EVALUATION OF A LINSEED OIL AND MINERAL SPIRITS COMPOUND USED AS A BRIDGE DECK SEALANT

Report 73-4

August 1973

SUPPLEMENT INCLUDING 1974-75 FIELD TEST RESULTS

Bridge #124 on Vermont Route 14

VERMONT DEPARTMENT OF HIGHWAYS

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ABSTRACT

An investigation was made to determine if yearly applications of linseed oil and mineral spirits were effective in protecting a portland cement concrete bridge deck from deterioration when exposed to a chloride environment.

Although visual observations gave little indication of deterioration, an analysis of concrete cores disclosed concentrations of from 0.7 to 3.5 pounds of chloride per cubic yard of concrete at the level of the reinforcing steel. Electrical potential measurements of 0.35 volts or greater were found on approximately 9% of the deck with overall readings higher than those taken 9 months earlier. Such test results indicate a linseed oil and mineral spirits compound does not provide sufficient protection to prevent deterioration of a concrete deck.

INTRODUCTION

Current Department of Highways policy calls for semiannual or annual applications of linseed oil and mineral spirits on exposed portions of bridge superstructures. The applications are made in an attempt to protect the concrete from scaling and spalling caused by freeze-thaw conditions and deicing chemical applications. The two components are mixed in a 50-50 ratio by volume and applied by District Maintenance forces.

This study was made at the request of the Bridge Maintenance Engineer, to determine the effectiveness of linseed oil and mineral spirits in protecting a portland cement concrete bridge deck exposed to a chloride environment.

BRIDGE DATA

Bridge #124 over the Black River on Vt Rte 14 was selected for evaluation. The 85 foot long by 27.3 foot wide simple span structure is located on a nearly flat grade approximately 0.2 of a mile north of the Village of Irasburg. The initial structure was constructed in 1939 and the deck was replaced in 1968. The new deck was placed in two longitudinal sections without any built-up curbs or walkways. Heavy spray applications of linseed oil and mineral spirits have been made each fall since the new deck was constructed. A temporary decrease in skid resistance at scattered locations was alleviated by applying a light sprinkling of sand.

Traffic

Average Daily Traffic	1969	1025
	1970	1050
	1971	1075
	1972	1100
Percent Trucks	6%	

Climatic Conditions

Period	Freeze-Thaw Cycles	Snowfall
1968-1969	66	100.7"
1969-1970	94	93.0"
1970-1971	129	151.9"
1971-1972	93	141.5"
1972-1973	106	122.3"

Deicing Salt Applications

Annual application in tons per 2 lane mile

1968-1970	Unknown
1970-1971	25.4 tons
1971-1972	39.3 tons
1972-1973	39.9 tons

FIELD OBSERVATIONS AND TEST RESULTS

Deck Condition

Both north and southbound lanes had a moderate to heavy broomed surface along the shoulders while traffic had reduced or eliminated the broom marks from the traveled areas. Surface pitting was also noted on about 20% of the northbound lane.

Transverse cracks were noted on the surface of the southbound lane at 18 inch to 3 foot intervals. The cracks could not be detected on the bottom of the deck although many pattern type shrinkage cracks were noted. A few short transverse and pattern cracks were noted in the northbound lane while many pattern cracks were noted on the bottom of the deck. The cracks in the bottom of the deck did not reveal any evidence of leakage from the roadway surface with the exception of some staining (efflorescence) adjacent to 8 inch to 12 inch long transverse cracks at 8 foot intervals along the fascia on the downstream side of the deck. A severe 4.5 foot crack with accompanying rust stains was also observed adjacent to the southerly end of the northbound lane, while an area approximately 0.3 of a foot wide and 2.8 feet in length has broken away from the southerly end of the southbound lane.

Eight shallow surface spalls ranging from ¼ inch to ½ inch in depth and from 2 inches to 6 inches in diameter were noted on the southbound lane in an area 18 feet to 30 feet from the southerly end of the deck. No evidence of rust stains due to steel corrosion were noted at the spall locations. The northbound lane was free of any surface spalling.

