TECHNOLOGY EVALUATION AND DEVELOPMENT SUB-PROGRAM

MANAGEMENT OF FARM FIELD VARIABILITY
III. EFFECT OF TILLAGE SYSTEMS ON SOIL AND PHOSPHORUS LOSS

FINAL REPORT

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EXECUTIVE SUMMARY

This report is the second of three reports from the SWEEP/TED project "Management of Farm Field Variability". The first report documented the rational, objectives, and general methodology of the project. In addition, it summarized the work on the quantification of soil loss in a complex three dimensional landscape in southern Ontario, and the influence of tillage translocation as a process responsible for the severe soil loss on shoulder/crest slope landscape positions.

The objective of this part of the project was to measure soil and phosphorus losses on various soil landscapes, under different tillage systems. A subset of benchmark locations (soil landscape positions) were selected from the provincial Tillage-2000 research/demonstration project. A total of approximately 400 different benchmarks were selected.

At each of the benchmarks the amount of ^{137}Cs, a soil tracer, was measured in the fall of 1987 and again in 1990. The ^{137}Cs in the soil came from atmospheric thermonuclear testing in the early 1950's and 1960's. The cesium was dispersed into the upper stratosphere around the world, and was subsequently deposited in the soil by precipitation. The cesium binds to the soil and will not move unless the soil it is bound to, also moves.

The measurements at each sample date and location involved taking 9 soil cores (3 m by 3 m grid) for estimation of plow layer depth and two samples for bulk density and to obtain the soil sample for subsequent cesium analysis. The ^{137}Cs was analyzed by high efficiency Gamma Spectroscopy methods. The soil was also used for measurement of total phosphorus. The purpose of the measurements was to use the change in ^{137}Cs between measurements, to give net soil losses. The soil losses could then be combined with the phosphorus measurements to give phosphorus losses in the various soil landscapes.

The method of estimating soil loss from ^{137}Cs is well known and used throughout the world. However, the method assumes that a relationship exists between the loss of cesium at a particular site and the amount of net soil loss. For water and wind erosion there is usually little deposition on upper, and mid-slope positions. Thus, cesium and soil loss should be related. However, as the previous report of this project has shown (from D.A. Lobb, M.Sc. Thesis, Dept. of Land Resource Science, University of Guelph), tillage translocation of soil is a major process redistributing soil in complex topography. This process results in significant lateral mixing of soil/cesium. The net effect is that cesium loss at a particular soil landscape is not necessarily related to soil loss. Thus, in the absence of a good mechanistic model or understanding of tillage translocation, only a full mass balance of cesium in the landscape can be used to estimate soil loss.

Unfortunately, the Tillage-2000 benchmarks were not established to monitor the full three dimensional landscape. Only a cross-section of the landscape was used. This is an efficient methodology to examine landscape effects on yield, water erosion, soil properties, under different tillage systems, but not for a full mass balance of cesium.

The moldboard tillage system resulted in considerably more change in ^{137}Cs (1987 to 1990) than either minimum or no-till systems. Average soil losses across all Tillage-2000 field sites were 60.0, 30.0, and 0.0 t ha^{-1} yr^{-1} for the moldboard, minimum, and no-till systems respectively. Estimated phosphorus losses were 40.0, 20.0, and 0.0 kg P ha^{-1} yr^{-1} for the same tillage systems respectively. The minimum-till average loss values are not a good indication because most of the loss occurred on two sites. For 9 out of the 11 minimum-till sites soil and phosphorus loss was negligible. On one minimum-till site the loss was excessive which probably is the result of poor mass balance rather than an actual loss. These estimated losses are based on the assumption that the average ^{137}Cs loss from the benchmarks is representative of the mass balance of the entire field.

Paired tillage comparisons gave similar trends in the soil and phosphorus loss estimates. Annual losses of phosphorus were on average 48.0 and 35.0 kg P ha^{-1} for the five paired moldboard versus minimum-tillage field sites respectively, and 20.0 and 4.0 kg P ha^{-1} for the paired moldboard and no-till sites respectively. The differences in the losses in the moldboard sites paired to either minimum or no-till treatments reflects differences in soil types and probably tillage intensity. The paired minimum and no-till sites had negligible losses. These sites (i.e. where minimum-till tends to be the conventional system) are lighter textured and in general are tilled less intensively than the minimum-till sites paired with the moldboard system. Thus, the data seem consistent with what is known about the influence of tillage on soil and phosphorus losses. However, it must once again be stated that the loss estimates may not represent off-field losses related to water runoff. This, however, is a scale problem regardless of the within field processes (tillage translocation or water redistribution) which can only be answered with a true three dimensional mass balance.

Average ^{137}Cs losses from specific landscape positions were quite variable, with large losses generally observed on shoulder/crest slope landscape positions. Soil losses from these landscape positions were very large, in many cases exceeding 100 t ha^{-1} yr^{-1}. The variable nature of the losses (or gains) is consistent with the study by Battiston et al. (1987)and the previous report from this project suggesting that tillage translocation is a dominant process responsible for soil redistribution within a field.

1.0 GENERAL INTRODUCTION

The first report of this project (Kachanoski et al., 1991a) documented the rational, objectives, and general methodology of the SWEEP/TED Management of Farm Field Variability project. In addition, two aspects of the study were also reported; (1) the quantification of soil movement in a complex three dimensional landscape of southern Ontario using ^{137}Cs as a tracer, and (2) the effect of tillage translocation on the loss of soil from shoulder and crest slope positions. The conclusions from these sections of the project have significant implications regarding the interpretation of the data collected for the other objectives.

2.0 OBJECTIVE

The objective of this section of the Management cf Farm Field Variability project was to determine the rates of soil erosion and phosphorus delivery on various soil landscapes, under different tillage systems.

2.1 Introduction

The study quantifying the movement of soil loss in a complex three dimensional landscape in southern Ontario indicated that soil loss on shoulder and crest slope landscape positions was greater than 100 t ha^{-1} yr^{-1} which confirmed an earlier study by Battiston *et al.* (1987). However, total soil loss from the entire three dimensional landscape was negligible. The study concluded that water erosion is not likely the major process responsible for the soil loss on these slope positions.

The second study of the project concluded that the mechanical action of tillage equipment is a major cause of the severe soil loss observed on shoulder slope positions in complex topography. Soil can be translocated several meters by one sequence of moldboard plow and secondary tillage operations.

The previous conclusions have a number of significant implications which have been discussed in detail in the first report (Kachanoski et al., 1991a). However, the most important implication with respect to this study, and to the overall SWEEP project, is that the severe soil loss responsible for the significant yield loss measured by Battiston et al. (1987), is not related to off-farm environmental effects. This is significant since the shoulder slope landscape positions are the only locations were soil loss in Ontario has been related to crop productivity losses (Battiston et al., 1987). Thus, there is no longer any experimental evidence linking a decline in croc productivity with off-farm environmental effects of sediment, phosphorus, and other chemicals. The existence of this linkage has been automatically assumed in the SWEEP program as indicated by the objectives and justifications given for the program. The assumption of this linkage is also evident in the methodologies used to test the effectiveness of "new technologies" in the SWEEP TECHNOLOGY EVALUATION AND DEVELOPMENT (TED) subprogram. In almost all cases the methods involve measurements related to the process of water erosion (surface % cover, rainfall simulation, aggregate stability, etc.). It is clear from the first studies of this project that elimination of water erosion risk will not necessarily reduce soil loss and subsequent losses in crop productivity. The second major implication is that the validity of all soil loss/erosion estimations (and associated chemical transport) using a soil tracer such as ^{137}Cs, is questionable unless the changes are known throughout the landscape. Even when the entire landscape distribution is known, the interpretation of net soil losses at a particular location from tracer concentrations with time is not straightforward.

The two implications stated above have direct bearing on this objective of the project. For this objective a selected set of the Tillage-2000 benchmarks were sampled in 1987 and again in 1990 for measurement of ^{137}Cs. The estimates of soil loss from the cesium method were to be combined with measurements of soil phosphorus concentrations, to obtain phosphorus loss estimates from the different tillage systems.

As indicated in the first report, the measurements of cesium and phosphorus on the Tillage-2000 sites were completed. However, it is clear from the first two studies that the data can not be interpreted in the manner originally described. For example, the severely eroded shoulder slopes in the detailed Brant Co. site had estimated soil losses of greater than 100 t ha^{-1} yr^{-1} (Kachanoski et al., 1991a). However, calculating a phosphorus loss for environmental purposes from this soil loss and a soil phosphorus concentration, is a meaningless activity. Most of the soil has not been transported off field, it has merely been redistributed to the concave lower slope landscape positions. In addition, the difference between the local topographic loss and the field loss cannot be interpreted as a delivery ratio, since in effect the off-field delivery ratio for tillage is zero.

Estimation of the erosion rate for specific locations is difficult because soil from the crest slope position (with lower ^{137}Cs content) is being translocated downslope to other slope positions, and the soil from these locations is being translocated even farther downslope. The physical analogy most closely resembling this is a travelling wave process. The net effect is that ^{137}Cs can be decreasing with time, at for example a mid-slope position, without any net loss of soil. This is contrary to all existing studies which assume that the net loss of ^{137}Cs is related to the net loss of soil. This is a very significant conclusion since the cesium method is being used throughout the world, and is being used by Agriculture Canada in the Soil Quality Evaluation Program (SQEP) benchmark sites.

The use of ^{137}Cs as a soil tracer is still valid, but the interpretation of the data must change. A more detailed understanding of the tillage translocation process is necessary to properly interpret the relationship between soil and cesium losses. Catenary sequences with definable crest and lower slope boundaries are likely to be required. A SWEEP/TED follow up project on the influence of tillage implement, slope gradient, and tillage speed is currently being completed. A Ph.D. program for D.A. Lobb has been established through the National Soil Conservation Program with the purpose of constructing a hillslope model to describe the translocation process.

Once a better understanding of the tillage translocation process is attained, more detailed use and interpretations can be made of the ^{137}Cs data collected in this study. At present the data can be used to group landscape positions into general erosion classes for examining yield response interactions with tillage systems. Also the loss from upper slope landscape positions can be quantified over the long term. However, quantification of soil loss for specific landscapes cannot be done, and will not be attempted except were sufficient control of the boundary conditions is believed to be present. The change in ^{137}Cs content over the 3 year monitoring period is also difficult to interpret because in many cases only one or two tillage sequences were carried out. On some benchmarks, the direction of tillage could easily have been all in one direction (up for example) and ^{137}Cs could increase over the time period. As stated in the initial proposal, measuring the change in ^{137}Cs over a three year period is pushing the method to its limit with respect to measurement accuracy, and the amount of natural variability present. However, this was without the additional confounding influence of massive redistribution of the tracer by tillage. Additional control on tillage direction would have been imposed in the study had the magnitude of its influence been fully understood.

3.0 METHODOLOGY

A comprehensive overview of the study is given in the first report by Kachanoski et al. (1991a), and will not be repeated here. Briefly, the individual benchmark locations from a subset of the Tillage-2000 farms were selected for measurement of ^{137}Cs. Measurements of cesium were taken in the fall of 1987 and again in the fall of 1990. Each benchmark location was sampled in the following manner. A soil probe (2.0 cm diameter) was used to obtain 9 soil cores in a 3 m by 3 m grid (1 m interval) centred at the benchmark. Each soil core was sectioned at the depth of the plow layer or start of the B horizon. This gave 9 measurements of the depth of the plow layer, and a composite soil sample from the plow layer. In addition, 2 more measurements of the soil bulk density were obtained by taking undisturbed soil cores (7.0 cm diameter by 7.0 cm depth). This sampling procedure was repeated at each benchmark and at each sampling time. A summary of the Tillage-2000 field sites and benchmarks sampled is given in Table 1.

The soil samples were dried, passed through a 2 mm sieve, and then analyzed for ^{137}Cs using high resolution Gamma Spectroscopy methods as outlined by de Jong et al. (1982). The soil ^{137}Cs contents (Bq kg^{-1}) were combined with the soil bulk density and plow layer depth measurements to give area based ^{137}Cs estimates (Bq m^{-2}). The measured changes in ^{137}Cs between 1987 and 1990 were used to estimate soil loss equations given in the first report by Kachanoski et al. (1991a).

As mentioned earlier, only field averaged estimations are given because tillage translocation within a field makes it difficult to estimate soil loss at a single benchmark. A summary of the individual measurements at each benchmark is given in Appendix IV, along with the elevation contour and relief maps showing the benchmark locations.

4.0 RESULTS AND DISCUSSION

4.1 Paired Tillage Sites

The field averaged ^{137}Cs measurements in the different paired tillage systems are given in Tables 2 to 4. Comparison between paired tillage treatments were carried out using a simple paired t statistical analysis. The average ^{137}Cs for all sites (unpaired), for the three tillage systems is given in Table 5.

The field averaged data for the paired moldboard and minimum-tillage site are given in Table 2. On average the moldboard sites lost 12 % of their cesium over the three years. The minimum-till sites lost approximately 6.5 % of their cesium. The cesium losses combined with the measurements of plow layer mass give estimated soil losses of 77 and 73 t ha^{-1} yr^{-1} for the moldboard and minimum-till systems respectively, which were not statistically different (prob. < 0.05). Note that these are the averages of each column. The average calculated phosphorus losses are also given in Table 2. The data indicate an annual phosphorus loss of 48 and 35 kg P ha^{-1} for the moldboard and minimum-till sites respectively, which were not statistically significant (prob. < 0.05). The soil loss in the minimum-till is similar to the soil loss in the moldboard because of the exponential relationship between soil loss and percent cesium loss. Thus, the one minimum-till site that lost 38% of its cesium gives an extremely high soil loss value. Three of the five minimum-till sites had negligible soil and phosphorus loss, and as will subsequently be shown six more minimum-till sites also had negligible losses. The high loss at the Dykstra site is probably the result of a poor mass balance of the field rather than an actual loss.

The field averaged cesium measurements for the paired no-till and moldboard sites is given in Table 3. On average the no-till had a negligible change in cesium (0.02 %) compared to a 3% loss in the moldboard sites. The difference in cesium losses were significant at the 0.07 probability level. The cesium losses along with measured soil properties gave soil loss estimates of 43 and 4 t ha^{-1} yr' for the moldboard and no-till sites respectively. The estimated phosphorus losses were 19 and 2 kg P ha^{-1} yr^{-1} respectively, which were significantly different at the 0.10 probability level.

The paired minimum and no-till sites both had negligible cesium losses. Thus, soil and phosphorus losses on average from these sites were negligible and not statistically different.

4.2 Unpaired Tillage Treatments

The 9 moldboard till sites lost on average 9.15 % of the ^{137}Cs over the 3 year period (1987 to 1990) (Table 5). All of the moldboard sites had a net loss of ^{137}Cs except the Chipps site which had a 7.9 % increase. The Chipps site was very sandy in texture (> 80 %) and would not be expected to have a high soil loss. Both the no-till and min-till treatments at Chipps had negligible change (< 0.5 %) in ^{137}Cs. The increase is attributed to mass balance errors from tillage translocation and the fact that the moldboard treatment was not paired very well with respect to topography and was mostly lower lying areas compared to the other sites. The average soil loss on the moldboard sites is estimated at 62 t ha^{-1} yr^{-1}.

The no-till sites on average gained 1.6 %, while the minimum-till sites lost 1.03 %. Both of these changes are within measurement error for the short period of time for the study. The minimum-till treatments had an estimated soil loss of 10 t ha^{-1} yr^{-1}, while the soil loss on the no-till treatments was negligible.

The cesium and soil loss estimates are reasonably consistent with previous studies on the effects of tillage on the rate of erosion. The estimated loss for the moldboard system is high, this may reflect the problems with estimating a good mass balance from a transect sampling procedure. The original design was set up to estimate losses from paired slope positions, but the dominance of the tillage translocation process prevents a meaningful interpretation at this scale.

4.3 Average Phosphorus Losses

As stated earlier the validity of estimated soil and phosphorus losses for environmental impact has a large error using the cesium data because the delivery ratio for the tillage translocation process is essentially zero at the field scale. How much of the estimated cesium loss is off-field and how much is within field redistribution is not known. The estimated field averaged losses of soil gives annual phosphorus losses of 40.0 kg P ha^{-1}, 20.0 kg P ha^{-1}, and 0.0 kg P ha^{-1}, for the moldboard, minimum, no-till systems respectively. Once again it must be stressed that these estimates have a very high error.

The distribution of the cesium within individual landscape units will be discussed in a later report along with the yield response data, so this is not repeated here. However, some of the Tillage-2000 field sites had specific features related to either the methodology of estimating soil loss by cesium or their specific treatment design. These are subsequently discussed.

4.4 Don Lobb Field Site

The Don Lobb Tillage-2000 site is located on Concession Road 15-16, Goderich Township, just north of Clinton, Ontario. An elevation contour map and 3D relief map of the site are given in Appendix IV. The site has a long running field scale comparisons of no-till and moldboard tillage systems. At the start of this study (October, 1987) the comparison had been in been in place for 7 years. The site has also been extensively sampled for surface runoff characteristics from a rainfall simulation study funded by the Ontario Ministry of the Environment, and for surface hydrologic properties by a SWEEP/TED project (O'Neill et al., 1990).

The soil on the site varies from a sandy loam at the front of the site to silty clay loam at the back of the site. The major change in texture occurs at 350 m along the site, just after the small ridge. Detailed texture information is given in Kachanoski et al. (1991b).

A total of 124 locations (62 for each of the two tillage systems) were sampled for ^{137}Cs concentration in the fall of 1987. At each sampling site a total of nine soil cores (2 cm diameter) were taken in a 1 m by 1m grid, along with two larger soil cores (7.6 cm diameter). The cores were used to obtain the depth of the plow layer and its average bulk density. The soil was used to determine the ^{137}Cs content using methods outlined in the first report. The site was resampled in the fall of 1990.

The locations of the sampling sites are given in Appendix IV, along with the measured values. The site was sampled before tillage in 1987 and 1990. Thus only two tillage sequences were completed between the sampling times.

As indicated in Appendix IV, the sampling was more intense on the first ridge at 300 m along the field. The contour and relief maps of the site indicate that the surface flow lines for runoff near this ridge are parallel to the treatment borders so little cross contamination (run-on) would occur. This allows a good mass balance of the ^{137}Cs. The region in front of the ridge (0 to approximately 200 m) has a slight cross gradient which may affect the mass balance of ^{137}Cs. This is even more of a problem with the section of the field after the ridge. So mass balances of cesium for these areas have to be viewed with caution.

The results of the ^{137}Cs measurements are summarized in Table 6. The results have been averaged for various sections of the field. In 1987 the average ^{137}Cs contents in no-till and moldboard till systems were 2788 and 2642 Bq m^{-2}. The difference in the cesium values in 1987 represents a 5.2 % greater loss in the moldboard compared to no-till system in the previous 7 years. Combined with the average measured soil mass in the plow layer of 335 kg m^{-2}, and using the equation (4.7) given in the first report (Kachanoski et al., 1991a), this gives an estimated soil loss rate of 17 t ha^{-1} yr^{-1}. This is extra soil loss in the moldboard over the loss in the no-till.

