MICHIGAN
STATE HIGHWAY DEPARTMENT
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MICHIGAN'S EXPERIMENT IN SNOW AND ICE REMOVAL ON HIGHWAYS BY RADIANT HEAT

Winter Season 1950-1951
Performance and Cost

Cooperative Research Project between
the Michigan State Highway Department
and Detroit Public Lighting Commission

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MICHIGAN'S EXPERIMENT IN SNOW AND ICE REMOVAL BY RADIANT HEAT

Performance and Cost Data for Season 1950-1951

This is the fourth progress report on the Michigan experiment in snow and ice removal on highways by radiant heat. It is the purpose of this report to present performance and cost information for the winter season of 1950-1951. As in the season of 1949-1950, the season of 1950-1951 was representative of a normal winter in the Detroit area; however, temperature records show that the average air temperature under operating conditions for 1950-1951 was slightly lower than that for 1949-1950, and considerably lower than that for 1948-1949. This is reflected in the higher energy consumption for the 1950-1951 season.

General Performance

The heating system was put into operation on November 23, 1950. The last operation period ended March 21, 1951. The severity of the past winter is reflected not only in operating cost, but also in operating difficulties encountered. Total operating hours for the 1950-1951 season were 926.35 hours, as compared to 548.70 for 1949-1950 and 506.59 for 1948-1949. Average air temperature during operation periods for 1950-1951 was 25° F., as compared to 28° F. and 31° F., respectively, for the previous seasons. The total snowfall for the 1950-1951 season was approximately the same as for the 1949-1950 season. The operating cost of the system per hour for 1950-1951 jumped to $2.02, as compared to $1.89 and $1.31, respectively, for the other seasons.

For the first time since the installation was made, transverse cracks in the bituminous concrete pavement opened to such an extent that the heating element wires broke on different occasions. In some cases, these transverse cracks in the surface were as much as 3/8 inch in width, and ran the full width of the pavement. The broken elements were repaired by removing a section of the surface

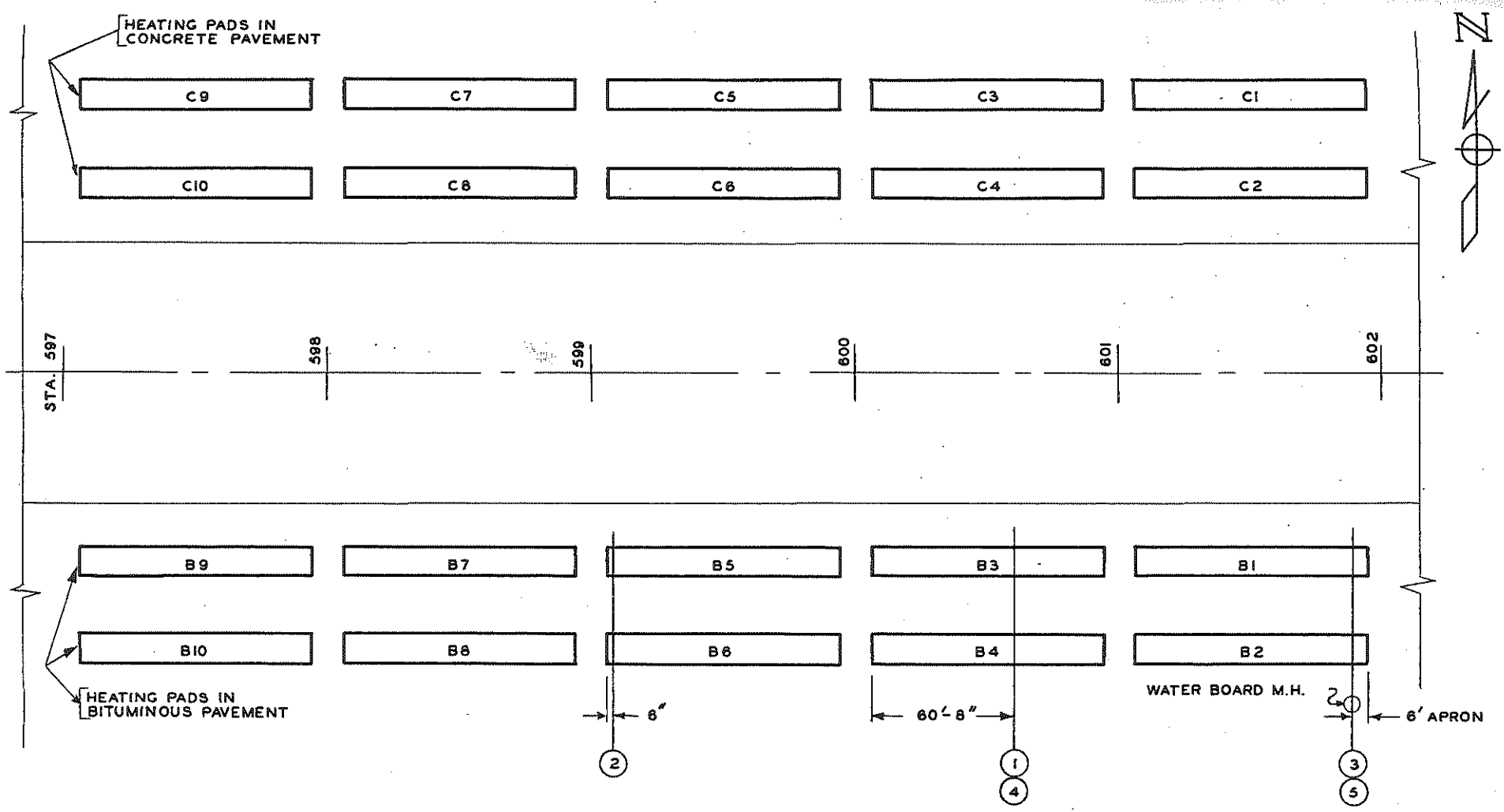
and attaching a piece of wire between the broken ends of the element, leaving enough slack to provide for future movement of the pavement. Figure 1 is a schematic diagram showing the position of breaks and date of occurrence. No breaks have occurred to date in the concrete section.

