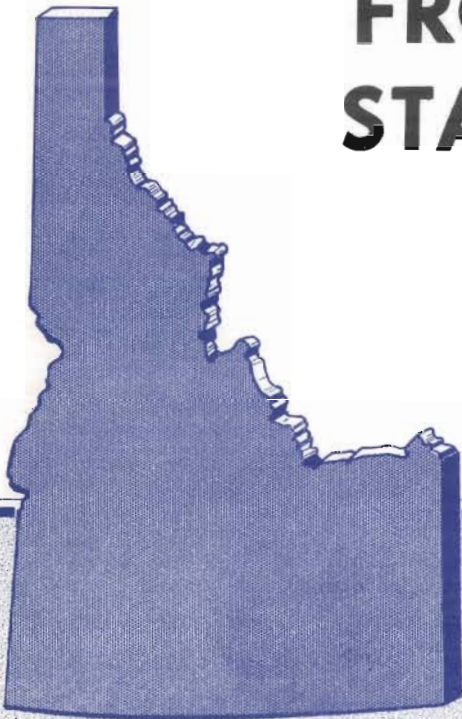


X-TRA

FROST HEAVES ON STATE HIGHWAY 15

July 1965

RESEARCH PROJECT NO. 31



STATE OF IDAHO DEPARTMENT OF HIGHWAYS

A STUDY OF FROST HEAVES
ON
STATE HIGHWAY NO. 15

July, 1965

Materials Section
and
District No. 3

State of Idaho
DEPARTMENT OF HIGHWAYS
Boise, Idaho

ACKNOWLEDGMENTS

This study was initiated by District 3 to determine the cause of the heaves occurring on Route 15 between Banks and New Meadows.

Charles F. Whipple, Resident Engineer, was in charge of the field investigation with Merl Sorich, Instrument man II, running levels over the frost heaves. The District Materials Section performed the drilling with Robert Charbaneau, District Geologist, giving supervision to the drilling program. The Central Laboratory performed tests on the samples and the report was prepared by the District and edited by the Research Division.

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SYNOPSIS

District 3 undertook an investigation of numerous typical frost heaves on State Highway No. 15 during the late Spring of 1964. Borings were made in the heaved area and in areas not evidently heaving adjacent, cores were taken and examined for ice lensing and material in the cores tested by the Central Laboratory. Efforts were made to determine sources of water from drainage areas and to correlate drainage and heaving.

It is evident that drainage does effect the amount of heaving and that snow depths create a major problem in keeping drainage channels open. In some instances improvements can be made, but in others, it appears prohibitive in time and cost. Efforts should be made to increase the depths of frost-free base and sub-bases to prevent or reduce surface distress from heaving. Possible other solutions are included in the recommendations.

INTRODUCTION

Several large frost heaves have been occurring every winter on State Highway 15 between Banks and New Meadows. These heaves have occurred on older sections of highway as well as many of the more recently constructed sections, including two having cement treated base.

This study was initiated by District Three to determine the cause and amount of heaving. It was hoped that the location of ice lensing within the base, subbase or subgrade soils could be determined. The source of water, whether from water table or flow from adjacent drainage in the mountainous terrain or from poorly drained fields in the valley, available to cause heaving was to be determined if possible.

Scope of the Investigation and Methods Used

The study was limited to 10 sites selected over a distance of 50 miles (See Figure 1). These sites are representative of numerous others having frost heaves. Sites were selected on two projects having cement treated base to determine the amount of heave occurring and differences in the heave near cracks in the pavement. Other sites were selected to determine if an apparent uniform heaving was occurring throughout the project. One large heave occurring in a cut appeared to stop at the point where French drains were known to begin. These sites were considered to be representative of other areas on this section of road.