The ^{137}Cs values in the fall of 1990 were 2778 and 2562 Bq m^{-2} for the no-till and moldboard system respectively. This difference averaged over the 10 years of treatment represents an average soil loss of 18.0 t ha^{-1} yr^{-1}, which is similar to the first estimate. The change in ^{137}Cs in the no-till from 1987 to 1990 is very small and represents an average soil loss of 3.7 t ha^{-1} yr^{-1}. Adding the soil loss from the no-till to the extra soil loss in the moldboard gives an estimated total soil loss in the moldboard of approximately 20 to 22 t ha^{-1} yr^{-1}. The change in ^{137}Cs in the moldboard from 1987 to 1990 is 3.1 %, which is significantly different from the no-till and gives an estimated soil loss of 22.5 t ha^{-1} yr^{-1}. This estimate is very similar to the first estimate, however this may be coincidental since the estimate based on only a 3 year change can have a large range.

The ^{137}Cs values for the first ridge are also given separately in Table 6. As indicated the values for the moldboard treatment are significantly lower on the ridge than in the rest of the sandy loam section of the field. This loss represents a soil loss of approximately 80 t ha^{-1} yr^{-1}. The no-till value did not change between the sampling times and is very similar to field average. However, it is noted that individual locations from both tillage systems had much more variable results. While this is expected with the moldboard till system as mentioned earlier, the amount of variability was not expected in the no-till. One of the major factors is the estimated soil mass in the plow layer. A difference of 19 or 20 cm. does not seem significant but it would change the estimated ^{137}Cs by 5 %, which is the same order of magnitude as a three year change at 25 t ha^{-1} yr^{-1}. This is why a number of replications of horizon depth, bulk density, and locations were used. Still, the variation in the no-till system is more than expected given the control used in the study.

The soil loss values given above for the various treatments represent approximate changes in the nature of the soil composition in the plow layer. However, as indicated in the introduction it is not valid to assume these losses represent off-field losses. The difference in soil loss rates between the ridge and entire sandy loam section are an indication of the problem. While the mass balance on the ridge is a reasonably accurate estimate of the soil loss from the ridge because the geometry of flow is essentially perpendicular to the tillage treatments and sampling scheme, the same cannot be said for the more general field average. Cross slope contamination between tillage systems, and a less frequent sampling intensity decrease the reliability of the field mass balance of cesium and thus soil loss. In addition, it is always difficult to interpret the depositional process with the cesium method because of problems with concentration changes. Nevertheless, the data in Table 6 indicate a significant loss of soil on average over the field at an estimated rate of between 20 and 30 t $ha^{-1} yr^{-1}$. A similar loss is not occurring on the no-till.

The average soil losses given above can be combined with measured estimates of phosphorus concentration in sediment to give a field loss of phosphorus. This can only be done for the entire field and not for individual slope positions as originally hoped, because cf the dominance of tillage translocation on soil loss and cesium changes. Measured soil phosphorus values from rainfall simulation at this site varied from 300 to 500 mg P kg^{-1}, with an average value of 390 mg P kg^{-1}. There was no significant difference between tillage systems. This gives an average phosphorus loss rate of approximately 8.8 kg P $ha^{-1} yr^{-1}$ and 1.0 kg P $ha^{-1} yr^{-1}$ for the moldboard and no-till systems respectfully.

The crest slope position of the ridge had ^{137}Cs values considerably lower than the rest of the field and lower than the average of the ridge. The values were 2560 and 1930 Bq m^{-2} in 1990 for the no-till and moldboard treatments respectively. This is an indication of the excess soil loss which may be attributed to tillage translocation. As stated in the introduction a phosphorus loss could be estimated but the rate may not represent environmental off-field transport. This is supported by the natural runoff monitoring which was carried out on this ridge for almost 20 months of the 3 year study (Kachanoski et ai., 1991c). No measurable soil erosion by rainfall was measured, which suggests the soil loss on the ridge was largely by tillage translocation.

The silty clay loam section of the field (> 340 m) had cesium values which were also lower than the average for the sandy loam section of the site. The average values were

2430 and 2540 Bq m^{-2} for the moldboard and no-till systems respectively in 1990. The cesium values in 1987 for the moldboard site were similar to the 1990 values, while the no-till average value was actually lower than the 1990 value. The increase in cesium in the no-till site is not surprising since the topographic maps indicate extensive flow lines crossing over from the moldboard to the no-till treatment. Thus soil could easily have deposited onto the no-till site. The flow boundaries are in general not well defined with respect to the treatment and Tillage-2000 benchmarks. Thus, no mass balance can be estimated. However, the average cesium value in the moldboard can be used to get an estimate of approximate increase in erosion relative to the sandy loam section. Using the relative cesium remaining in 1987, and assuming this difference is the cumulative difference over the 20 years that the cesium has been in the soil, the increased soil loss in the silty clay loam section is 12.7 t ha^{-1} yr^{-1} compared to the moldboard sandy loam section. Thus, an estimate for this area is approximately 35 t ha^{-1} yr^{-1}. Phosphorus concentrations in the moldboard soil were similar in the two sections, so phosphorus loss in the silty clay loam section is estimated at 20.0 kg P ha^{-1} yr^{-1}.

4.5 Murray Lobb Field Site

This site is located on the farm adjacent to the Don Lobb site, and in 1987 had an existing 5 year comparison of a no-till versus a moldboard plow system. An elevation contour map and a 3D relief map of the site are given in Appendix IV. The site is interesting because the moldboard treatment is situated as a strip between the no-till areas and a visual difference in the elevation of the two treatments is present. This indicates a massive loss of soil in the moldboard compared to the no-till system.

The site was not a regular Tillage-2000 site but it was a good opportunity to quantify the soil loss on these treatments, and the site was also going to be used for other SWEEP/TED studies so it was sampled for ^{137}Cs. The yield was also monitored on selected soil landscapes and included in the database, but detailed soil data are not available. The texture is sandy loam to loam. The cesium was sampled on the different soil landscapes in the moldboard treatment and on the adjacent locations in the no-till on both sides of the tilled area. The sampling was carried out in the spring of 1988 and again in 1990. Unfortunately the field crew sampled the wrong locations in 1990 (only at the edges of the treatments) so only the 1987 data will be discussed. The site will be resampled again in 1992. The data will be given to Agriculture Canada when it is available.

A summary of the ^{137}Cs data is given in Table 7. The average $^{'13}$7Cs in the moldboard treatment was 1042 Bq m^{-2} compared with 1723 and 1535 Bq m^{-2} in the no-till on either side of the moldboard. The average difference of cesium on a field basis is 36 %, which is the change over the 5 years the treatments have been in place. Using the average measured mass of the plow layer for the site (200 kg m^{-2}), this represents an estimated soil loss rate of 120 t ha^{-1} yr^{-1}.This rate is very large and confirms the differences observed visually in the elevation data. The rates are similar to the massive rates measured at the Brant site (Kachanoski et al., 1991a) and the tillage translocation studies.

Overall, the values even in the no-till sites are much lower than those measured in the Don Lobb site which is on the adjacent farm. The low no-till values are a reflection of soil losses before the site was put into no-till. Using the average value on the no-till Don Lobb site as a reference level of cesium (i.e. 2780 Bq m^{-2}), the moldboard site at Murray Lobb has lost 63 % of its ^{137}Cs as of 1987. This is a minimum loss since the no-till treatment at the Don Lobb site must have lost some ^{137}Cs as well. This loss of cesium represents an estimated soil loss rate of approximately 80 t ha^{-1} yr^{-1} for the past 20 years. This rate is slightly lower than the estimate based on the 5 year comparison of the no-till and moldboard treatments, but it is a very conservative estimate and is still very high.

The differences in the Murray Lobb and Don Lobb field sites can not be attributed entirely to differences in tillage translocation. The comments from the farm cooperators indicate that the Murray Lobb site was much more intensively and frequently tilled. However the soil is also much more sandy in the Don Lobb site, especially at the front of the field, which means that runoff and erosion would be less than the Murray Lobb site. The lower lying areas in the Murray Lobb site need to be sampled in more detail to complete a better mass balance of cesium on the entire site before an estimate of off-farm soil loss can be made. This will be done in the summer of 1992. The soil phosphorus values in the surface soil were similar to the Don Lobb site, varying from 475 to 635 mg P kg^{-1} and averaging 560 mg P kg^{-1}, so phosphorus loss is expected to be at least double the Don Lobb site. However, a better estimate of the cesium mass balance is needed to confirm this.

The previous work on tillage translocation concentrated on the movement of soil downward or upward in the same direction of the tillage. The tillage process, however, can also move considerable soil laterally, which may be a problem if tillage is done the same direction each year. The cesium sampling at the Murray Lobb site was also carried out at each benchmark at the edge of the no-till moldboard treatment. The results are given in Table 7, and indicate that the ^{137}Cs content is 250 % and 70 % higher than the moldboard and no-till sites respectively (significant at the 0.05 probability level). This suggests that soil movement out to the edge of the plot is occurring. Usually this is controlled by reversing the direction of plowing each year. However, at the edge of a plot where the final plow furrow slice is positioned, there will be a tendency for soil to spread out laterally and reversing the direction may not be 100 %efficient. Thus a natural "dispersion zone" will exist at the boundary between the plots. How large this zone is, is not known but it would contribute to the variability in cesium mass balance, and could possibly be the cause of the high cesium loss at this site.

4.6 Steward Field Site

The Steward field site is located near Brighton, Ontario. The field site is 260 m long and 70 m wide. The tillage treatments were a fall moldboard plow versus a no-till, which were established in the fall of 1987. Thus, the first sampling for ^{137}Cs in the fall of 1987 does not have a treatment effect. An elevation contour map and 3D relief map of the site are given in Appendix IV.

The site is characterised by two hillslope units and a centre depressional area. The soil is classified as the Bondhead series. The first four benchmarks -n hill #1 have an average of sand, silt, and clay content of 50 %, 39 %, and 11 % respectively. The last four benchmarks on the second hill have 45 % sand, 43 % silt, and 12 % clay. Thus, the texture is fairly uniform across the site. The slope is approximately 5 % to 6 % on the sides of the two hillslopes.

The average measured ^{137}Cs values for the two sampling dates are given in Table 8. The average ^{137}Cs content in 1987 was 2478 and 3973 Bq m^{-2}, for the no-till and moldboard till plots respectively. Since these are the initial values before any tillage treatments, the differences in cesium values cannot be attributed to the tillage treatments. The difference in initial values is very large (38 %, significant at the 0.05 probability level), and indicates the errors that can be made with a single sampling where the sites are only side by side comparisons. This problem is avoided by sampling on both sides of a treatment, and using the average as was done in the two Lobb sites. The initial differences are associated with the past history of the field and are surprising based on the visual uniformity of the two sites.

The initial cesium values indicate that the site which had the no-till treatment had significantly more soil loss in the past, than the site of the moldboard till treatment. The cesium values in the crest/shoulder slope positions are significantly lower (20 to 30 %) in both treatments, which is consistent with the previous sites and the process of tillage translocation.

The 1990 ^{137}Cs values were 2449 and 3502 Bq m^{-2} for the no-till and moldboard treatments respectively. Thus, the moldboard treatment had an 11.8 % change in ^{137}Cs in 3 years, compared to a 1.2 % change in the no-till. This change in cesium represents estimated soil loss rates of 110 and 8.0 t ha^{-1} yr^{-1} for the moldboard and no-till sites respectively. Once again the estimated rates of soil loss on the moldboard site are very high. The soil losses on the two shoulder slope position of the two hills were very different. On hill #1, the ^{137}Cs loss was 16.6 % over the 3 years, while the loss on the second hill was only 2 %. This is consistent with tillage translocation which may actually increase cesium values over a short time period on some shoulder slopes positions if tillage is more frequently upward on these sites.

The low cesium loss on the no-till site indicates that the significant soil loss that was historically occurring on this site has been stopped. The phosphorus concentration in the surface soil was 380 to 425 mg P kg^{-1} with an average of 400 mg P kg^{-1}. Combined with the estimated soil loss rates above, this gives estimated phosphorus loss rates of 44.0 and 3.3 kg P ha^{-1} yr^{-1}, for the moldboard and no-till sites respectively. Once again these numbers have to be viewed with caution on the moldboard site with respect to off-field transport. However, even the lower lying areas on this site had significant cesium loss on the moldboard treatment indicating soil loss off of the site was quite high.

4.7 Anthony Field Site

The Anthony field site is located in the regional municipality of Halton, just west of the town of Acton. The elevation contour map and the 3D relief map of the site are given in Appendix IV. The tillage treatments were a spring moldboard plow versus a spring soil-save tillage (minimum).

The site has significant topography with a long (approximately 140 m) slope at the start of the field. The gradient of this first part of the field is a maximum at benchmark #4 at 4 to 5 %. The soil is loamy textured (Font series) and relatively uniform in the field with sand contents only varying from 47 to 58 %. The first hillslope which includes benchmarks #1 to #6 is reasonably uniform with little cross-slope transport between tillage system except possibly in the lower slope positions.

The cesium measurements for the different slope positions of the first long hillslope are given in Table 9. As indicated, the values in 1987 show a significant difference between treatments which can not be attributed to differences in tillage system. In addition, the distribution of cesium does not suggest significantly more soil loss on the upper convex portions of the topography. The past tillage pattern is not known exactly, but because of the ridge in the corner of the field it was not predominantly in the direction of the transect/topography.

The Tillage-2000 treatments were set up perpendicular to the major topography changes which resulted in the tillage direction also being perpendicular to the major topography. This is a situation which is almost a worst case scenario for maximizing tillage translocation. The only thing worse would be to have tillage always in the same direction. The 1990 cesium measurements indicate the dramatic effect that tillage can have on the redistribution of soil/cesium. The crest slope position of the moldboard treatment lost 40 % of its cesium, while the shoulder lost 22 %. The lower slope positions on average gained 2.5 %. The data also show that cesium/soil loss on the crest/shoulder position of the soil-save treatment lost only 15 %, which is much less than the moldboard treatment. The lower slopes of this treatment also gained soil. The data suggest that different tillage systems move significantly different soil amounts and the direction of tillage may have a dramatic influence as well. All of these observations are supported by the previous tillage translocation data.

The authors do not believe that the differences in cesium loss between tillage systems is related to differences in off field losses of soil. The lower slope positions have gained significant soil/cesium but the exact amount cannot be estimated without knowing the exact size of the area gaining soil. The first benchmark is situated at approximately 30 m from the edge of the field. If it is assumed that the first benchmark is typical of the entire lower area then the area weighted average would indicate a loss of 11 % rather than 16 %. If tillage translocation is the process, then it is highly likely that the net gain in cesium is much higher in the last 30 m, so the loss would again be lower. The presence of significant lateral (between treatments) differences is also a problem, because as indicated in the Murray Lobb site, there can be a cross contamination from tillage translocation at the boundary of the treatments. This would be much more severe for the moldboard treatment which inverts the soil in a lateral motion.

A bias in the cesium estimates of soil loss is also suggested from the rainfall simulation data and soil hydrologic measurements from this site (O'Neill et al., 1990). The measured field saturated hydraulic conductivity at this site was 30.0 and 23.0 cm hr^{-1} for the moldboard and minimum-till sites respectively. Thus, the infiltration rate should be quite high, and higher in the moldboard than minimum-till system. The measured infiltration rate from a 12.0 cm hr^{-1} rainfall simulation was 8.4 and 8.6 cm hr^{-1} for the minimum and moldboard treatments respectively. These measurements were made on the lower, middle, and upper slope positions of the same hillslope. Total average soil loss for the simulations were 0.52 and 0.46 t ha^{-1} for the minimum and moldboard respectively at the high rainfall rate. At the low rainfall simulation rate of 4 cm hr^{-1}, no runoff or soil loss was measured after 30 minutes of simulation. There was no significant differences in bulk density, porosity, or macro-porosity between the two tillage systems.

The high infiltration rates, and low erodibility of both of the tillage systems suggests that the soil loss estimated from the cesium changes is probably a severe overestimation. The simulation data and hydraulic property data are also not consistent with the significantly higher cesium losses in the upper slope positions of the moldboard system. All of these observations suggest that as in the other sites the cesium loss is largely a reflection of tillage translocation and not water erosion. The data suggest that moldboard tillage will result in much higher redistribution of soil from shoulder/crest slope positions than a soil-saver (chisel-disc) tillage treatment.

5.0 SUMMARY

The moldboard tillage system resulted in considerably more net change in ^{137}Cs than either the minimum or no-till systems, at the selected Tillage-2000 benchmark locations. The estimated soil losses were 60.0, 20.0, and 0.0 t ha^{-1} yr^{-1} for the moldboard, minimum, and no-till systems respectively. Field phosphorus losses would be 27.0, 7.0, and 0.0 kg P ha^{-1} yr^{-1}, for the same tillage systems respectively. The estimated soil and phosphorus losses are based on the assumption that the average cesium loss from the benchmarks is representative for the entire field. The benchmarks were set up to characterize the major changes in topography by the transect method. This approach is valid for sites where the major process causing soil and cesium loss is water erosion. Unfortunately, studies just completed indicate that tillage translocation of soil is a dominant process in Ontario soils. Thus, the estimated soil and phosphorus loss estimates given here could have significant error because a true three dimensional mass balance of cesium is required.

Individual soil and phosphorus loss rates for specific landscape positions were not calculated because they have no physical meaning with respect to off-field environmental processes. The level of cesium can still be used as an index of soil loss (tillage translocated and water) for analyzing it's impact on yield etc. This is included in the next report of this project. Work currently under way on understanding the nature of the tillage translocation process will help in separating soil loss from specific landscapes into water versus tillage translocation losses.

