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PERMAFROST DATABASE SPRING 1996 DATA

by

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December 1997

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16. Abstract

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ABSTRACT

Temperature sensors at eight DOTPF permafrost sites were read in the spring of 1996. The sensors were read (milli-volts for thermocouples and kilo-Ohms for thermistors). The temperature sensors are than converted to centigrade for the eight sites. These temperatures were entered in a historical permafrost data base. Spring 1996 subsurface temperature profiles are provided. The data base is in a spread sheet format.

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1. INTRODUCTION

1.1 PROJECT SCOPE

There are eight AKDOT&PF permafrost test sites in which ground temperature is periodically monitored. It was the purpose of this study to measure ground temperature at these eight sites and update a historical permafrost temperature data base for them. The sites studied are shown in Figures 1-1 and 1-2.

1.2 METHODOLOGY

Subsurface temperatures were recorded during the spring 1996. Table 1-1 shows the site visit dates for each of the eight sites.

Table 1-1. Dates Each Test Site Was Visited

Locations	Spring Trip
Chitina	05/18/96
Gardiner Creek	05/18/96
Bonanza Creek	05/18/96
Alder Creek	05/18/96
Canyon Creek	05/18/96
Bethel Highway	04/02/96; 04/03/96
Airport Overpass	05/17/96
Goldstream Bridge	05/17/96

Seven of the permafrost test sites require manual data recording. The Bethel highway, the most recent test site, has two automatic data recorders that record thermistor data. These automatic data recorders are supplemented with several sensors that require manual data

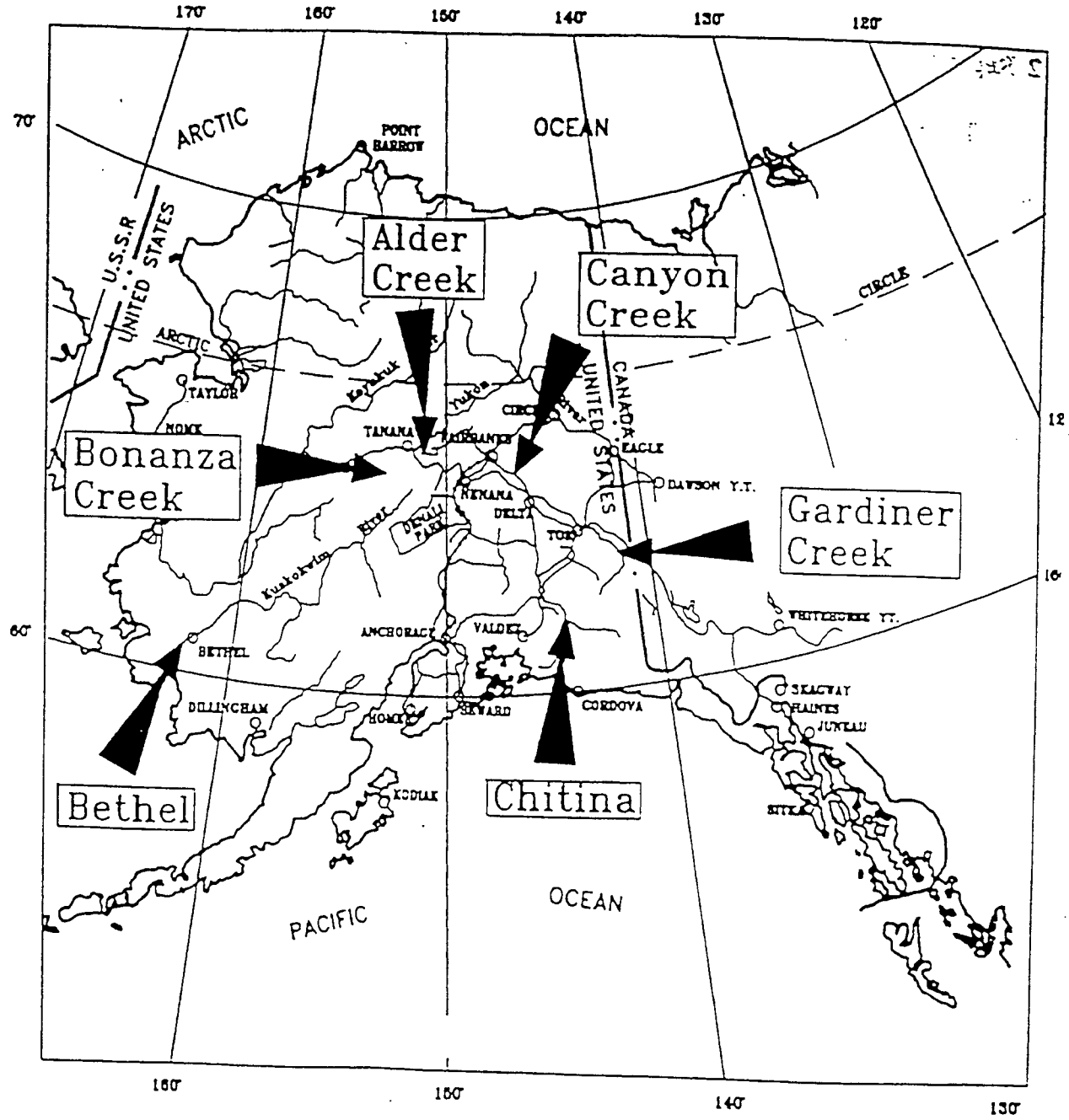

Figure 1-1: Test Sites in State Region

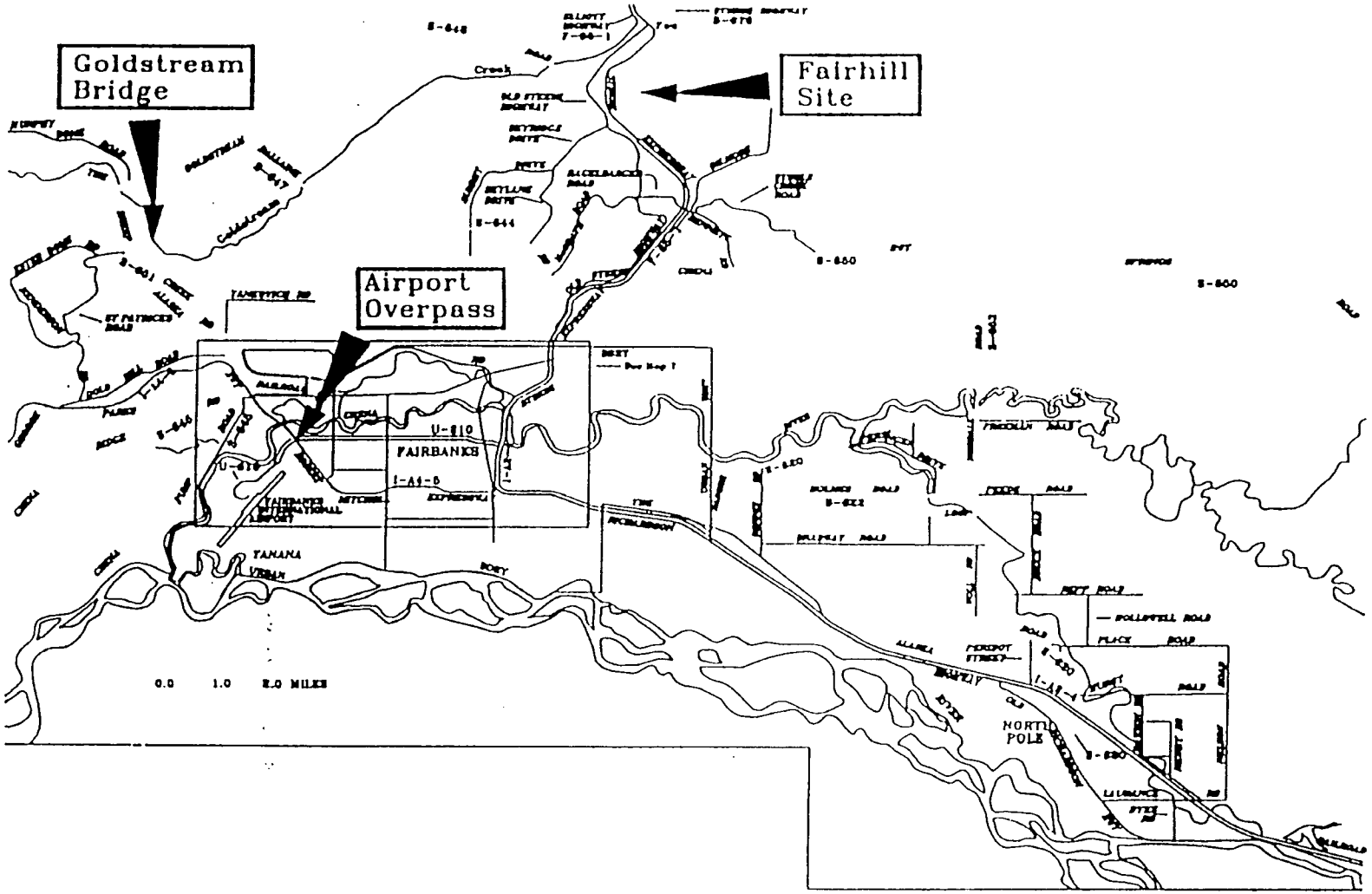

Figure 1-2: Test Sites in Fairbanks Region

recording. All sites have both thermocouples and thermistors for measuring temperature. Thermocouple data are read in milli-volts in reference to a thermos ice bath. Thermistors are read in kilo-Ohms. Later, all readings were entered in a spread sheet and converted to temperature in $^{\circ}C$. Selected instruments at each site were plotted and compared with the first recorded temperature data for the site.

1.3 REPORT OVERVIEW

This report provides a summary of the subsurface temperature data taken during the spring of 1996 for eight previously constructed experimental roadway sites in Alaska. The type of construction for each site is presented below in Table 1-2.

Table 1-2. Permafrost Test Sites and Site Descriptions

Locations	Experimental Item Tested
Chitina	Styrofoam (TM) installation
Gardiner Creek	Air Convection cooling ducts
Bonanza Creek	Soil berm with insulation, with air ducts, or with reinforced fill
Alder Creek	Insulation layers, toe berms & experimental wood chips as fill
Canyon Creek	Peat underlay in road cut section
Bethel Highway	Thermosyphons and insulation layers
Airport Overpass	Reinforced Earth structural settlements on permafrost
Goldstream Bridge	Bridge with pilings into permafrost

2. EXECUTIVE SUMMARY

It was the purpose of this study to record 1996 spring ground temperature data for eight AKDOT&PF permafrost test sites. This task was completed. Discussion of this collected data and of equipment status at each site is included in this report.

Ground Temperatures

Spring ground temperatures were measured at seven AKDOT&PF permafrost test sites. The fill at the Gardiner Creek test site was partially excavated and new fill was installed. During construction, the instrumentation was torn out and rendered unrepairable. Subsequently, no readings were available at this site.

The Airport overpass was extended during the summer of 1996. Thus, future ground temperature data at that site may be affected. Further, many of the sensors at the Airport overpass again require repair.

Generally, 1996 spring ground temperatures were colder than those recorded during the first recording year for each site.

3. TEST SITE TEMPERATURES

3.1 CHITINA

This test site includes the first insulated roadway sections over permafrost in North America. The site was constructed in 1969 to evaluate 2" and 4" thicknesses of Styrofoam insulation beneath a 6' high embankment. There are 13 vertical strings, with 125 copper-constantan thermocouples. The test site geometry is shown in Hulsey's (1994) "Permafrost Database, 1993" report.