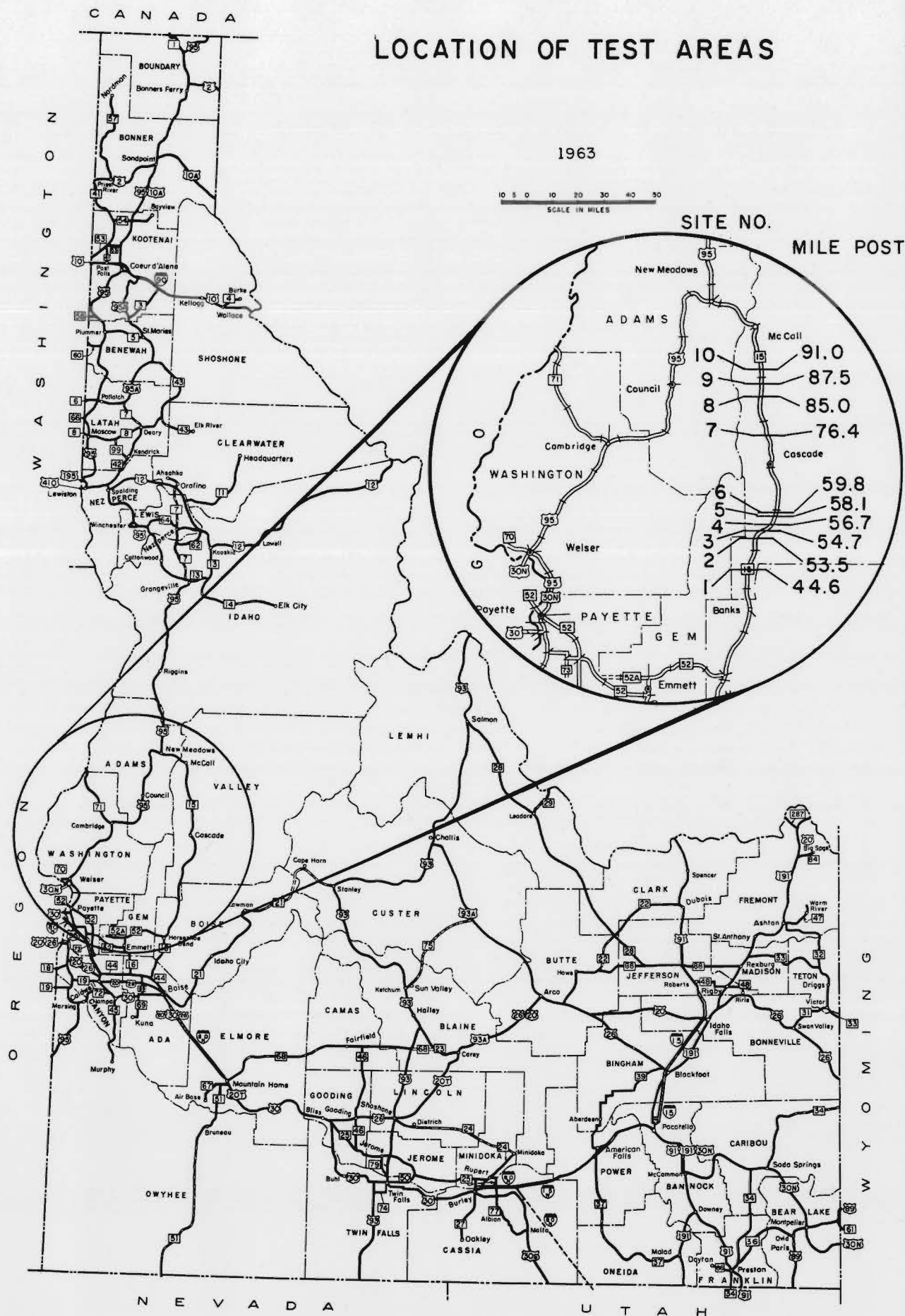


FIGURE 1

Cores were taken within each site by means of a diamond drill to obtain a cross section of the pavement, base, subbase and subgrade. Since the roadway was frozen during the drilling, cores were relatively easy to obtain. These cores were examined for evidence of ice lenses and then submitted to the Laboratory for tests. The tests made were to include mechanical and hydrometer analysis, moisture content, sand equivalent and such others as deemed feasible. The core samples were taken with a 1" core bit and were large enough for the mechanical and hydrometer analysis and moisture content tests only.

A permanent bench mark was used at each site for reference for precise levels to determine the amount of heave with reference to late summer elevations at the same place.

It was hoped that the information gathered from the investigation would be helpful in determining the cause and corrective measures to be taken.

Climate of Area

The elevation of the highway at Banks is approximately 3,000 feet and increases to an elevation of 4,700 feet at Round Valley to 5,300 feet at the summit north of McCall. Winter snows remain throughout the winter months until the end of April with snow depths varying from less than a foot to more than four feet on level ground. Winter temperatures drop to a -40°F. and the mean high during the day does not rise above freezing until late February or early March. Precipitation throughout this area exceeds 25 inches and during the winter months exceeds twelve inches of water over much of the area. Winter conditions throughout this area are as severe as any in Southwestern Idaho.

Results of Investigation

Plan and Profile sketches and boring logs are shown for each site. These sketches and the results of laboratory tests are given in Appendix A and B. Core samples were taken and the material tested show that the material consists of a silty sand. The amount of material passing the No. 200 sieve ranges from 14 per cent to more than 50 per cent. The percentage smaller than 0.02 mm ranges from 9 to 30 per cent in comparison. This silty sand lies immediately below the crushed gravel base or the cement treated base. Tests for sand equivalent or plasticity index were not made as the cores did not provide sufficient material.

Examination of each core for frost lenses was made. In several instances (Sites 3, 6, 8, 9, and 10) frost lenses were in evidence for the area where heaving occurred.

Elevations taken during the March, 1964, investigation and again in September indicated that heaving exceeded 0.5 feet in several of the areas. These elevations also indicated a uniform heaving of the roadbed of from 0.15 - 0.30 feet for the distance over which levels were taken in Sites 5 and 9.

It appears that poor drainage due to snow filled ditches and snow blocked culverts caused water to back up into the base and subgrade. Thawing snow and early spring rains add to the water supply with night-time freezing further increasing the heaves.

Frost criteria established by laboratory test by the Cold Regions Research and Engineering Laboratory of the U. S. Corps of Engineers would

rate all the silty sand materials as frost susceptible. Their criteria is stated as follows: (1)

"Most inorganic soils containing 3 per cent or more of grains finer than 0.02 mm in diameter by weight are frost susceptible for pavement design purposes. Gravels, well graded sands, and silty sands, especially those approaching the theoretical maximum density curve, which contain $1\frac{1}{2}$ to 3 per cent finer by weight than 0.02 mm size should be considered as possibly frost susceptible and should be subjected to standard laboratory frost susceptibility test to evaluate actual behavior during freezing."

The samples containing the larger quantities smaller than 0.02 mm are rated as more susceptible to frost by this criteria. Appendix A gives the Corps of Engineer's classification and minimum design thickness for frost for the soil tested for each sample tested.

Several heaves appear to be aggravated by adjacent drainages for which no culverts were provided, particularly sites 1 and 3. Since other areas show heaving even though culverts are present, we are led to the conclusion that providing a culvert does not necessarily solve the problem if drainage is other wise impaired.

Heaving occurs at the grade points at site 6 and 10 and in part of a cut at site 8. Drainage being blocked by snow contributes to these frost heaves.

(1)

Linell, K. A., Hennion, F. B., Lobacz, E. F., Corps of Engineers Pavement Design in Areas of Seasonal Frost, HRB Record 33.

Recommendations

It is most difficult to make any practical recommendations to prevent the frost heaves in this area. Water is available from numerous sources and with the extreme depth of snow, it is very difficult to improve drainage during the critical time of the year when heaving does occur. It appears that each frost heave is a distinct problem, although similarities are common. The following recommendations are made for improvement of drainage to reduce frost heaving when possible:

1. Drainage is very important - Keep channels open to culverts from all drainage areas when feasible.
2. Open up surface drainage at lower end of cuts to permit water to flow away from the highway. This applies to water flowing on the shoulder trapped by snow berms as well as water in the roadway ditch. Cutting through the berm of snow will permit the water to escape over the embankment.
3. Consider placing additional cross drains where it appears that water is diverted into base and subgrade material before reaching a culvert.
4. Whenever possible, open channels through berms of snow on shoulders to drainages on down hillside of roadway.
5. Areas that heave when surface drainage is not the primary cause of the heaving, should be excavated and replaced with clean granular material and drained by means of perforated pipe, french drains, etc.