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Table 1: Summary of Selected Tillage-2000 Sites

Study Site		County	Dominant Soil Type	Tillage * Comparison	Benchmark Sites
Tillage-2000:					
1.	Anthony	Halton	Font Sandy Loam	min-mold	20
2.	Bee	Kent	Brookston Clay	min-mold	12
3.	Dykstra	Victoria	Solmesville Clay Loam	min-mold	18
4.	Martin	Waterloo	Woolwich Loam, Maryhill Loam, Fox Sandy Loam	min-mold	22
5.	Murrell	Middlesex	Guelph Loam	min-mold	18
6.	Schaly	Simcoe	Minesing Marly Clay	min-mold	18
7.	Smith	Durham	Bondhead Sandy Loam	min-mold	16
8.	Steward	Northumberland	Bondhead Sandy Loam	NT-mold	16
9.	Lobb, D.	Huron	Fox Sandy Loam, Huron Clay Loam	NT-mold	121
10.	Lobb, M.	Huron	Burford Sandy Loam	NT-mold	33
11.	Riddell	Middlesex	Bryanston Silt Loam	NT-mold	30
12.	Temple	Perth	Huron Clay Loam	NT-mold	18
13.	Smith	Durham	Bondhead Sandy Loam	NT-mold	16
14.	Chipps	Norfolk	Silverhill Fine Sandy Loam, Waterin Loamy Fine Sand	NT-min	30
15.	Ghent	Wellington	Perth Silt Loam	NT-min	18
16.	Johnson	Wellington	Guelph Loam	NT-min	30
17.	Pottruff	Brant	Guelph Sandy Loam	NT-min	32
18	Strathmere	Middlesex	Fox Sandy Loam	NT-min	24
				Sub total	492

* mold = moldboard plow, min = minimum tillage, NT = no-till treatment

Table 2: Field Averaged Cesium-137 Measurements for the Minimum and Moldboard Paired Tillage-2000 Sites

FIELD SITE	TILLAGE COMPARISON	^{137}Cs (Bq m^{-2}) 1987	^{137}Cs (Bq m^{-2}) 1990	DIFF. (%)	BULK DENSITY (g m^{3})	Ap DEPTH (cm)	Ap MASS (kg^{-3})	Ap PHOSPHORUS (g P kg^{-1})	SOIL LOSS (t ha^{-1} yr^{-1})	PHOSPHORUS LOSS (kg P ha^{-1} yr^{-1})
ANTHONY	MOLDBOARD	1515	1261	-17	1.0	22.0	239.80	708	94.85	67.15
	MIN-TILL	2192	1928	-12	1.2	26.0	312.00	708	87.09	61.66
DYKSTRA	MOLDBOARD	1594	1232	-23	0.9	24.0	223.20	405	122.43	49.58
	MIN-TILL	2479	1525	-39	1.1	25.2	275.01	405	274.10	111.01
MARTIN	MOLDBOARD	2226	1855	-17	1.1	25.1	281.23	760	110.54	84.01
	MIN-TILL	1655	1637	- 1	1.2	21.4	245.80	760	6.23	4.73
SMITH	MOLDBOARD	1650	1709	4	1.2	27.3	324.28	810	0.00	0.00
	MIN-TILL	2082	2116	2	1.0	24.0	240.00	810	0.00	0.00
BEE	MOLDBOARD	1561	1430	-8	1.3	24.2	314.60	702	60.39	42.39
	MIN-TILL	1618	1903	18	1.4	24.7	335.92	702	0.00	0.00
AVERAGE	MOLDBOARD	1709	1497	-12	1.1	24.5	276.62	677	77.64 [a]*	48.63[a]
	MIN-TILL	2005	1822	6	1.2	24.3	283.95	677	73.48[a]	35.48[a]

* values in the same column with the same letter are not significantly different at the 0.05 probability level.

Table 3: Field Averaged Cesium-137 Measurements for the No-till and Moldboard Paired Tillage-2000 Sites

FIELD SITE	TILLAGE COMPARISON	^{137}Cs ($Bq\ m^{-2}$) 1987	^{137}Cs ($Bq\ m^{-2}$) 1990	DIFF (%)	BULK DENSITY ($g\ cm^{-3}$)	Ap DEPTH (cm)	Ap MASS ($kg\ m^{-2}$)	Ap PHOSPHORUS ($mg\ P\ kg^{-1}$)	SOIL LOSS ($t\ ha^{-1}\ yr^{-1}$)	PHOSPHORUS LOSS ($kg\ P\ ha^{-1}\ yr^{-1}$)
D. LOBB	MOLDBOARD	2642	2562	- 3	1.3	25.1	331.06	390	22.50	8.78
	NO-TILL	2788	2778	- 0	1.4	24.4	339.72	390	2.71	1.06
STEWARD	MOLDBOARD	3973	3502	-12	1.2	33.3	399.36	402	109.65	44.08
	NO-TILL	2478	2449	- 1	1.3	23.9	313.09	402	8.17	3.29
TEMPLEMAN	MOLDBOARD	2518	2381	-5	1.2	27.3	324.28	565	39.94	22.56
	NO-TILL	2081	2116	2	1.0	24.0	239.80	565	0.00	0.00
CHIPPS	MOLDBOARD	2363	2551	8	1.2	31.0	356.38	725	0.00	0.00
	NO-TILL	2245	2233	- 1	1.2	25.2	294.84	725	3.51	2.54
AVERAGE	MOLDBOARD	2874	2749	- 3	1.2	29.2	352.77	520	43.02 [a*]	18.86 [a]
	NO-TILL	2398	2394	- 0	1.2	24.4	296.86	520	3.60 [b]	1.72 [b]

* values in the same column with different letters are significantly different at the 0.07 probability level.

Table 4: Field Averaged Cesium-137 Measurements for No-till and Minimum-till Paired Tillage-2000 Sites

FIELD SITE	TILLAGE COMPARISON	^{137}Cs (Bq m^{-2}) 1987	^{137}Cs (Bq m^{-2}) 1990	DIFF (%)	BULK DENSITY (g cm^{-3})	Ap DEPTH (cm)	Ap MASS (kg m^{2})	Ap PHOSPHORUS (mg P kg^{-1})	SOIL LOSS (t ha^{-1} yr^{-1})	PHOSPHORUS LOSS (kg P ha^{-1} yr^{-1})
CHIPPS	MIN-TILL	2332	2341	0.4	1.1	27.7	313.01	725	0.00	0.00
	NO-TILL	2245	2233	-0.5	1.4	25.2	294.84	725	3.51	2.54
POTTRUFF	MIN-TILL	2438	2550	4.6	1.3	24.6	330.18	580	0.00	0.00
	NO-TILL	2588	2496	-3.6	1.4	24.2	329.12	580	26.31	15.26
JOHNSON	MIN-TILL	2531	2578	1.9	1.2	32.2	379.96	741	0.00	0.00
	NO-TILL	2569	2543	-1.0	1.3	28.2	360.96	741	0.00	0.00
GHENT	MIN-TILL	2070	2154	4.1	1.2	22.5	278.88	1100	0.00	0.00
	NO-TILL	2178	2122	-2.6	1.3	23.4	292.63	1100	16.86	18.55
STRATHMERE	MIN-TILL	2026	2055	1.4	1.3	24.5	328.57	562	0.00	0.00
	NO-TILL	3249	3464	6.6	1.4	29.1	404.63	562	0.00	0.00
MURRELL	MIN-TILL	2422	2563	5.8	1.2	24.9	296.67	563	0.00	0.00
	NO-TILL	2266	2506	10.1	1.1	26.4	298.66	563	0.00	0.00
AVERAGE	MIN-TILL	2303	2374	3.0	1.2	26.1	321.21	711	0.00 [a] *	0.00 [a]
	NO-TILL	2516	2561	1.5	1.3	26.1	330.14	711	0.00 [a]	0.00 [a]

* values in the same column with the same letters are not significantly different at the 0.05 probability level.

Table 5: Field Averaged Cesium-137 Measurements for Unpaired Tillage-2000 Sites

TILLAGE SYSTEM	^{137}Cs (Bq m^{-2}) 1987	1990	DIFFERENCE (%)	ESTIMATED SOIL LOSS (t ha^{-1} yr^{-1})
MOLDBOARD (n=9)	2323	2128	-9.15	62.3
MINIMUM-TILL (n=11)	2167	2122	-1.03	33.4
NO-TILL (n=10)	2493	2523	+1.08	0.0

Table 6: Field Averaged Cesium-137 Measurements at Don Lobb Tillage-2000 Site

	^{137}Cs (Bq m^{-2})					
	NO-TILL			MOLDBOARD		
SPATIAL LOCATION	1987	1990	DIFFERENCE (%)	1987	1990	DIFFERENCE (%)
Sandy loam section (0-335 m)	2788	2778	-0.4	2642	2562	-3.0
Sandy loam ridge (235-335 m)	2729	2788	2.2	2588	2380	-8.0

Table 7: Average Cesium-137 Measurements at Murray Lobb Tillage-2000 Site, Spring 1988

	^{137}Cs (Bq $^{-2}$)			
BENCHMARK	**NO-TILL #1**	**MOLDBOARD**	**NO-TILL #2**	**EDGE**
1	1902	1515	2367	3248
2	2018	1600	2516	2904
3	1695	1293	1240	2129
4	1907	1426	1575	2456
5	1305	1172	1270	1552
6	1428	613	1431	2360
7	1473	619	1199	1649
8	2780	1485	1886	2861
9	1176	467	1353	2489
10	1526	432	1054	2762
11	1693	840	991	3588
AVERAGE =	1723 [a] *	1042 [b]	1535 [a]	2545 [c]

* average values with different letters are significantly different at the 0.05 probability level.

Table 8: Average Cesium-137 Measurements at Steward Tillage-2000 Site

SPATIAL LOCATION	^{137}Cs(Bq m^{-2}) NO-TILL 1987	NO-TILL 1990	DIFFERENCE (%)	MOLDBOARD 1987	MOLDBOARD 1990	DIFFERENCE (%)
Hill #1	2552	2558	0.2	3933	3478	-11.6
Hill #2	2354	2267	-3.7	4038	3543	-12.3
Field Average	2478	2449	-1.2 [a*]	3973	3502	-11.9 [b]

* average differences with different letters are significantly different at the 0.05 probability level.

Table 9: Measurements of Cesium-137 for the First Major Hillslope of Anthony Tillage-2000 Site

SLOPE POSITION	^{137}Cs (Bq m^{-2}) MOLDBOARD 1987	MOLDBOARD 1990	DIFFERENCE (%)	MINIMUM-TILL 1987	MINIMUM-TILL 1990	DIFFERENCE (%)
Crest	1529	906	-40.7	2167	1840	-15.1
Shoulder	1513	1178	-22.1	2469	2117	-14.2
Back (middle)	1488	1241	-16.6	1921	1859	-3.2
Back (lower)	1353	1351	0.0	1892	1936	+2.3
Footslope	1157	1215	+5.0	2045	2327	+13.7
Average	1408	1178	-16.3 [a*]	2099	2014	-4.1 [b]

* average differences with different letters are significantly different at the 0.10 probability level.

APPENDIX IV

^{137}Cs, Soil, and Elevation Measurements for the Selected Tillage-2000 Benchmarks

Table IV.1: Anthony Tillage-2000 Field Site Cesium-137 Data

	1987					1990						1990-1987			
BENCH	Avg.:	Bulk				Avg.2	Bulk					Avg	Bulk		
	Depth	Density	Mass	Cesium		Depth	Density	Mass	Cesium			Depth	Density	Mass	Delta
	cm	g/cm3	g	Bq/kg	Bq/m2	cm	g/cm3	g	Bq/kg	Bq/m2	Bq/m2	cm	g/cm3	g	Bq/m2
TREATMENT 1															
An_1_01	21	1.1	23	8.9	2045	30	1.3	39	5.7	2327	282	25	1.2	31	-920
An_1_02	19	1.1	22	8.7	1892	22	1.2	25	7.3	1936	44	20	1.2	24	-256
An_1_03	24	1.0	24	7.9	1921	22	1.4	30	6.0	1859	-62	23	1.2	27	-442
An_1_04	38	1.0	37	6.6	2469	29	L4	39	5.1	2117	-353	33	1.2	38	-484
An_1_05	34	1.1	38	5.8	2167	26	1.3	33	5.3	1840	-327	30	1.2	35	-87
An_1_06	25	1.3	32	6.4	2073	21	1.3	26	6.5	1562	-511	23	1.3	29	127
An_1_06a	28	1.1	30	7.7	2294										
An_1_07	31	1.1	33	7.7	2542	24	1.3	32	6.7	2264	-279	28	1.2	33	-213
An_1_08	29	0.9	27	8.6	2354	20	1.3	26	6.8	1852	-502	25	1.1	27	-389
An_1_09	29	1.1	31	7.1	2160	20	1.3	26	5.9	1594	-567	25	1.2	28	-244
Avg	28	1.1	30	7.5	2192	24	1.3	31	6.1	1928	-253	26	1.2	30	-331
TREATMENT 2															
An_2_01	19	1.0	19	6.1	1157	18	1.3	23	5.1	1215	58	19	1.1	21	-178
An_2_02	25	0.8	21	6.6	1353	20	1.2	24	5.4	1351	-2	23	1.0	22	-2^{2}9
An_2_03	26	0.8	21	7.1	1488	18	1.2	22	5.4	1241	-248	22	1.0	22	-328
An_2_04	25	0.9	22	6.9	1513	16	1.3	21	5.4	1178	-335	21	1.1	22	-300
An_2_04a	25	0.9	23	6.7	1529	13	1.2	15	5.8	906	-623	19	1.0	19	-146
An_2_05	24	0.8	20	7.3	1469	20	1.1	22	6.2	1386	-83	22	1.0	21	-192
An_2_06	24	0.9	20	6.2	1264	13	1.6	21	4.7	1003	-251	19	1.2	21	-301
An_2_06a	24	1.0	24	6.7	1595										
An_2_07	28	1.0	28	7.2	2022	23	1.3	30	5.4	1656	-366	26	1.1	29	-467
An_2_08	24	1.1	26	6.8	1750	18	1.2	22	6.3	1423	327	21	1.1	24	-55
An_2_09	25	0.9	22	6.9	1529	15	1.4	22	5.5	1248	-281	20	1.2	22	-274
Avg	25	0.9	22	6.8	1515	18	1.2	22	5.5	1261	-247	21	1.1	22	-247

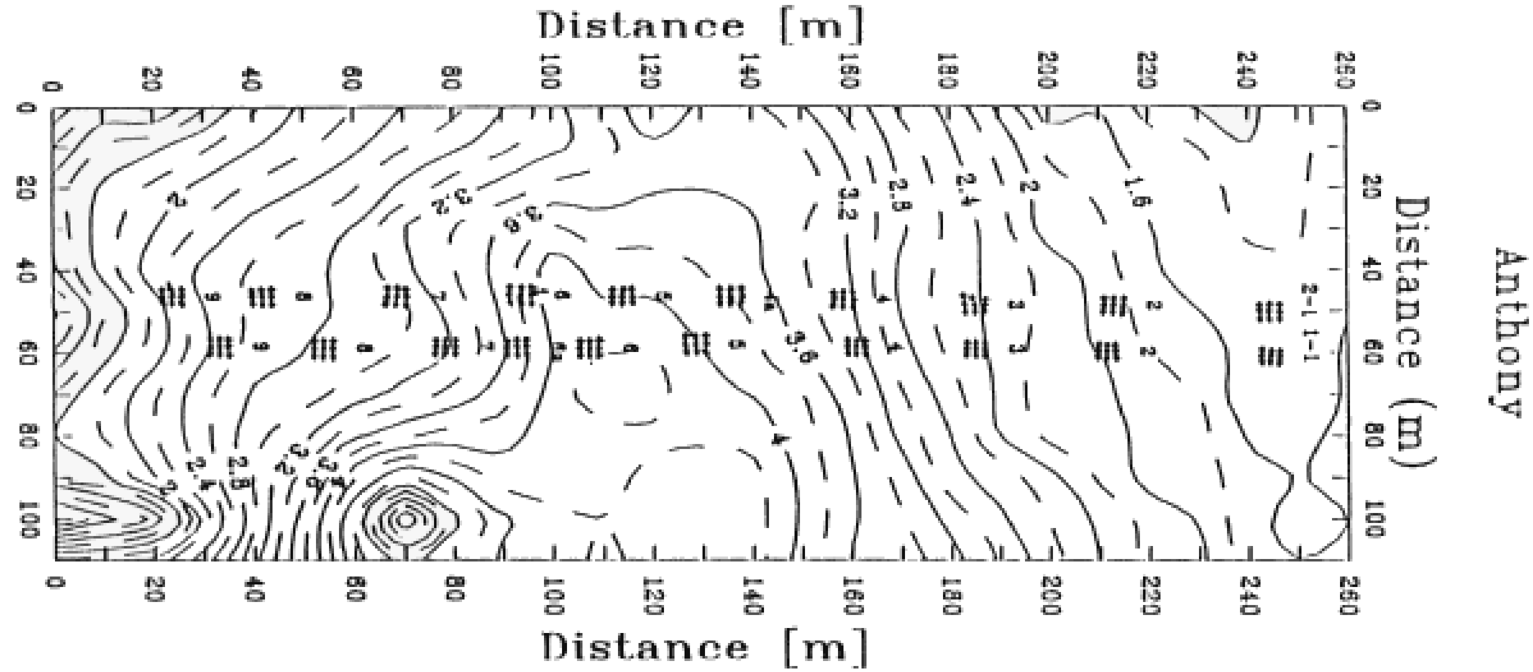

Figure IV.1: Anthony Tillage-2000 field site elevation contour map showing benchmark positions.

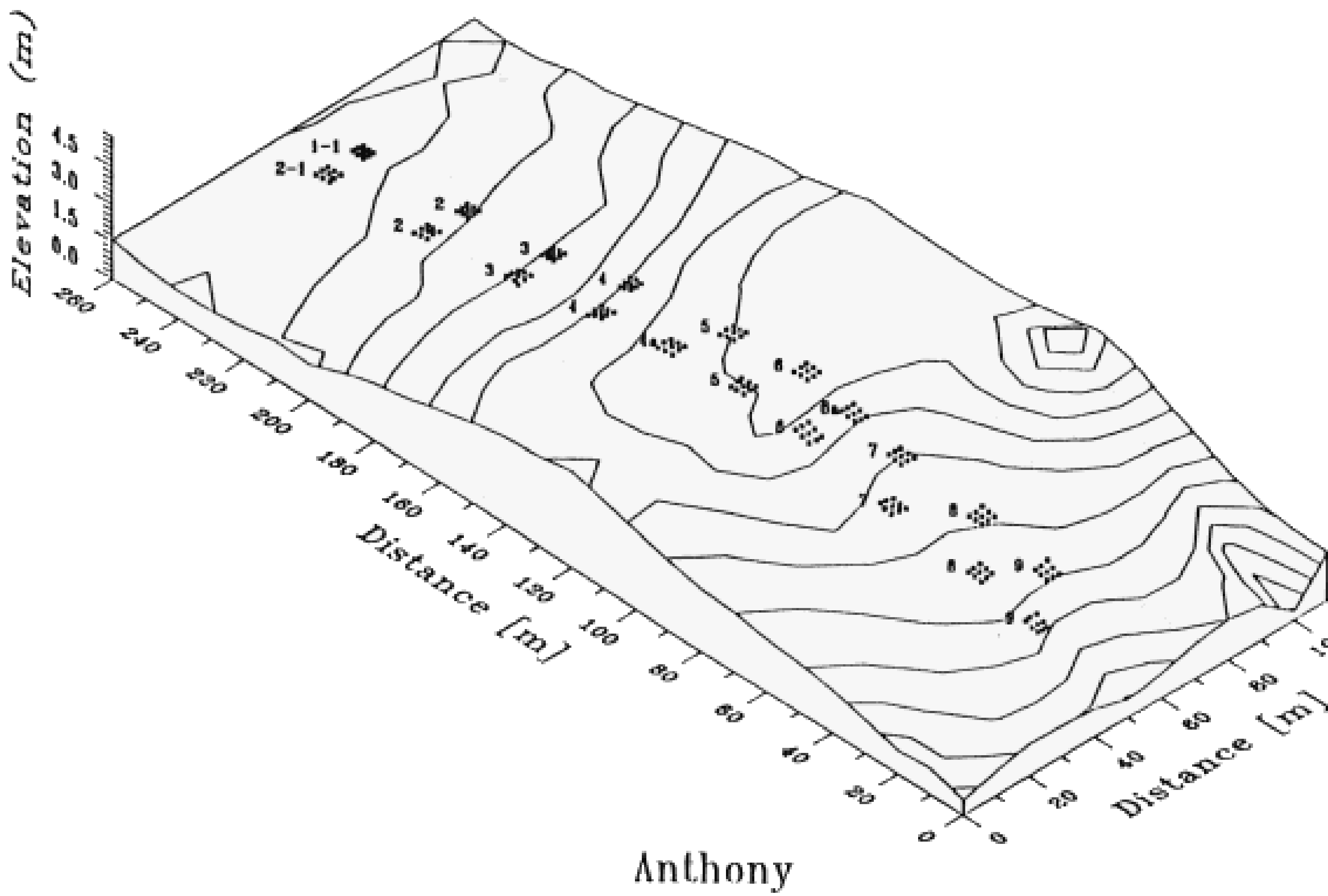

Figure IV.2: Anthony Tillage-2000 field site 3D relief map.