Ground Temperatures

Twelve temperature strings were read on May 18, 1996. The remaining string required repair and no data were available. Spring 1996 ground temperatures at the roadway centerline for the uninsulated cross-section were compared to 1981 temperatures (see Figure 3.1-1). The spring 1996 ground temperatures were colder. Figure 3.1-2 shows ground temperatures at the roadway centerline for the cut section; temperatures in 1996 were warmer to -6 feet and slightly colder for the remaining 30 feet of depth.

Ground temperature variations at both the 2-inch and 4-inch insulation sections were not presented. Because of previous damage to these instrumentated sections, the sensors require renumbering. The proper order for the previously damaged sensors is still under study. Generally, the thermocouples at this site have been working well for the past 23 years.

3.2 ESTER WEST

Two sites were constructed between 1973 and 1975 to evaluate performance for: a) insulation depth and width, b) embankment, and c) berm shapes and air-cooling ducts on roadway stability. There are 41 strings at 12 stations. There are eight instrumented cross-sections at Bonanza Creek and four instrumented sections at Alder Creek (see Table 3.2-1.).

Table 3.2-1. Station Information at Ester West Site

Station	Description
Bonanza Creek:	
Station 166+25	Insulated toe without berm
Station 166+80	Normal Embankment
Station 167+30	Undisturbed section
Station 167+50	10' wide silt berm
Station 168+25	20' wide berm with air duct
Station 168+75	Insulated 20' wide berm with air duct
Station 169+25	Insulated 20' wide berm
Station 170+00	20' wide berm
Alder Creek:	
Station 1103+00	Top insulated cut
Station 1103+45	Undisturbed section
Station 1121+10	Grid insulation system

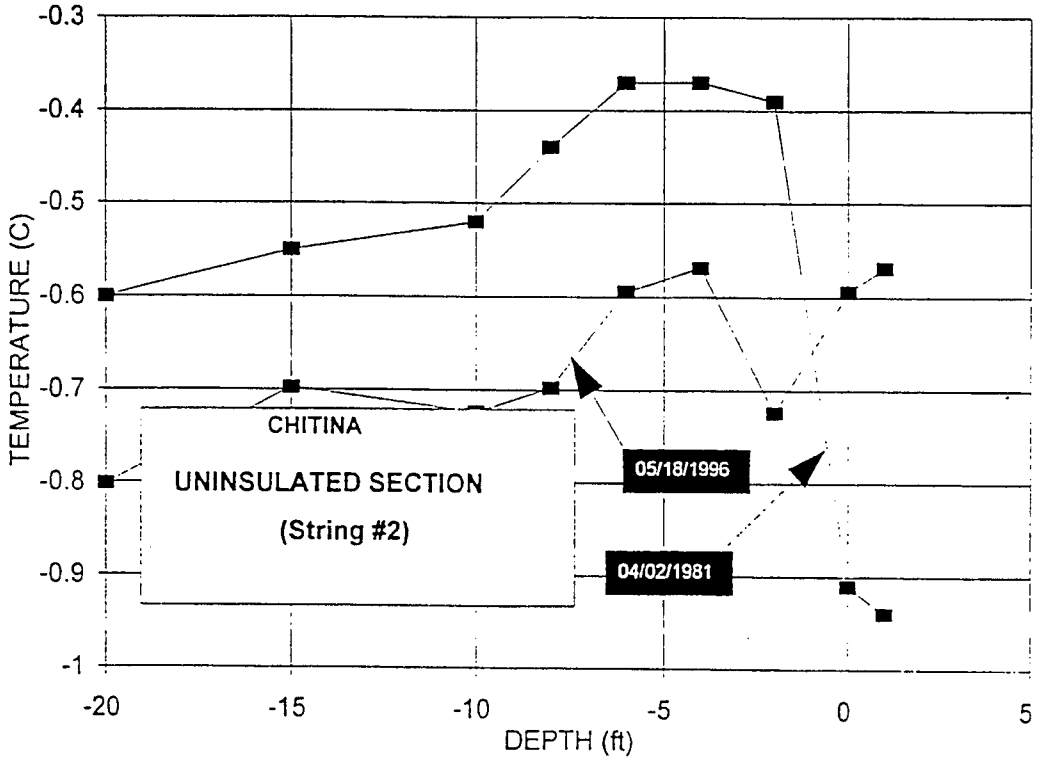

Figure 3.1-1: Spring Temperatures (1996 vs 81) for string #2

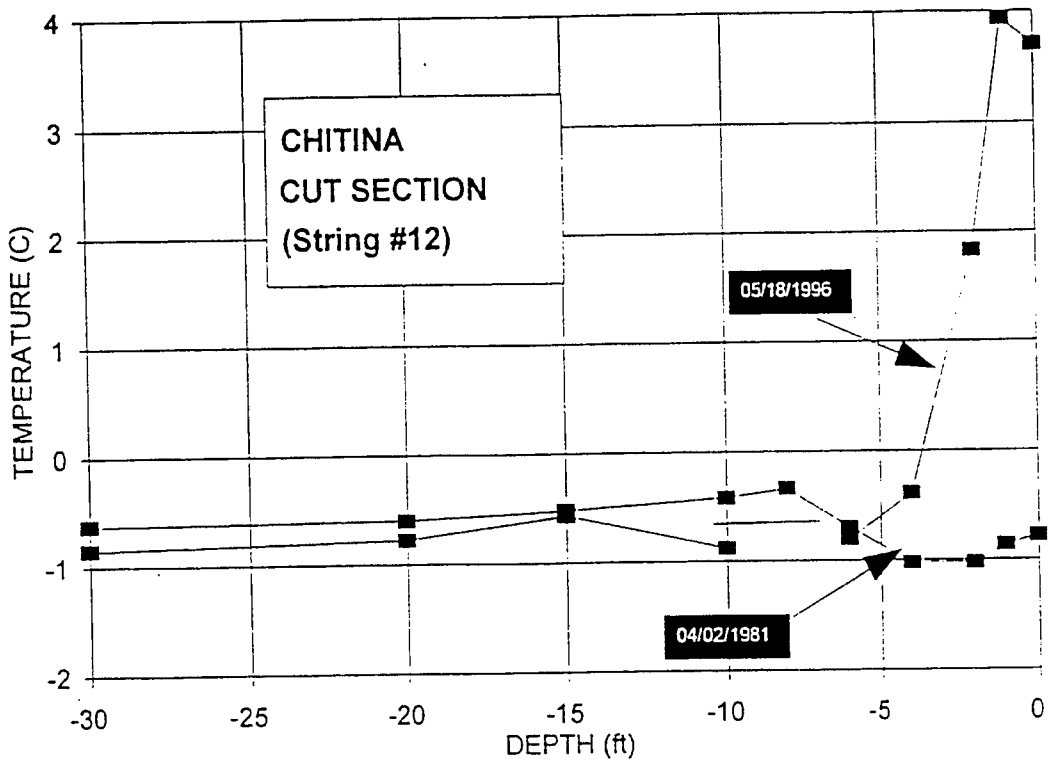

Figure 3.1-2: Spring Temperatures (1996 vs 81) for string #12

The location of the instrumented sections (stations) and corresponding descriptions are listed in Table 3.2-2.

Table 3.2-2. String Locations at Ester West (Alder, Bonanza Creeks)

Site	Location	String Position
Bonanza		
Strings S-1 to S-3	166+25: Insulated toes without Berms	hor,vert
Strings S-4 to S-7	166+80: Normal embankment(control section)	hor,vert
Strings S-8 to S-12	167+50: 10' wide silt berm	hor,vert
Strings S-13 to S-17	168+25: 20' berm with air ducts	hor,vert
Strings S-18 to S-22	168+75: Insulated 20' berm with air ducts	hor,vert
Strings S-23 to S-25	169+25: Insulated 20' berm	hor,vert
Strings S-26 to S-29	170+00: 20' wide berm	hor,vert
Alder		
Strings S-31 to S-33	1103+00: Top insulated cut	hor,vert
String S-34	1114+80 to 1115+00 (100' lt of roadway centerline)	vert
Strings S-35 to S-38	1121+10: Grid Insulation System	hor,vert
Strings S-39 to S-41	1121+55: 4" bottom insulated cut	hor,vert

Ground Temperatures

String 41 at Alder Creek and strings 5, 14, 17, 27 and 29 at Bonanza creek require repair. The switch for string 14 needs to be replaced. Generally, the 1996 spring ground temperatures were colder than those of 1982. Ground temperatures for strings 27 and 40 (stations 1121+10 & 1121+55) were unreasonable. These strings need to be carefully examined. It is probably that the switches require replacement.

A comparison of spring ground temperatures over a 13 year period are presented in Table 3.2-3. Spring temperature variations with depth are presented in Figures 3.2-1 to 3.2-10.

Table 3.2-3. Ester West Summary of Recorded Temperatures (1996 vs 1982)

Location	Description	Spring
Roadway Centerline:		
1103+00 (#32, vert)	top uninsulated	colder
1121+10 (#37, vert)	grid insulation	warmer[a]
1121+55 (#40, vert)	4" insulation @ 10'	warmer[a]
Distance from centerline:		
166+80 (#6,vert,45' rt)	normal embankment	colder
167+50 (#9,vert,62' lt)	10' wide silt berm	colder
167+30 (#12,vert,75' rt)	d.o.	colder
168+25 (#16,vert,48' rt)	20' berm, air ducts	colder
168+75 (#21,vert,48' rt)	insulated 20' berm, air ducts	colder
169+25 (#24,vert,51' rt)	insulated 20' berm	colder
170+00 (#28,vert,51' rt)	20' wide berm	colder
1103+45(#33,vert,55' lt)	top insulated cut at undisturbed section	slightly colder

[a]These ground temperatures are unreasonable; temperature string needs to be serviced.

3.3 CANYON CREEK

Fifteen temperature sensor strings were installed during 1975 construction work on the Richardson Highway. As part of an experimental construction, layers of frozen peat were placed beneath the pavement in a road cut in ice-rich permafrost. These strings have 192 thermocouples and 12 thermistors to monitor thaw depths and changes in sub surface temperatures at three different sections. At each cross section, a string was placed horizontally at the bottom of the sub cut, and three to four strings were installed vertically. An additional vertical string was placed in an undisturbed forest.

