MONITORING SALINITY AFTER TILE DRAINAGE

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INTRODUCTION

Adequate drainage is a fundamental requirement of all irrigation projects and is often not considered sufficiently when irrigation systems are installed. The Saskatchewan Irrigation Development Centre (SIDC) is no exception. Irrigation began on the Outlook Irrigation Demonstration Farm in 1949. Since then, salinity and waterlogged conditions have developed. Although the occurrence of salinity was noted as early as 1963, it was not until the 1980's that any investigative studies were done (Jones, 1986). Jensen and Wright, in 1986 suggested that subsurface drainage be installed at the centre.

Field 11, in the southwest corner of SIDC, had been flood irrigated until 1985. At that time, salinity had developed to the point that most of the field was unsuitable for demonstration purposes. In the fall of 1986, subsurface drainage was installed in the 9 ha of Field 11 (Figure 1). Corrugated perforated plastic pipe with a filter sock was installed at a depth of 1.2-1.5 meters on a 15 and 30 meter grid. Water flowed from the outlet immediately and continued until the water table stabilized.

Other development included deep ripping of the northern portion of the field to promote infiltration and leaching and the installation of a linear move irrigation system that can be used to apply a uniform fall irrigation. No leaching water was applied, in 1987 but a 475 mm fall irrigation was applied after the 1988 harvest.

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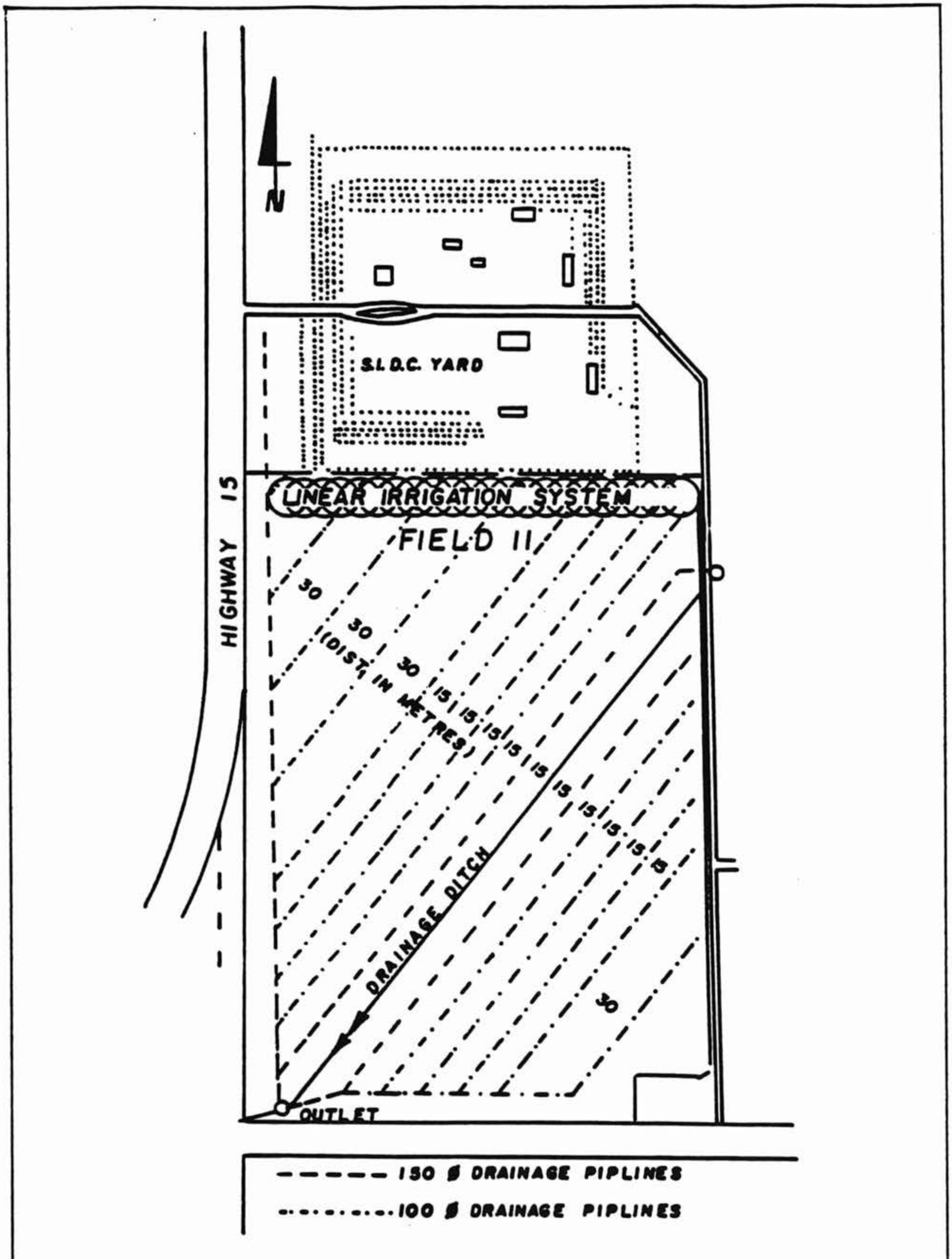