Table IV.2: Bee Tillage-2000 Field Site Cesium-137 Data

	1987					1990					1990-1987				
BENCH	Avg.2 Depth cm	Bulk Density g/cm3	Mass g	Cesium Bq/kg	Bq/m2	Avg.2 Depth cm	Bulk Density g/cm3	Mass g	Cesium Bq/kg	Bq/m2	Bq/m2	Avg Depth cm	Bulk Density g/cm3	Mass g	Delta Bq/m^2
TREATMENT 1															
Be_1_01	24	1.5	36	4.0	1423	27	1.3	35	4.1	1493	70	25	1.4	35	102
Be_1_02	23	1.3	29	6.2	1820	24	1.2	29	6.5	1966	146	23	1.2	29	188
Be_1_03	24	1.5	35	5.6	1940	26	1.3	32	5.3	1774	-165	25	1.4	34	-22
Be_1_04	26	1.3	33	4.3	1416	20	1.3	26	4.5	1215	-201	23	1.3	30	115
Be_1_05	25	1.4	35	3.1	1069	21	1.3	28	3.3	945	-125	23	1.3	31	108
Be_1_06	28	1.2	34	5.0	1700	24	1.1	26	4.5	1188	-512	26	1.2	30	-103
Avg	25	1.4	34	4.7	1561	24	1.2	29	4.7	1430	-131	24	1.3	31	65
TREATMENT 2															
Be_2_01	20	1.1	23	3.8	854	26	1.5	38	3.4	1350	496	23	1.3	30	-79
Be_2_02	28	1.3	36	7.3	2650	24	1.3	32	6.5	2170	-480	26	l.3	34	-132
Be_2_03	24	0.9	22	6.3	1379	30	1.6	48	5.3	2660	1282	27	1.2	35	-269
Be_2_04	25	1.4	35	5.8	2031	29	1.4	42	5.4	2403	372	27	1.4	38	-53
Be_2_05	22	1.3	29	4.4	1248	23	1.5	35	3.7	1338	90	23	1.4	32	-175
Be_2_06	22	1.6	36	4.2	1544	22	1.4	31	4.6	1497	-48	22	1.5	34	184
Avg	24	1.3	30	5.3	1618	26	1.5	38	4.8	1903	285	25	1.4	34	-87

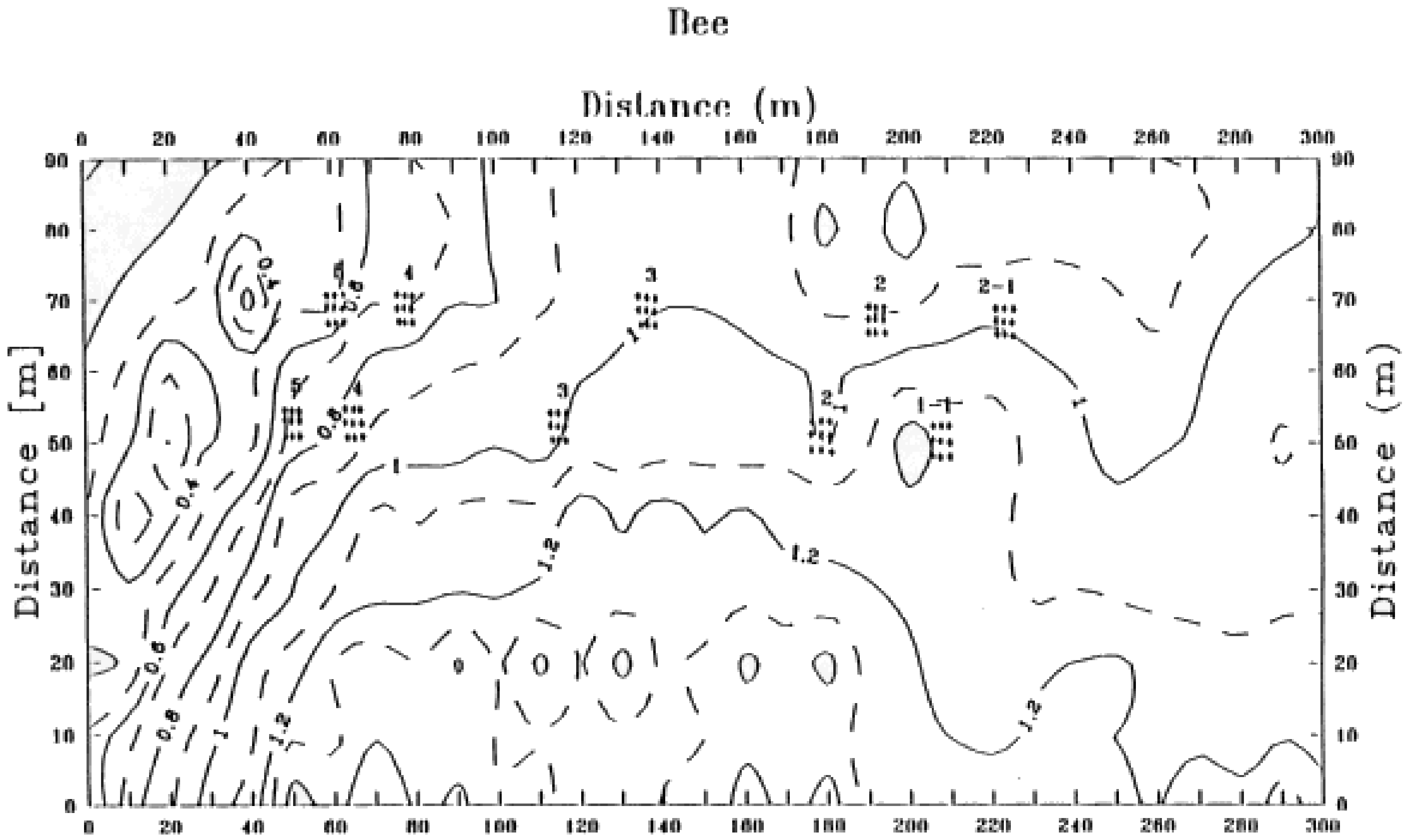

Figure IV.3: Bee Tillage-2000 field site elevation contour map showing benchmark positions.

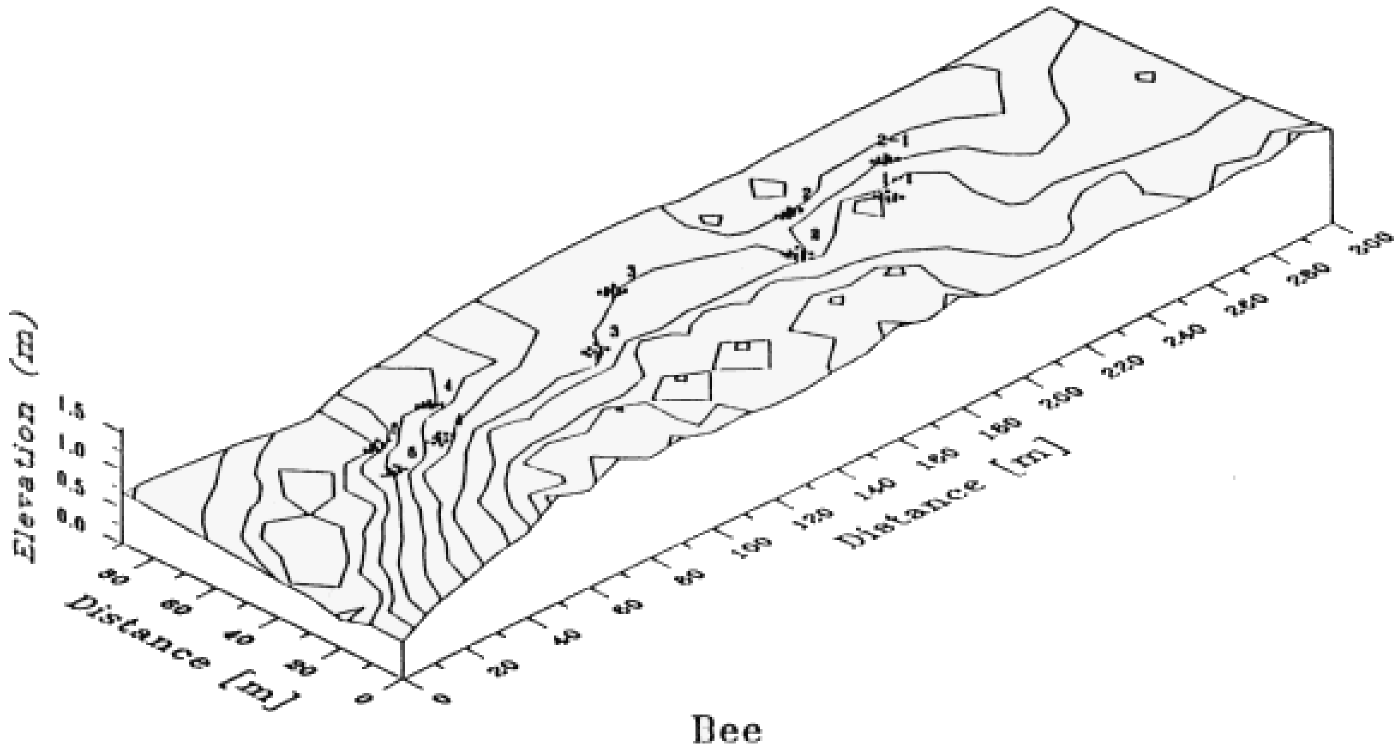

Figure IV.4: Bee Tillage-2000 field site 3D relief map.

Table IV.3: Chipps Tillage-2000 Field Site Cesium-137 Data

BENCH	1987 Avg.2 Depth cm	1987 Bulk Density g/cm^3	1987 Mass g	1987 Cesium Bq/kg	1987 Bq/m^2	1990 Avg.2 Depth cm	1990 Bulk Density g/cm^3	1990 Mass g	1990 Cesium Bq/kg	1990 Bq/m2	Bq/m2	1990-1987 Avg Depth cm	1990-1987 Bulk Density g/cm^3	1990-1987 Mass g	Delta Bq/m^2
TREATMENT 1															
Ch_1_01	25	1.0	24	7.7	1853	24	1.2	29	6.5	1999	147	24	1.1	27	-221
Ch_1_02	27	1.0	27	9.5	2528	32	1.3	41	6.2	2665	137	30	1.1	34	-1009
Ch_1_03	31	1.2	36	7.4	2671	30	1.2	36	5.9	2205	-467	30	1.2	36	-433
Ch_1_04	23	0.9	22	8.3	1843	22	1.2	27	7.4	2092	249	23	1.1	25	-127
Ch_1_05	30	1.1	33	7.6	2458	33	1.3	41	5.8	2532	74	31	1.2	37	-526
Ch_1_06	27	1.0	27	8.3	2267	31	1.2	37	7.2	2818	551	29	1.1	32	-256
Ch_1_07	29	1.1	31	8.6	2701	26	1.3	34	7.9	2839	137	28	1.2	33	-92
Ch_1_08	23	1.0	24	8.0	1938	28	1.4	38	5.4	2133	196	26	1.2	31	-736
Ch_1_09	29	0.9	27	8.7	2363	25	1.2	29	6.9	2091	-272	27	1.1	28	-434
Ch_1_10	29	1.0	30	9.0	2695	32	1.2	36	5.3	2041	-653	30	1.1	33	-1118
Avg	27	1	28	8.3	2332	28	1.2	35	6.4	2341	10	28	1.1	32	-495
TREATMENT 2															
Ch_2_ 01	27	1.1	28	8.8	2460	24	1.1	26	8.2	2236	-224	25	1.1	27	-51
Ch_2_02	26	1.0	27	6.9	1887	21	1.3	26	7.3	2030	143	24	1.1	27	213
Ch_2_03	26	1.0	25	7.2	1804	22	1.2	26	7.0	1940	137	24	1.1	26	37
Ch_2_04	27	1.1	29	8.9	2574	24	1.2	30	8.9	2772	198	26	1.2	29	136
Ch_2_05	27	1.1	31	7.5	2315	24	1.3	33	5.9	2026	-289	26	1.2	32	-397
Ch_2_06	28	1.2	34	7.5	2534	24	1.3	32	7.1	2411	-123	26	1.3	33	8
Ch_2_07	27	1.1	31	7.4	2332	24	1.4	32	6.9	2329	-3	26	1.2	32	-55
Ch_2_08	26	1.1	29	8.0	2368	24	1.2	29	7.7	2367	-1	25	1.2	29	11
Ch_2_09	26	1.1	28	7.6	2154	24	1.3	31	6.7	2137	-17	25	1.2	29	-187
Ch 2_10	28	1.0	27	7.5	2019	24	1.3	30	6.6	2081	62	26	1.1	28	-176
Avg	27	1.1	29	7.7	2245	24	1.3	30	7.2	2233	-12	25	1.2	29	4.6
TREATMENT 3															
Ch_3_01	26	1.1	29	7.3	2097	25	1.2	29	7.2	2203	106	26	1.1	29	74
Ch_3_02	32	1.3	41	7.0	2894	32	1.2	38	7.0	2791	-103	32	1.2	40	146
Ch_3_03	28	1.3	35	6.9	2423	51	1.4	72	4.1	3110	686	39	1.3	54	-1368
Ch_3_04	26	1.0	27	7.2	1925	24	1.3	32	6.5	2147	222	25	1.2	29	-121
Ch_3_05	30	1.2	37	7.0	2575	37	1.1	40	6.4	2668	93	34	1.1	38	-122
Ch_3_06	27	1.1	29	8.3	2388	36	1.1	39	6.5	2665	277	31	1.1	34	-487
Ch_3_07	30	1.1	34	7.6	2591	46	1.1	50	5.3	2771	180	38	1.1	42	-888
Ch_3_08	29	1.3	38	6.7	2547	21	1.1	22	7.6	1791	-755	25	1.2	30	403
Ch_3_09	26	1.1	29	7.7	2233	34	1.2	39	6.9	2872	639	30	1.1	34	-150
Ch_3_10	31	0.9	29	6.8	1953	30	1.1	31	7.5	2488	534	30	1.0	30	324
Avg	28	1.1	33	7.3	2363	34	1.2	39	6.5	2551	188	31	1.2	36	-219

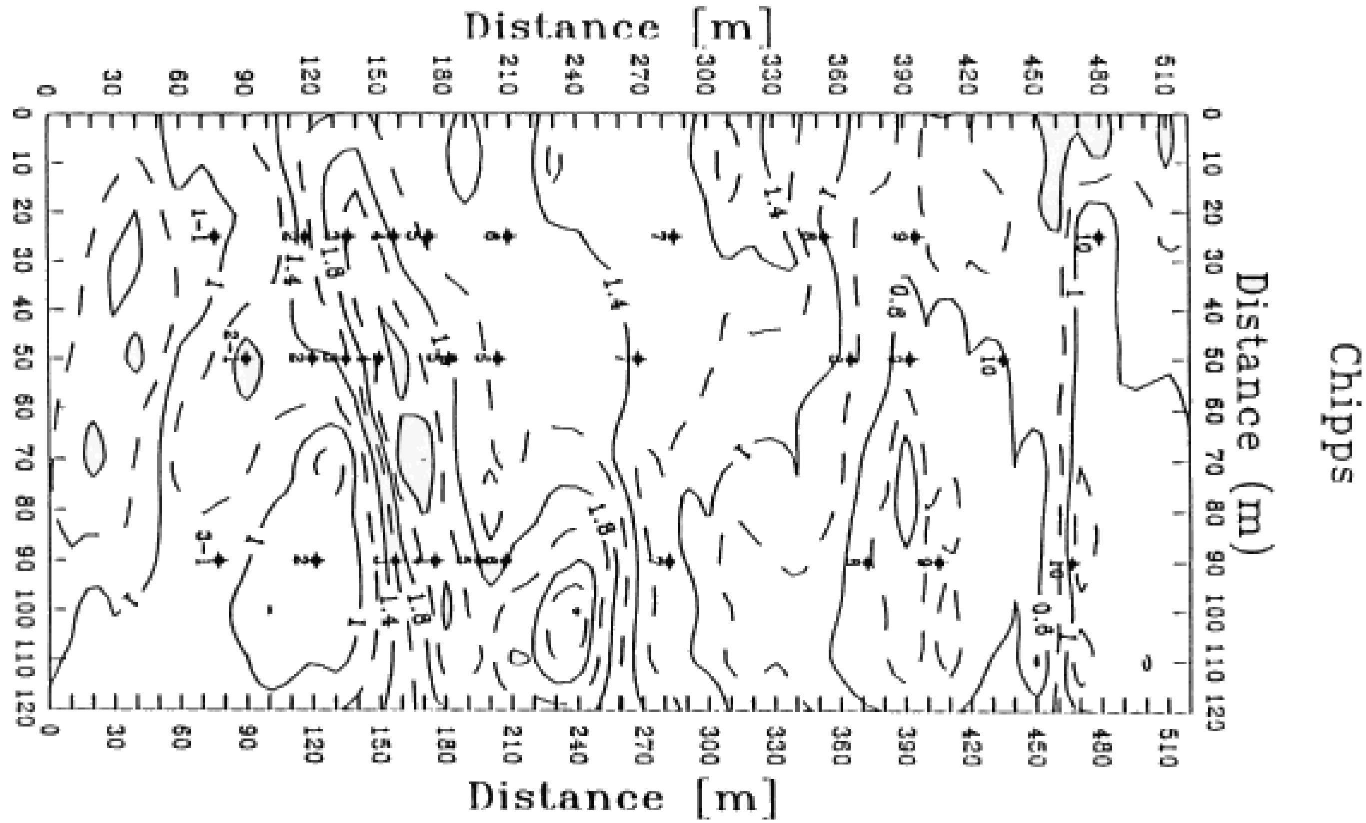

Figure IV.5: Chipps Tillage-2000 field site elevation contour map showing benchmark positions.