During this season, there were several prolonged snow periods which illustrate clearly the added burden imposed on the heating system when installed on a flat roadway with no provision for rapid runoff of melt water. On such occasions, when the snow falls intermittently for several days, the heating system is required not only to melt the normal snowfall and the slush thrown onto the heated strips from adjacent unmelted lanes by passing vehicles, but also to maintain the resultant layer of water at above-freezing temperature, thus necessitating that the system be energized for a considerably longer period. If the heating system were installed on an inclined raodway, the melt water would drain off immediately and the system would turn "OFF" much sooner, with a considerable saving in cost of operation.

Complete operative cost data for the 1950-1951 winter season, furnished by the Detroit Public Lighting Commission, will be found in Table I. In Table II, there have been compiled comparative operative data, by months, for the three winter seasons of 1948-49, 1949-50, and 1950-51. Additional comparative operative information including the three winter seasons has been summarized also in Table III.

A brief account of the performance of the system throughout the major storms follows.

November 23 and 24, 1950: Snowfall started in the early morning of November 23 and continued lightly all day, with temperatures around +12° F. to +15° F. Roads were covered with packed snow. The heating elements in the concrete section were not working, but the bituminous section was clear.



BREAK	DATE
1	11-24-50
2	12-26-50
3	1-14-51
4	1-21-51
5	1-27-51

NOTE:-

At points #1 & 4 also #3 & 5 where breaks occurred on two occasions, the second break was beyond previously repaired area. All repairs to heating elements were checked for uniform current distribution by measuring the current in each wire of the element prior to resurfacing. The additional sections of heating element installed at points of fracture were provided with slack to prevent breaks due to separation of fractured pavement.

