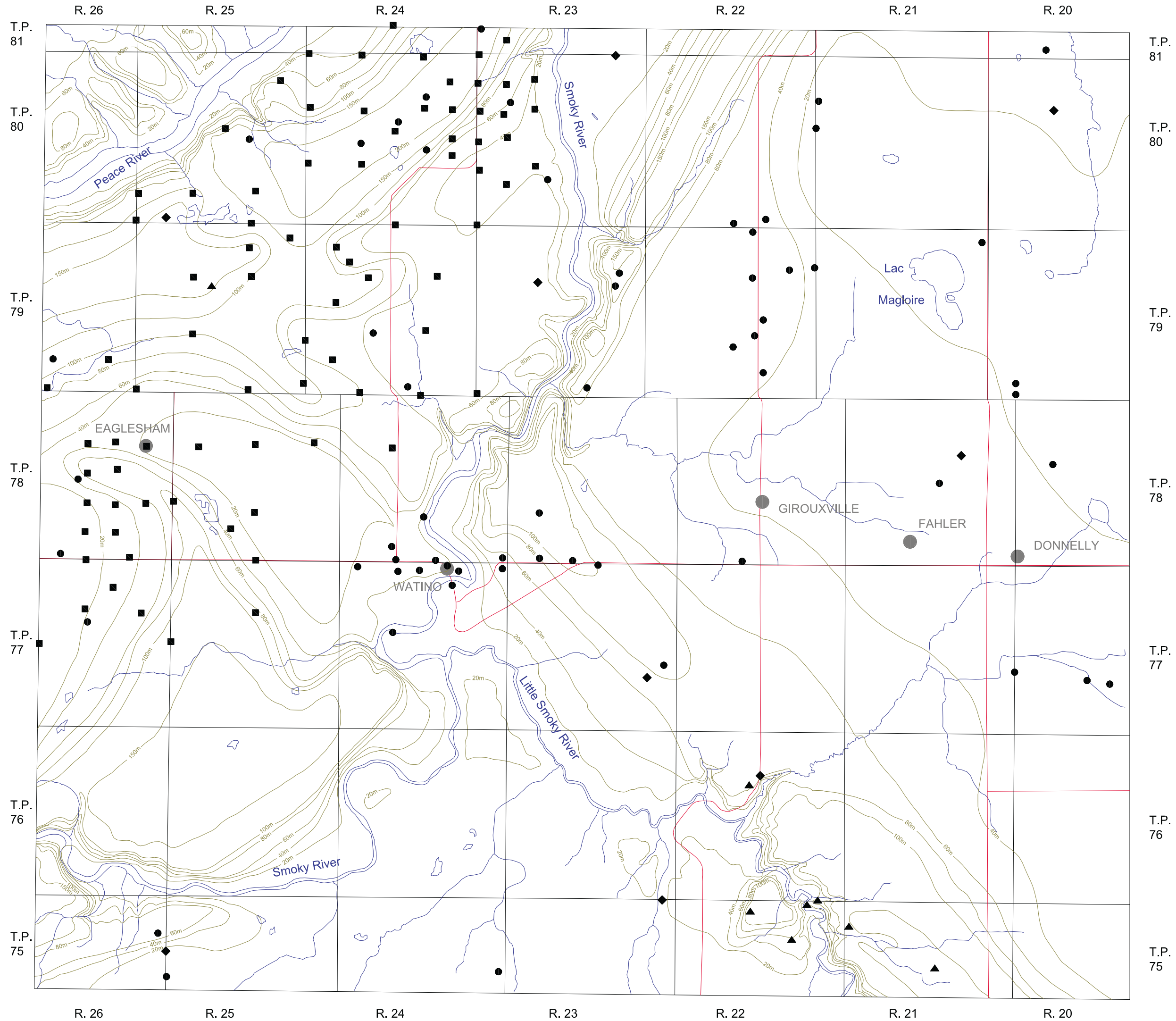
BEDROCK TOPOGRAPHY

SCALE 0 5 KILOMETRES

1:100,000

EDMONTON, ALBERTA MARCH, 1999

MAP 4



LEGEND

Data source

MDA drillhole

PFRA-CAESA drillhole

Water well

Oil/Gas well

DONNELLY

Town or hamlet; identifier

Drainage

Provincial highway

Contour; interval = 20m (to 100m) and 50m (>100m)

S.A. BALZER, P.GEOL.