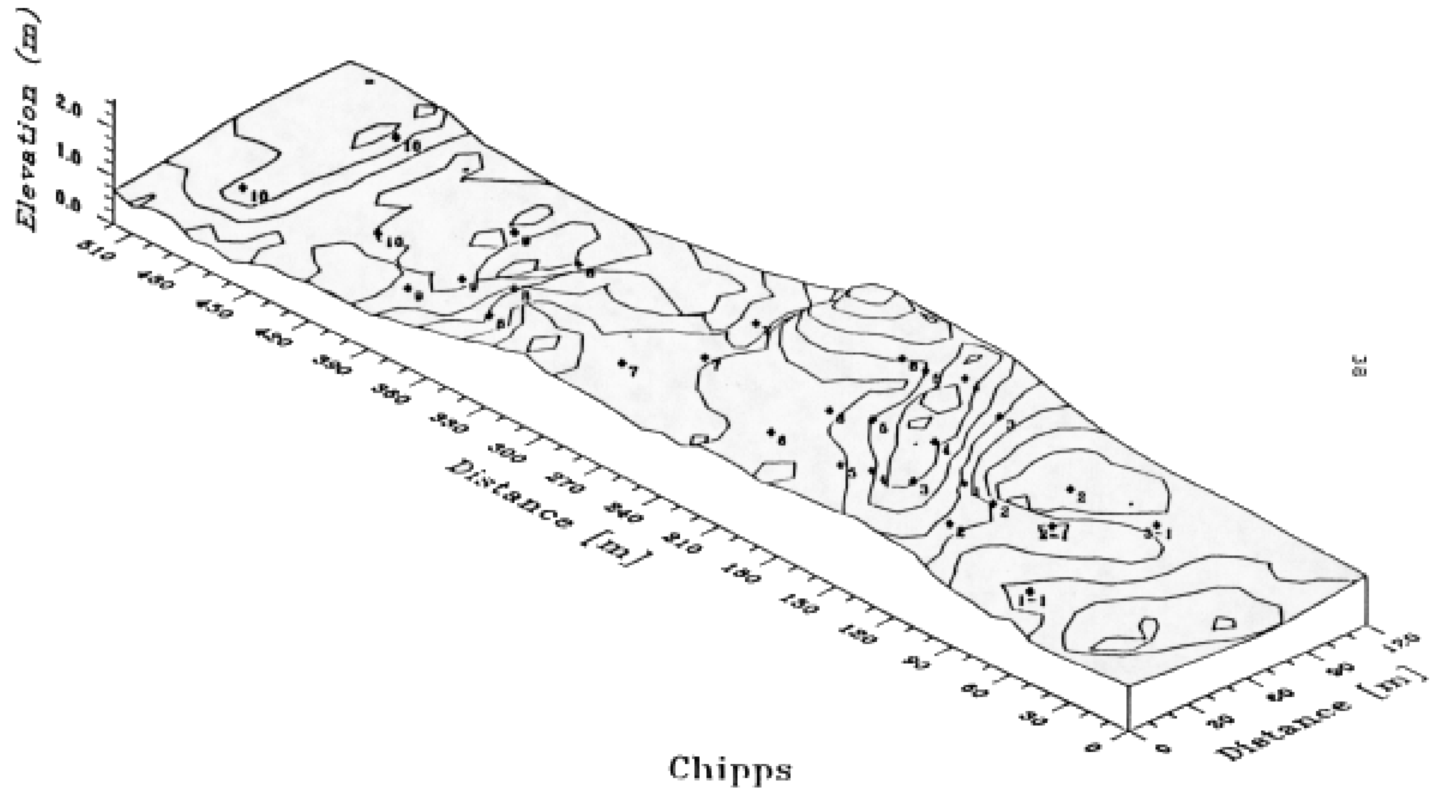

Figure IV.6: Chipps Tillage-2000 field site 3D relief map.

Table IV.4: Dykstra Tillage-2000 Field Site Cesium-137 Data

	1987					1990						1990-1987			
BENCH	Avg.2 Depth cm	Bulk Density g/cm^3	Mass g	Cesium Bq/kg	Bq/m^2	Avg.2 Depth cm	Bulk Density g/cm^3	Mass g	Cesium Bq/kg	Bq/m2	Bq/m2	Avg Depth cm	Bulk Density g/cm^3	Mass g	Delta Bq/m^2
TREATMENT 1															
Dy_1_01	29	0.8	25	5.3	1303	24	1.1	26	6.0	1590	287	27	1.0	25	240
Dy_1_02	23	1.1	26	7.4	1913	25	0.9	22	6.6	1494	-419	24	1.0	24	-132
Dy_1_03	27	0.7	19	6.2	1173	29	0.6	18	5.9	1060	-113	28	0.7	18	-29
Dy_1_03a	26	1.1	28	6.5	1815										
Dy_1_04	26	1.1	27	7.5	2035	24	0.8	19	6.7	1337	-698	2.5	0.9	23	-138
Dy_1_05	19	1.3	24	5.3	1286	19	0.8	15	5.5	818	468	19	1.0	19	63
Dy_1_06	21	1.2	24	6.1	1476	18	0.9	16	6.0	1013	-463	20	1.0	20	40
Dy_1_07	22	1.0	21	6.6	1362	20	0.7	14	6.3	866	-496	21	0.8	17	-13
Dy_1_08	30	1.0	30	6.6	1987	25	1.0	26	6.2	1681	-306	27	1.0	28	43
Avg	25	1.0	25	6.4	1594	23	0.8	19	6.1	1232	-334	24	0.9	22	-2
TREATMENT 2															
Dy_2_01	27	1.1	30	6.8	2042	26	0.8	22	7.0	1569	-473	26	1.0	26	143
Dy_2_02	30	1.1	34	7.3	2460	28	0.9	26	6.8	1865	-595	29	1.0	30	-52
Dy_2_03	29	1.3	39	9.7	3804	18	0.8	15	9.8	1495	-2309	23	1.1	27	170
Dy_2_03a	26	1.2	30	7.3	2166										
Dy_2_04	31	1.0	30	7.8	2370	13	1.3	17	8.0	1412	-957	22	1.1	24	132
Dy_2_05	15	1.9	29	8.8	2530	16	0.8	12	8.2	1042	-1488	16	1.3	21	-50
Dy_2_06	19	1.2	22	8.8	1984	15	0.9	14	8.6	1253	-732	17	1.1	18	25
Dy_2_07	23	1.0	23	8.3	1930	15	0.9	14	7.9	1161	-769	19	1.0	19	-23
Dy_2_08	33	1.3	41	7.3	3025	34	1.0	35	6.6	2402	-622	33	1.1	38	-148
Avg	26	1.2	31	8.0	2479	21	0.9	19	7.9	1525	-993	23	1.1	25	25

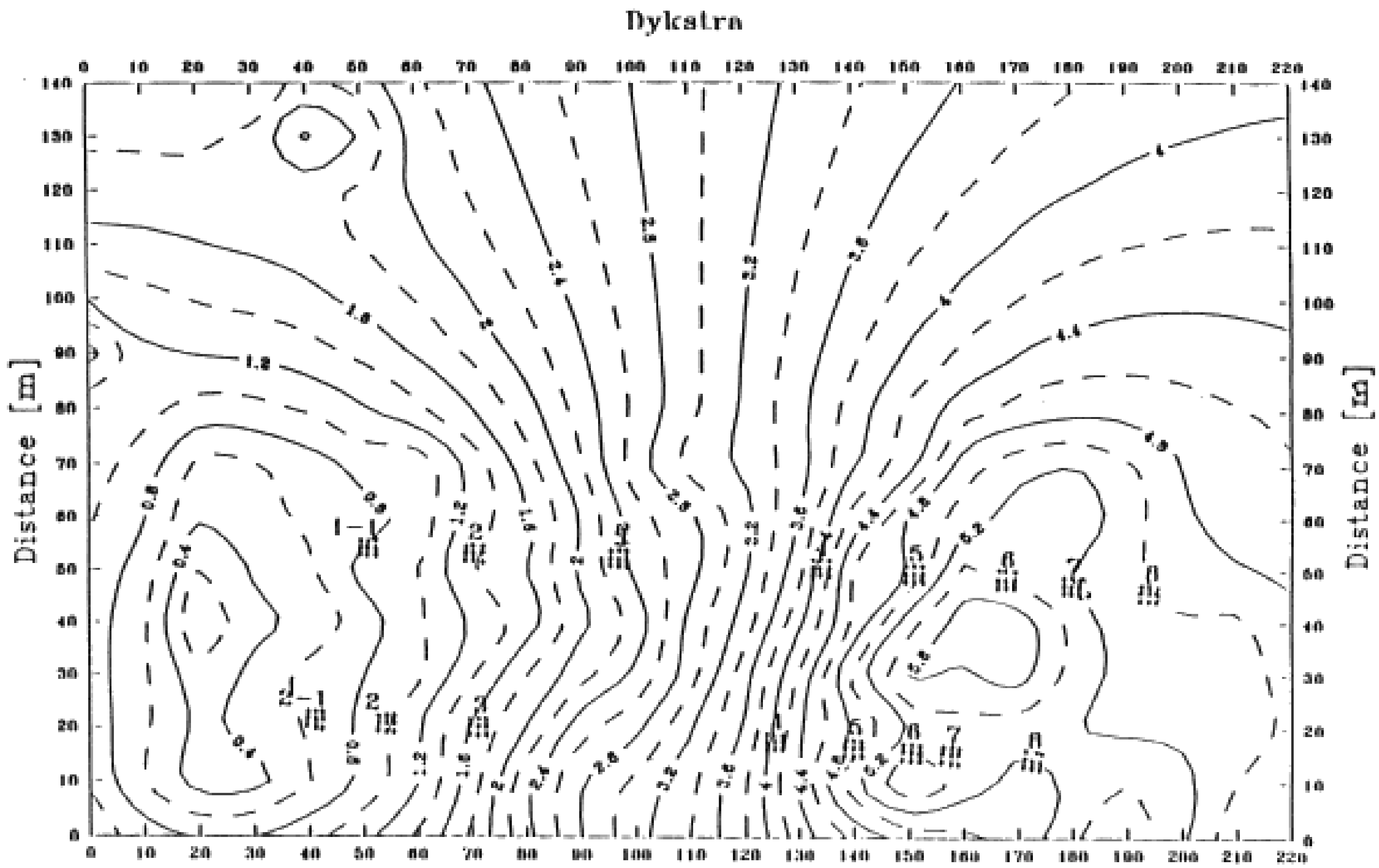

Figure IV.7: Dykstra Tillage-2000 field site elevation contour map showing benchmark positions.

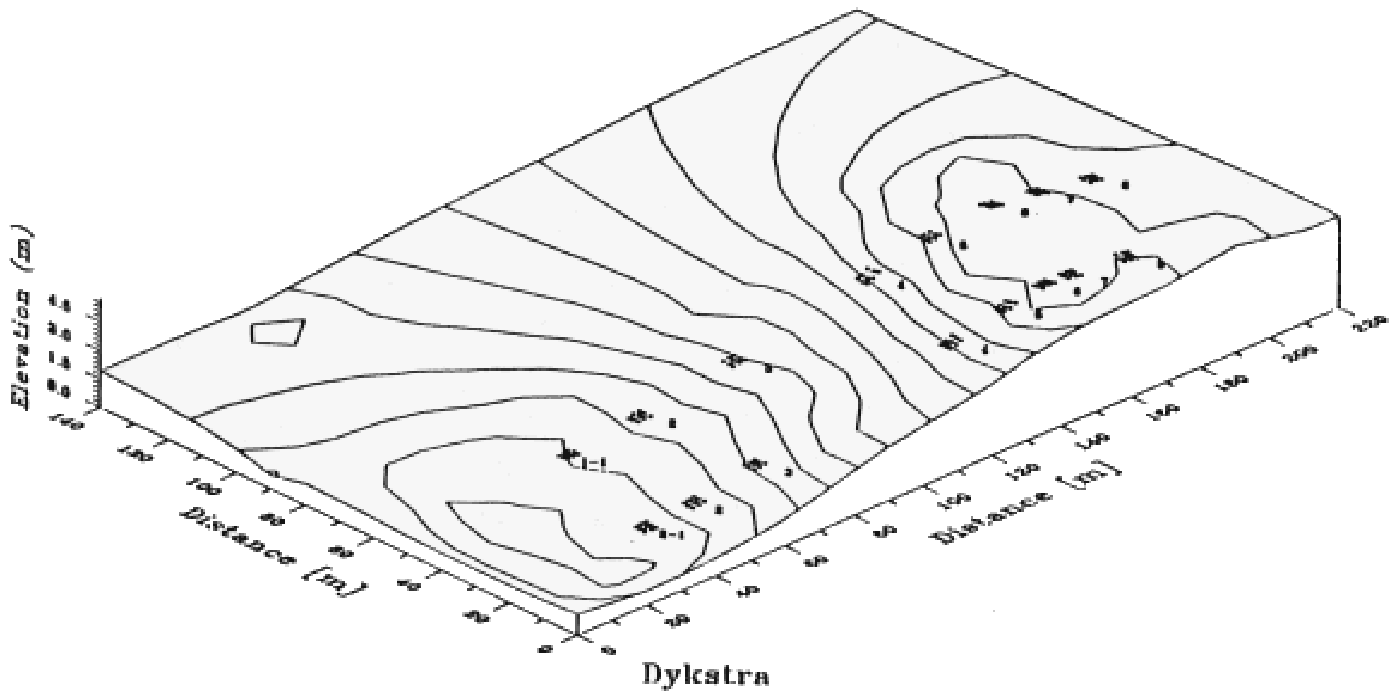

Figure IV.8: Dykstra Tillage-2000 field site 3D relief map.

Table IV.5: Ghent Tillage-2000 Field Site Cesium-137 Data

			1987					1990				1990-1987			
BENCH	Avg.2 Depth cm	Bulk Density g/cm^3	Mass g	Cesium Bq/kg	Bq/m^2	Avg.2 Depth cm	Bulk Density g/cm^3	Mass g	Cesium Bq/kg	Bq/m2	Bq/m2	Avg Depth cm	Bulk Density g/cm^3	Mass g	Delta Bq/m^2
TREATMENT 1															
Gh_101	18	1.1	19	7.0	1352	23	1.2	29	5.0	1500	148	21	1.1	24	-420
Gh_102	21	1.3	28	7.5	2114	28	1.2	33	6.5	2236	123	25	1.3	31	-199
Gh_103	28	1.2	35	7.9	2753	31	1.2	38	6.4	2576	-177	29	1.2	37	-455
Gh_104	22	1.4	32	8.0	2518	25	1.3	33	5.9	2031	-488	24	1.4	32	-579
Gh_105	25	1.2	29	8.1	2343	26	1.3	33	6.4	2247	-96	25	1.2	31	-425
Gh_106	18	1.3	23	9.1	2041	22	1.2	26	7.0	1892	-149	20	1.2	24	-416
Gh_107	20	1.2	25	7.7	1895	24	1.3	30	6.6	2100	206	22	1.2	28	-213
Gh_108	22	1.2	26	9.6	2536	25	1.3	32	8.6	2928	391	24	1.2	29	-141
Gh_109	21	1.3	26	6.6	1731	23	1.3	29	5.4	1620	-111	22	1.3	28	-289
Gh_110	23	1.2	28	8.8	2492	23	1.3	29	6.8	2091	-401	23	1.3	29	-487
Avg	22	1.2	27	8	2178	25	1.2	31	6.5	2122	-55	23	1.2	29	-362
TREATMENT 2															
Gh_201	20	1.3	26	7.0	1798	22	1.2	27	5.3	1495	-303	21	1.3	26	-401
Gh_202	21	1.2	26	7.4	1922	23	1.2	28	7.3	2169	247	22	1.2	27	82
Gh_203	24	1.3	30	8.2	2450	27	1.3	35	7.8	2856	406	25	1.3	32	21
Gh_204	22	1.2	25	7.5	1873	23	1.2	28	6.5	1915	42	22	1.2	27	-178
Gh_205	21	1.2	26	6.2	1580	23	1.2	28	6.5	1886	306	22	1.2	27	165
Gh_206	24	1.2	27	9.0	2443	27	1.2	33	6.8	2386	-57	25	1.2	30	-554
Gh_207	19	1.3	24	7.6	1855	23	1.3	30	6.7	2105	250	21	1.3	27	-152
Gh_208	21	1.3	27	7.6	2089	23	1.2	28	6.9	1991	-98	22	1.3	28	-118
Gh_209	21	1.2	26	9.4	2473	25	1.3	32	7.8	2584	111	23	13	29	-357
Gh_210	20	1.2	24	9.1	2220	22	1.2	27	7.6	2148	-73	21	1.2	26	*-277*
Avg	21	1.2	26	7.9	2070	24	1.2	30	6.9	2154	83	22	1.2	28	-177

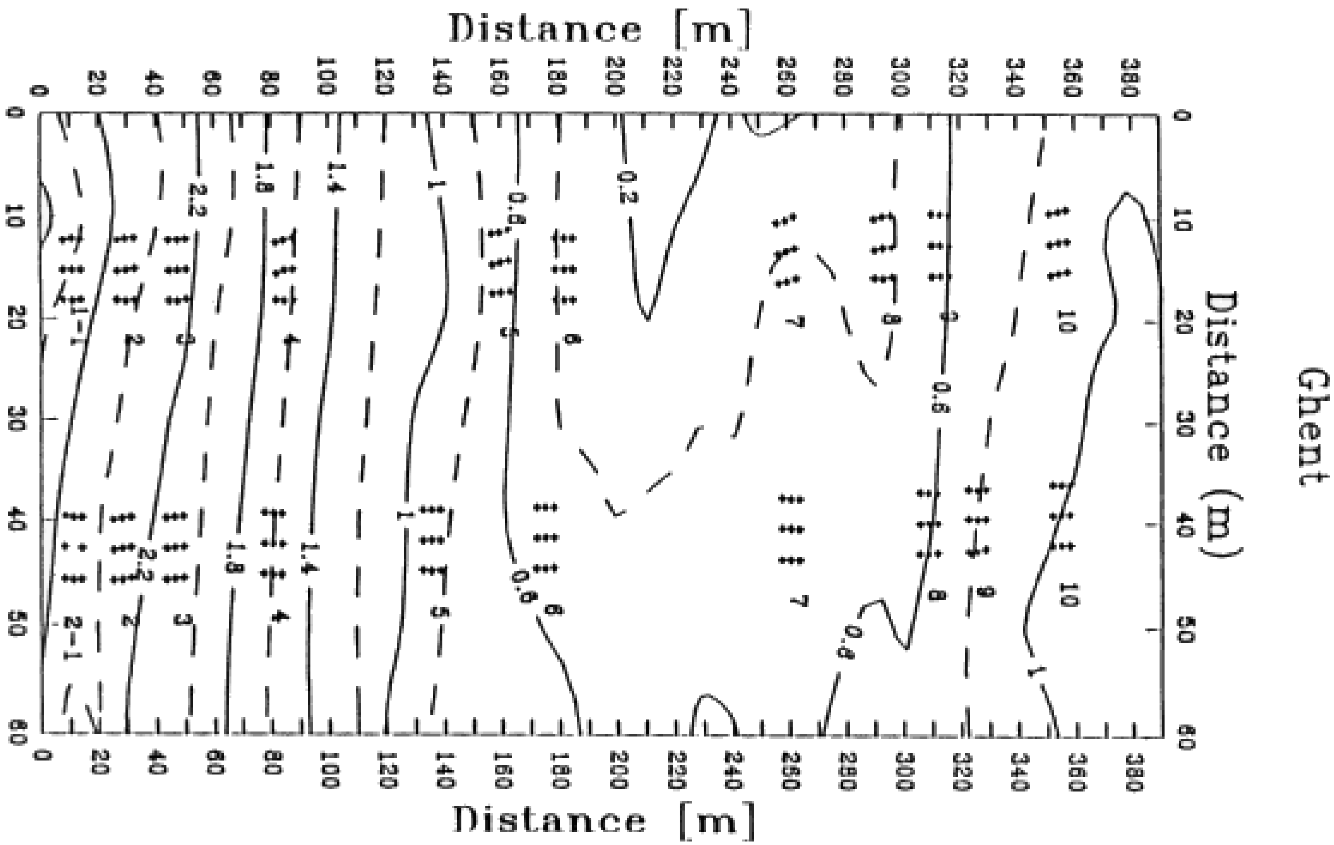

Figure IV.9: Ghent Tillage-2000 field site elevation contour map showing benchmark positions.