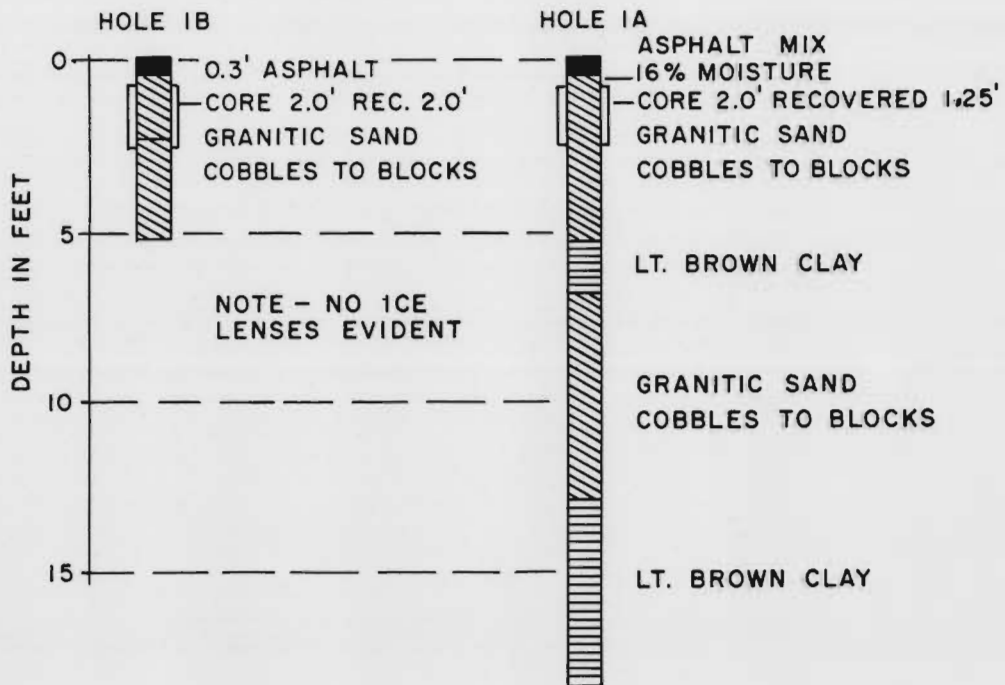
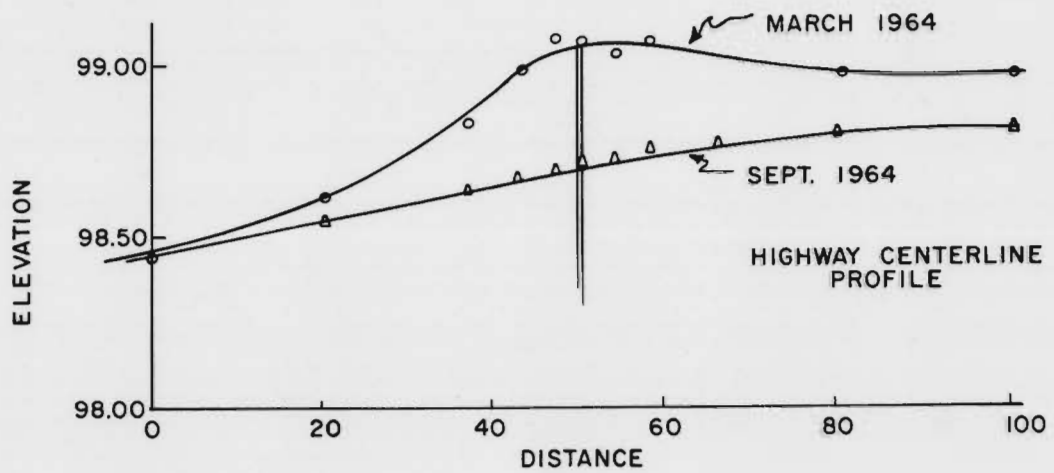
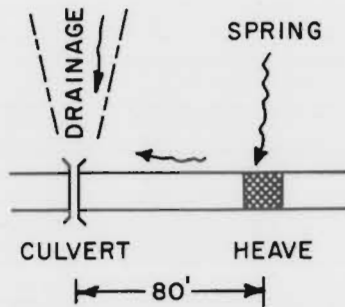
6. Consideration should be given to a minimum thickness of clean base having very low frost heaving potential to depths in excess of two feet on all future projects in this area.
7. The frost heave on either side of the structure at site 9 can be minimized, insofar as abruptness is concerned, by placing a wedge of gravel tapering from nothing to about four feet in thickness at the abutment wall. This wedge should extend at least 25 to 50 feet back from the wall dependent on the severity of the heave.
8. Experimentally on a couple of short cut areas, fill ditches completely with gravel and pave to the edge of the cut slope. A bituminous curb should be constructed at the edge of the cut slope to prevent snow and water from the pavement percolating into the base beneath. This should be considered experimental, and only tried on a couple cuts.
9. Experimentally try various types of stabilization to determine how effective the treatments are in reducing frost heave.
10. Experimentally try insulation of the subgrade where serious heaving occurs. The use of Dow Chemical Company - styrofoam blanket on the subgrade is a possibility, and has been tried with apparently satisfactory results on projects in Canada and Michigan, and undergoing tests in other states.

B I B L I O G R A P H Y

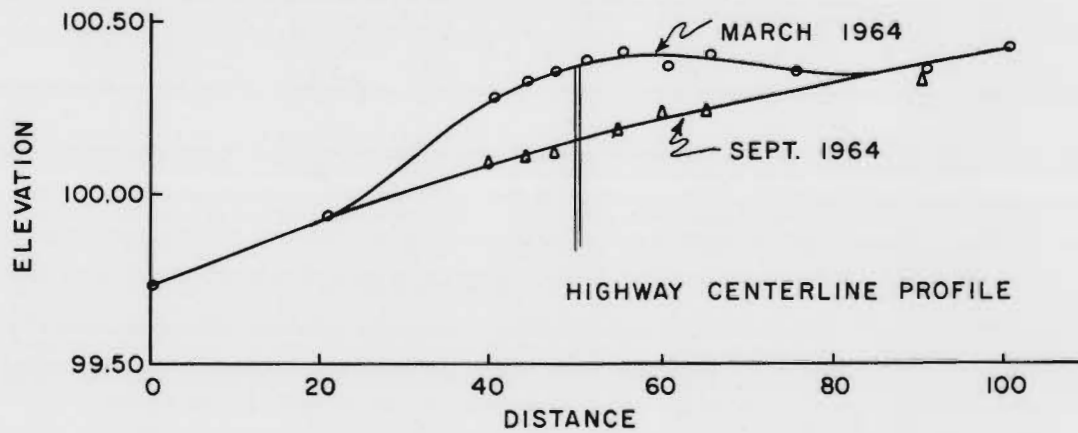
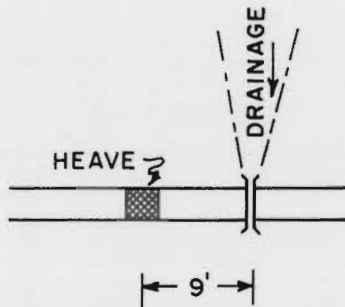
Linell, K. A., Hennion, F. B., Lobacz, E. F., Corps of Engineers Pavement Design in Areas of Seasonal Frost, Highway Research Board Record No. 33, 1963.