FIGURE I

EIGHT MILE ROAD EXPERIMENTAL PAVEMENT HEATING
LOCATION OF BREAKS IN BITUMINOUS PAVEMENT

DETROIT PUBLIC LIGHTING COMMISSION

TABLE I

SUMMARY OF OPERATING DATA AND COSTS FOR SEASON 1950-51

DATA FURNISHED BY DETROIT PUBLIC LIGHTING COMMISSION

SYSTEM IN OPERATION		Time "ON"	CONCRETE SECTION		BITUMINOUS SECTION		PRECIPITATION		Average Mean at Site-°F	Average Temperature of Pavement at Control Point*	
From	To	Hr. Min.	Energy Consumed KWH	Cost P.L.C. Rate	Energy Consumed KWH	Cost P.L.C. Rate	Snowfall Sleet Inches	Water Equivalent Inches		Concrete °F	Bituminous °F
NOVEMBER											
9:00 p.m. 11-23-50	4:40 p.m. 11-24-50	19 : 40	1040		1060		0.4	0.12	14	36	36
2:15 a.m. 11-25-50	12:00 noon 11-28-50	81 : 48	4620		6060		8.0	1.13	22	29	49
	November Totals	101 : 28	5660	$125.93	7120	$150.65	8.4	1.25			
DECEMBER											
11:55 p.m. 12- 1-50	11:40 a.m. 12- 2-50	11 : 45	460		520		0.1	0.51	34	36	44
4:25 p.m. 12- 7-50	2:30 p.m. 12- 8-50	22 : 15	820		920		0.2	1.47	21	38	46
8:05 p.m. 12- 9-50	4:20 a.m. 12-10-50	8 : 35	460		520		0.1	0.01	30	36	41
3:30 a.m. 12-11-50	8:25 p.m. 12-14-50	88 : 55	2880		3760		1.0	0.07	26	35	53
1:18 a.m. 12-15-50	1:10 p.m. 12-16-50	35 : 52	1740		2000		0.9	0.04	27	36	53
1:07 a.m. 12-22-50	6:05 p.m. 12-22-50	16 : 58	1040		840		1.0	0.10	29	34	52
11:27 p.m. 12-24-50	7:30 a.m. 12-25-50	8 : 03	580		680		T	T	17	30	38
11:23 p.m. 12-25-50	1:30 p.m. 12-28-50	62 : 07	4860		5910		3.2	0.11	10	35	23
	December Totals	254 : 30	12840	$247.48	15150	$286.58	6.5	1.91			
JANUARY											
10:04 a.m. 1- 7-51	2:38 p.m. 1- 7-51	4 : 34	240		220		0.3	0.02	19	39	53
3:40 a.m. 1- 8-51	10:33 a.m. 1- 8-51	6 : 53	360		320		0.1	0.01	20	31	36
6:15 p.m. 1-14-51	1:10 a.m. 1-16-51	30 : 45	1500		2000		3.8	0.27	31	36	51
2:18 a.m. 1-21-51	1:15 p.m. 1-21-51	10 : 57	580		600		0.3	0.03	18	35	53
10:15 a.m. 1-23-51	11:10 a.m. 1-24-51	24 : 55	1280		1530		2.7	0.16	29	38	52
7:00 p.m. 1-25-51	10:50 a.m. 1-26-51	15 : 50	800		800		0.3	0.03	22	35	47
11:25 p.m. 1-26-51	10:45 a.m. 1-30-51	83 : 20	2980		3660		4.9	0.27	15	23	50
	January Totals	177 : 14	7740	$161.31	9130	$184.68	12.4	0.79			
FEBRUARY											
5:30 a.m. 1-31-51	5:30 p.m. 2- 4-51	108 : 00	7640		7440		5.2	0.29	11	27	40
12:15 a.m. 2- 5-51	5:45 p.m. 2- 8-51	89 : 30	4160		3720		1.5	0.42	24	36	48
1:40 p.m. 2- 9-51	10:25 a.m. 2-15-51	140 : 25	5420		5200		0.7	0.67	25	26	41
	February Totals	337 : 55	17220	$321.63	16360	$307.09	7.4	1.38			
MARCH											
12:07 a.m. 3- 1-51	8:00 a.m. 3--1-51	7 : 53	240		280		T	0.11	34	37	53
11:05 p.m. 3- 2-51	12:40 p.m. 3- 3-51	13 : 35	340		380		T	0.35	34	39	53
7:10 a.m. 3- 9-51	8:05 a.m. 3- 9-51	0 : 55	-		-		T	T	22	31	52
10:01 a.m. 3-14-51	10:35 a.m. 3-14-51	0 : 34	-		-		0.2	0.46	33	36	No Record
5:15 a.m. 3-19-51	1:30 a.m. 3-21-51	32 : 15	990		1200		5.5	0.49	25	34	52
	March Totals	55 : 12	1570	$ 37.58	1860	$ 44.10	5.7	1.41			
	Season Totals	926 : 21	45030	$893.93	49620	$973.10	40.4	6.74	25		

* Control temperatures fluctuate ± 1° F. of values given in Table I.
Concrete section control set to operate between 36-38 degrees F.
Bituminous section control set to operate between 50-55 degrees F. This higher setting was necessary to compensate for position of control bulb in relation to surface. The bulb had become displaced closer to heating element and further from surface.