Chloride Analysis

Four, 1 3/4 inch diameter by 2 inch thick cores were taken from the deck on June 7, 1973. Two cores were taken from each lane at 1 and 2 foot offsets from the fascia. Following is a summary of the chloride analysis made on each sample.

Core No.	Depth of sample	Chloride in parts per million	Chloride in lbs. per c.y. of concrete
1	0-½"	851	3.4
1	½" - 1"	638	2.6
1	1" - 1½"	638	2.6
1	1½" - 2"	568	2.3
2	0-½"	726	2.9
2	½" - 1"	393	1.6
2	1" - 1½"	606	2.4
2	1½" - 2"	673	2.7
3	0-½"	1409	5.6
3	½" - 1"	708	2.8
3	1" - 1½"	428	1.7
3	1½" - 2"	183	0.7
4	0-½"	2565	10.3
4	½" - 1"	1899	7.6
4	1" - 1½"	1164	4.7
4	1½" - 2"	883	3.5

Electrical Potential Measurements

Electrical potential measurements were taken on the northbound lane on September 2, 1972 utilizing a saturated copper sulfate half cell. The measurements were again taken over the entire deck on July 17, 1973. The second reading on the northbound lane showed an increase from the initial average of 0.26 volts to an average of 0.30 volts. Potential readings at the four core locations ranged between 0.30 and 0.35 volts.

See equi-potential contours of the deck on page 4.

Miscellaneous Laboratory Testing of Linseed Oil and Mineral Spirits

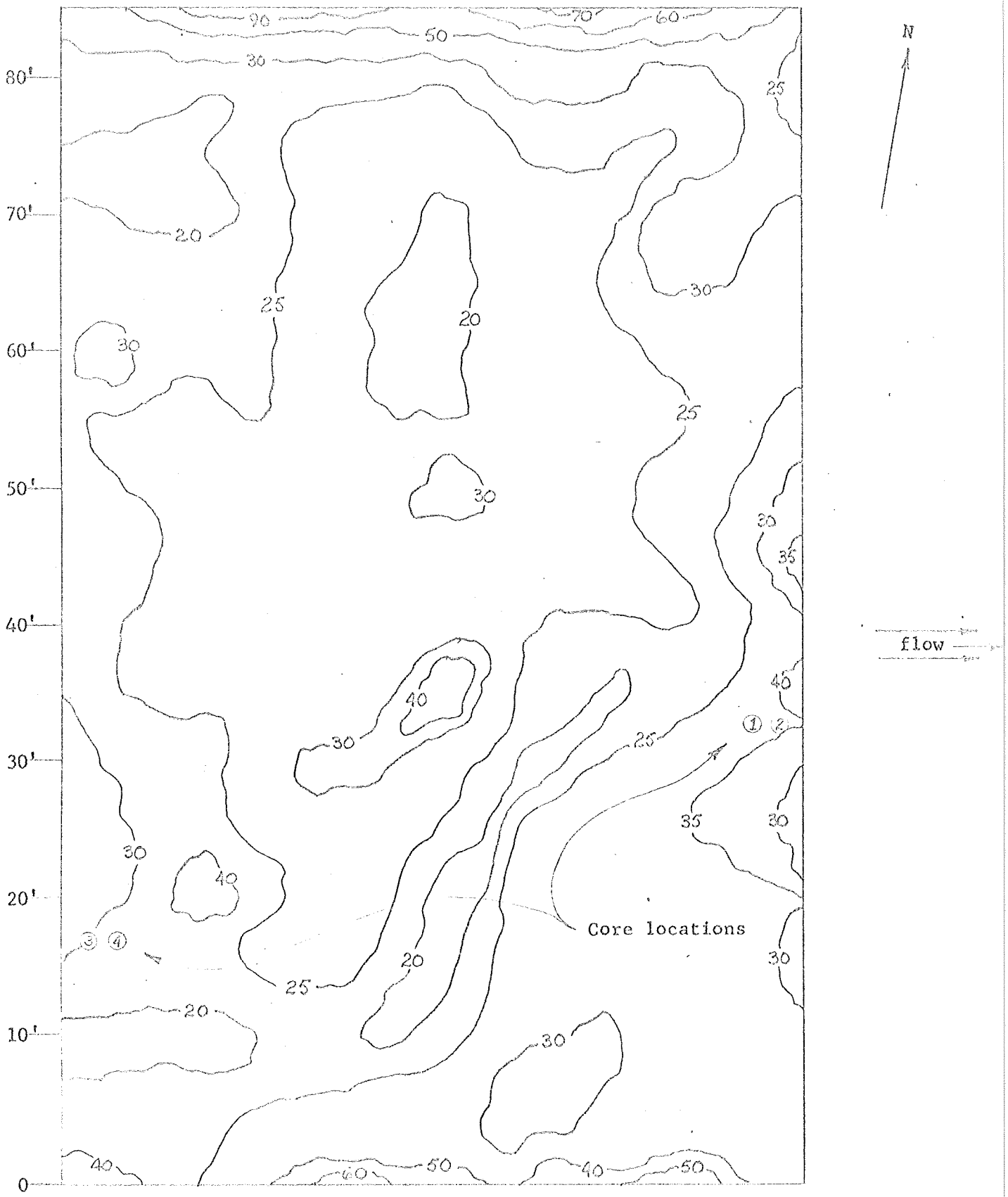
Electrical resistance tests are being conducted on a concrete test slab treated with three heavy applications of linseed oil and mineral spirits. The readings have averaged 6,500 ohms per square foot which indicates that the sealant does reduce moisture penetration but does not produce a waterproof seal.