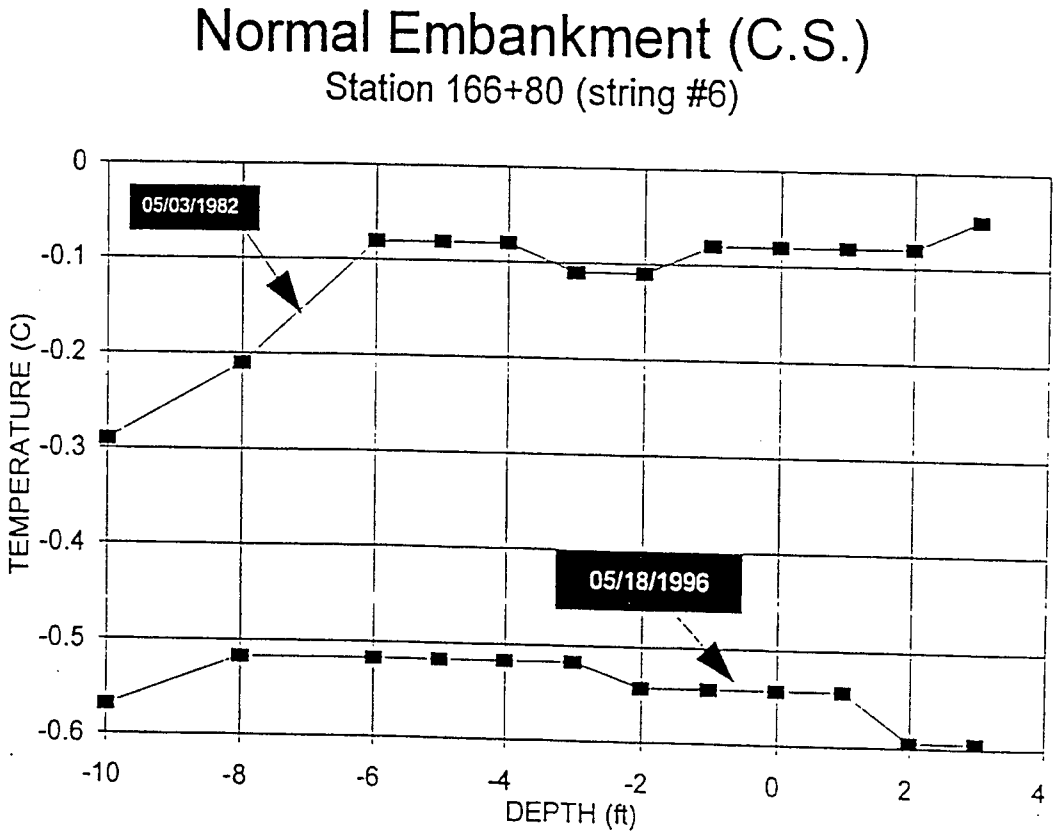

Figure 3.2-1: Spring Temperatures (1996 & 1982), string #6 (sta. 166+80)

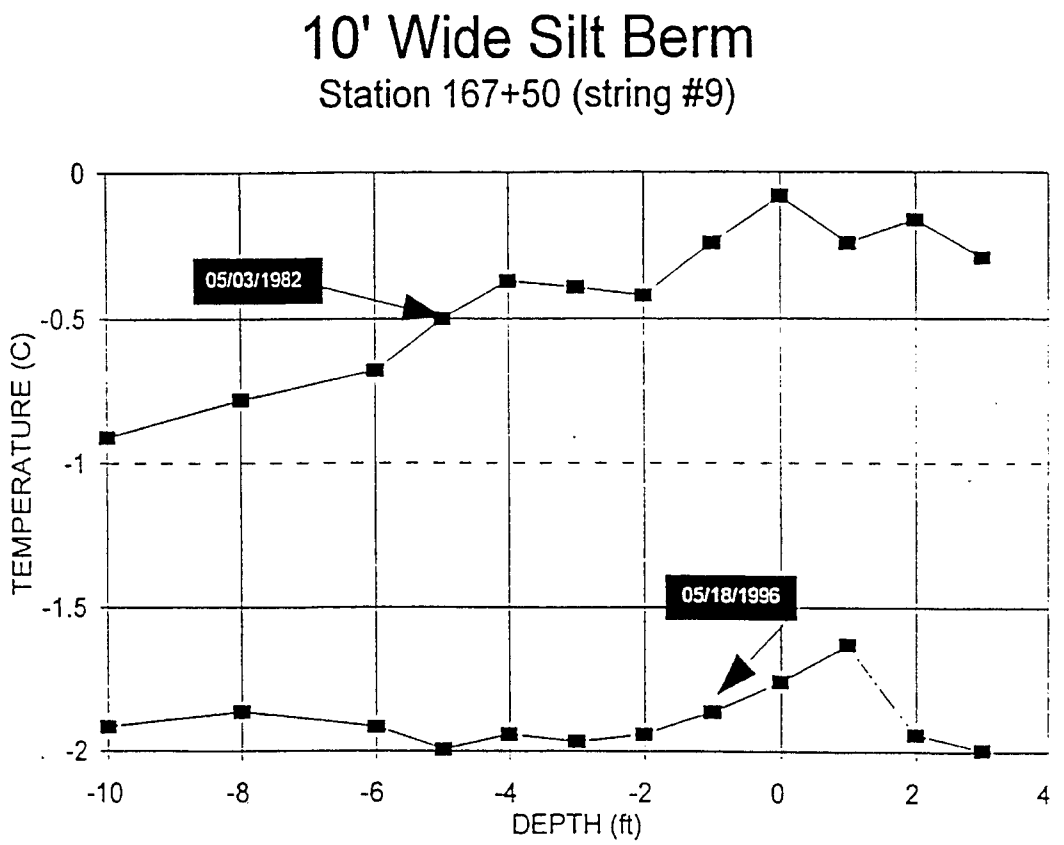

Figure 3.2-2: Spring Temperatures (1996 & 1982), string #9 (sta. 167+50)

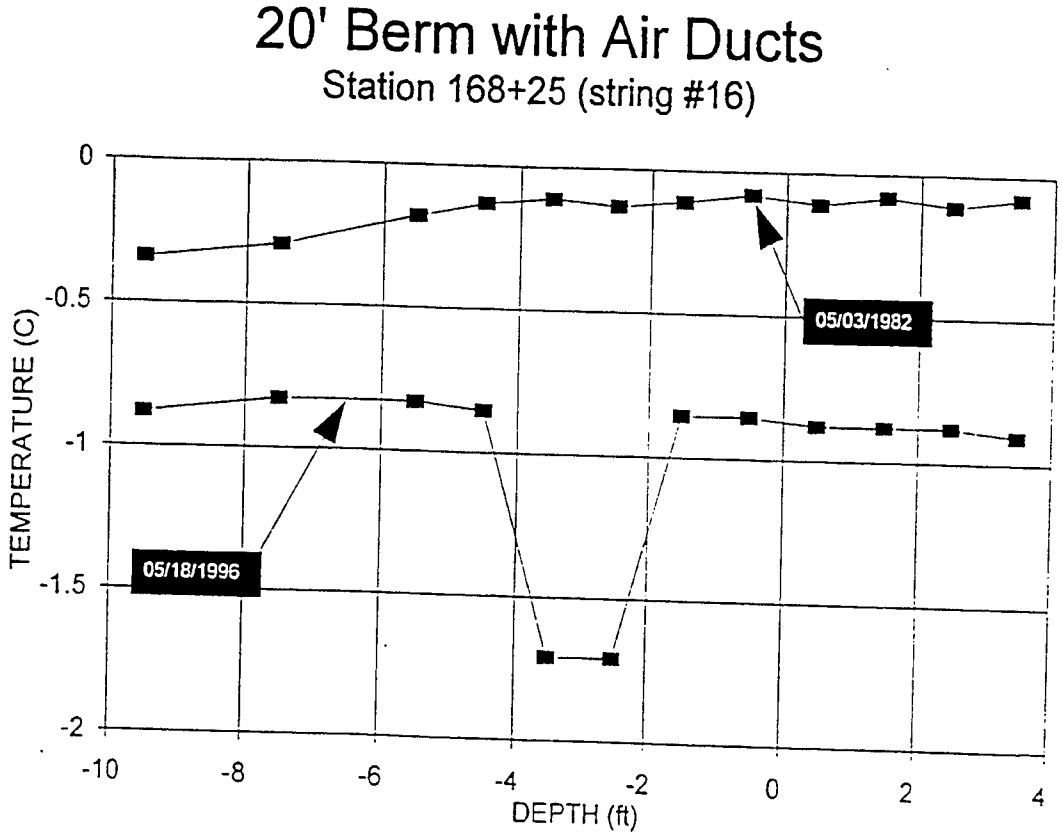

Figure 3.2-3: Spring Temperatures (1996 1982), string #16 (sta. 168 + 25)

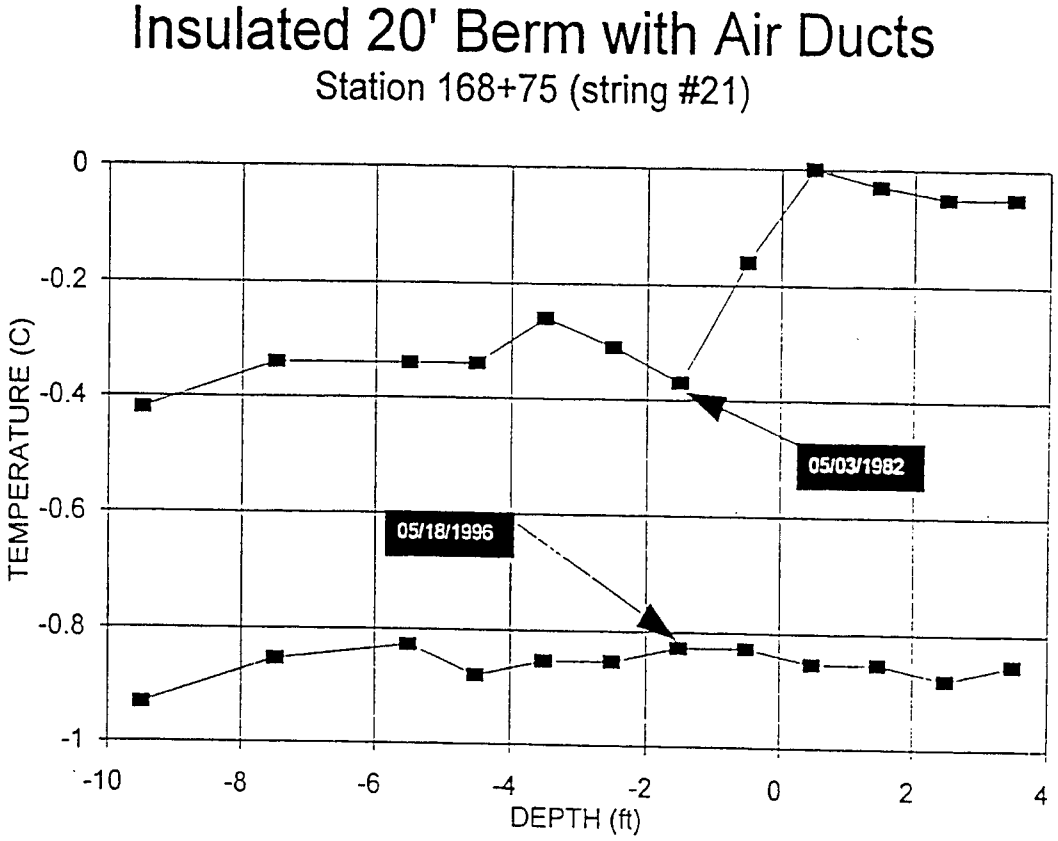

Figure 3.2-4: Spring Temperatures (1996 & 1982), string #21 (sta.168+75)