APPENDIX A

SITE NO 1 MILEPOST 44.7

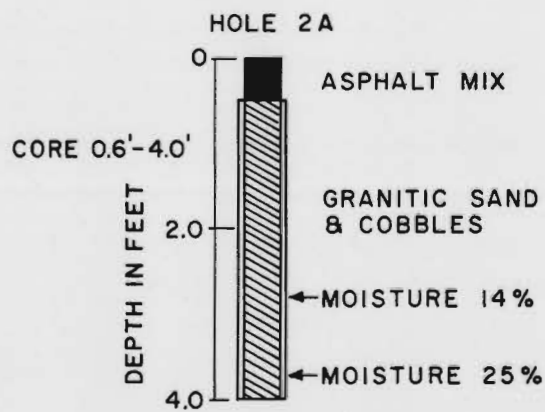


SITE NO 2
MILEPOST 53.5



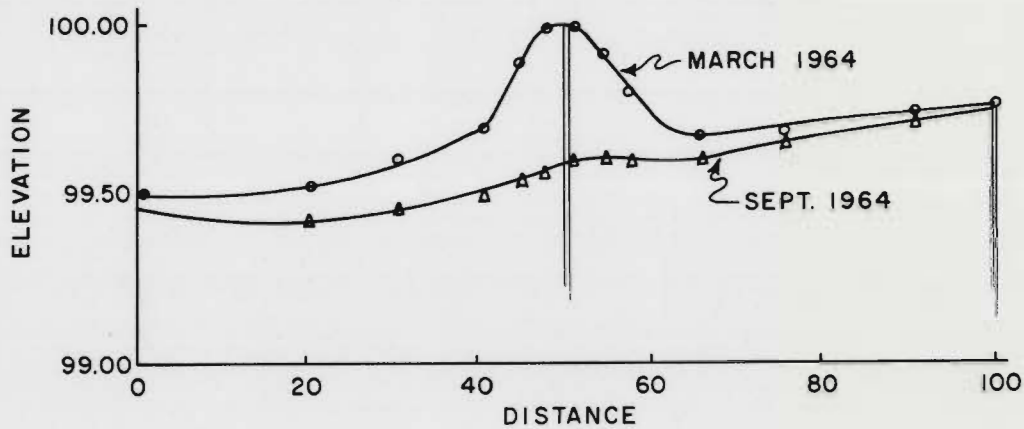
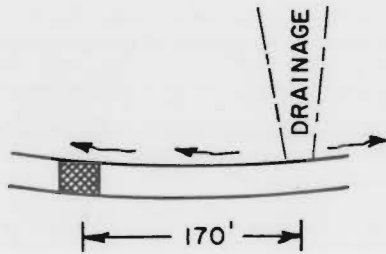
CORE RECOVERED

0.6 - 1.0	} 1.33' R
1.0 - 2.0	
2.0 - 3.0	- 1.0
3.0 - 4.0	- 0.8



NOTE - NO ICE LENSES EVIDENT

SITE NO 3 MILEPOST 54.7



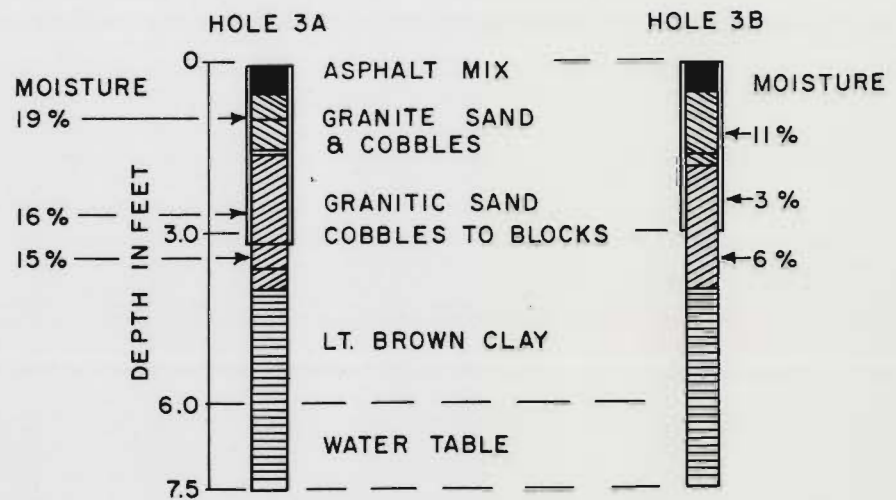
CORE RECOVERIES

HOLE 3A

0.6 - 3.3 = 2.5'

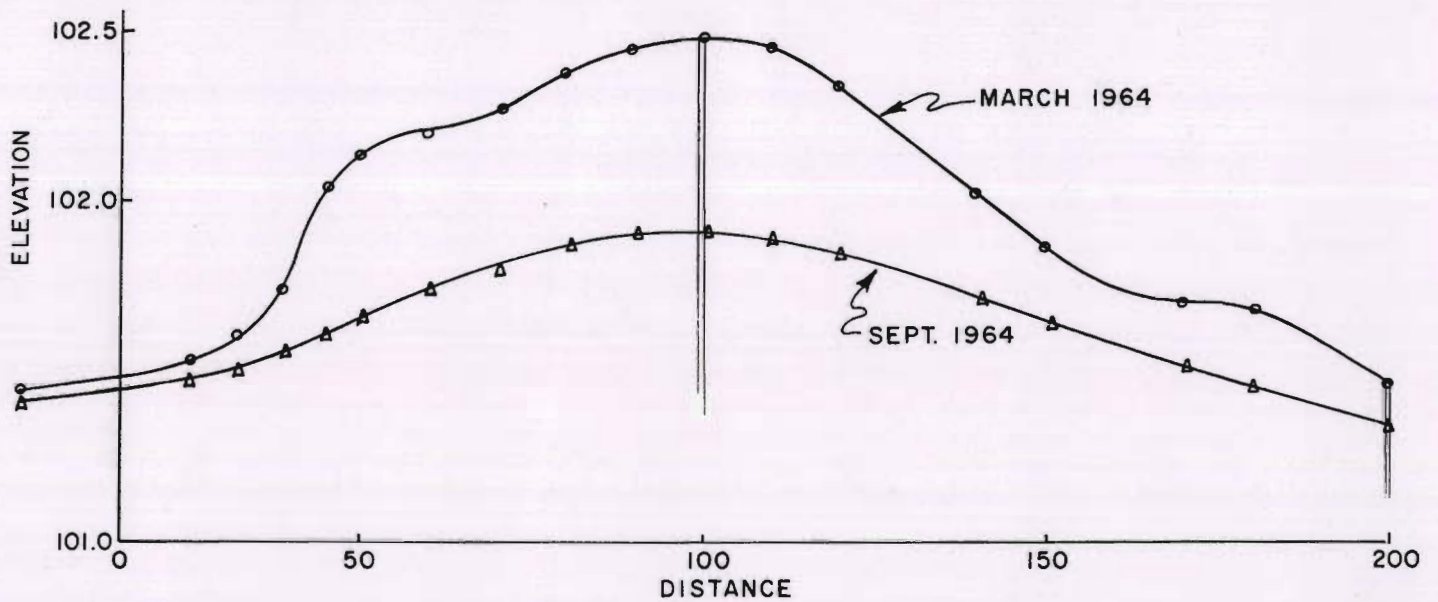
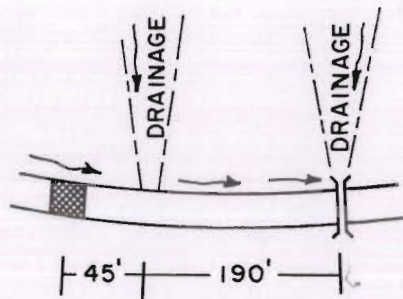
HOLE 3B