Concrete samples tested with linseed oil and mineral spirits are currently under exposure to freeze-thaw cycling in the laboratory as an additional method of evaluation. No visual deterioration has yet been detected on the samples.

BRIDGE #124 ON VT ROUTE 14

IRASBURG, VERMONT

EQUI-POTENTIAL CONTOURS - VOLTS x 10^{-2}



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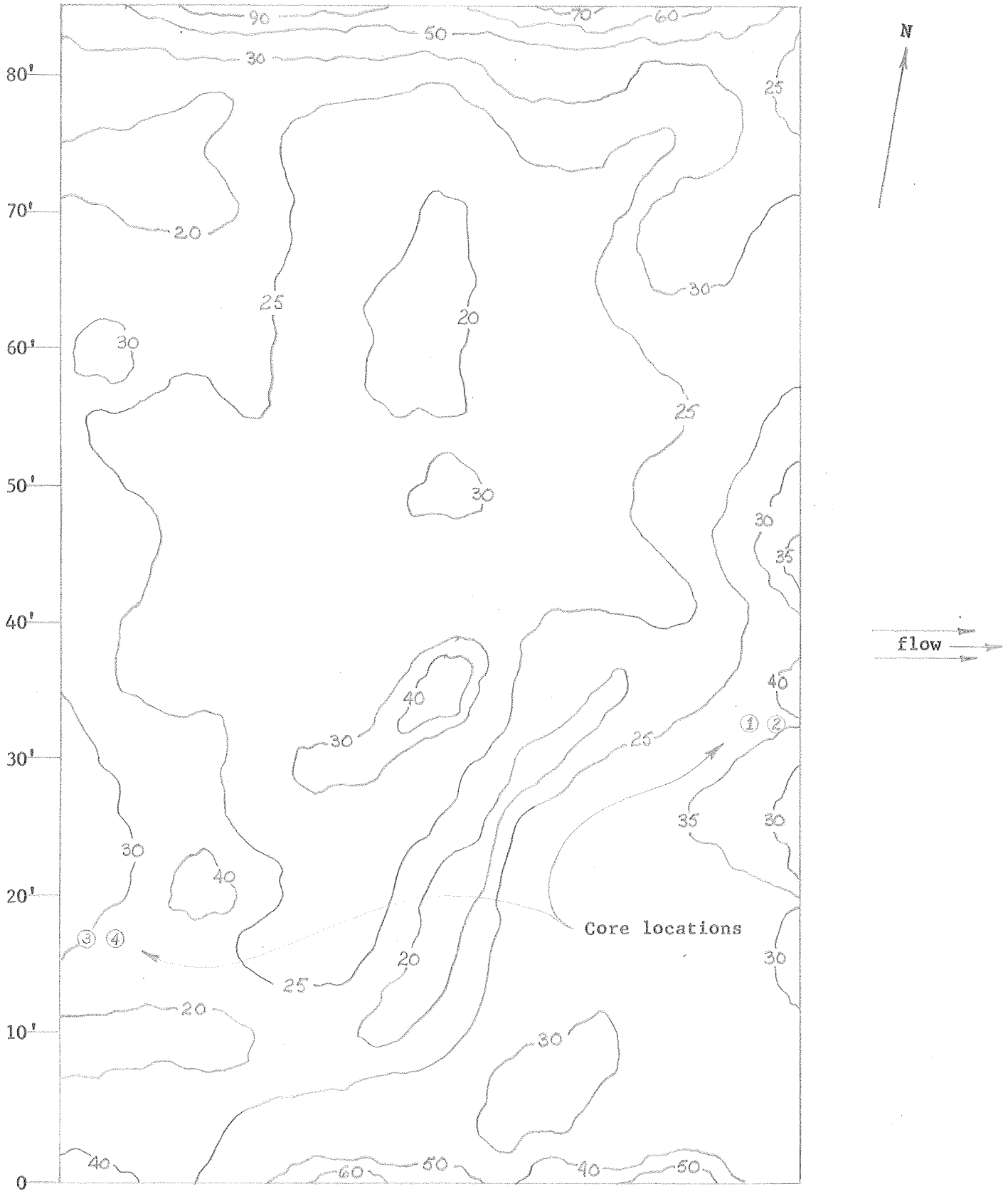