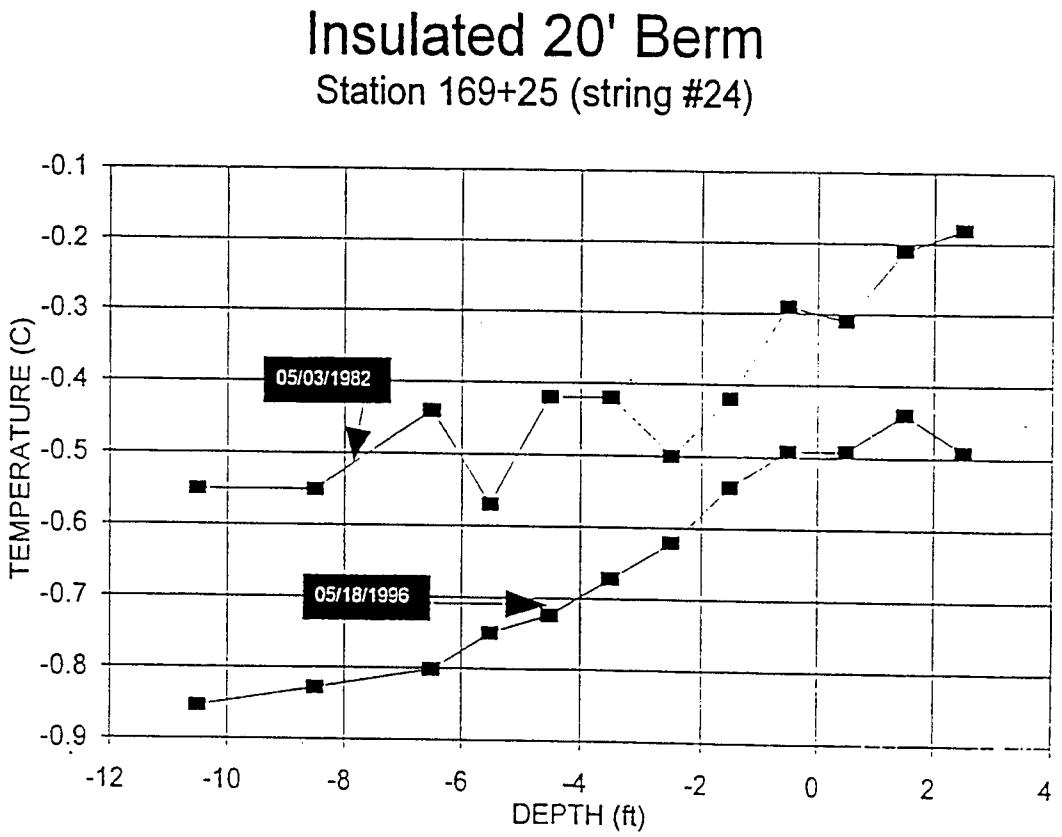

Figure 3.2-5: Spring Temperatures (1996 & 1982), string #24 (sta.169+25)

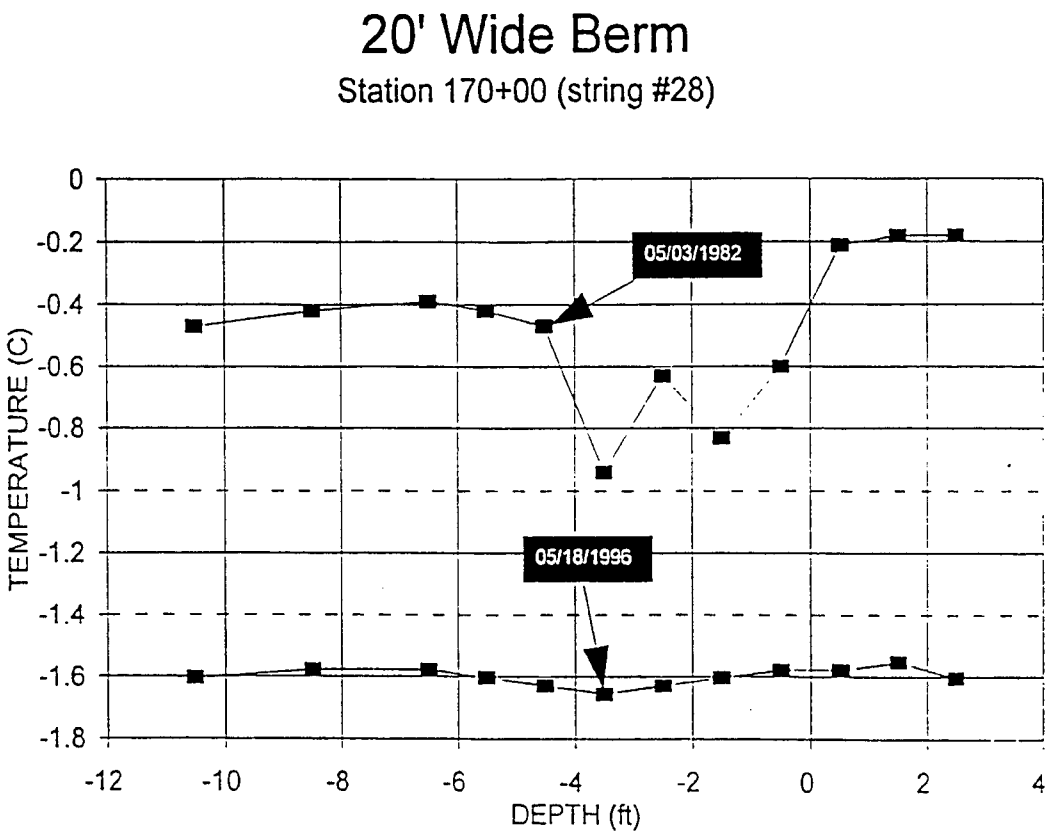

Figure 3.2-6: Spring Temperatures (1996 & 1982), string #28 (sta.170+00)

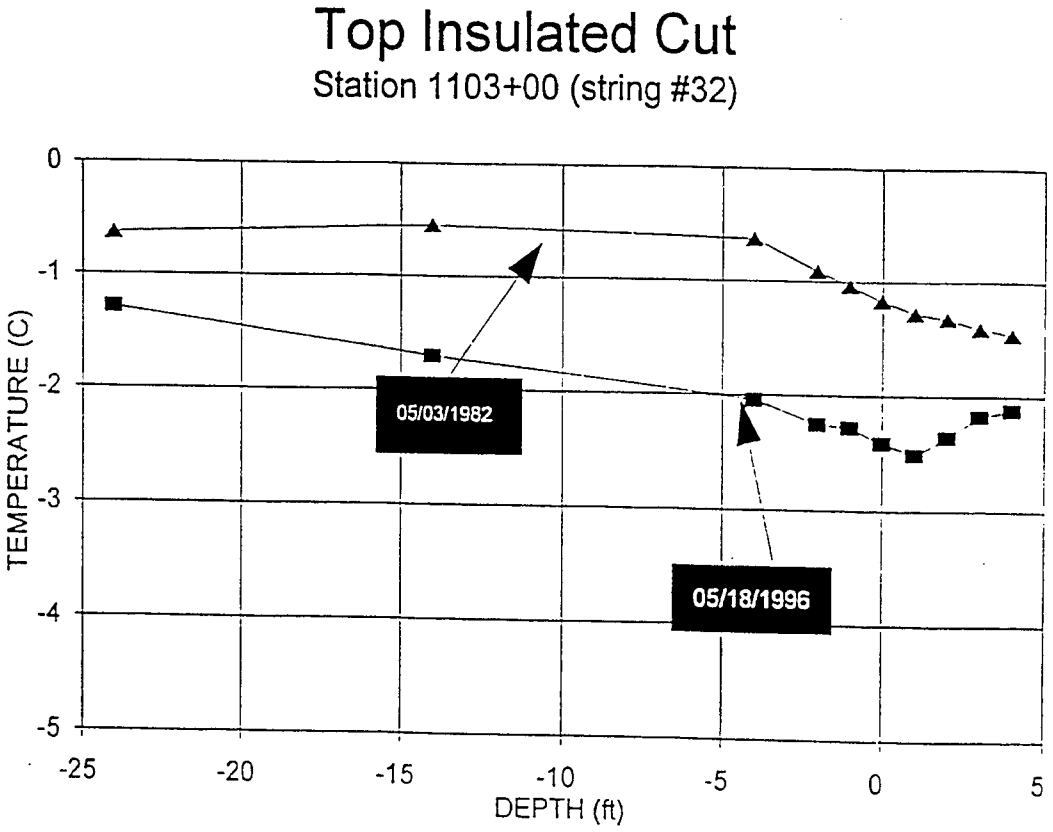

Figure 3.2-7: Spring Temperatures (1996 & 1982), string #32 (sta. 1103+00)

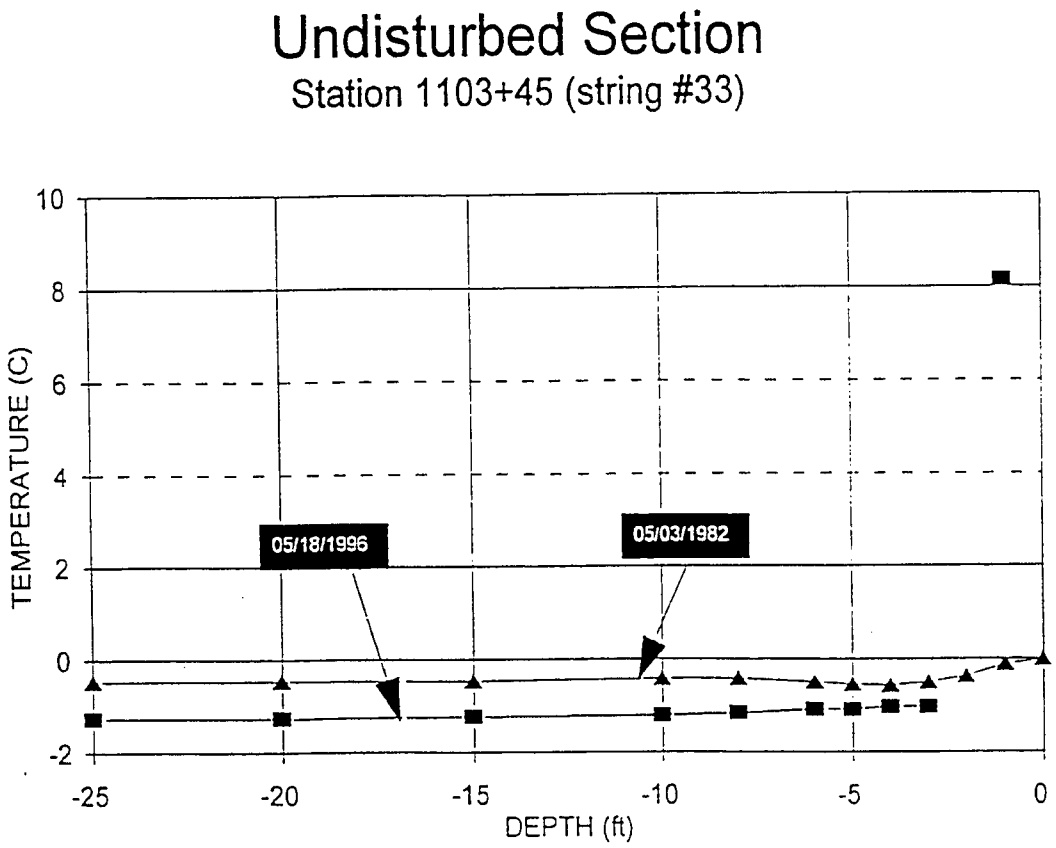

Figure 3.2-8: Spring Temperatures (1996 & 1982), string #33 (station 1103+45)