1.1 - 3.1 = 2.0'



ICE LENSES LOGGED AT 1.6', 3.3' HOLE 3A

SITE NO 4
MILEPOST 56.7

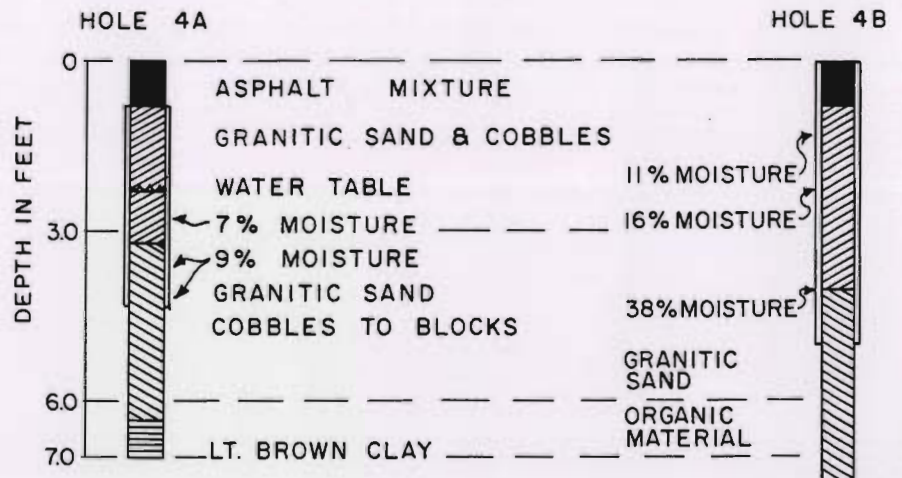


CORE RECOVERIES

HOLE 4A
1.4' - 4.4' = 3.0'

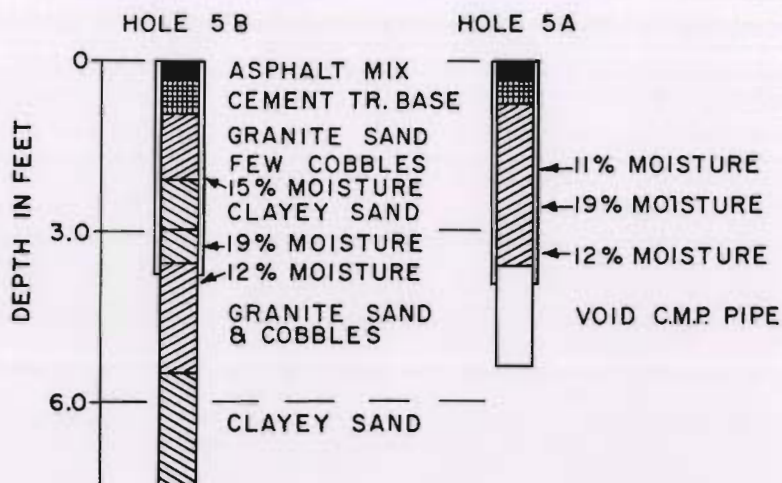
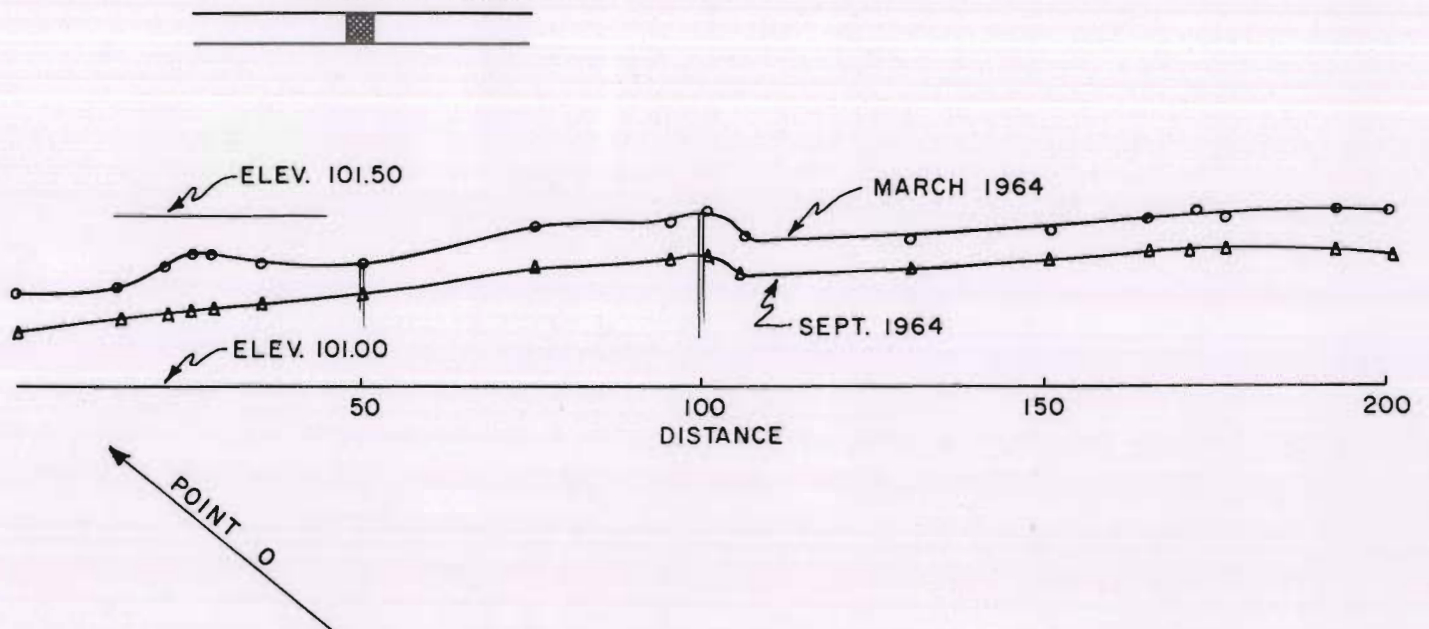
HOLE 4B
1.1' - 5.0' = 4.6'