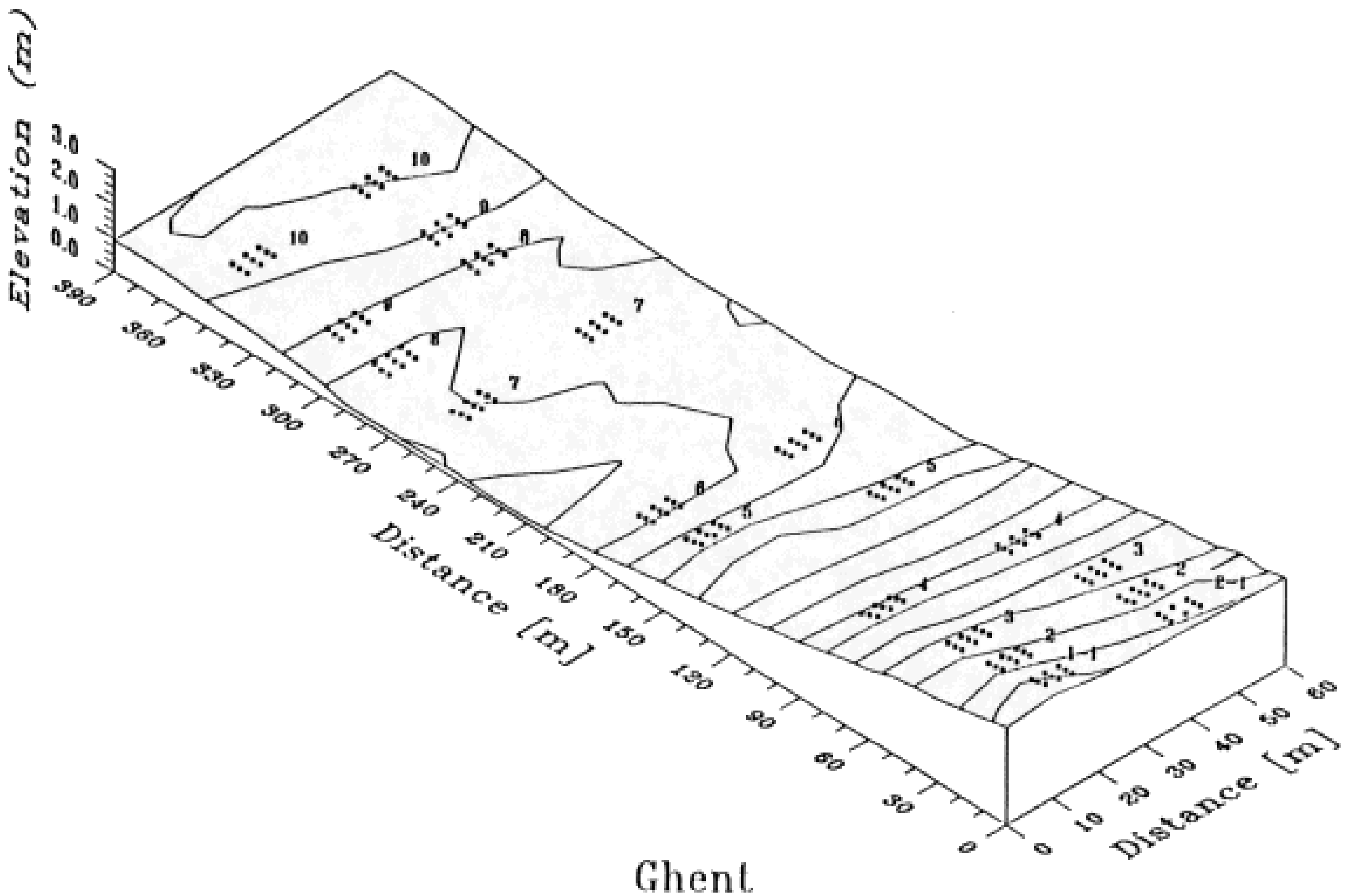

Figure IV.10: Ghent Tillage-2000 field site 3D relief map.

Table IV.6: Johnson Tillage-2000 Field Site Cesium-137 Data

	1987					1990						1990-1987			
BENCH	Avg.2 Depth cm	Bulk Density g/cm^3	Mass g	Cesium Bq/kg	Bq/m^2	Avg.2 Depth cm	Bulk Density g/cm^3	Mass g	Cesium Bq/kg	Bq/m2	Bq/m2	Avg Depth cm	Bulk Density g/cm^3	Mass g	Delta Bq/m^2
TREATMENT 1 - Conv. Till															
Jo_1_01	23	1.4													
Jo_1_02	25	1.3	32	6.7	2120	27	1.3	34	6.1	2192	72	26	1.3	33	-91
Jo_1_03	28	1.2	34	7.3	2513	37	1.3	49	5.9	3054	541	33	1.3	42	-476
Jo 1_04	29	1.1	33	7.0	2340	28	1.2	33	6.0	2099	-241	28	1.2	33	-230
Jo_1_05	57	1.2	69	6.0	4139	63	1.1	72	4.1	3095	-1044	60	1.2	70	-1219
Jo_1_06	26	1.2	31	8.6	2657	32	1.3	42	7.6	3366	709	29	1.3	36	-185
Jo_1_06a	25	1.2	31	8.9	2736	28	1.2	34	7.4	2608	-128	26	1.2	32	-359
Jo_1_07	31	1.2	38	5.6	2149	46	1.3	61	3.9	3467	317	39	1.3	49	-777
Jo_1_08	28	1.2	33	7.8	2576	31	1.2	37	6.6	2593	17	29	1.2	35	-329
Jo 1_09	26	1.1	29	7.7	2197	29	1.1	32	6.8	2318	121	28	1.1	30	-173
J6_1_10	35	1.2	42	7.7	3242	39	1.1	44	6.0	2790	-453	37	1.2	43	-599
Jo_1_11	28	1.3	37	7.9	2896	32	1.2	39	5.6	2302	-594	30	1.3	38	-746
76_1_12	26	1.0	27	7.2	1950	29	1.2	35	6.2	2317	367	27	1.1	31	-212
Jo_1_12a	22	0.8	17	8.8	1539	28	1.0	26							
16_1_13	23	0.9	21	11.6	2386	27	0.8	23	9.7	2314	-72	25	0.9	22	-300
Avg	29	1.2	34	7.8	2531	34	1.2	40	6.3	2578	-30	32	1.2	38	-438
TREATMENT - No Till															
Jo 2_01	29	1.3	37	6.4	2392	31	1.5	46	5.1	2473	81	30	1.4	41	-416
Jo_2_02	23	1.3	32	7.3	2373	22	1.4	31	5.9	1899	-475	23	1.4	32	-375
Jo_2_03	21	1.4	28	6.3	1782	21	1.4	30	5.7	1764	-18	21	1.4	29	-97
Jo 2_04	25	1.3	33	6.8	2271	32	1.4	44	5.5	2543	273	29	1.3	39	-427
Jo_2_05	62	1.1	69	7.0	4819	65	1.3	87	4.0	3726	-1093	63	1.2	78	-2092
Jo_2_06	24	1.2	28	9.3	2626	28	1.3	36	7.5	2866	240	26	1.2	32	425
Jo 2 06a	24	1.3	31	8.5	2598	28	1.3	37	5.9	2276	-322	26	1.3	34	-757
Jo_2_07	27	1.2	32	8.7	2757	25	1.3	34	7.3	2576	-181	26	J.2	33	-341
Jo_2_08	25	1.2	30	7.2	2184	24	1.5	35	6.8	2538	354	24	1.4	33	1
Jo_2_09	23	1.1	26	7.6	2000	21	1.3	28	7.5	2208	208	22	1.2	27	54
Jo_2_10	26	1.1	28	9.1	2515	29	1.2	35	8.2	2998	484	28	1.!	31	-145
Jo-2_11	24	1.2	28	8.1	2292	22	1.5	32	6.2	2084	-207	23	1.3	30	479
Jo_2_12	26	1.3	32	7.6	2477	27	1.4	37	7.2	2794	317	26	1.3	35	-11
Jo_2_13	26	1.0	27	10.8	2887	29	1.1	30	8.9	2858	-29	27	1.0	29	-393
Avg	28	1.2	33	7.9	2569	29	1.3	39	6.6	2543	-26	28	1.3	36	-422

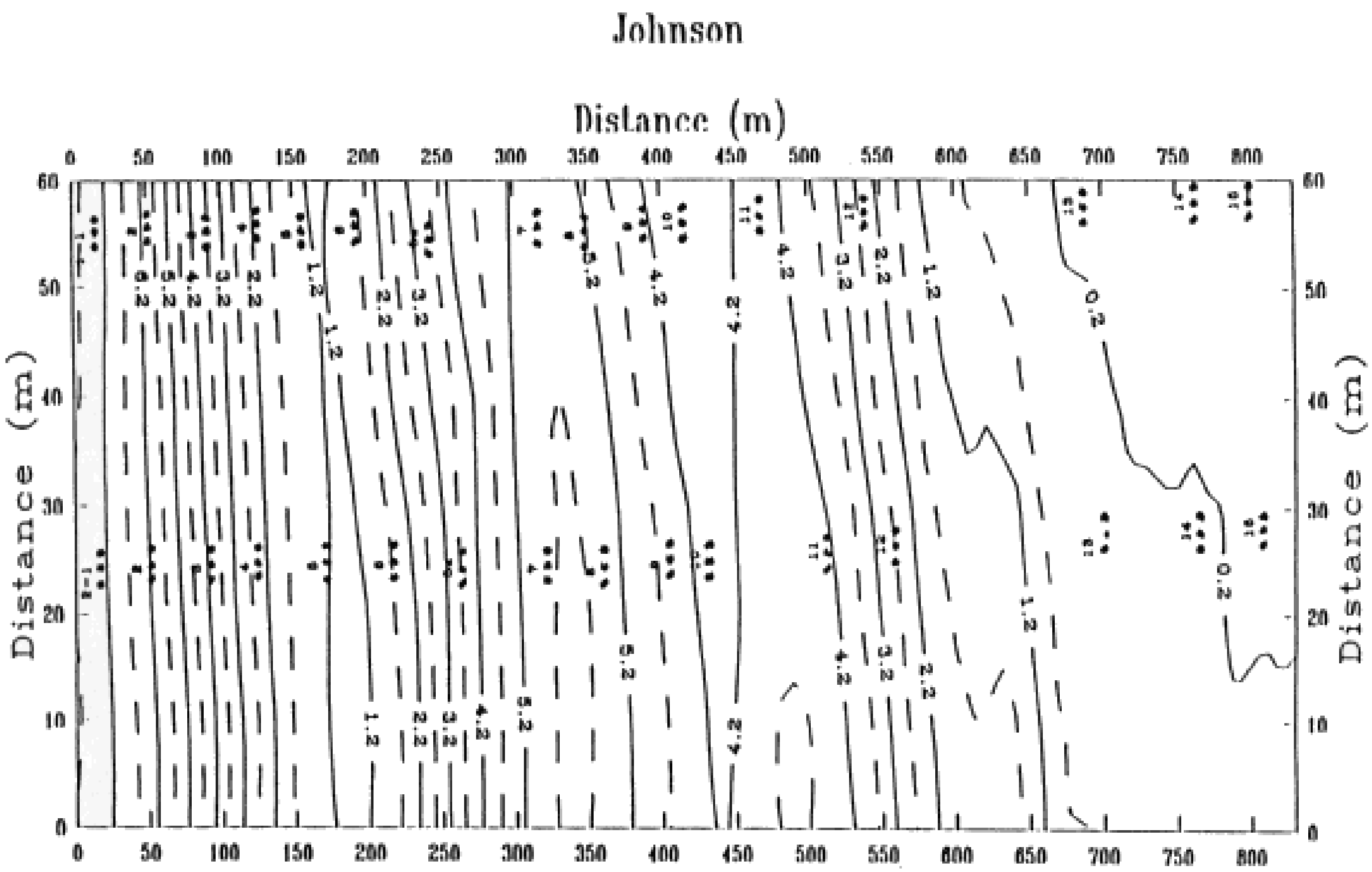

Figure IV.11: Johnson Tillage-2000 field site elevation contour map showing benchmark positions.

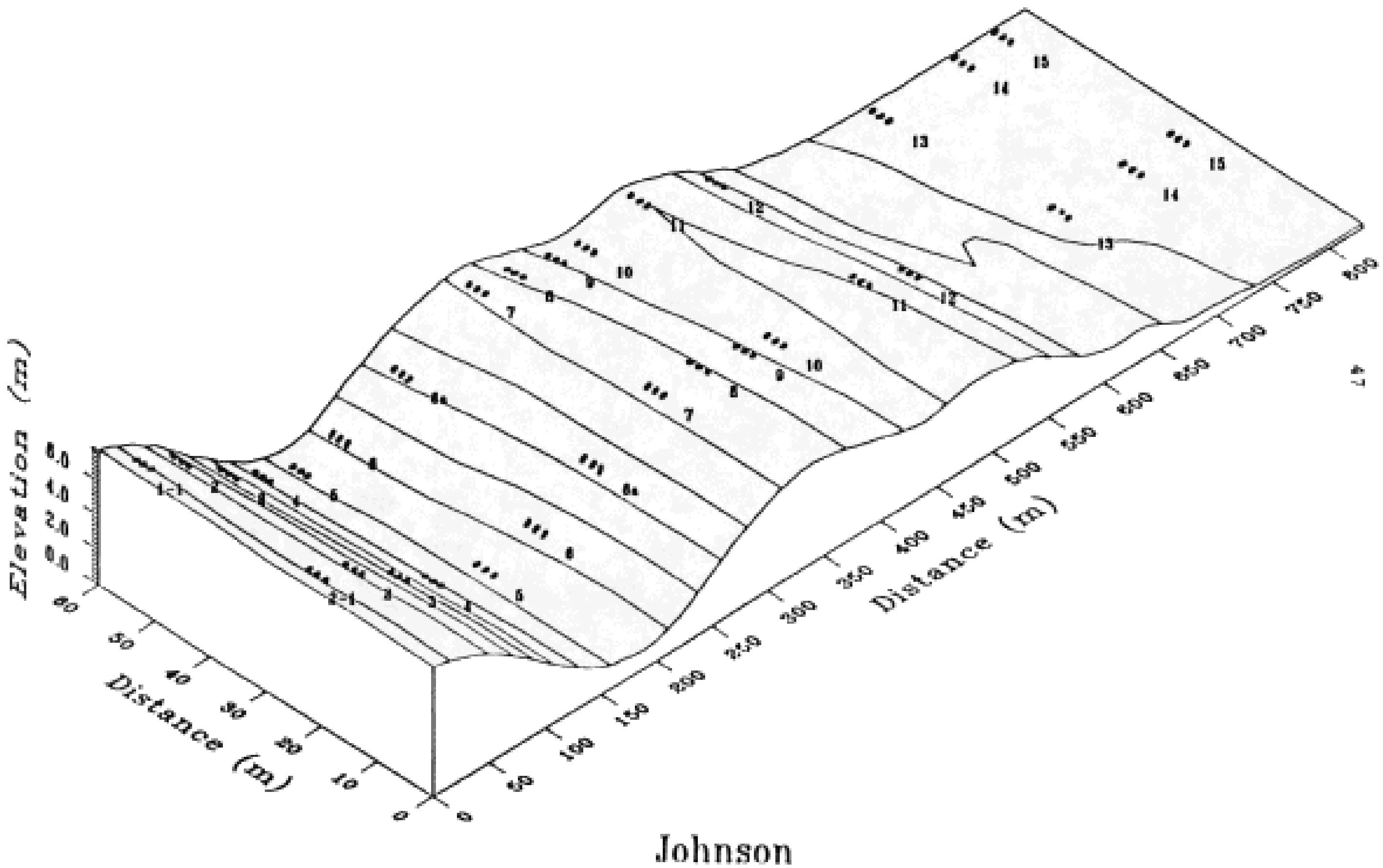

Figure IV.12: Johnson Tillage-2000 field site 3D relief map.