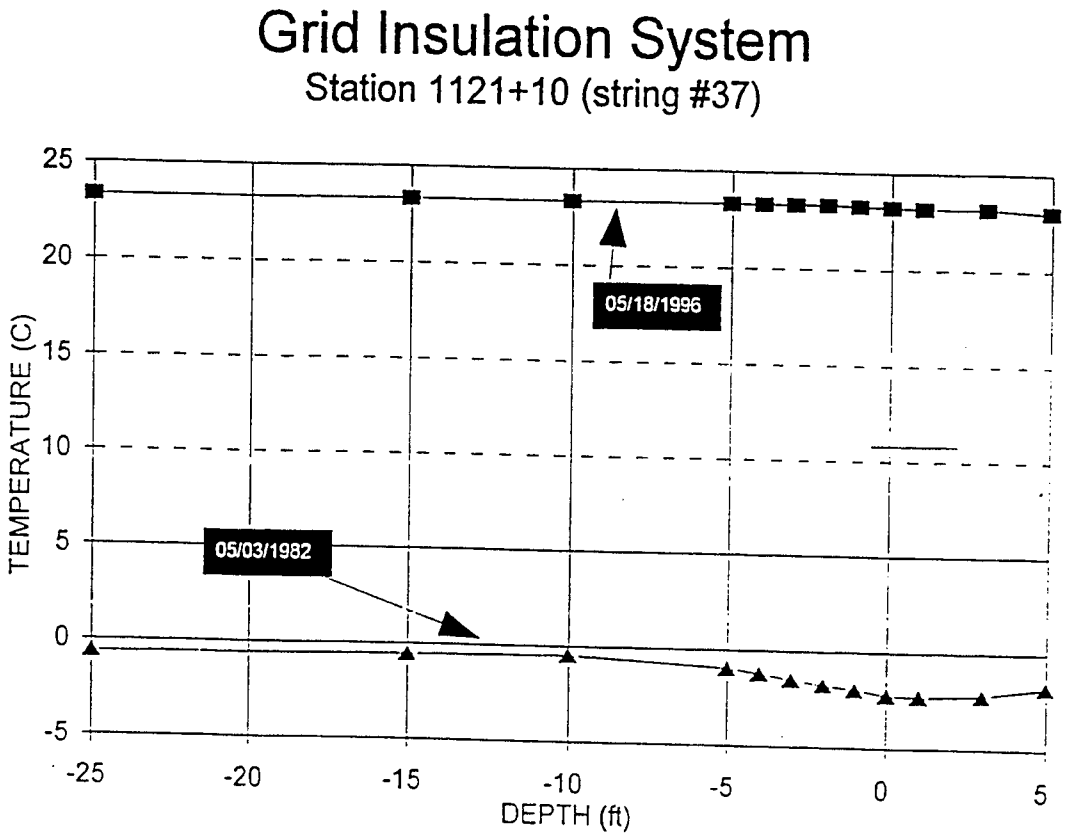

Figure 3.2-9: Spring Temperatures (1996 & 1982), string #37 (sta. 1121+10)

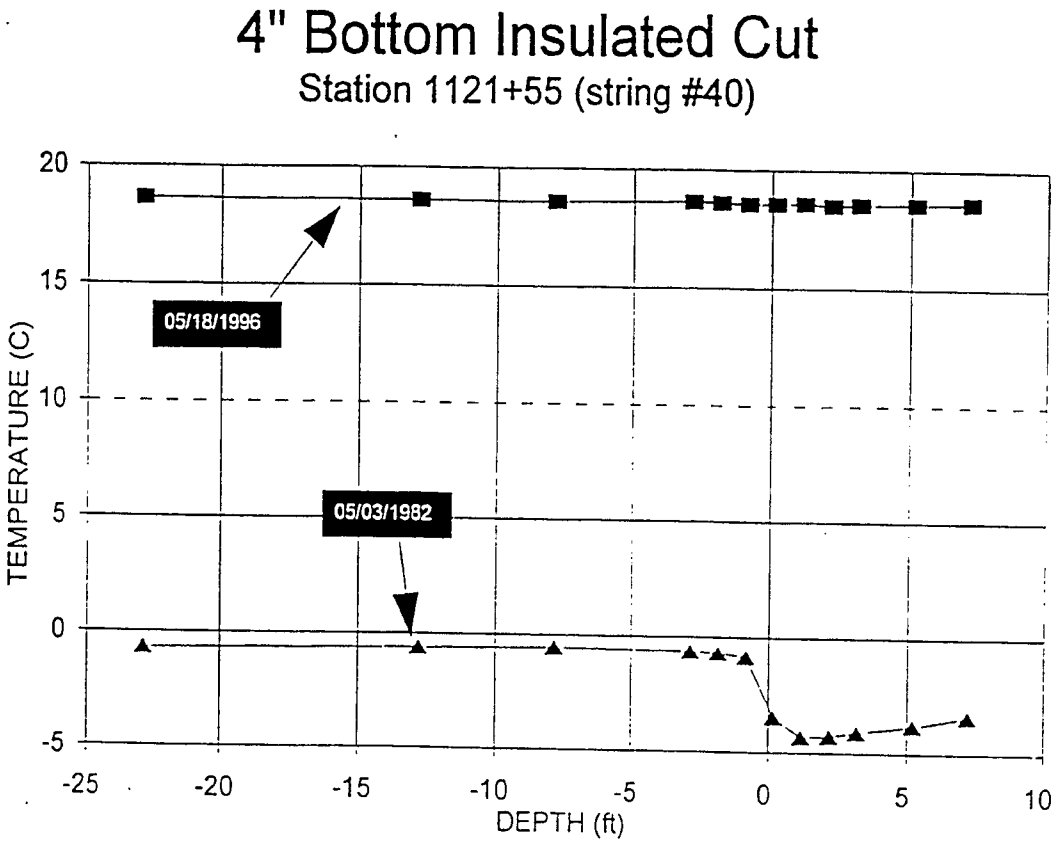

Figure 3.2-10: Spring Temperatures (1996 & 1982), string #40 (station 1121+55)

Ground Temperatures

Researchers measured horizontal and vertical ground temperatures on May 18, 1996 and compared the findings with those of with April 17, 1981. Selected locations were examined in this study (see Table 3.3-1).

Table 3.3-1. Canyon Creek Summary of Recorded Temperatures(1996 vs 1981)

String	Location(Hor, vert)	Spring
#1: sta 3247+10 Control section	Hor, bottom of subcut	colder[a]
#5: d.o.	vert, roadway centerline	colder[b]
#3: sta 3250+62, 5' peat section	Hor, bottom of peat	colder
#8: sta 3249+00, 4' peat section	vert, roadway centerline	colder
#14: d.o.	vert, 50' lt of centerline	colder[c]

[a]Except for 48 ft from centerline, than it is warmer.
[b]Warmer at 3 ft and colder below this depth.
[c]Warmer to 1 ft and colder below this depth.

Generally, the 1996 spring ground temperatures were colder than those at the same location in 1981.

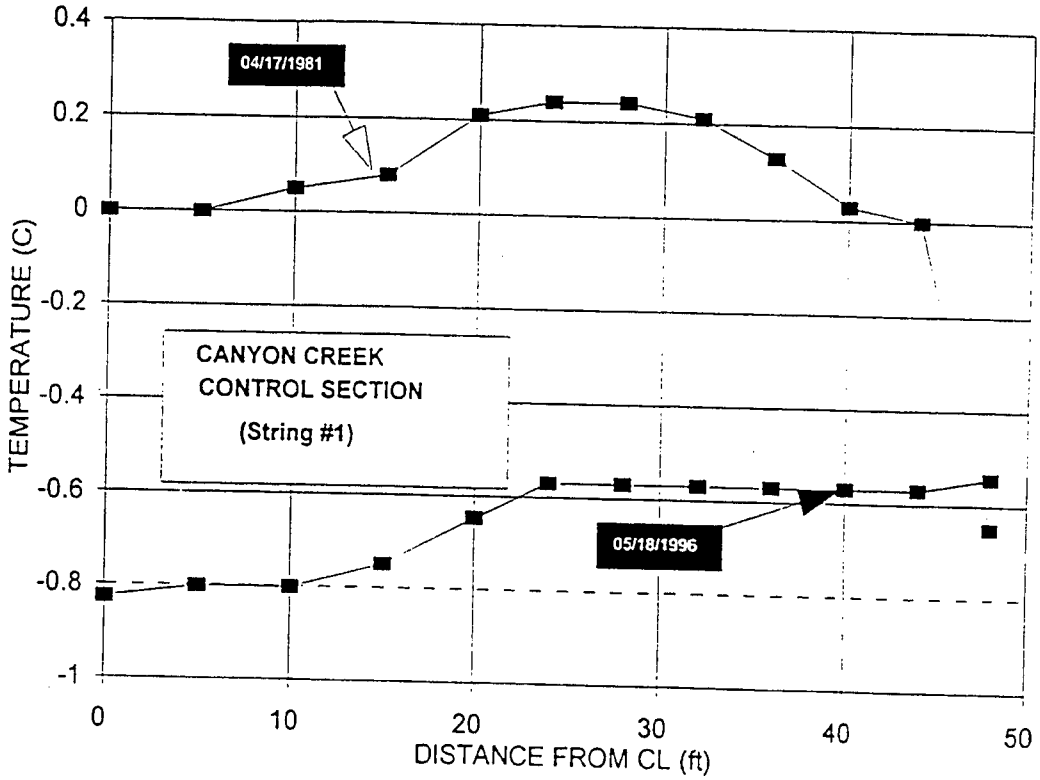

Figure 3.3-1: Spring Temperatures (1996 & 1981), string #1 (Control section)

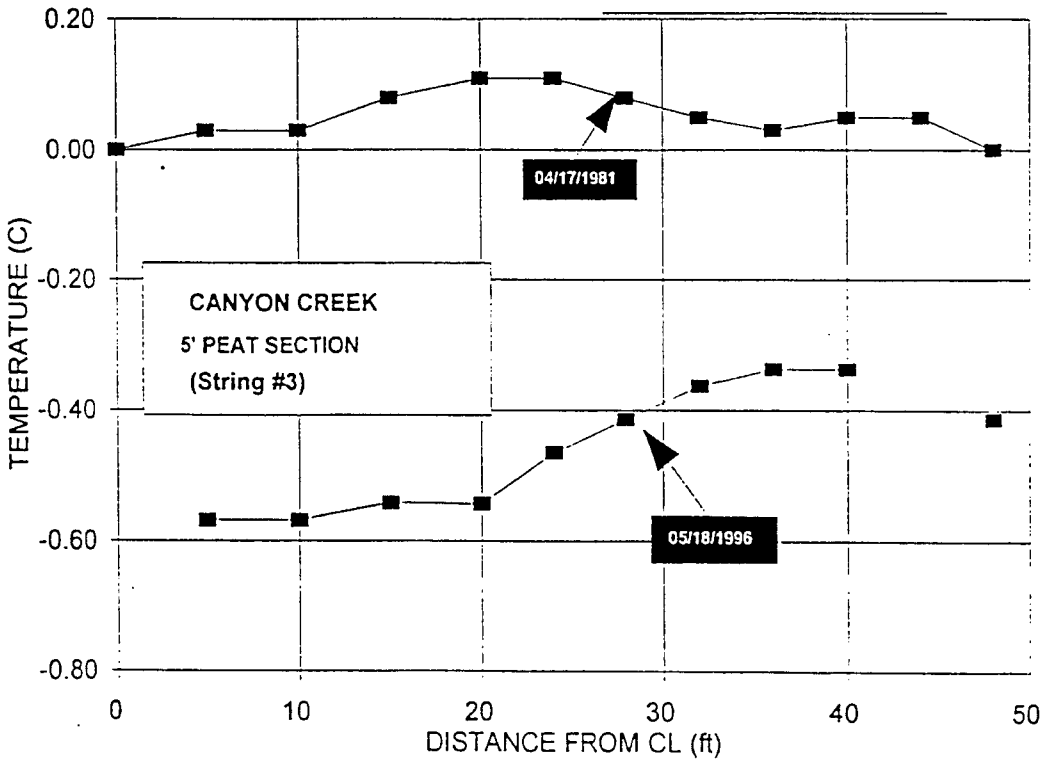

Figure 3.3-2: Spring Temperatures(1996 & 1981), string #3 (5' Peat Section)