TABLE II

SUMMARY OF OPERATING TIME, ENERGY CONSUMPTION, AND WEATHER CONDITIONS

WINTER SEASONS 1948-49, 1949-50, AND 1950-51

Month	Time "ON" - Hours			KWH Consumption					
				1948-49		1949-50		1950-51	
	1948-49	1949-50	1950-51	Conc.	Asph.	Conc.	Asph.	Conc.	Asph.
November	0.00	66.7	101.5	0	0	1980	2280	5660	7120
December	79.65	83.55	254.5	2590	2180	2080	2780	12840	15150
January	190.93	116.50	177.23	5010	5600	4400	5200	7740	9130
February	142.01	140.01	337.92	3540	3770	8560	7960	17220	16360
March	94.00	122.69	55.20	2670	3470	4840	4860	1570	1860
April	0.00	19.25	0.00	0	0	920	680	0	0
Total	506.59	548.70	926.35	13810	15020	22780	23860	45030	49620

WEATHER CONDITIONS DURING OPERATIONS									
Month	1948 - 1949			1949 - 1950			1950 - 1951		
	Snowfall, Inches	Water, Equiv.	Mean Air Temp., °F	Snowfall, Inches	Water, Equiv.	Mean Air Temp., °F	Snowfall, Inches	Water, Equiv.	Mean Air Temp., °F
November	-	-	-	4.5	0.76	32	8.4	1.25	18
December	0.50	0.49	38	4.7	0.48	33	6.5	1.91	24
January	4.6	0.26	35	9.2	0.71	30	12.4	0.79	34
February	3.1	0.39	25	12.6	2.29	25	7.4	1.38	20
March	2.1	0.11	25	9.6	0.81	24	5.7	1.41	30
April	-	-	-	0.4	0.40	26	-	-	-
Total	10.3	1.25		41.0	5.45		40.4	6.74	
	Ave. Temp.		31	Ave. Temp.		28	Ave. Temp.		25

A snowfall of ½ inch was recorded at 8:00 a.m. on November 24. Temperature between the hours of 12:00 midnight and 8:00 a.m. of November 24 ranged from 4° F. to 5° F. The heating elements on both sections were working, but due to extremely low temperatures, the lanes were covered by a 3-inch ice ridge, with water at the contact between ice and road surface. At these low temperatures, the melt waters were frozen into an ice ridge. A light snow started again about 10:00 p.m. on the 24th.

November 25, 26, 27, and 28, 1950: A total of 8 inches of snow fell in this period. Air temperatures ranging from 8° F. to 29° F., with an average of 22° F., were recorded. The heating elements worked very well throughout the period, keeping the sections clear except when de-icing chemicals were applied to adjacent lanes. This caused slush, which was splashed onto the heated sections, causing added load. This condition cannot be avoided on this particular installation. Very little ice build-up was experienced at the ends of heated sections.

December 7 and 8, 1950: Rain turning to snow and ice fell during this period. The streets were icy; mean air temperature was around 21° F. The heating elements dried the pavement in the wheel tracks.

December 9 to 15, 1950: Mostly light snow flurries prevailed throughout this period, with temperatures ranging from 22° F. to 27° F. Heating elements kept tracks clear of ice and snow. Slight ice build-up occurred along edges and ends of heated strips. See Figure 2.

December 22, 1950: Snowfall of 1 inch was recorded, resulting in ice on pavement. Temperature was around 32° F. The heating elements worked satisfactorily; wheel tracks were clear, except for slush splash.

December 26 to 28, 1950: Snowfall of 4 inches fell on December 26, between 1:00 a.m. and 9:30 a.m., with air temperatures around 10° F. Heating elements kept pavement bare, but a two-inch ice ridge developed on the sides of heated areas.