FIGURE 1 DRAINAGE INSTALLATION - FIELD 11
SASKATCHEWAN IRRIGATION DEVELOPMENT CENTRE

Soils of Field 11 consist of imperfectly to poorly drained Bradwell series which are saline to some degree or well-drained calcareous Bradwell series with Ap horizon > 20 cm thick and saline subsoils (> 2.0 m). Bradwell soils are Orthic Dark Brown Chernozemics developed on medium to moderately coarse textured lacustrine sediments overlying a finer textured lacustrine material (Stushnoff and Acton, 1987).

The purpose of the study is to monitor the changes in salinity within Field 11 as a result of the drainage system and subsequent leaching.

MONITORING

The electromagnetic terrain conductivity meter model EM38, developed by Geonics Ltd. is the main tool to monitor salinity. The EM38 is capable of detecting salinity to a depth of 1.5 meters in the vertical position and 0.75 meters in the horizontal position (McNeill, 1986). Although the EM38 reading (ECa) is affected by moisture, temperature, soil texture and soil mineralogy, the majority of the meter response is due to salinity (McNeill, 1980).

The monitoring of salinity was initiated in October 1986, at the time of drainage installation in Field 11. Subsequent measurements have been made in October 1987 and 1988. In order to reduce the variability of influences due to moisture and temperature, monitoring will continue in October each year. The field was surveyed on 15 m grid and permanent markers installed along the field edges in order that the actual salinity monitoring sites could be accurately located in subsequent years.

Samples for saturated paste extract analysis (ECe) were taken at specific grid points in 1986 and 1988. Although sampling in 1986 was from 0-0.5 m and 0.5-1.0 m, in 1988, the samples were taken from 0-0.15 m, 0.15-0.30 m and 0.3-0.6 m. Future monitoring will include consistent sampling depths.

The ECa data were grided and contoured using geostatistics software. GEOSOFT permits the calculation of areal extent of salinity at contour intervals selected to represent non-saline, slight, moderate and several salinity levels. To determine the change in salinity, the ratio of the 1988 values divided by the 1986 readings were contoured. This exercise provided a map of the magnitude of change in salinity over Field 11.

RESULTS

Samples for ECe were taken at 18 sites in 1986 and 15 sites in 1988. Since there was a difference in sampling depths, a comparison was conducted on the 0-50 cm samples of 1986 and the average value of the 3 samples representing 0-60 cm in 1988 at the 15 sites common to the two years. A paired t-test (Table 1) proved that there was a significant reduction in ECe in the 0-60 cm depth.

Table 1
SIDC Salinity

Paired t-Test to compare ECe

Mean ECe 1986 (0-0.5 m)	8.42 mS/cm
Mean ECe 1988 (0-0.6 m)	2.57 mS/cm
Mean Difference	5.85 mS/cm
Number of Pairs	15
t	7.41
df	14
$t_{0.01}$	4.21

Since $t > t_{0.01}$

Therefore there is a significant difference between the mean ECe.

A paired t-test conducted on the 375 EM readings in each of the horizontal and vertical positions (Table 2) confirmed that there was a significant reduction in salinity in the 0-60 cm range. The EM38 horizontal readings showed 25% reduction from 1986 to 1988. Interestingly, there was no significant change in the EM38 vertical readings. Both the ECe and the ECa data showed a significant reduction of salinity in the upper portion of the soil profile.