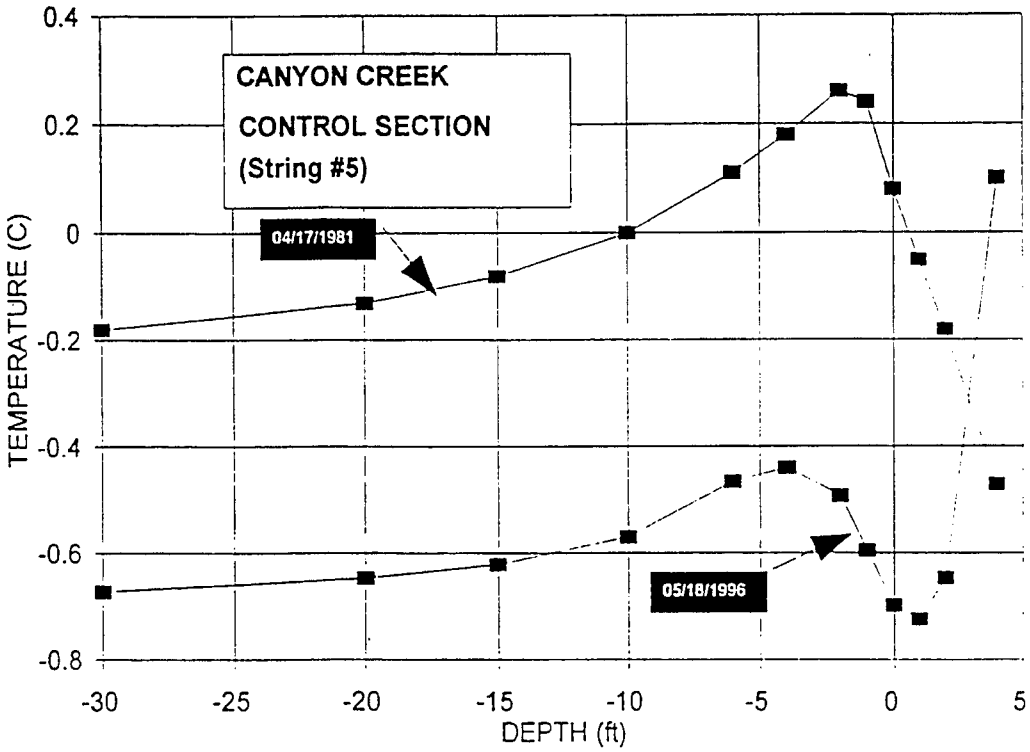

Figure 3.3-3: Spring Temperatures (1996 & 1981), string #5 (Control section)

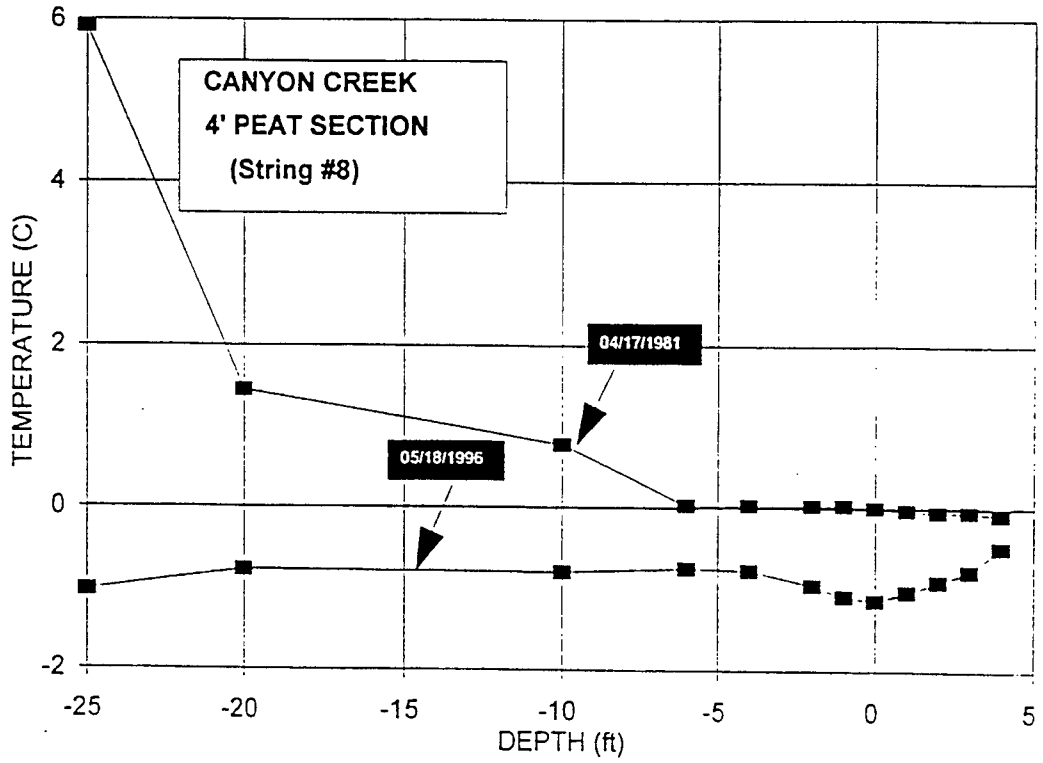

Figure 3.3-4: Spring Temperatures (1996 & 1981), string #8 (4' Peat section)

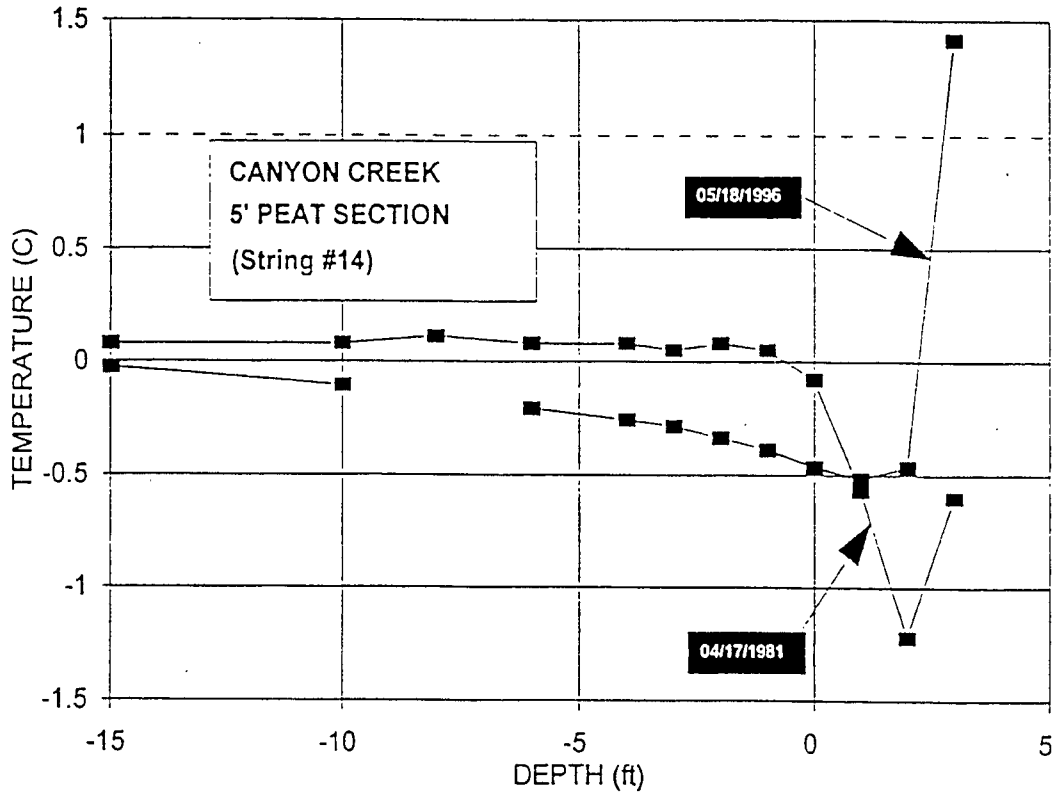

Figure 3.3-5: Spring Temperatures(1996 & 1981), string #14 (5' Peat section)

3.4 AIRPORT OVERPASS

The backfill behind backwalls for an overpass bridge was instrumented in 1985 as part of a four-lane overpass and interchange of the Parks Highway over Airport road. The instrumentation was installed to evaluate permafrost temperature changes beneath Reinforced Earth fills. There are six strings consisting of both thermocouple sensors and thermistors installed vertically and horizontally at the overpass.

Ground Temperatures

The first spring temperatures were recorded on April 24, 1986. Spring ground temperatures recorded on May 18, 1996 were compared with the first recorded temperatures for this site. The 1996 spring temperatures varied in a similar manner, but the 1996 temperatures were generally colder. After the spring readings, the Airport overpass was extended as part of a new construction project. Thus, future ground temperature readings may reveal a change in behavior. The temperature variations are shown in Figures 3.4-1 thru 3.4-3.

3.5 GOLDSTREAM BRIDGE

This was the first project with instrumented piling for determining temperatures and thaw depths at a small stream crossing with frozen silt permafrost foundation soils. There are four vertically installed strings at this test site. Each of the strings was mounted on either the pier or the abutment of the bridge. Thus this test site was used to collect ground temperatures in order to determine the effect of building bridges on pilings supported in permafrost.

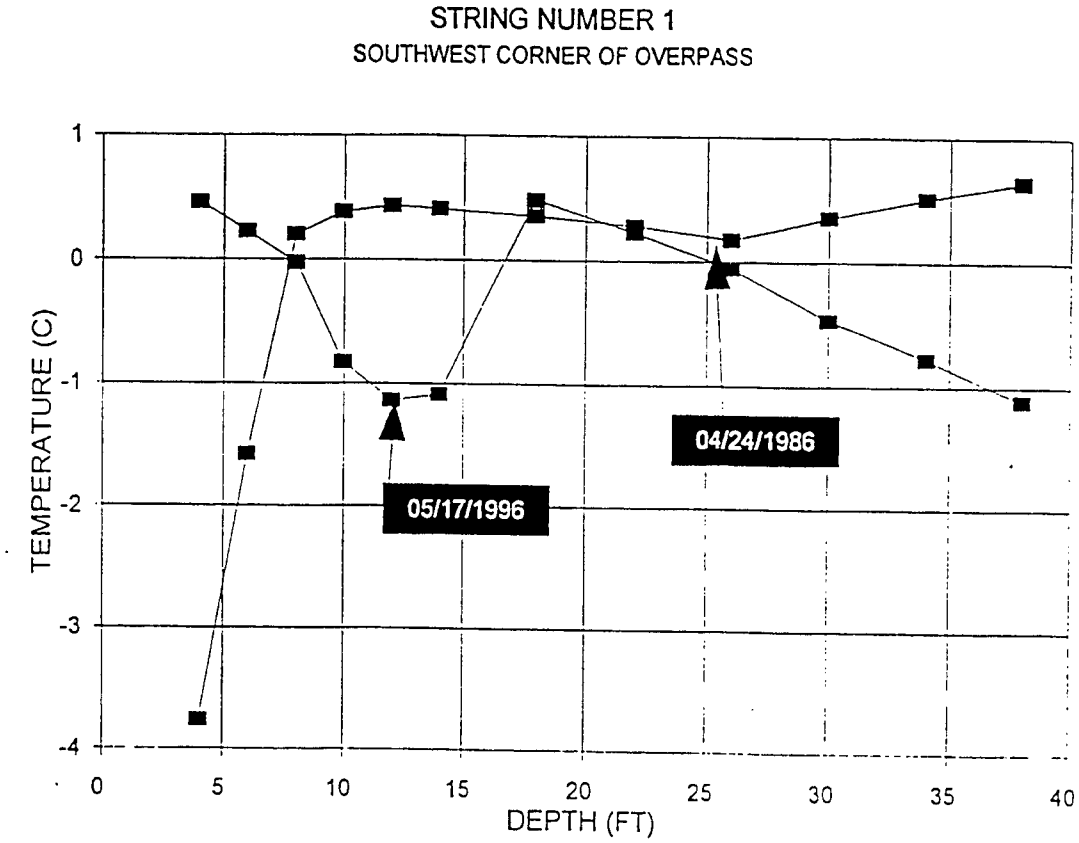

Figure 3.4-1: Spring Temperatures (1996 & 1986), string #1 (S.W. corner)