January 14 and 15, 1951: Snowfall started at 6:00 p.m. on January 14, and ended at 10:00 a.m. January 15, resulting in a 4-inch depth. Air temperature was around 29° F. The heated areas were free of ice and snow, but were wet. A 2-inch ice ridge formed on the sides of the heated areas. See Figure 3.

January 21, 1951: A snowfall of one inch occurred at air temperature of about 10° F. Heating elements kept tracks clear, but wet.

January 26 and 28, 1951: About four inches of snow fell between 9:00 p.m., January 26, and 5:00 a.m., January 28, at an air temperature of about 15° F. The snow came so fast that it froze on the heated sections. By 9:00 a.m. on January 28, the heated areas were clear, but wet. Ridges of ice three to four inches thick formed between and at outer edges of heated areas. This is the heaviest ice-ridge formation noted so far in the experiment.

January 31 to February 4, 1951: Heavy 4-inch snowfall occurred between 2:00 p.m., January 31, and 8:00 a.m., February 1. The average air temperature was 11° F. By 4:00 p.m., February 1, the roads were very slippery and conditions were too much for the heating elements during the peak of the storm. However, at 8:00 a.m., February 1, the inside tracks of both heated sections were clear. The outside tracks, in both cases, were covered with slush thrown there by passing vehicles. Ends of heated areas had a 2-inch ice ridge. See Figures 4 and 5.

February 5 to 8, 1951: This was a period of light snowfall, rain, and sleet. Air temperature averaged 24° F. The heating elements kept tracks free of ice and snow.

TABLE III

SUMMARY OF COMPARATIVE OPERATING DATA FOR THREE SEASONS

	1948 - 1949	1949 - 1950	1950 - 1951
Total Time "ON"	506.59 hrs.	548.70 hrs.	926.35 hrs.
Total KWH Consumption	28830 kwh	46640 kwh	94650 kwh
Concrete section	13810 kwh	22780 kwh	45030 kwh
Asphalt section	15020 kwh	23860 kwh	49620 kwh
Total Cost (DPLC rate)	$663.42	$1,041.02	$1,867.03
Concrete section	$319.66	$ 507.24	$ 893.93
Asphalt section	$343.76	$ 533.78	$ 973.10
Energy Consumption per 500-ft. Section per Hour of Operation			
Concrete section	27.3 kwh	41.5 kwh	48.6 kwh
Asphalt section	29.7 kwh	43.5 kwh	53.6 kwh
Percent difference	8.8	4.8	10.3
Energy Consumed per 500-ft. Section per Hr. per Sq. Ft. of Heating Surface			
Concrete section	18.4 watts	27.9 watts	32.7 watts
Asphalt section	20.0 watts	29.3 watts	36.1 watts
Cost per 500-ft. Section per Hour of Operation			
Concrete section	$ 0.63	$ 0.92	$ 0.97
Asphalt section	$ 0.68	$ 0.97	$ 1.05
Cost of System per Hr. of Operation	$ 1.31	$ 1.89	$ 2.02
Total snowfall	10.3 inches	41.0 inches	40.4 inches