Table 2
SIDC Salinity

Paired t-Test to compare ECa

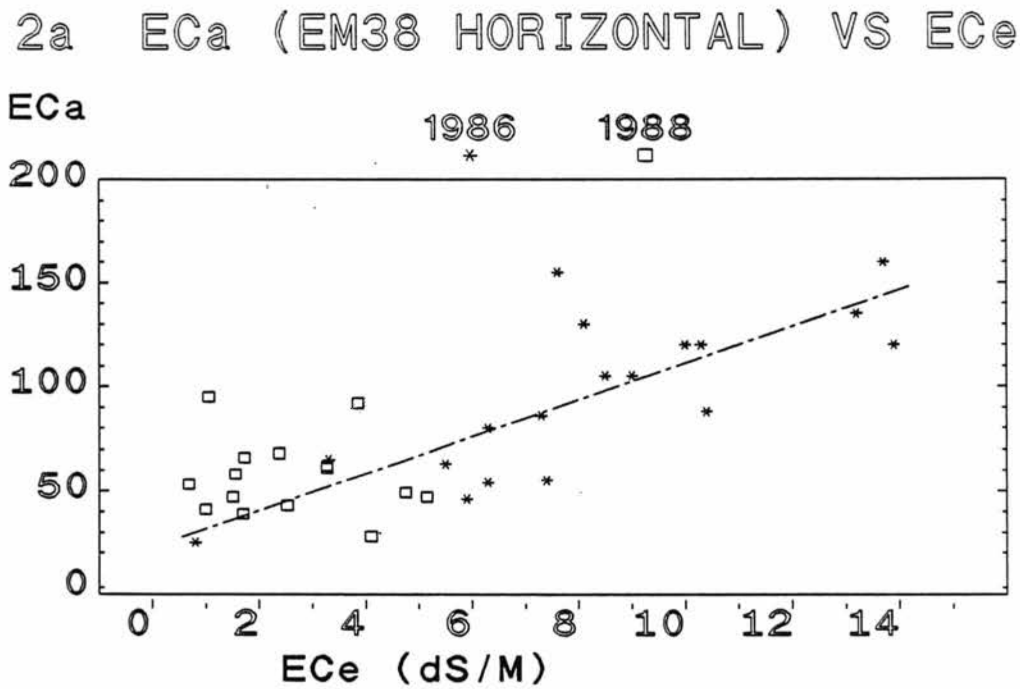
	EM 38 Vertical	EM 38 Horizontal
Mean ECa 1986	79	71
Mean ECa 1988	82	53
Mean Difference	3	18
Number of Pairs	375	375
t	2.48	13.9
df	374	374
$t_{0.05}$	2.77	
$t_{0.01}$		3.64

Since $t_v < t_{0.05}$, therefore there is no significant difference between the mean ECa for the EM38 vertical.

Since th > t0.01, therefore there is a significant difference between the mean ECa for the EM38 horizontal.

In order to relate the ECa values to standard ECe interpretations, a regression analysis of the ECa and ECe was conducted. The values plotted in Figure 2a represent 1986 ECa (horizontal) vs ECe (0-50 cm) for 18 sites and 1988 ECa (horizontal) vs ECe (0-60 cm) for 15 sites. Figure 2b contains 1986 ECa (vertical) vs ECe (0-100 cm) and 1988 ECa (vertical) vs ECe (0-60 cm). In both cases, a linear regression for the 1986 data is plotted.

There is a significant correlation between the ECa (horizontal) and the ECe (0-50 cm) for the 1986 data (r^2 = 0.60). It is obvious from Figure 2a that the 1988 data matches the 1986 data well. In fact, a regression of the EM38 horizontal data from both years show little change in the correlation (r^2 = 0.58). There is no significant difference in using the 1986 regression line compared to using a regression of the collective data.



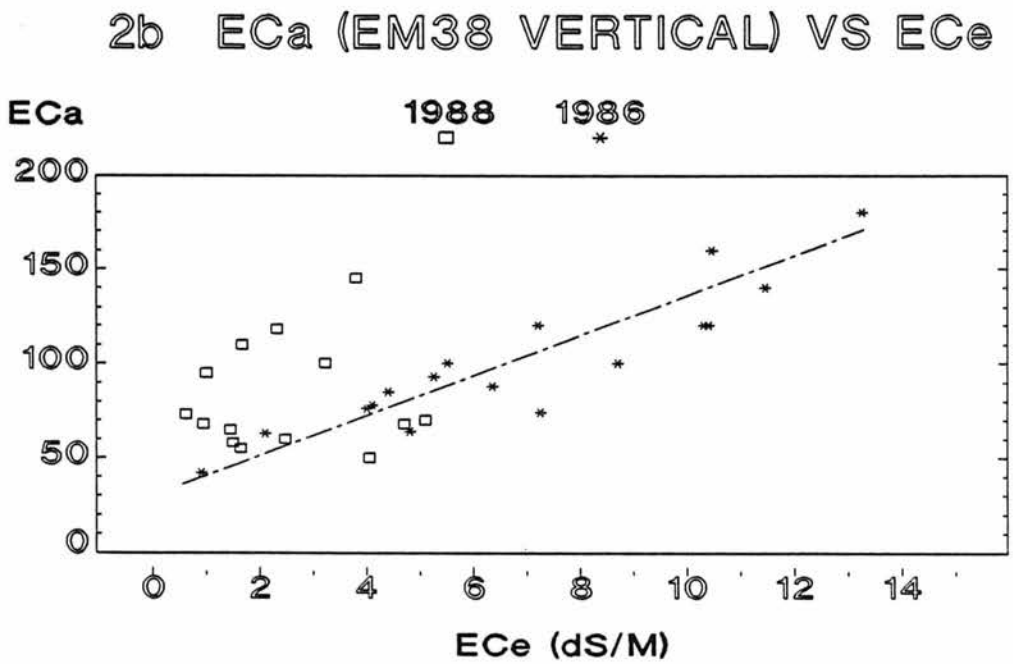


Figure 2: Comparison of ECe and ECa

SIDC SALINITY

There was a highly significant correlation between the ECa (vertical) and the average ECe (0-100 cm) for the 1986 data ($r^2 = 0.84$). There was no comparable sampling depth in 1988 and as expected, there is no significant correlation between the ECa (vertical) and the ECe (0-60 cm) for the 1988 data.