NO ICE LENS NOTED



SITE NO 5 MILEPOST 58.1

HEAVE AT CRACK



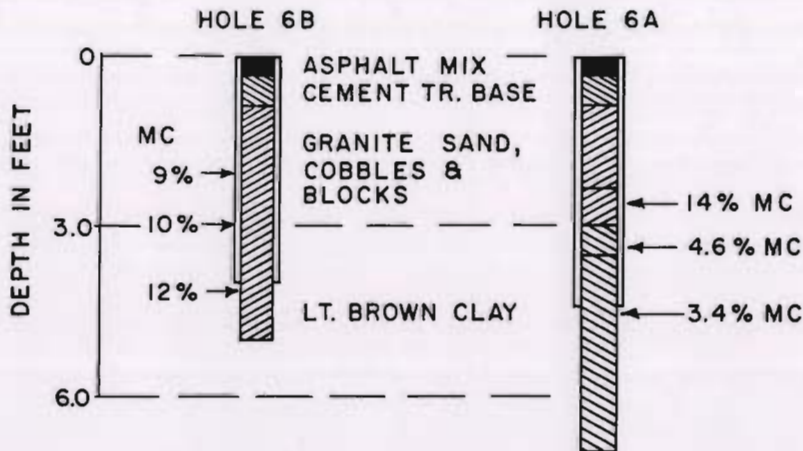
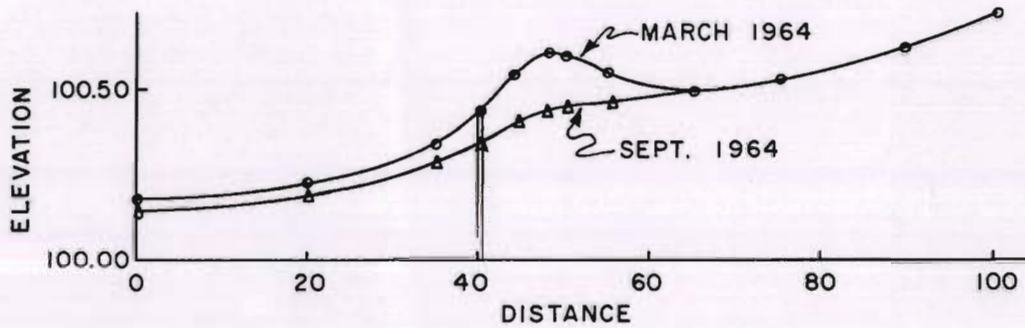
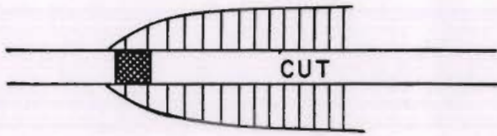
CORE RECOVERIES

HOLE 5A
0.7' - 3.7' = 2.9'

HOLE 5B
1.0' - 4.0' = 3.0'

HOLE 5B ICE LENS AT 2.0, 2.9
HOLE 5A NO ICE LENS EVIDENT

SITE NO 6
MILEPOST 59.8



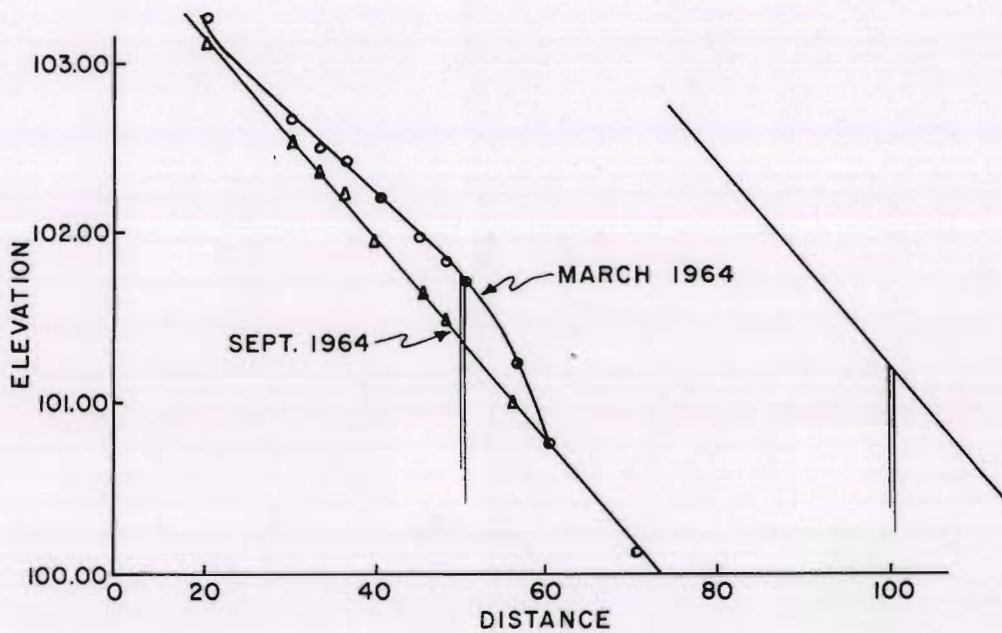
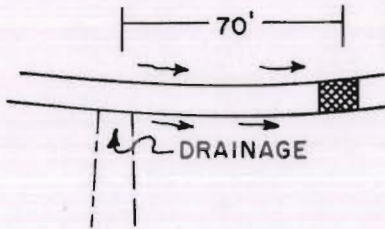
CORE RECOVERIES

HOLE 6A
1.4' - 4.4' = 2.73'

HOLE 6B
1.0' - 4.0' = 3.00'

HOLE 6A - ICE LENS AT 2.3, 3.1 AND 3.5
HOLE 6B - NO ICE LENS EVIDENT

SITE NO 7
MILEPOST 76.4

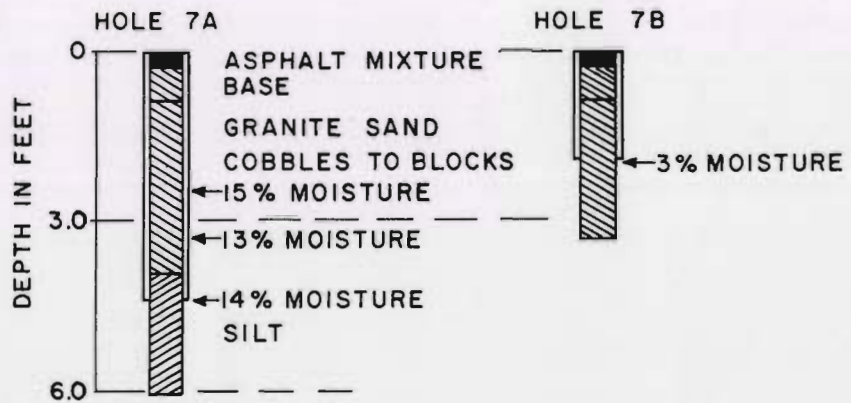


CORE RECOVERIES

HOLE 7A
1.4' - 4.4' = 2.65'
FROST TO 4.0'