WINAGAMI 83N NORTHWEST QUARTER

DRIFT THICKNESS

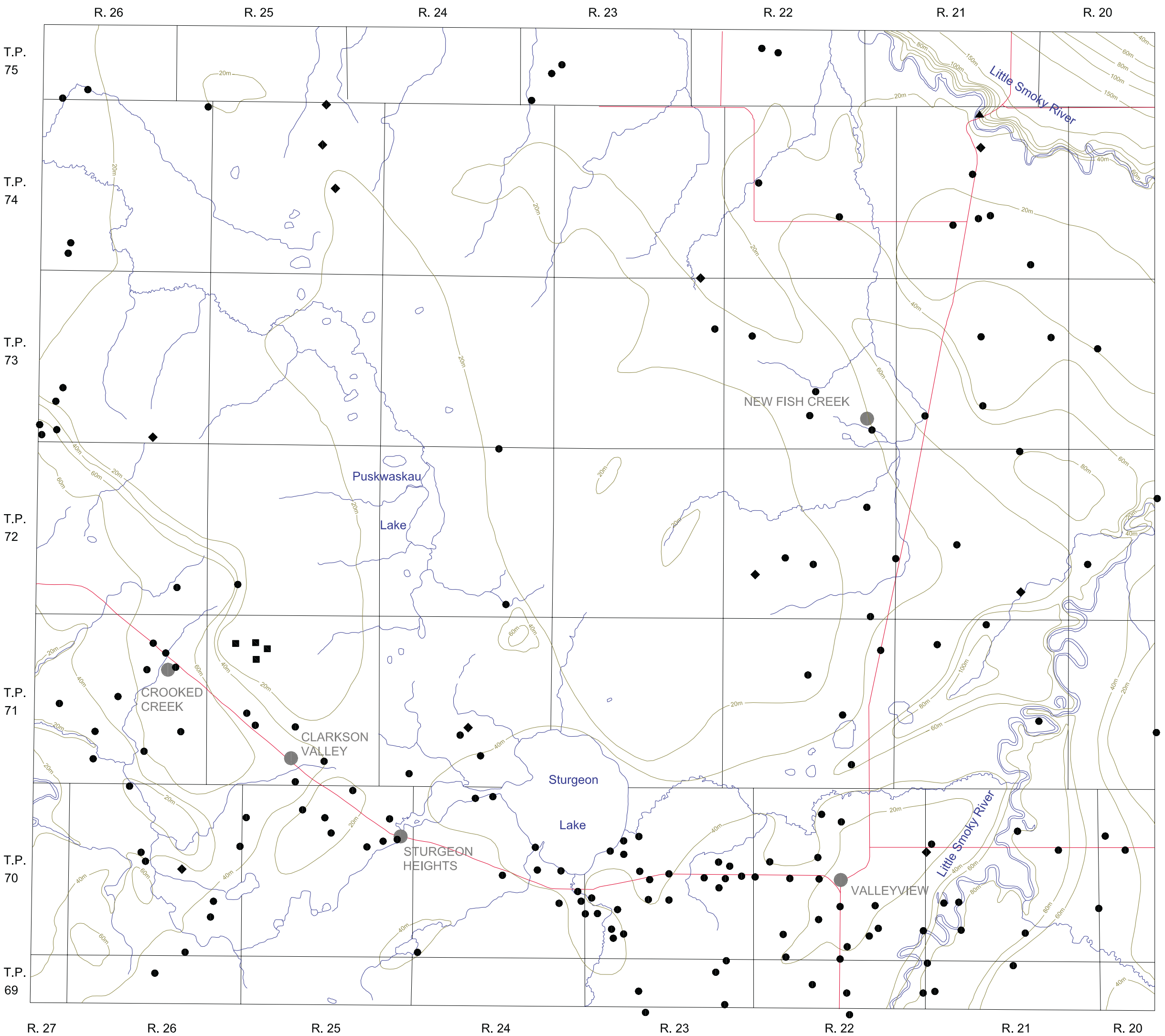
SCALE 0 5 KILOMETRES

1:100,000

EDMONTON, ALBERTA

MARCH, 1999

MAP 5



LEGEND

Data source

- MDA drillhole
- PFRA-CAESA drillhole
- Water well
- Oil/Gas well
- DONNELLY — Town or hamlet; identifier
- Drainage
- Provincial highway
- Contour; interval = 20m (to 100m) and 50m (>100m)

S.A. BALZER, P.GEOL.

WINAGAMI 83N SOUTHWEST QUARTER

DRIFT THICKNESS

SCALE 1:100,000 KILOMETRES

EDMONTON, ALBERTA

MARCH, 1999

MAP 6