The regression equations of the 1986 data are adequate to differentiate classes for interpretation of the EM readings (Table 3). The correlation coefficients are comparable those found in other studies (McKenzie et al, 1988; McNeill, 1986).

Table 3
SIDC Salinity

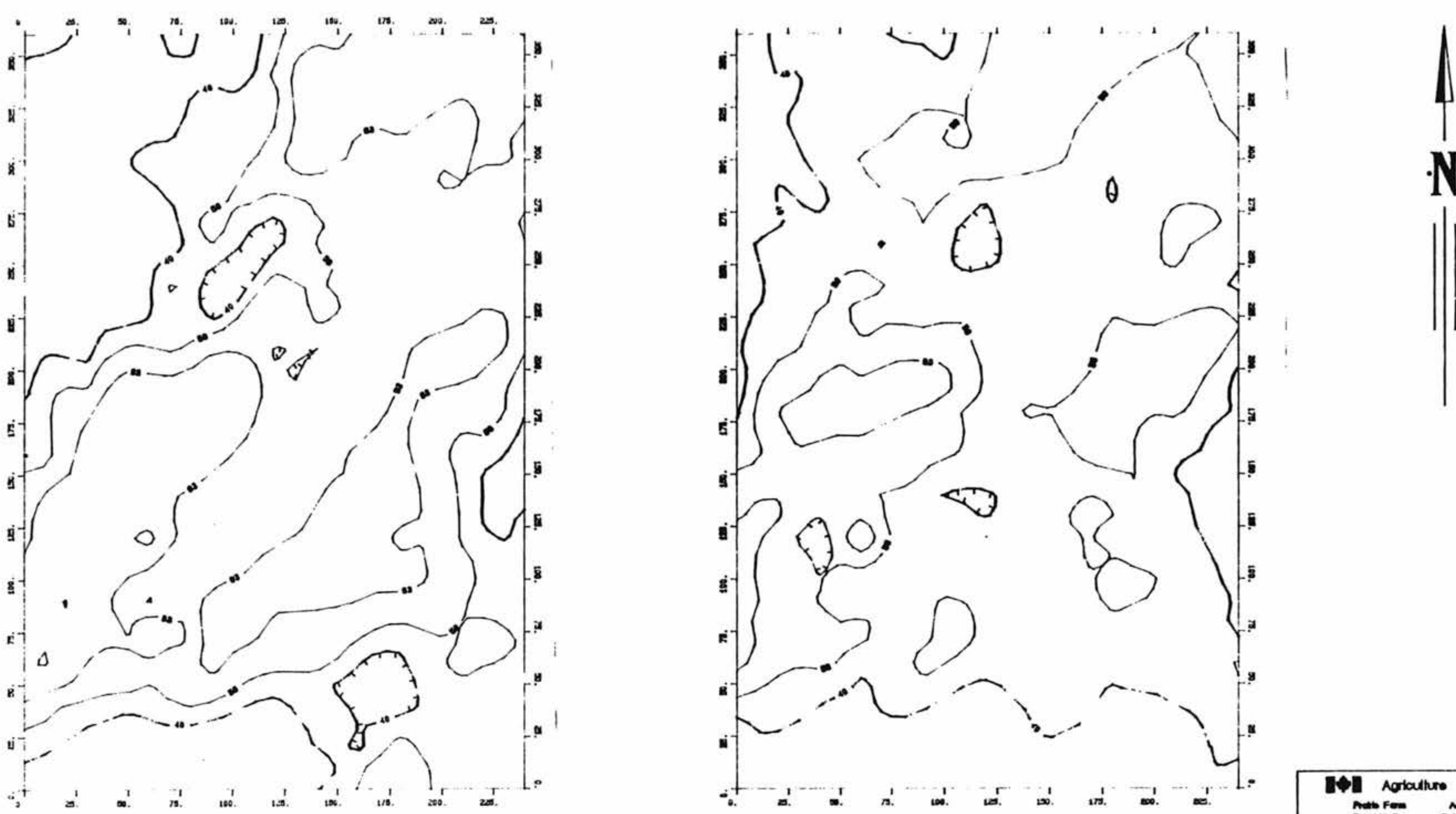
Comparable ECa Values for Salinity Classes

Salinity Level	ECe	ECa (Vertical)	ECa (Horizontal)
Non-Saline	0-2 dS/m	0- 50	0- 40
Slight	2-4	50- 72	40- 58
Moderate	4-8	72-114	58- 93
Severe	8-16	114-199	93-163

Figure 3 shows the distribution of salinity using the EM38 horizontal readings for the two years. The contour lines indicate less variability in readings and a reduction in the area of severely saline soils. The two large areas in the central portion of the field, with ECa > 93 in 1986 appear as several smaller areas on the 1988 map.