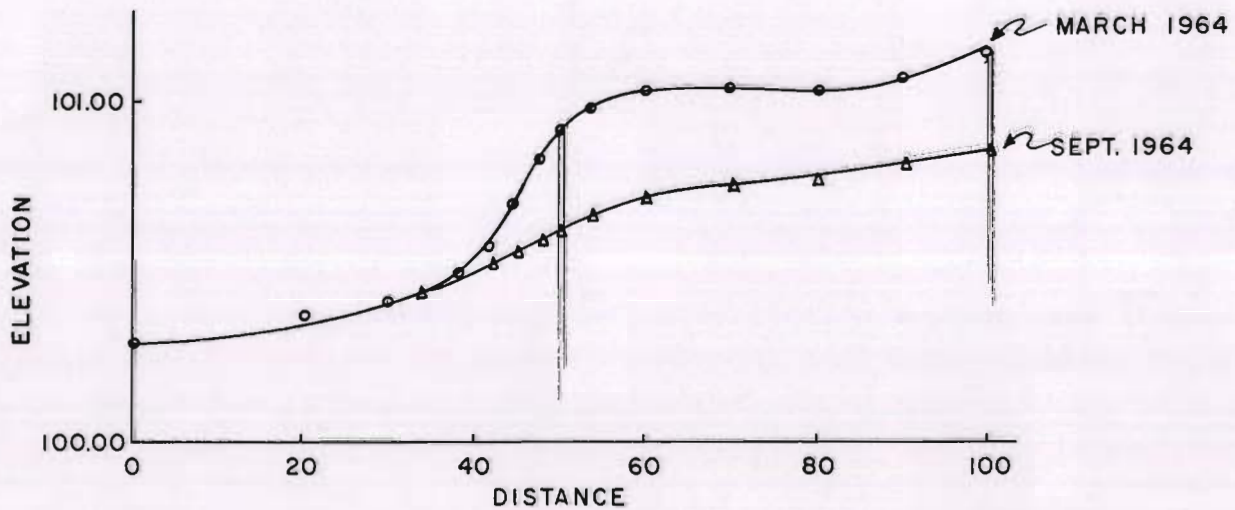
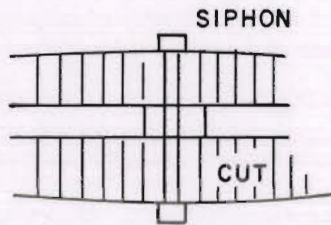
HOLE 7B
MATERIAL NOT
FROZEN

NO ICE LENS
EVIDENT



SITE NO 8

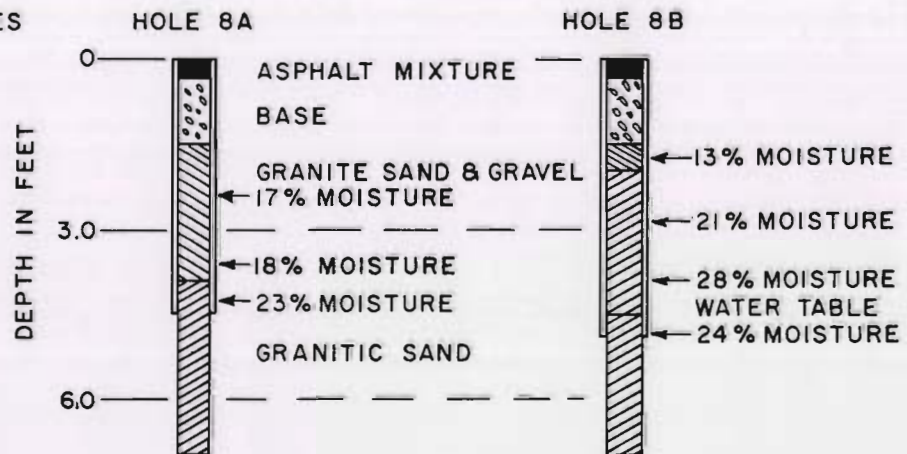
MILEPOST 85.0



CORE RECOVERIES

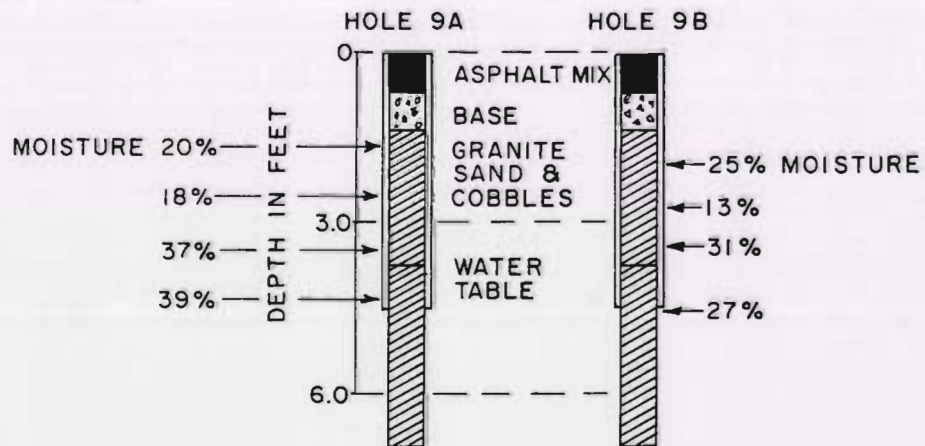
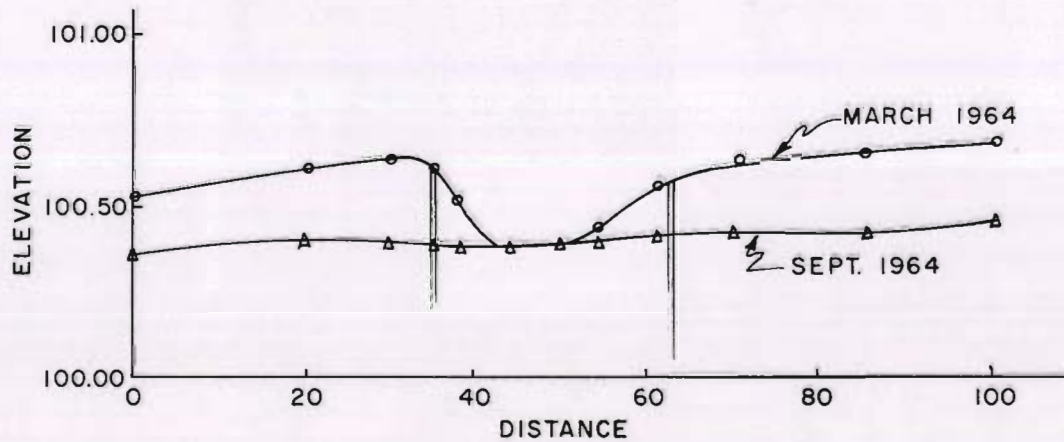
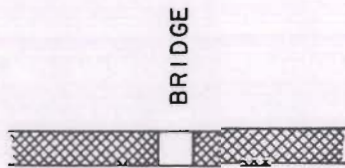
HOLE 8A
1.5' - 4.5' = 3.0'

HOLE 8B
1.8' - 4.8' = 3.0'