Table IV.7: Don Lobb Tillage-2000 Field Site Cesium-137 Data

			1987					1990				1990-1987			
BENCH	Avg.2 Depth cm	Bulk Density g/cm^3	Mass g	Cesium Bq/kg	Bq/m^2	Avg.2 Depth cm	Bulk Density g/cm^3	Mass g	Cesium Bq/kg	Bq/m2	Bq/m2	Avg Depth cm	Bulk Density g/cm^3	Mass g	Delta Bq/m^2
Lo_1_01_2	21	1.2	25	14.5	3635	24	1.0	23	11.6	2821	-814	22	1.1	24	-536
Lo_1_02_2	19	1.3	25	10.6	2637	24	1.2	27	8.4	2406	-2.31	22	1.2	26	-459
Lo_1_03_2	21	1.2	2.5	10.1	*2559*	19	1.2	23	9.0	2165	-394	20	1.2	24	-135
Lo_1_04_2	25	1.1	28	12.1	3338	23	1.1	24	11.1	2837	-501	24	1.1	26	-99
Lo_1_05_2	20	1.4	28	8.9	2518	23	1.2	27	7.7	2213	-305	22	1.3	28	-207
Lo_1_06_2	18	1.3	24	10.8	2390	21	1.1	23	8.8	2124	-466	19	1.2	24	-360
Lo_1_07_2	24	1.2	30	11.1	3292	27	1.1	30	10.0	3209	-83	26	1.2	30	-158
Lo_1_08_2	19	1.3	24	10.1	2465	*22*	*1.2*	27	9.1	2545	80	21	1.2	26	-136
Lo_1_09_2	21	1.3	28	10.3	2888	27	1.2	32	9.8	3268	380	24	1.2	30	11
Lo_1_10_1	31	1.1	35	10.4	3607	33	1.3	41	8.9	3892	285	32	1.2	38	-365
Lo_1_10_2	26	1.2	32	10.5	3369	28	1.2	34	8.4	3012	-356	27	1.2	33	-557
Lo_1_10_3	25	1.3	32	11.1	3494	30	1.2	35	8.7	3227	-256	27	1.2	34	-641
Lo_1_10_4	29	1.3	37	11.0	4030	26	1.3	34	9.3	3348	-682	27	1.3	35	-400
Lo_1_11_1	27	1.2	32	8.8	2866	31	1.2	36	7.0	2675	-191	29	1.2	34	-507
Lo_1_11_2	23	1.4	33	8.6	2821	26	1.2	30	7.1	2229	-593	25	1.3	31	-377
Lo_1_11_3	33	1.3	42	8.7	3645	27	1.2	34	6.1	2142	-1504	30	1.3	38	-875
Lo_1_11_4	32	1.3	43	8.8	3779	33	1.4	47	7.1	3505	-274	33	1.4	45	-597
Lo_1_12_1	25	1.4	36	7.5	2680	30	1.3	39	6.4	2648	-33	28	1.4	38	-295
Lo_1_12_2A	20	1.4	29	8.3	2851	33	1.3	43	6.7	3088	237	26	1.4	37	-426
Lo_1_12_3	24	1.3	31	8.4	2628	26	1.3	35	7.4	2749	121	25	1.3	33	-186
Lo_1_12_4	20	1.5	29	7.9	2317	23	1.4	32	7.2	2392	75	22	1.4	31	-100
Lo_1_13_1	22	1.3	28	7.5	2125	19	1.3	25	6.0	1571	-554	20	1.3	27	-328
Lo_1_13_2	24	1.5	35	8.1	2863	27	1.3	36	5.5	2089	-774	26	1.4	36	-844
Lo_1_13_3	18	1.4	24	7.4	1818	22	1.4	30	6.0	1899	81	20	1.4	27	-331
Lo_1_13_4	16	1.4	23	6.0	1365	19	1.5	28	6.7	1995	630	18	1.4	25	250
Lo_1_14_1	22	1.3	29	9.0	2643	25	1.3	32	8.0	2660	17	23	1.3	31	-178
Lo_1_14_2	20	1.4	29	7.3	2113	25	1.4	36	6.3	2363	251	22	1.4	32	-220
Lo_1_14_3	17	1.5	25	7.6	1867	26	1.3	34	4.8	1715	-152	21	1.4	30	-787
Lo_1_14_4	16	1.4	23	7.7	1754	21	1.5	31	7.0	2279	525	18	1.5	27	-102
Lo_1_15_1	18	1.4	24	8.4	2024	18	1.3	24	7.2	1840	-184	18	1.3	24	-190
Lo_1_15_2	16	1.4	22	7.4	1657	22	1.4	32	6.0	1997	340	19	1.4	27	-296
Lo_1_15_3	19	1.4	26	8.4	2210	21	1.3	28	6.3	1840	-371	20	1.4	27	-475
Lo_1_15_4	19	1.4	26	7.9	2019	21	1.3	26	7.4	2052	33	20	1.3	26	-25
Lo_1_16_1	21	1.3	27	8.0	2178	22	1.2	27	6.4	1791	-387	21	1.3	27	-358
Lo_1_16_2	19	1.4	27	7.7	2058	18	1.4	27	5.9	1645	-413	19	1.4	27	-414
Lo_1_16_3	20	1.4	27	7.3	1963	21	1.2	24	6.1	1529	-434	20	1.3	26	-223
Lo_1_16_4	18	1.4	26	8.3	2136	21	1.3	28	7.5	2206	70	20	1.4	27	-129
Lo_1_17_1	22	1.4	30	9.3	2790	28	1.3	36	7.1	2722	-68	25	1.3	33	-605
Lo_1_17_2	20	1.4	28	8.6	2446	23	1.5	34	6.4	2287	-158	22	1.4	31	-592
Lo_1_17_3	19	1.3	2.5	7.1	1761	21	1.3	28	7.1	2080	319	20	1.3	26	92
Lo_1_17_4	18	1.4	25	8.7	2144	18	1.3	23	7.6	1814	-330	18	1.3	24	-176
Lo_1_18_1	22	1.4	30	8.8	2592	25	1.1	28	7.6	2248	-344	23	1.2	29	-209
Lo_1_18_2	18	1.4	26	8.1	2096	20	1.4	29	5.9	1813	-283	19	1.4	27	-531
Lo_1_18_3	18	1.3	23	9.0	2081	24	1.3	30	6.5	1998	-82	21	1.3	26	-583
Lo_1_18_4	16	1.3	21	9.2	1883	23	1.4	32	7.8	2652	769	19	1.4	26	-249
Lo_1_19_1A	20	1.3	26	10.1	3304	43	3.0	132	6.5	9130	5826	32	2.2	69	-2205

Table IV.7 Cont'd: Don Lobb Tillage-2000 Field Site Cesium-137 Data

	1987					1990						1990-1987			
BENCH	Avg.2 Depth cm	Bulk Density g/cm^3	Mass g	Cesium Bq/kg	Bq/m^2	Avg.2 Depth cm	Bulk Density g/cm^3	Mass g	Cesium Bq/kg	Bq/m2	Bq/m2	Avg Depth cm	Bulk Density g/cm^3	Mass g	Delta Bq/m^2
Lo_1_19_2A	20	1.4	28	9.4	3980	54	1.4	77	6.0	4845	866	37	1.4	53	-1655
Lo_1_19_3	19	1.4	27	8.2	2219	24	1.1	27	6.7	1887	-332	22	1.3	27	-335
Lo_1_19_4	45	1.4	61	8.9	5372	24	1.3	31	6.4	2095	-3277	34	1.3	46	-935
Lo_1_20_2	28	1.4	38	10.2	3893	34	1.4	47	7.3	3591	-301	31	1.4	42	-1062
Lo_1_21_2A	20	1.4	29	7.8	2891	32	1.4	47	5.2	2351	-340	26	1.4	38	-881
Lo_1_22_2	18	1.4	25	7.4	1852	24	1.3	30	5.8	1825	-27	21	1.3	28	-402
Lo_1_23_2	17	1.4	24	7.6	1791	26	1.2	33	3.7	12.34	-557	22	1.3	29	-1082
Lo_1_24_2	25	1.4	34	9.7	3349	29	1.3	39	9.0	3660	311	27	1.4	37	-95
Lo_1_25_2	17	1.3	23	9.6	2243	23	1.4	35	8.8	3253	1010	21	1.4	29	-100
Lo_1_26_2	16	1.4	21	9.1	1935	24	1.3	33	5.3	1799	-136	20	1.4	27	-973
Lo_1_27_2	19	1.5	28	7.6	2143	25	1.5	37	6.4	2482	339	22	1.5	32	-273
Lo_1_28_2	19	1.4	27	7.6	2035	22	1.4	32	7.5	2305	470	20	1.4	29	82
Lo_1_29_2	17	1.4	23	8.9	2194	19	1.5	28	7.6	2217	22	18	1.5	26	-268
Lo_1_30_2	20	1.4	28	9.3	2624	19	1.3	24	7.1	1786	-838	19	1.4	26	-500
Lo_1_31_2						22	1.4	30	7.2	2245	2245	11	0.7	7	528
Lo_1_32_2	20	1.4	27	8.1	2216	24	1.4	34	7.0	2512	296	22	1.4	30	-228
Avg	21	1.4	29	8.9	2601	23	1.3	34	7.2	2335	-23	23	1.3	31	-408
Min	16	1.1	21	6.0	1365	18	1.0	23	3.7	1234	-3277	11	0.7	7	-2205
Max	45	1.5	61	14.5	5372	54	3.0	132	11.6	9130	-3277	37	2.2	69	528

Table IV.7 Cont'd: Don Lobb Tillage-2000 Field Site Cesium-137 Data

	1987					1990						1990-1987			
BENCH	Avg.2 Depth cm	Bulk Density g/cm^3	Mass g	Cesium Bq/kg	Bq/m^2	Avg.2 Depth cm	Bulk Density g/cm^3	Mass g	Cesium Bq/kg	Bq/m2	Bq/m2	Avg Depth cm	Bulk Density g/cm^3	Mass g	Delta Bq/m^2
Lo_2_01_2	25	1.0	24	16.5	3983	23	1.0	24	14.5	3599	-384	24	1.0	24	-279
Lo_2_02_2	25	1.1	27	10.3	2757	22	1.4	30	9.5	2958	200	23	1.2	28	-96
Lo_2_03_2	26	1.2	30	10.1	3054	23	1.3	29	10.1	3111	58	24	1.2	30	160
Lo_2_04_2	26	1.1	28	10.2	2908	25	1.1	28	9.3	2777	-131	26	1.1	28	-107
Lo_2_05_2	22	1.2	27	8.7	2393	23	1.2	26	8.8	2461	69	23	1.2	27	159
Lo_2_06_2	20	1.1	22	10.7	2305	18	1.2	22	10.8	2509	204	19	1.1	22	151
Lo_2_07_2	26	1.1	28	11.7	3309	25	1.^{2}	29	10.8	3273	-36	25	1.1	29	-92
Lo_2_08_2	23	1.2	28	11.7	3228	23	1.2	28	10.8	3200	-28	23	1.2	28	-88
Lo_2_09_2	25	1.2	31	11.3	3522	24	1.2	28	10.4	3086	-435	24	1.2	30	-87
Lo_2_10_1	30	1.2	35	10.9	3807	30	1.4	43	9.4	4281	475	30	1.3	39	-392
Lo_2_10_2	27	1.3	34	10.6	3619	30	1.3	40	8.9	3757	137	28	1.3	37	-436
Lo_2_10_3	33	1.1	37	10.7	3975	30	1.4	41	10.7	4726	751	31	1.3	39	272
Lo_2_10_4	28	1.3	37	11.0	4076	29	1.4	41	9.3	4024	-51	29	1.4	39	-434
Lo_2_11_1	30	1.2	36	8.1	2907	28	1.4	39	6.0	2454	-453	29	1.3	38	-669
Lo_2_11_2	25	1.3	32	7.0	2228	31	1.3	40	4.6	1951	-278	28	1.3	36	-775
Lo_2_11_3A	20	1.2	23	9.3	3227	32	1.4	46	6.2	2960	-267	26	1.3	35	-988
Lo_2_11_4	36	1.3	47	8.1	3811	30	1.5	47	8.4	4127	317	33	1.4	47	336
Lo_2_12_1	23	1.3	30	8.2	2506	23	1.5	36	6.8	2602	96	23	1.4	33	-337
La_2_12_2	18	1.4	25	8.2	2081	25	1.5	36	5.4	2046	-35	21	1.4	31	-769
Lo_2_12_3	26	1.3	33	7.8	2586	26	1.4	37	7.6	2997	411	26	1.4	35	100
Lo_2_12_4	26	1.3	34	5.9	2013	23	1.5	34	6.8	2445	432	24	1.4	34	444
Lo_2_13_1	21	1.4	30	6.0	1790	20	1.6	32	5.5	1857	67	21	1.5	31	-78
Lo_2_13_2	17	1.5	26	6.7	1724	20	1.4	28	5.4	1610	-114	18	1.5	27	-272
Lo_2_13_3	18	1.3	24	7.3	1764	18	1.6	29	5.8	1784	20	18	1.5	27	-341
Lo_2_13_4	20	1.4	28	6.8	1927	19	1.5	28	5.8	1702	-225	19	1.5	28	-226
Lo_2_14_1	21	1.4	30	7.5	2233	22	1.5	32	6.7	2250	17	21	1.4	31	-131
Lo_2_14_2	18	1.5	27	7.3	1961	19	1.3	26	6.1	1635	-326	19	1.4	26	-234
Lo_2_14_3	17	1.4	23	7.5	1709	17	1.6	27	5.5	1533	-176	17	1.5	25	-444
Lo_2_14_4	16	1.4	23	5.3	1215	17	1.3	23	5.4	1280	65	17	1.4	23	63
Lo_2_15_1	22	1.5	32	7.7	2458	23	1.4	31	7.4	2439	-19	22	1.4	32	20
Lo_2_15_2	23	1.5	33	8.6	2871	22	1.3	28	7.6	2208	-663	22	1.4	30	-174
Lo_2_15_1	23	1.4	33	9.3	3053	22	1.5	33	8.9	3055	2	23	1.4	33	38
Lo_2_15_2	21	1.3	28	7.9	2219	21	1.5	31	7.9	2547	328	21	1.4	29	128
Lo_2_16_1	21	1.5	30	7.5	2268	21	1.4	28	7.5	2176	-92	21	1.4	29	102
Lo_2_16_2	21	1.6	33	7.2	2358	20	1_3	26	7.3	1993	-365	21	1.4	29	114
Lo_2_16_3	22	1.3	30	8.4	2487	21	1.4	30	7.5	2344	-144	22	1.4	30	-165
Lo_2_16_4	20	1.4	29	7.5	2176	19	1.6	29	7.3	2244	68	20	1.5	29	61
Lo_2_17_1	19	1.4	*26*	8.5	2241	23	1.4	33	8.4	2905	664	21	1.4	30	103
Lo_2_17_2	22	1.4	31	8.1	2557	22	1.2	26	7.3	1999	-558	22	1.3	29	-149
Lo_2_17_3	27	1.3	36	8.9	3152	24	1.5	37	8.2	3198	46	26	1.4	36	-82
Lo_2_17_4	20	1.4	28	7.9	2202	21	1.6	33	7.2	2341	339	20	1.5	31	-89
Lo_2_18_1	23	1.4	35	8.9	3073	22	1.4	31	8.1	2696	-378	23	1.4	33	-94
Lo 2_18_2	21	1.5	30	8.4	2539	25	1.3	33	7.1	2470	-69	23	1.4	32	-309
Lo_2_18_3A	20	1.5	30	9.8	4207	35	1.4	49	6.7	3528	-679	27	1.4	40	-1057
Lo_2_18_4A	20	1.5	29	8.7	3590	42	1.5	63	5.8	3894	304	31	1.5	46	-1164

Table IV.7 Cont'd: Don Lobb Tillage-2000 Field Site Cesium-137 Data

	1987					1990						1990-1987			
BENCH	Avg.2 Depth cm	Bulk Density g/cm^3	Mass g	Cesium Bq/kg	Bq/m^2	Avg.2 Depth cm	Bulk Density g/cm^3	Mass g	Cesium Bq/kg	Bq/m 2	Bq/m2	Avg Depth cm	Bulk Density g/cm^3	Mass g	Delta Bq/m^2
Lo_2_19_1A	20	1.5	30	9.7	3561	40	1.6	63	6.7	4433	922	30	1.5	46	-1189
Lo_2_19_2	25	1.5	36	8.9	3232	27	1.5	40	7.3	3038	-193	26	1.5	38	-476
Lo_2_19_3	28	1.3	36	10.1	3637	28	1.5	41	9.4	4095	458	28	1.4	39	-84
Lo_2_19_4	29	1.4	40	10.2	4112	26	1.4	37	8.2	3231	-861	28	1.4	39	-581
Lo_2_20_2	2.5	1.4	36	9.3	3336	28	1.5	41	8.1	3561	^{2}25	27	1.4	39	272
Lo 2_21_2A	20	1.4	28	8.3	2292	52	1.5	75	6.0	4763	2473	36	1.4	51	-1010
Lo_2_12_2	16	1.4	24	6.6	1556	16	1.6	25	6.1	1596	41	16	1.5	24	-70
Lo_2_23_2	14	1.5	20	6.3	1244	15	1.6	23	6.3	1672	428	14	1.5	22	178
Lo 2_24_2	24	1.4	34	9.4	3194	21	1.5	31	9.0	2976	-217	23	1.4	33	17
Lo_2_25_2	20	1.4	29	8.1	2343	21	1.4	30	8.7	2309	466	21	1.4	30	327
Lo_2_26_2	18	1.4	25	8.5	2139	17	1.5	27	8.0	2255	116	17	1.5	26	22
Lo_2_27_2	17	1.4	24	6.2	1301	17	1.5	25	7.5	1996	495	17	1.5	25	415
Lo_2_28_2	21	1.5	30	8.1	2452	16	1.5	25	6.3	1670	-782	19	1.5	28	-398
Lo_2_29_2	16	1.5	23	8.0	1879	17	1.4	2.3	7.6	1847	-32	17	1.4	23	25
Lo_2_30_2	16	1.4	22	8.9	1968	26	1.6	41	7.2	3116	1148	21	1.5	31	-418
Lo_2_31_2	22	1.4	31	8.6	2598	19	1.5	29	8.1	2448	-250	21	1.5	30	-44
Lo_2_32_2	22	1.4	31	8.1	2511	19	1.5	30	7.4	2325	-136	21	1.5	31	-86
Avg	22	1.4	30	8.7	2673	24	1.4	34	7.7	2723	55	23	1.4	32	-194
Min	14	1.0	20	5.3	1215	15	1.0	22	4.6	1230	-861	14	1.0	22	-1189
Max	36	1.6	47	16.5	4207	52	1.6	75	14.5	4765	-861	36	1.5	51	444

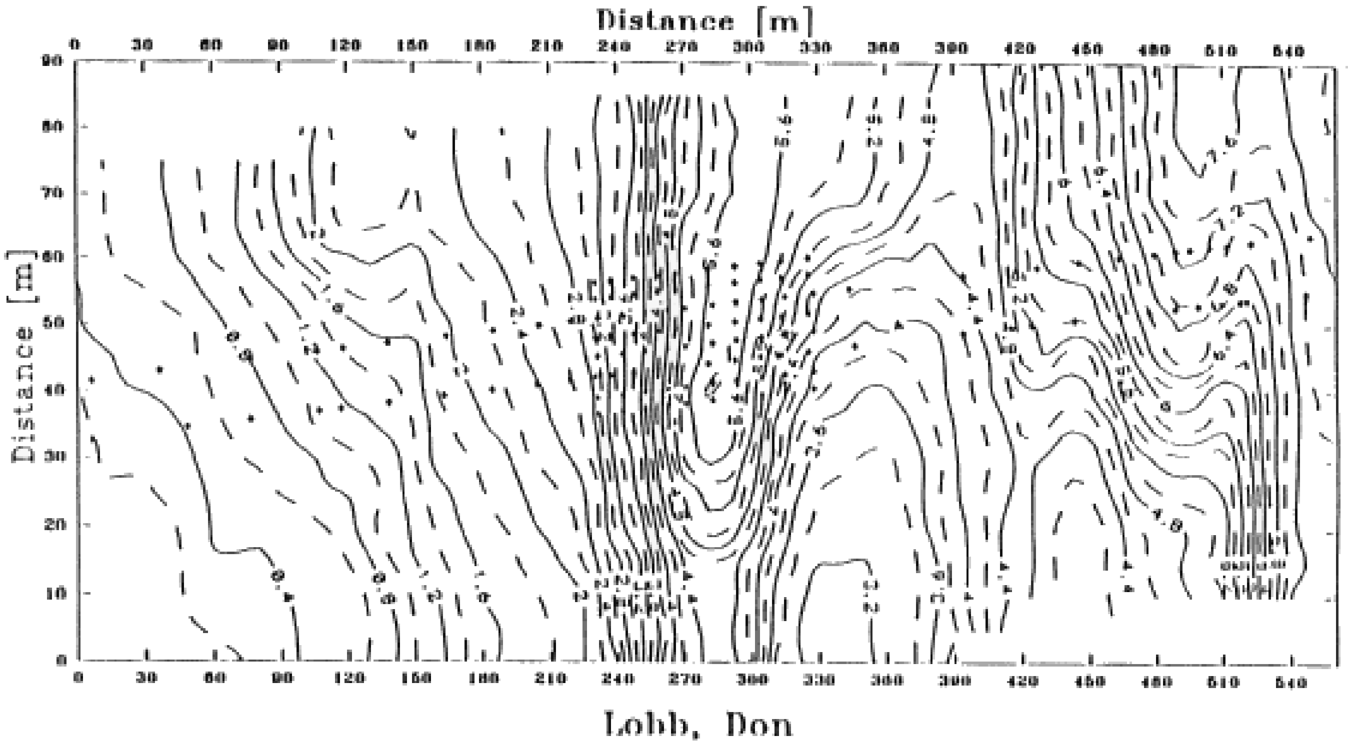

Figure IV.13: Don Lobb Tillage-2000 field site elevation contour map showing benchmark positions.