The reduction of salinity in the 0-0.6 m depth is apparent in Figure 5a. The area of severely saline soil has been almost eliminated and the area of moderately saline soil significantly reduced. In 1988, 70% of the field has an equivalent EC (0-60 cm) of less than 4 m S/cm from compared to only 40% in 1986.

The EM38 vertical readings (Figure 4) also show a reduction of the severely saline areas, and less variability, particularly south and east of the drainage ditch. An area of ECa > 114 is completely eliminated, although there is little change in the 114



1986 HORIZONTAL

1988 HORIZONTAL

NON - SALINE <40
SLIGHTY SALINE 40-58
MODERATELY SALINE 58-93
SEVERELY SALINE 93-163

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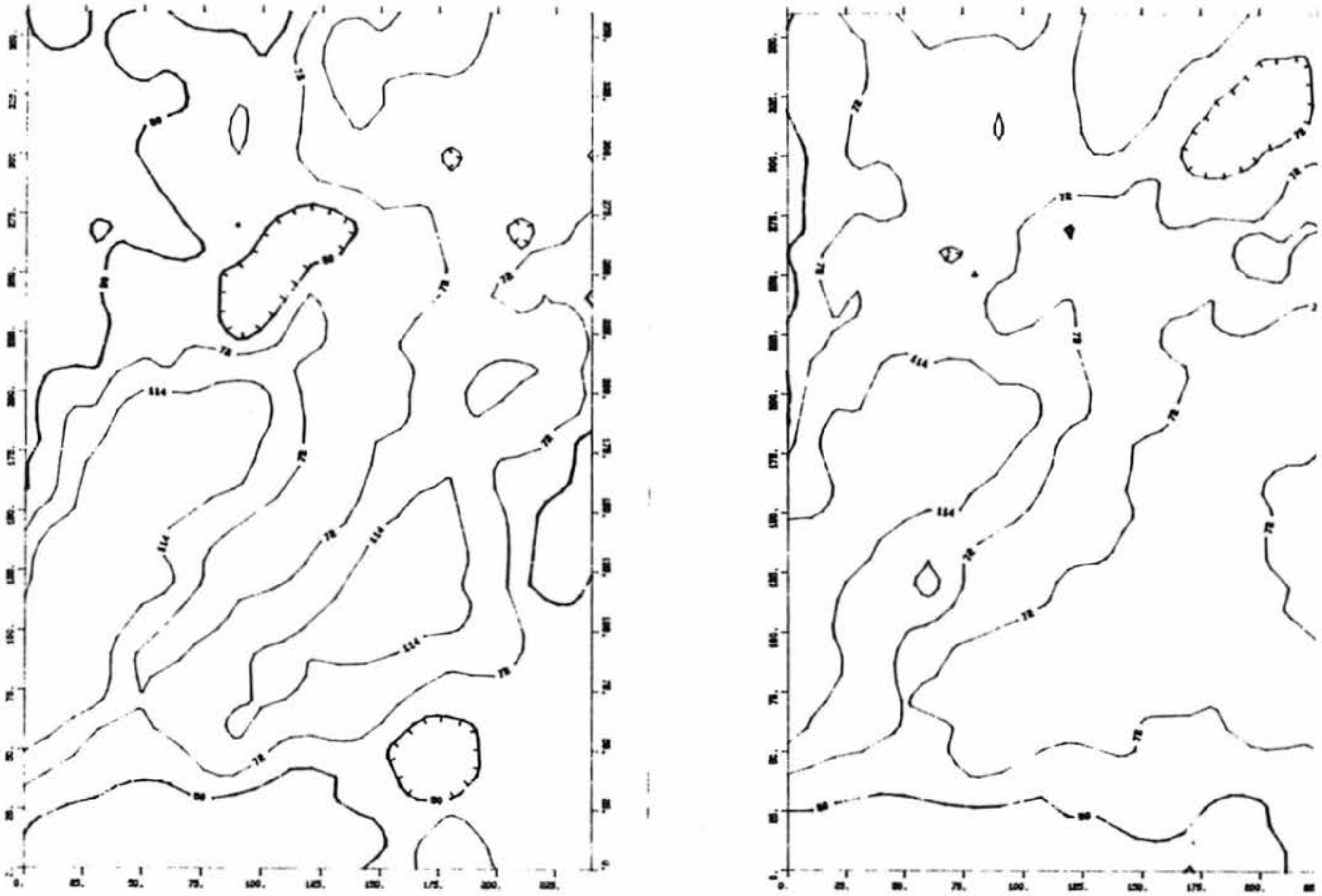
FIGURE 3
EM38 HORIZONTAL CONTOURS