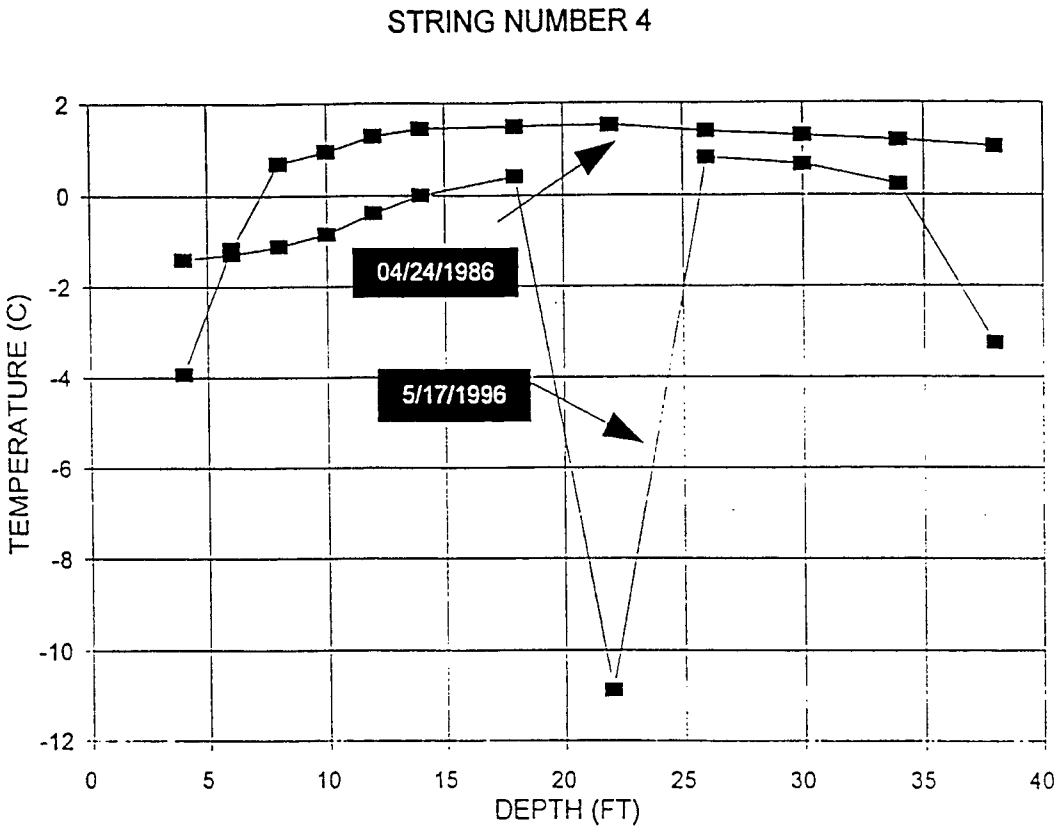

Figure 3.4-2: Spring Temperatures (1996 & 1986), string #4 (N.E. corner)

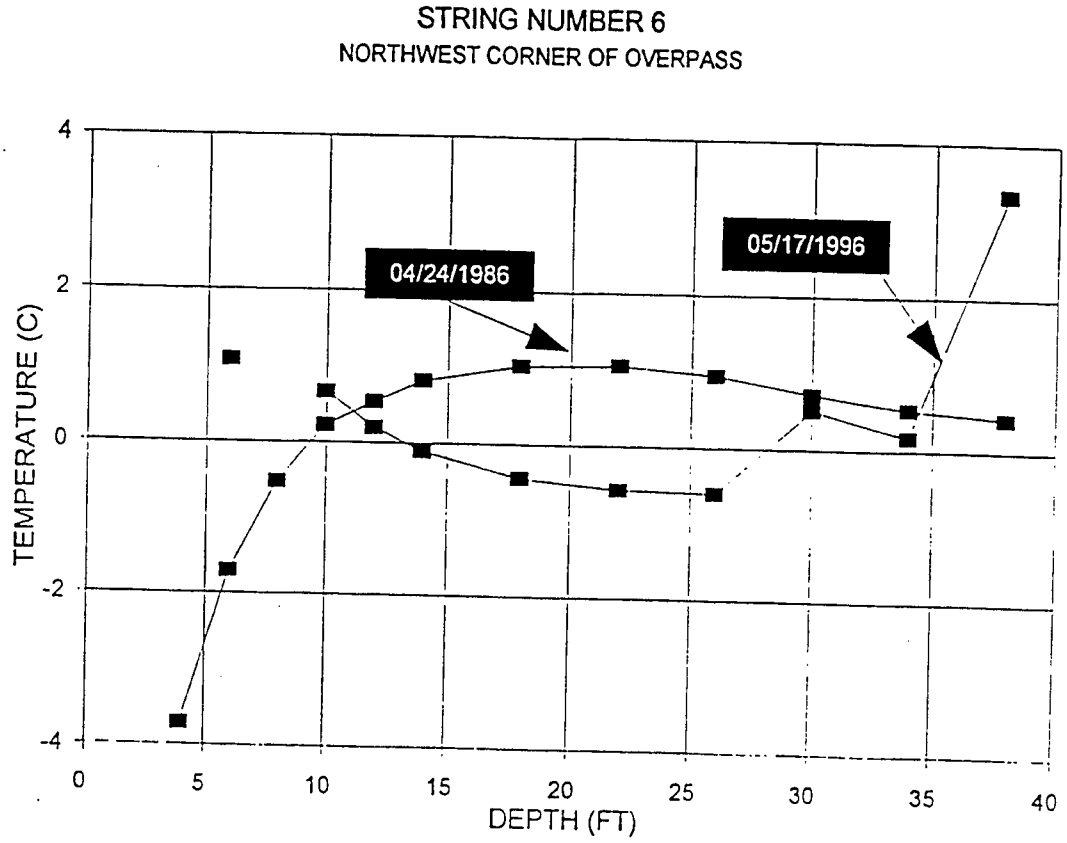

Figure 3.4-3: Spring Temperatures (1996 & 1986), string #6 (N.W. corner)

Ground Temperatures

The first ground temperatures at this site were recorded in 1969. Spring temperatures at Abutment 1 and Pier 3, recorded in April 22, 1969, were compared with temperatures recorded on May 17, 1996. Under Abutment 1, the 1996 spring temperatures were warmer than those of 1969. The data shows that the 1996 spring thaw depth is approximately 19 feet at Pier 3. These observations are shown in Figures 3.5-1 thru 3.5-2.

3.6 GARDINER CREEK

This site was instrumented to monitor temperatures around circular air ducts. Eighty thermocouples were installed to monitor temperatures at the top, bottom, left and right of the air duct in for both the north side and south side ducts.

Ground Temperatures

All of the temperature sensors at this site were damaged beyond repair. This occurred during a fall construction project in which maintenance work was done on the fill. Thus, no future readings will be available at this site.

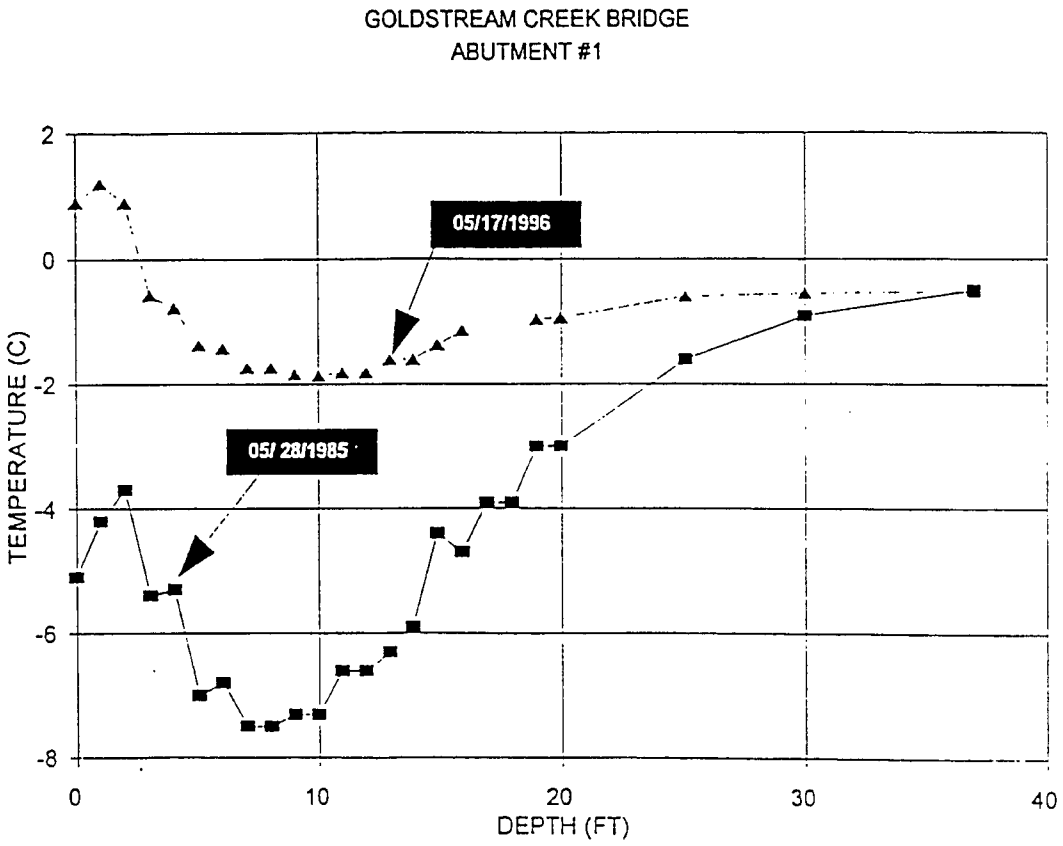

Figure 3.5-1: Spring Temperatures (1996 & 1985), Under Abutment 1

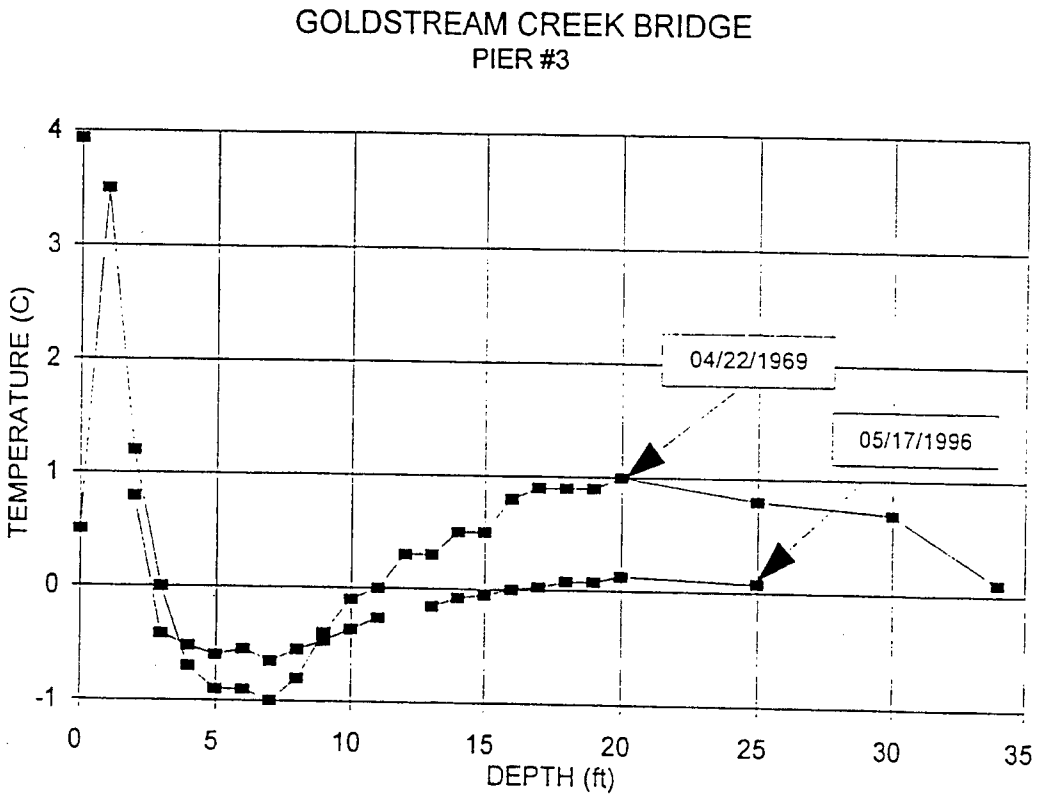

Figure 3.5-2: Spring Temperatures (1996 & 1985), Under Pier 3

3.7 BETHEL HIGHWAY

The Bethel Highway was built in 1990. Forty-eight Thermosyphons and a layer of insulation were installed under the roadway to control subsurface ground temperature. During construction, ten temperature measurement strings were installed. These strings consist of 110 thermocouple and 28 thermistors. Some sensors are connected to two data loggers; others must be recorded manually. The two data loggers are referenced as "A" and "B".