DISCUSSION

A visual inspection of bridge #124 revealed little indication of deck deterioration after five winters of deicing chemical applications. The few shallow surface spalls noted in the southbound lane were probably due to scattered pieces of unsound aggregate at the surface. Moisture absorption and subsequent freezing would result in fracturing and removal of such pieces along with surrounding material. Transverse cracks noted in the deck surface did not extend through the full depth of the slab and numerous pattern type shrinkage cracks on the bottom of the deck revealed no evidence of leakage from the roadway surface.

The analysis of cores taken from the deck disclosed that chlorides have infiltrated through the linseed oil and mineral spirits sealant. The concentrations found in the top ½ inch of the cores ranged between 2.9 and 10.3 pounds of chloride per cubic yard of concrete while readings at the 1½ inch to 2 inch level ranged between 0.7 and 3.5 pounds. Such chloride concentrations at the top level of the reinforcing steel can be expected to result in corrosion of the steel. (The California Division of Highways has shown that steel corrosion will occur when the chloride concentrations at the level of the reinforcing steel reach approximately 1.5 pounds per cubic yard of concrete).

Upon finding chlorides at the level of the steel, electrical potential measurements were taken on the deck. Most of the readings ranged from 0.2 to 0.3 of a volt. Such readings generally indicate that the steel is in a passive condition. However, readings over 0.35 volts were found in 5 areas which encompassed approximately 9% of the deck area. Such readings indicate active corrosion of the steel within these areas.

The electrical potential measurements taken on the northbound lane show an average increase of 0.04 volts when compared against readings taken 9 months earlier at the same location. The increase in the electrical potential readings was no doubt due to the increased depth of chloride intrusion which had occurred since the first readings were taken.

Electrical resistance readings taken on a concrete test slab treated with linseed oil and mineral spirits averaged 6,500 ohms per square foot. Such readings indicate the compound does reduce the penetration of moisture although it does not produce a waterproof seal. Resistance readings of 300 to 500 ohms per square foot are normally obtained on untreated concrete while a satisfactory waterproofing system will produce readings in excess of 500,000 ohms per square foot.