1986 VERTICAL

1988 VERTICAL

NON - SALINE <50
SLIGHTY SALINE 50-72
MODERATELY SALINE 72-114
SEVERELY SALINE 114-199

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PROJECT SIDC FIELD #11

FIGURE 4
EM38 VERTICAL CONTOURS

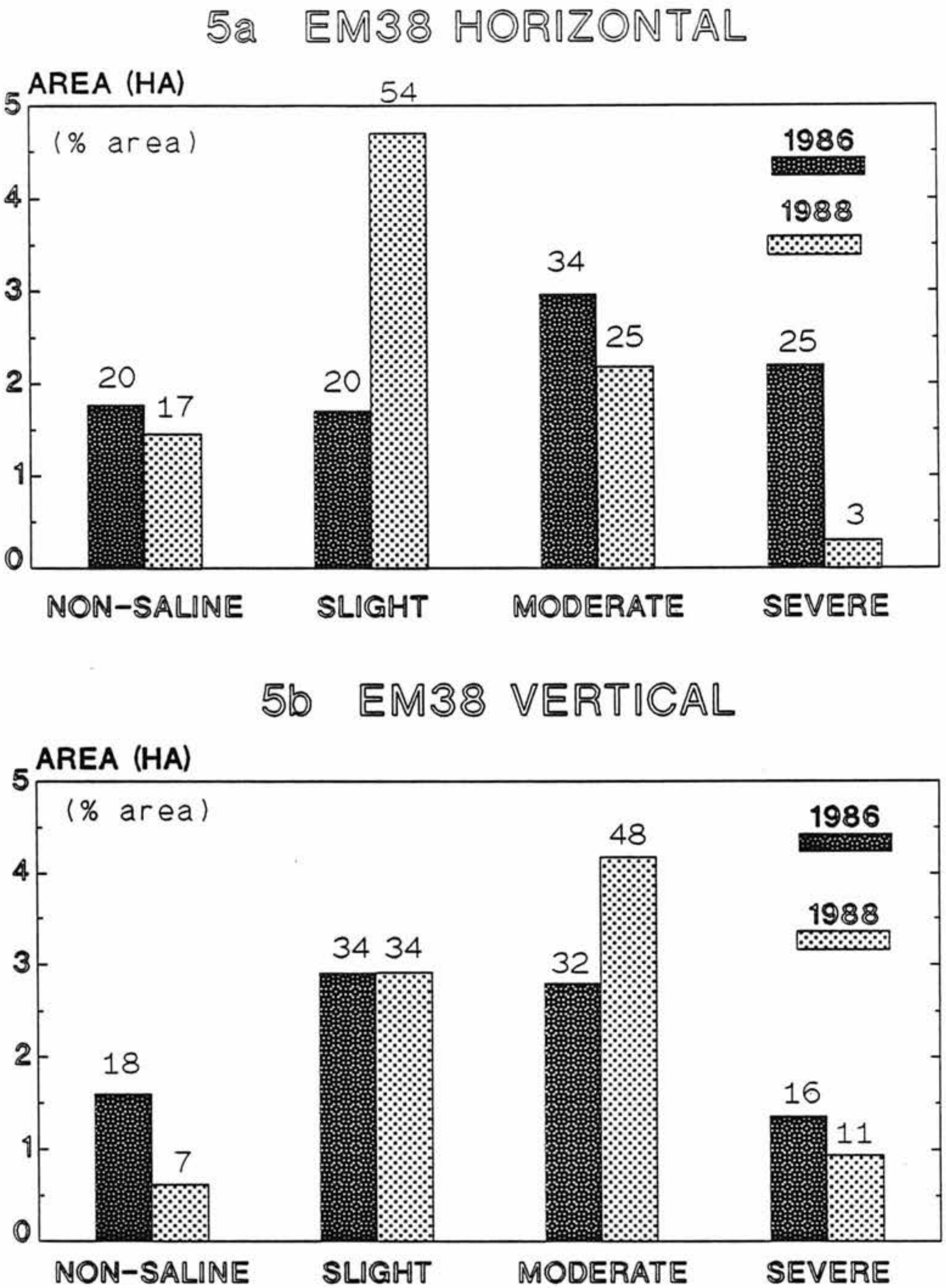


Figure 5: Area Analysis
SIDC SALINITY

contour west of the drainage ditch. Interestingly, there is an increase in salinity in the northwest corner of the field, which was non-saline prior to drainage.