HOLE 8A - ICE LENS AT 1.8, 3.1, 3.4
HOLE 8B - NO ICE LENS EVIDENT

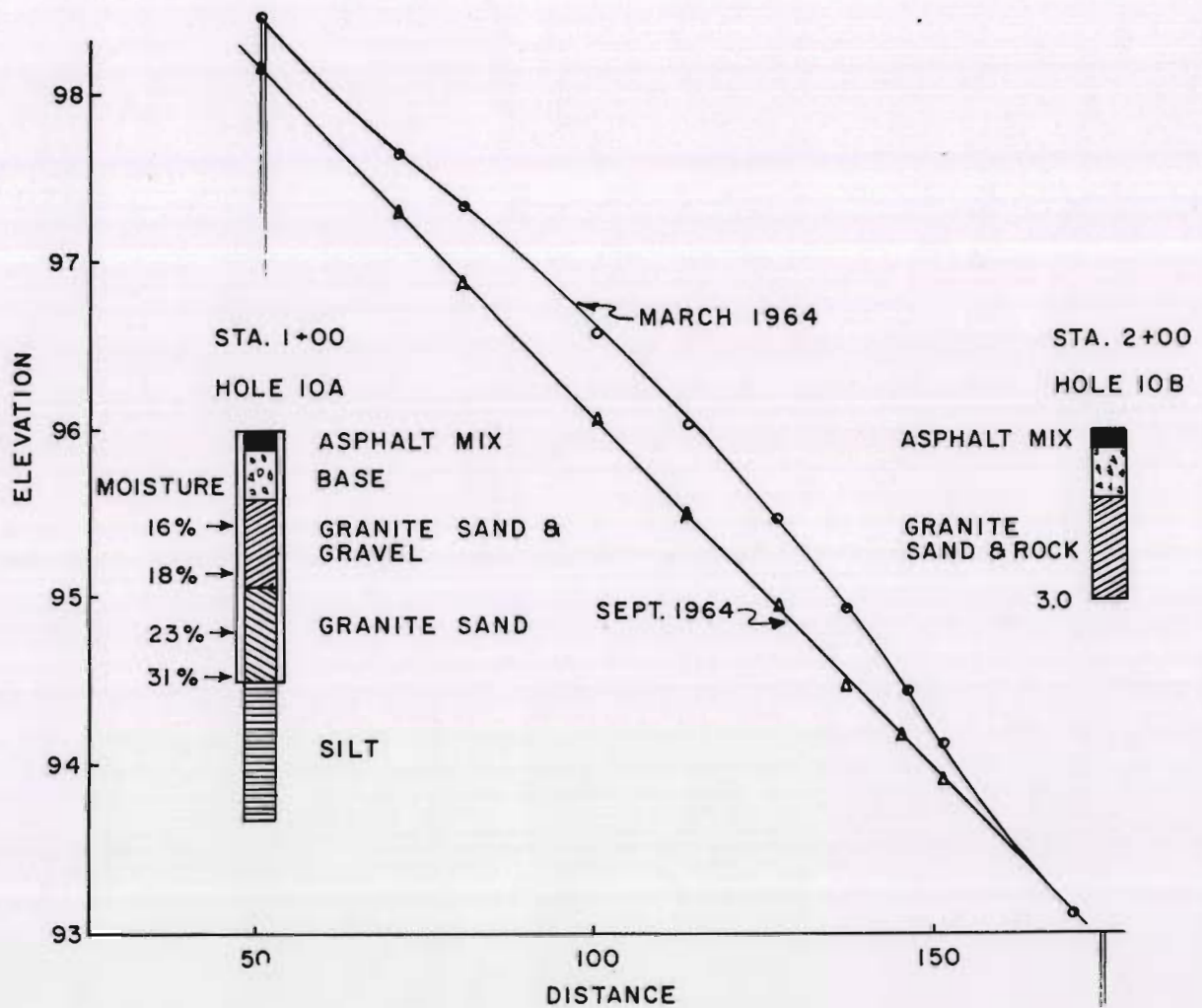
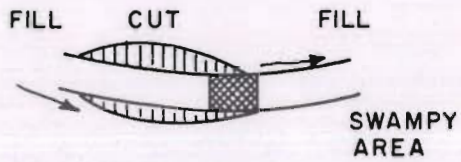
SITE NO 9
MILEPOST 87.5



HOLE 9A - ICE LENS AT 2.1, 3.3
HOLE 9B - ICE LENS AT 3.3

SITE NO 10

MILEPOST 91.0



HOLE 10A - ICE LENS AT 3.3
HOLE 10B - NO CORES

APPENDIX B

MECHANICAL AND HYDROMETER ANALYSIS OF MATERIAL OBTAINED FROM CORES

	Site No. 1.		Site No. 2		Site No. 3		Site No. 4		Site No. 5		Site No. 6	
	0.8-1.3	1.3-1.9	0.5-4.0	3A	3B	4A	4B	4A	5A	5B	6A	6B
Passing	1.9-2.2	1.9-2.2	0.5-4.0	0.6-4.0	1.7-4.0	0.8-6.3	0.8-4.0	4.0-7.5	0.8-3.6	0.9-5.5	0.9-3.0	0.9-5.0
3" Sq	100											
1" Sq		100										
½" Sq	100	100	100	100	100	100	100	100	100	100	100	100
No. 4	96	84	97	97	97	98	97	99	99	99	98	98
No. 10	80	67	86	88	90	87	89	91	92	91	90	89
No. 50	30	36	50	53	56	49	57	59	59	51	62	56
No. 100	21	26	36	39	41	35	43	46	48	46	52	44
No. 200	17	19	27	29	30	26	33	37	39	38	44	35
0.02 mm	10	11	15	16	17	17	21	23	23	24	28	22
0.005 mm	6	6	7	10	9	9	13	14	13	15	19	13
0.001 mm	3	3	2	4	4	4	6	5	5	7	9	5
C of E Frost Design Class.	F-2	F-2	F-2	F-3	F-3	F-3	F-3	F-3	F-3	F-3	F-4	F-3
C of E Design Th. Min.	14½	14½	21	21	21	21	21	21	21	21	21+	21

	Site No. 7		Site No. 8		Site No. 9		Site No. 10	
	7A	7B	8A	8B	9A	9B	10A	10B
Passing	0.4-4.0	0.9-3.4	0.3-1.4	0.3-1.9	0.7-4.5	1.4-4.0	1.3-2.8	4.5-7.0
3" Sq	100							
1" Sq		100						
½" Sq	99	100	100	98	99	99	98	100
No. 4	96	97	95	98	98	97	87	98
No. 10	89	92	87	90	95	97	76	96
No. 50	63	51	62	51	61	63	39	74
No. 100	50	34	49	40	46	48	28	69
No. 200	39	23	36	29	39	38	21	63
0.02 mm	23	11	18	14	28	29	10	34
0.005 mm	12	5	10	8	18	19	5	11
0.001 mm	4	3	6	3	9	10	1	3
C of E Frost Design Class.	F-3	F-2	F-3	F-2	F-3	F-3	F-2	F-3
C of E Design Th. Min.	21	14½	21	14½	21	21	14½	21