CONCLUSION

Various studies have shown that applications of linseed oil based compounds offer anti-scaling and spalling protection to the concrete at relatively low cost. However, the results of this investigation indicate that heavy annual applications of linseed oil and mineral spirits do not provide sufficient waterproofing to protect an exposed portland cement concrete bridge deck from chloride intrusion when the deck is subjected to heavy winter deicing salt application. The chloride levels found in the 5 year old deck under evaluation indicate that severe corrosion of the reinforcing steel will follow with accompanying deterioration of the concrete.

BRIDGE #124 HALF CELL POTENTIAL SUMMARY

TO IRASBURG ↑

← FLOW

	1' OFFSET				5' OFFSET				10' OFFSET			
	*	**	***	****	*	**	***	****	*	**	***	****
0	30	10	10	20	36	50	58	52	18	42	50	50
5	12	20	20	18	22	25	28	20	28	30	28	24
10	20	26	25	19	24	26	25	20	26	29	26	24
15	28	29	25	22	26	24	25	22	26	28	24	24
20	26	34	32	20	24	27	26	34	26	27	28	24
25	28	30	27	22	32	34	29	21	26	26	26	22
30	26	32	29	20	28	20	22	20	24	20	24	20
35	28	38	37	25	24	28	27	20	26	23	25	22
40	32	26	27	24	32	26	25	19	28	25	25	20
45	26	36	26	23	24	25	24	20	26	25	25	20
50	24	32	22	18	24	22	23	18	24	24	26	20
55	28	26	24	22	24	25	25	23	26	25	26	22
60	22	26	29	20	24	26	25	26	26	27	25	22
65	22	28	26	22	26	32	30	20	28	27	27	22
70	26	29	24	26	26	30	24	18	26	22	23	20
75	22	31	26	20	22	26	22	18	22	26	24	19
80	22	25	26	20	24	29	24	22	26	32	30	20
85	22	51	56	32	28	60	56	40	40	77	75	36
90	48				52				64			

DATE TESTED		
	*	9/21/72 — Avg. 0.26 Volts
	**	7/17/73 — Avg. 0.29 Volts
	***	5/14/74 — Avg. 0.27 Volts
	****	11/26/75 — Avg. 0.23 Volts

1975 Chloride Results

DEPTH	PPM	LB/C.Y.	PPM	LB/C.Y.	PPM	LB/C.Y.
0-1"	131	0.5	2474	9.9	2782	11.1
1-2"	28	0.1	1330	5.3	1802	7.2
	OFFSET	1'	OFFSET	5'	OFFSET	10'

1975 Chloride Results

DEPTH	PPM	LB/C.Y.	PPM	LB/C.Y.	PPM	LB/C.Y.
0-1"	131	0.5	2474	9.9	2782	11.1
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	OFFSET	1'	OFFSET	5'	OFFSET	10'

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	*	**	***	****	*	**	***	****	*	**	***	****
0	30	10	10	20	36	50	58	52	18	42	50	50
5	12	20	20	18	22	25	28	20	28	30	28	24
10	20	26	25	19	24	26	25	20	26	29	26	24
15	28	29	25	22	26	24	25	22	26	28	24	24
20	26	34	32	20	24	27	26	34	26	27	28	24
25	28	30	27	22	32	34	29	21	26	26	26	22
30	26	32	29	20	28	20	22	20	24	20	24	20
35	28	38	37	25	24	28	27	20	26	23	25	22
40	32	26	27	24	32	26	25	19	28	25	25	20
45	26	36	26	23	24	25	24	20	26	25	25	20
50	24	32	22	18	24	22	23	18	24	24	26	20
55	28	26	24	22	24	25	25	23	26	25	26	22
60	22	26	29	20	24	26	25	26	26	27	25	22
65	22	28	26	22	26	32	30	20	28	27	27	22
70	26	29	24	26	26	30	24	18	26	22	23	20
75	22	31	26	20	22	26	22	18	22	26	24	19
80	22	25	26	20	24	29	24	22	26	32	30	20
85	22	51	56	32	28	60	56	40	40	77	75	36
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