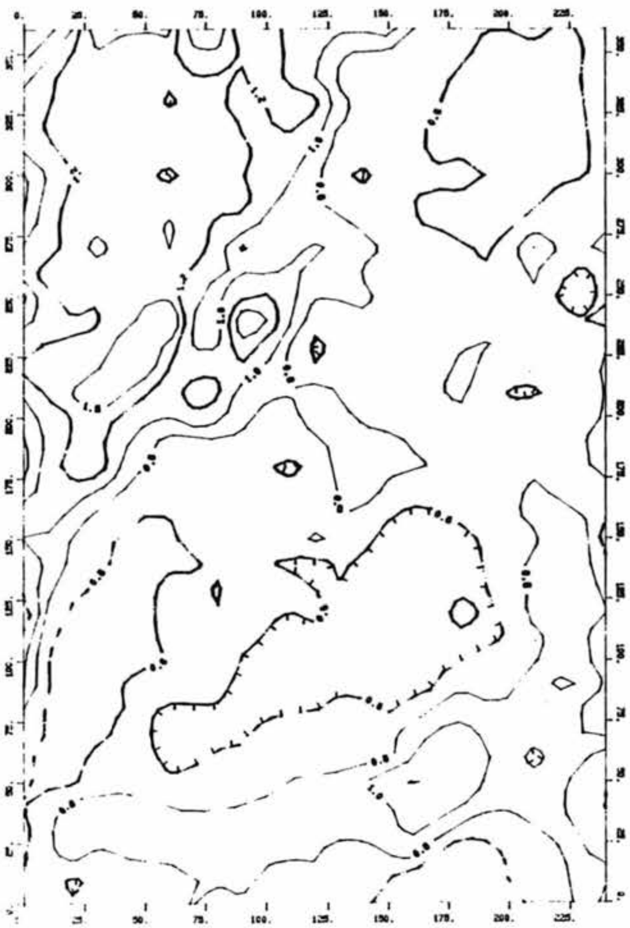
Figure 5b confirms that there has been a shift in both the severely saline area and the non-saline area towards the moderately saline group. The data would suggest that the increase in moderate salinity may be due to the leaching of salts to beyond the depth of penetration of the EM38 horizontal but still within the range of the vertical position. To test this explanation, a ratio of the 1988 EM readings to the 1986 readings was contoured. In Figure 6, a contour of greater than 1.0 indicates an increase in salinity.

Very revealing patterns emerge from Figure 6. Only in the northwest portion of Field 11 is there significant increases in salinity. In the vertical position, half of the field showed increasing scaling while the other half had lower salinity (Figure 7). In the horizontal position most of the field had decreased salinity values. The increased salinity in both cases are in the areas that were non-saline in 1986.

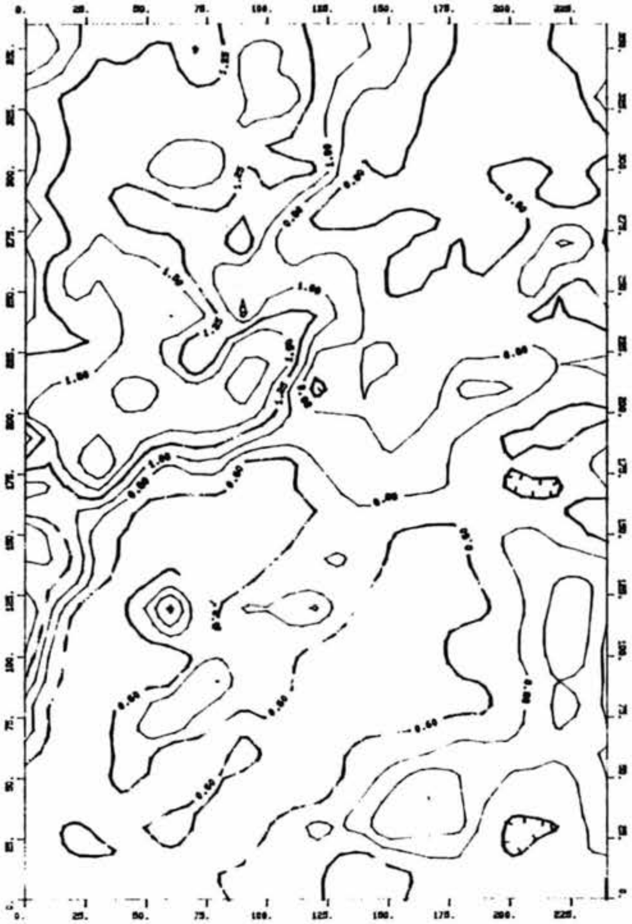
There are two factors in the change in salinity in Field 11 from 1986 to 1988. In the first place, there has been leaching of the salts from the severely saline and moderately saline areas. This change has been detected clearly with the EM38 horizontal, however the salts have not been leached below the detection limit of the EM38 vertical.