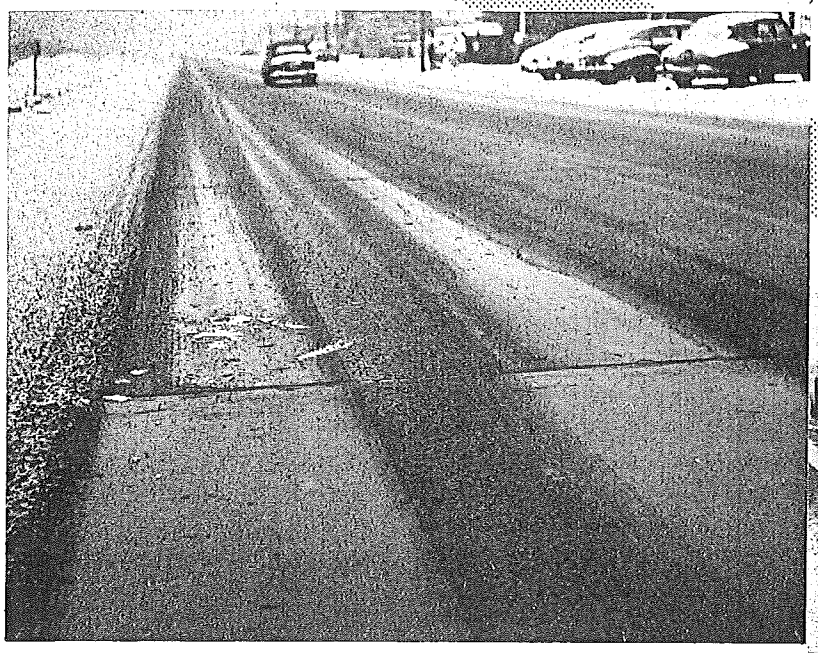


FIGURE 2. VIEW OF CONCRETE HEATED SECTION, SHOWING WIDTH OF MELTED AREA AT EXTREME WEST END, AND TRACKING OF WATER ONTO ADJACENT UNHEATED PAVEMENT. STORM 12/15/50

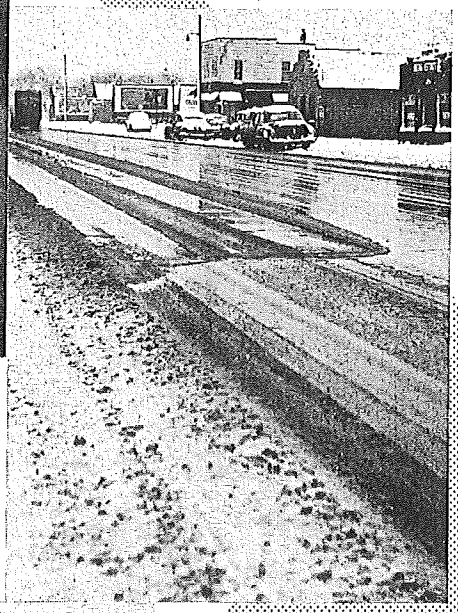


FIGURE 3. VIEW SHOWING TYPICAL ICE BUILD-UP ADJACENT TO HEATED AREAS. RIDGES ON BITUMINOUS SECTION - 2 INCHES HIGH. STORM 1/15/51

FIGURE 4. VIEW SHOWING INSIDE TRACK ON CONCRETE SECTION COVERED BY SLUSH FROM ADJACENT LANE. OUTSIDE TRACK IN FOREGROUND IS CLEAR. STORM 2/1/51

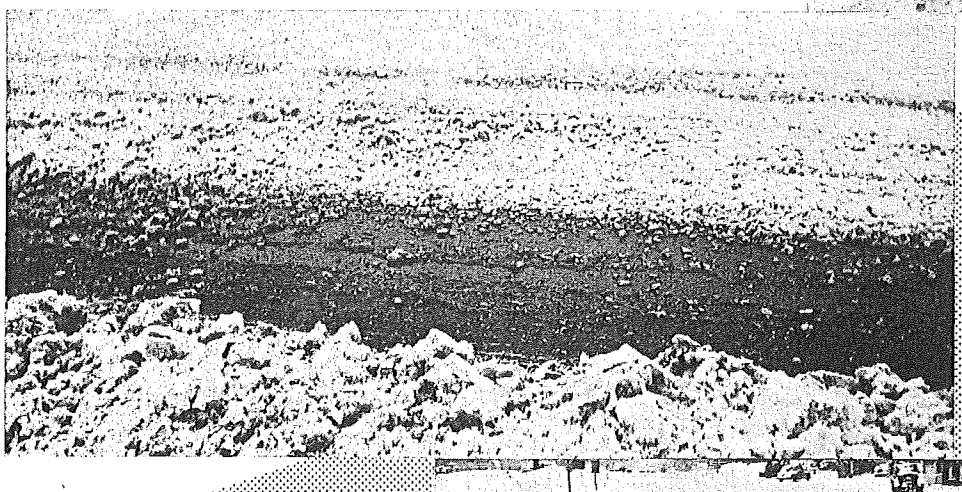


FIGURE 5. INSIDE TRACK ON BITUMINOUS SECTION PARTIALLY COVERED BY SLUSH FROM ADJACENT LANE. STORM 2/1/51