Manual temperature data were collected and the data files for the two data loggers were downloaded on April 2, 1996. During this trip, the battery that supplies data logger "A" was down. This battery was replaced.

Data from the automatic recorders were available for only part of the year; this is due to the discharging of the batteries. When the batteries are fully charged, the data appears very reliable and provides an hourly "snapshot" of air temperature and subsurface temperature conditions. Air temperature, temperatures above and below the insulation layer, and ground temperature about 2 feet 2 inches from a thermosyphon are presented in Figures 3.7-1 and 3.7-2. The thermosyphons and insulation layer still appear effective in maintaining a frozen subgrade.

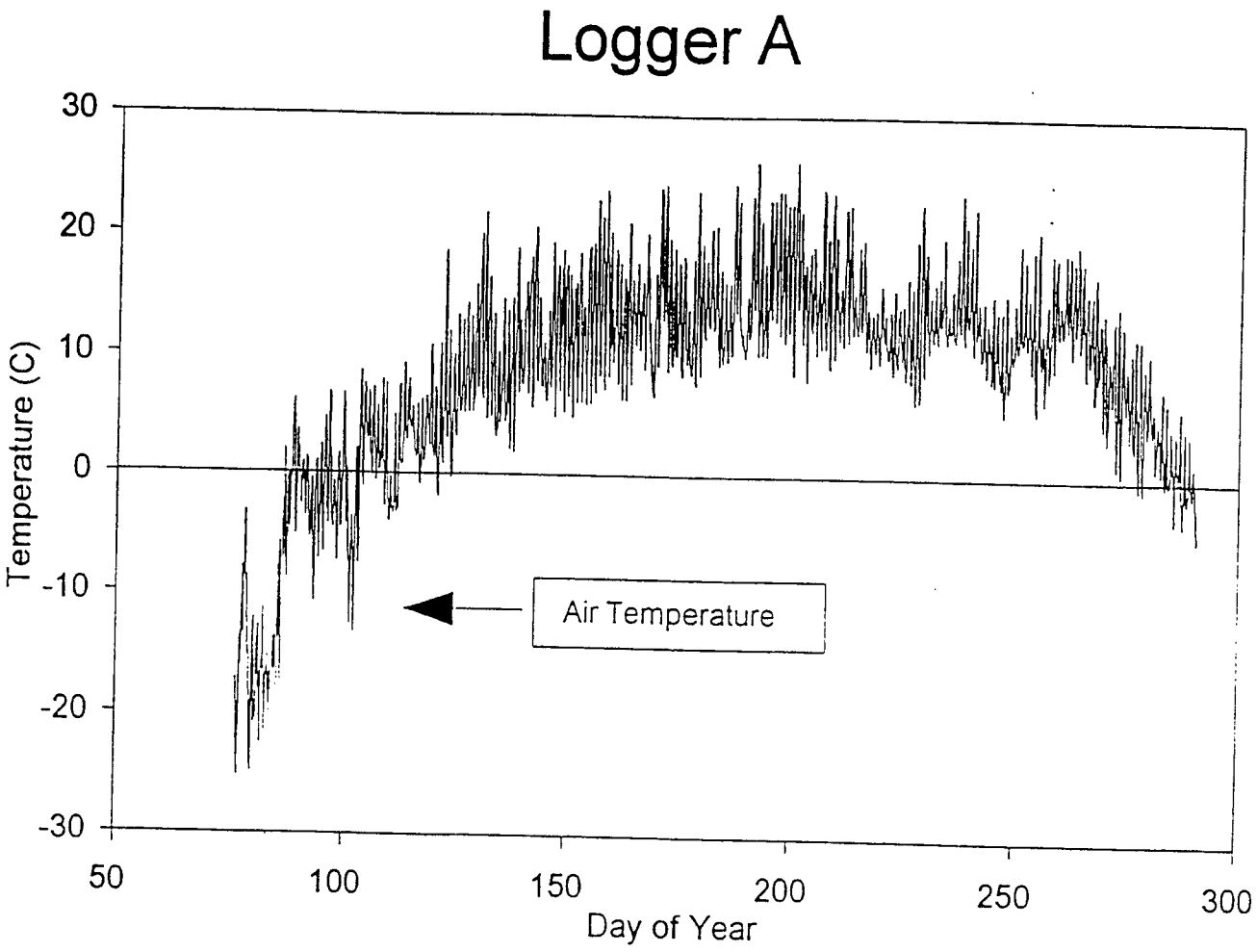

Figure 3.7-1: Air Temperatures for Logger A

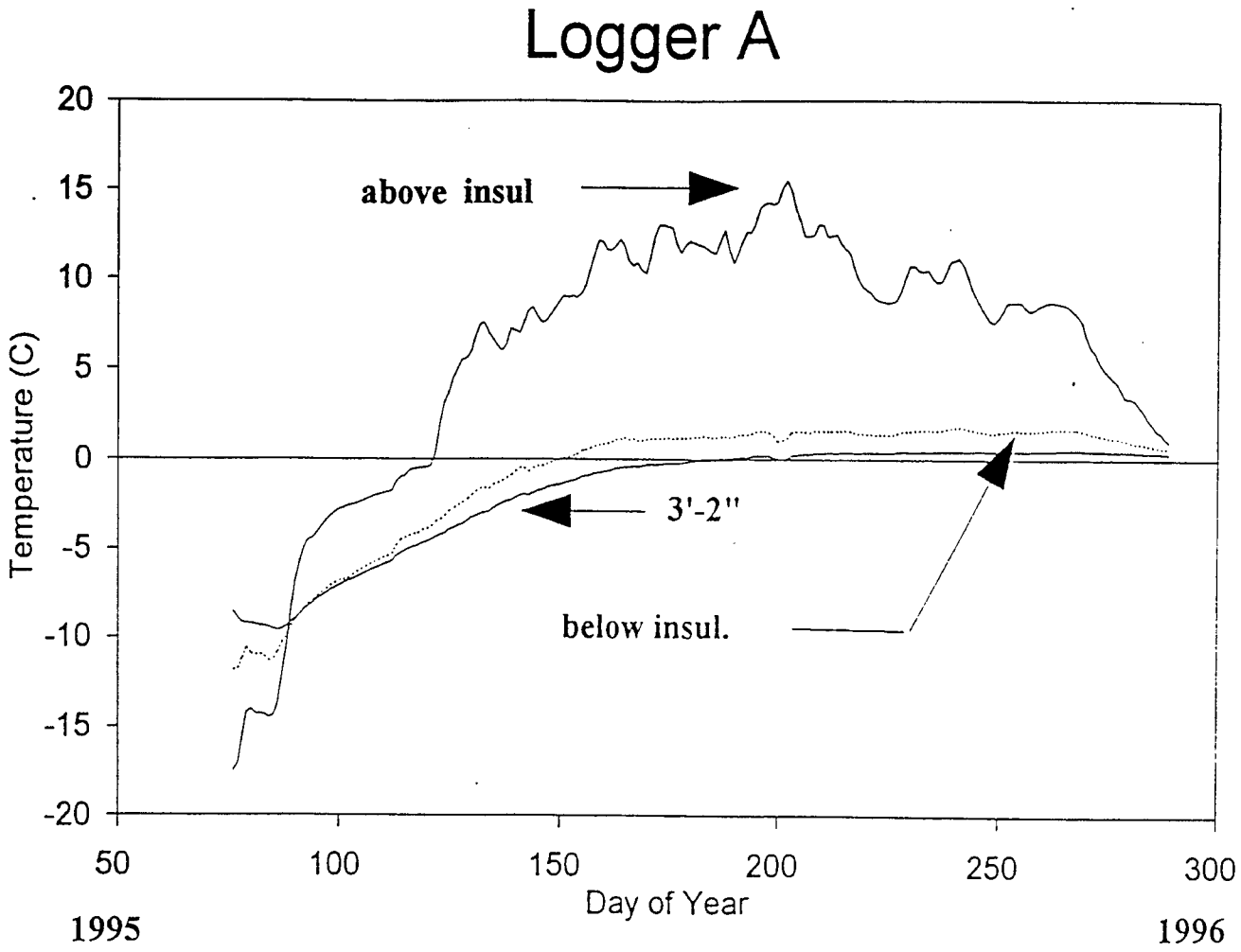

Figure 3.7-2: Temps above/below insulation & 3'-2" from Thermosyphon for Logger A

4. SUMMARY AND CONCLUSIONS

A spring visit was made to all eight permafrost test sites. Temperature data were taken at seven. The instrumentation at the Gardiner Creek test site was torn out between the fall 95 and spring 96 visits. These instruments were damaged beyond repair, and as a result no future data will be available at this site. The bridge reinforced earth backwall at the airport overpass was extended during the 1996 summer construction season. Thus, future temperature data will probably be affected by the new construction.

A layer of insulation in combination with 49 thermophsyons appears to be an effective method for stabilizing the permafrost test site along the Bethel Highway. Only minimal thawing is occurring in the fill below the insulation.

At the remaining sites, ground temperatures in 1996 were colder than ground temperatures first recorded soon after these sites were constructed.

5. RECOMMENDATIONS FOR FUTURE RESEARCH

The Alaska Division of Transportation & Public Facilities has been monitoring thaw depths at several experimental test sites since 1969. At most sites, ground temperatures have been recorded at least twice a year. At some sites, additional information such as roadway movements have also been recorded. In the past, experimental findings at these sites have been useful in comparing the effectiveness of alternative construction methods in permafrost regions.

At the Bethel test site, it is recommended that solar cells be installed to keep the automatic data recorder 12 volt marine batteries charged. Without this, the batteries sometimes only last a portion of a year. This has been responsible for data loss and in some cases unreliable data.

Improved methodologies for predicting performance of roadways over permafrost can be a significant cost savings to the state of Alaska. Thus, that site-measured temperature data should be supplemented with: 1) original soil moisture data, and 2) a site subsurface soil exploration through soil borings to determine soil moisture and characterize both frozen and unfrozen thermal properties of the subsurface soils at these sites. These data could be used to develop an improved methodology for predicting ground thaw and settlement as a function of time. Results from predictive models using site soil conditions should be compared with field performance information.

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