Secondly there has been an increase in the salinity of the non-saline soils of the northwest portion of the project. This change was detected by both positions of the EM38. The increase in salinity is likely due to deep-ripping which would have mixed salts from lower depths into the upper soil profile. Further monitoring of this area will determine if the soils will be leached back down the profile.

Finally, the reduced salinity in the upper soil profile has provided better growing conditions. Visual observations and yield measurements of barley have reinforced the results of the EM38 monitoring.



1988/1986 HORIZONTAL



1988/1986 VERTICAL

CONTOURS OF RATIO 1988/1986
<1.0 SHOWS A REDUCTION IN SALINITY
>1.0 SHOWS AN INCREASE IN SALINITY

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FIGURE 6
SALINITY CHANGE

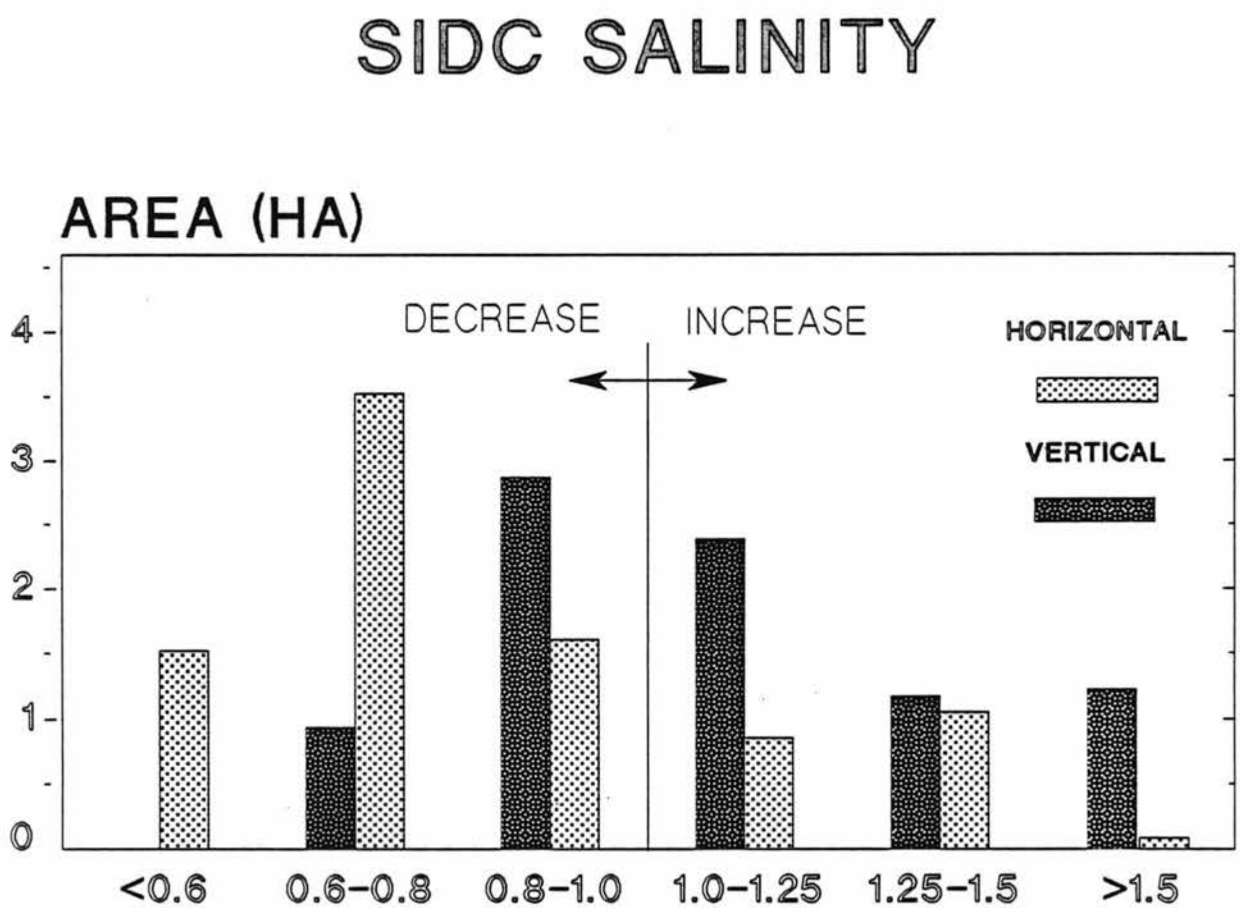

Figure 7: RATIO OF EM VALUES

CONCLUSION

The installation of subsurface drainage and subsequent irrigation management on Field 11 at the SIDC, has reduced the salinity in the 0-60 cm depth. There has been a significant reduction of the severely saline areas. Although salts have been removed from the upper soil profile, they have not been removed from the total root zone (0-100 cm).

ACKNOWLEDGMENTS

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