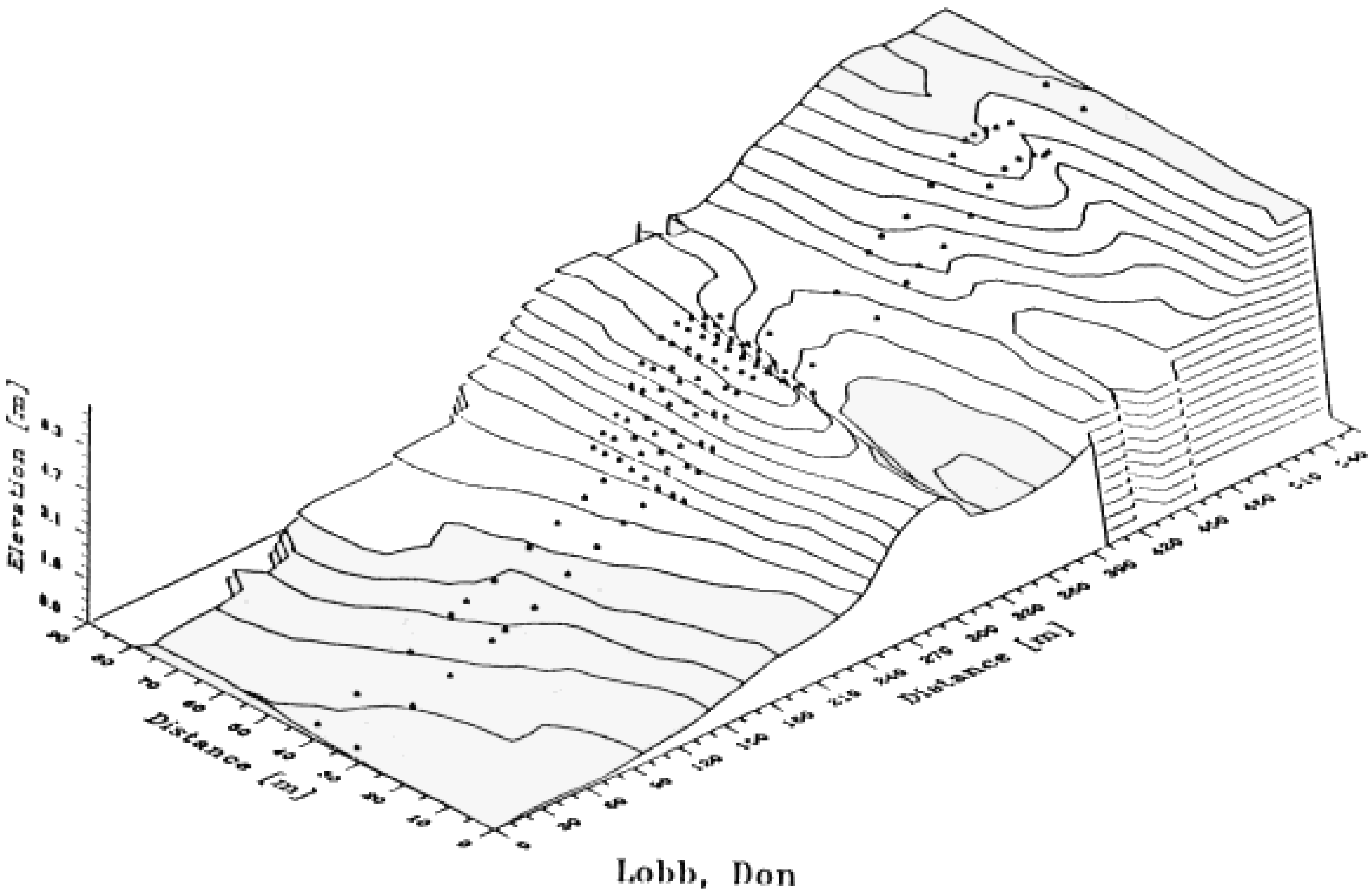

Figure IV.14: Don Lobb Tillage-2000 field site 3D relief map.

Table IV.8: Murray Lobb Tillage-2000 Field Site Cesium-137 Data

	1987					1990						1990-1987			
BENCH	Avg.2 Depth cm	Bulk Density g/cm^3	Mass g	Cesium Bq/kg	Bq/m^2	Avg.2 Depth cm	Bulk Density g/cm^3	Mass g	Cesium Bq/kg	Bq/m2	Bq/m2	Avg Depth cm	Bulk Density g/cm^3	Mass g	Delta Bq/m^2
TREATMENT 1															
Lm_1_01	15	1.3	20	7.6	1524	23	1.2	29	5.1	1484	-39	19	1.3	24	-585
Lm_1_02	15	1.4	21	7.3	1532	19	1.4	27	5.0	1374	-157	17	1.4	24	-522
Lm_1_03	16	1.3	21	6.3	1300	20	1.3	2.5	6.4	1639	339	18	1.3	23	58
Lin_ I_04	13	1.3	17	8.2	1433	18	1.2	22	7.5	1670	237	16	1.3	20	-106
Lm_1_05	11	1.4	16	7.3	1146	18	1.3	23	4.6	1078	-68	15	1.3	19	-518
Lm_1_06	8	1.4	11	5.4	604	16	1.2	20	5.3	1082	477	12	1.3	16	-6
Lm_1_07	6	1.3	8	7.4	623	21	1.4	28	4.7	1366	743	14	1.4	18	-484
Lm_1_08	13	1.4	17	8.5	1477	21	1.3	27	8.6	2444	967	17	1.3	22	91
Lm_1_09	5	1.6	8	5.7	467	18	1.4	26	4.4	1154	688	11	1.5	17	-214
Lm_1_10	7	1.7	12	3.9	452	17	1.4	23	6.1	1454	1002	12	1.6	17	407
Lm_1_11	7	1.6	12	7.1	842	18	1.2	22	2.3	510	-333	13	1.4	17	422
Avg	11	1.4	15	6.8	1036	19	1.3	25	5.4	1387	351	15	1.4	20	-245
TREATMENT 2															
Lm_2_01	25	1.3	31	7.6	2369	38	1.3	50	6.1	3140	771	32	1.3	41	-544
Lm_2_02	24	1.4	33	7.6	2535	27	1.5	39	8.0	3286	751	25	1.4	36	263
Lm_2_03	14	1.3	18	7.0	1247	18	1.5	28	5.3	1525	278	16	1.4	23	-340
Lm_2_04	15	1.4	20	7.9	1570	17	1.5	25	9.4	2421	851	16	1.4	22	403
Lm_2_05	16	1.3	20	6.2	1267	25	1.4	36	5.4	2011	743	21	1.4	28	-191
Lm_2_06	17	1.3	23	6.3	1457	19	1.5	27	5.5	1549	91	18	1.4	25	-153
Lm_2_07	13	1.4	18	6.4	1173	19	1.4	28	5.4	1550	376	16	1.4	23	-195
Lm_2_08	18	1.3	23	8.3	1940	20	1.5	29	8.0	2379	439	19	1.4	26	-14
Lm_2_09	11	1.4	15	8.7	1314	18	1.5	26	9.1	2475	1162	14	1.4	21	141
Lm_2_10	8	1.3	11	9.5	1034	26	1.4	36	7.1	2628	1593	17	1.3	23	-493
Lm_2_11	8	1.4	12	8.6	992	8	1.3	10	10.9	1100	108	8	1.3	11	270
Avg	15	13	20	7.6	1536	21	1.4	30	7.3	2188	651	18	1.4	25	-78

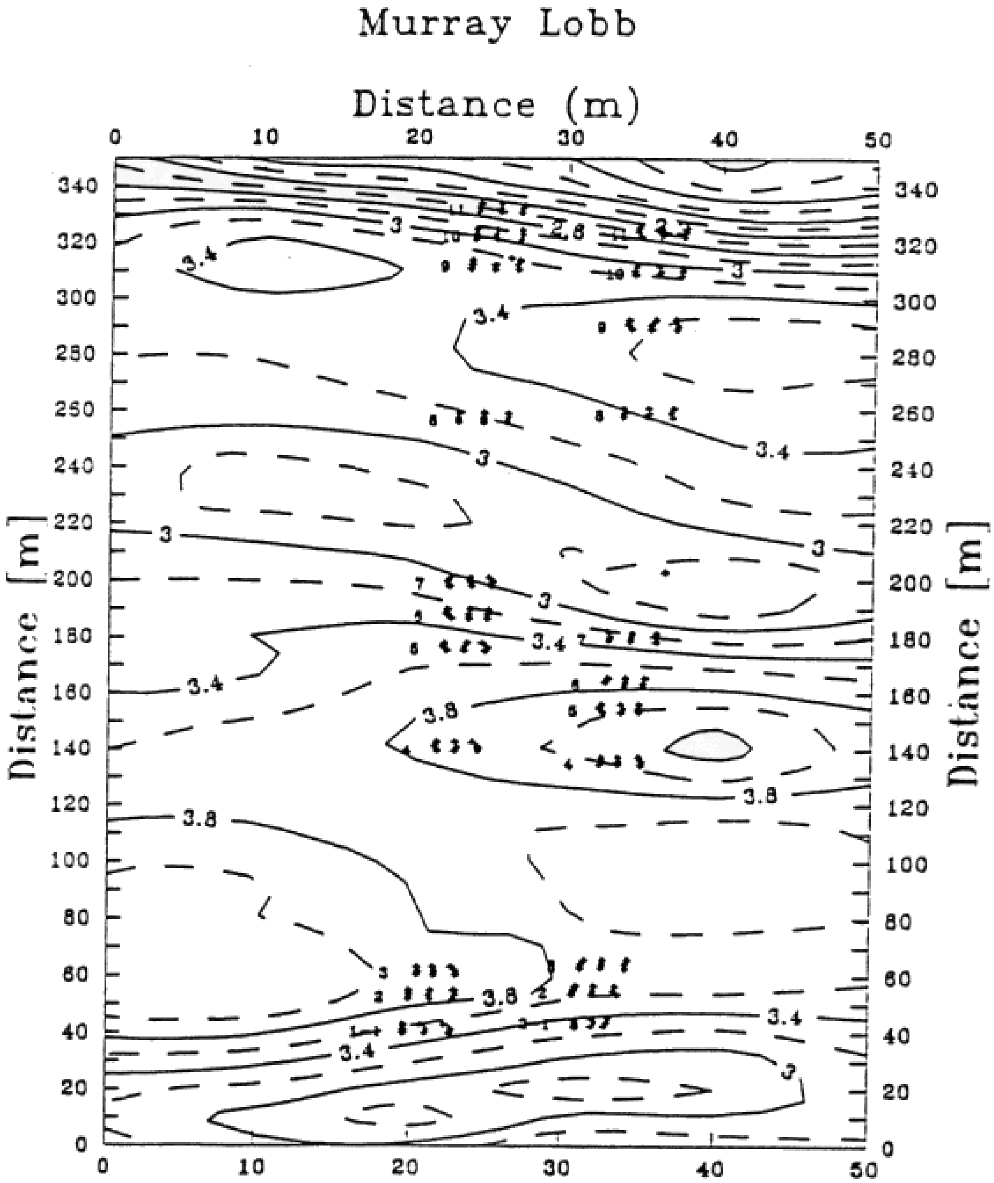

Figure IV.15: Murray Lobb Tillage-2000 field site elevation contour map showing benchmark positions.

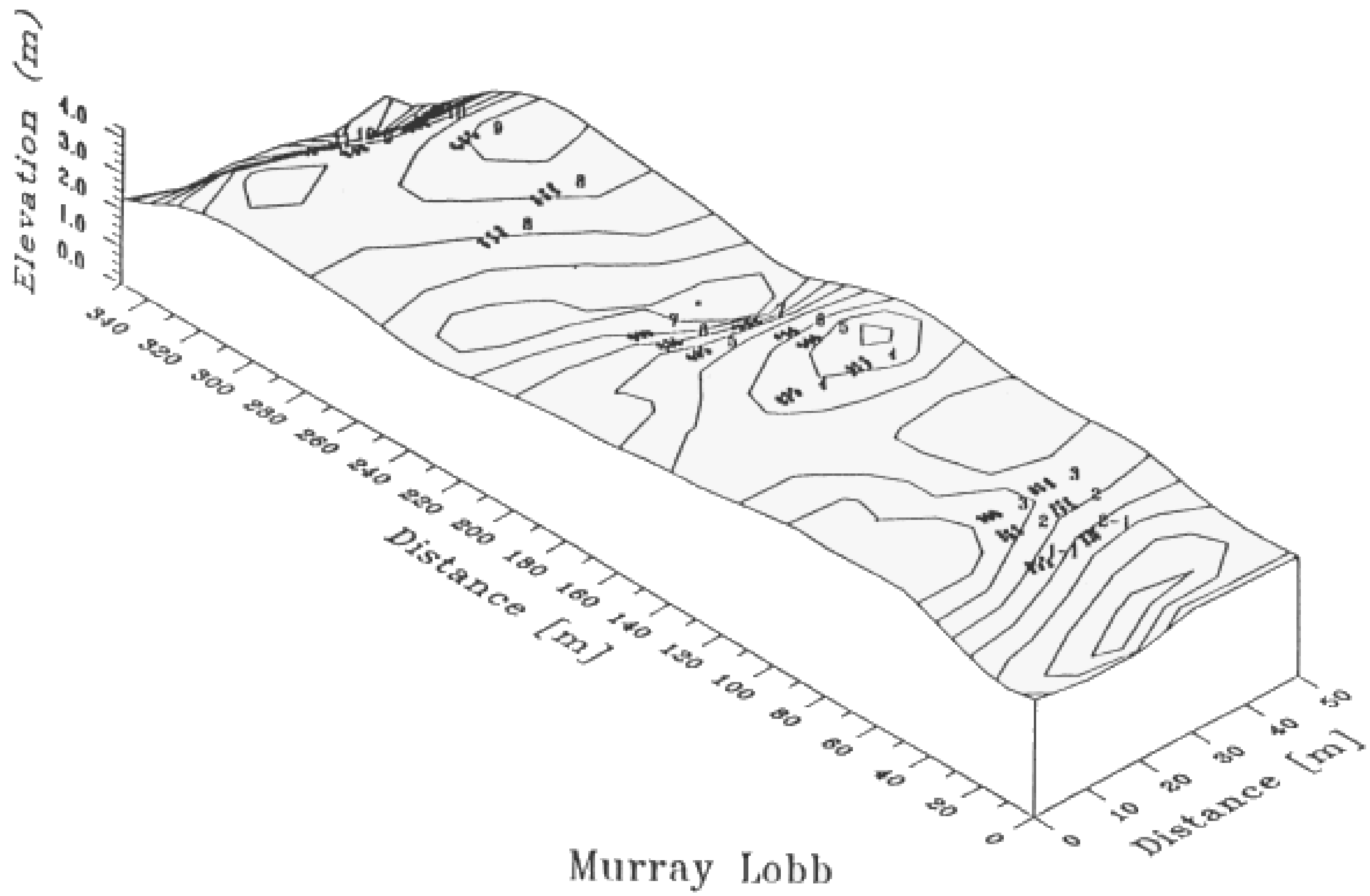

Figure IV.16: Murray Lobb Tillage-2000 field site 3D relief map.

Table IV.9: Martin Tillage-2000 Field Site Cesium-137 Data

	1987					1990					1990-1987				
BENCH	Avg.2 Depth cm	Bulk Density g/cm^3	Mass g	Cesium Bq/kg	Bq/m^2	Avg.2 Depth cm	Bulk Density g/cm^3	Mass g	Cesium Bq/kg	Bq/m2	Bq/m2	Avg Depth cm	Bulk Density g/cm^3	Mass g	Delta Bq/m^2
TREATMENT 1															
Ma_1_01	22	1.1	24	5.6	1344	20	1.3	26	5.1	1373	30	21	1.2	2.5	-75
Ma_1_02	26	1.2	30	7.7	2323	26	1.2	31	7.0	2296	-28	26	1.2	31	-97
Ma_1_03	23	1.1	25	5.5	1386	19	1.4	26	5.2	1378	4	21	1.2	25	-41
Ma_1_04	23	1.1	26	6.2	1631	21	1.4	28	6.1	1803	172	22	1.2	27	41
Ma_1_05	22	1.2	25	6.7	1698	20	1.2	25	5.6	1445	-253	21	1.2	25	-235
Ma_1_06	25	1.0	24	7.2	1717	18	1.2	22	6.7	1559	-158	22	1.1	23	-69
Ma_1_07	21	1.1	24	6.1	1442	17	1.3	23	5.5	1310	-132	19	1.2	23	-109
Ma_1_08	24	1.1	27	5.9	1575	20	1.5	30	5.8	1801	226	22	1.3	28	44
Ma_1_09	24	1.1	26	6.4	1690	17	1.4	24	5.9	1473	-218	20	1.3	25	-89
Ma_1_10	22	0.9	21	7.6	1571	17	1.3	22	6.6	1487	-84	19	1.1	21	-172
Ma_1_11	22	1.1	24	7.6	1829	20	1.3	26	7.7	2079	250	21	1.2	2.5	116
Avg	23	1.1	25	6.6	1655	20	1.3	26	6.1	1637	-18	21	1.2	25	-62
TREATMENT 2															
Ma_2_01	24	0.9	23	7.8	1 774	16	1.3	20	6.6	1403	-371	20	1.1	22	-194
Ma_2_02	33	0.8	28	8.7	2409	28	1.2	34	6.6	2337	-72	31	1.0	31	-550
Ma_2_03	26	0.9	25	7.4	1820	20	1.5	30	6.5	2067	247	23	1.2	27	-170
Ma_2_04	27	1.0	27	9.3	2522	26	0.9	23	6.8	1622	-900	26	0.9	25	-568
Ma_2_05	26	1.1	29	8.4	2426	18	1.4	25	6.8	1802	-624	22	1.3	27	-363
Ma_2_06	31	1.0	31	10.0	3083	33	1.0	33	7.8	2697	-386	32	1.0	32	-561
Ma_2_07	23	1.1	25	8.3	2111	17	1.5	23	6.3	1661	-450	20	1.3	25	-437
Ma_2_08	26	1.1	*27*	*7.5*	2045	28	0.7	19	7.0	1375	-670	*27*	0.9	23	-38
Ma_2_09	24	1.4	34	7.0	2360	24	1.6	39	5.1	2096	-264	24	1.5	36	-587
Ma_2_10	19	1.1	22	6.9	1522	29	0.6	19	5.8	1144	-378	24	0.9	20	-194
Ma_2_11	28	1.0	28	8.6	2415	27	1.4	38	5.5	2200	-215	27	1.2	33	-951
Avg	26	1.1	27	8.2	2226	24	1.2	28	6.4	1855	-371	25	1.1	27	-419

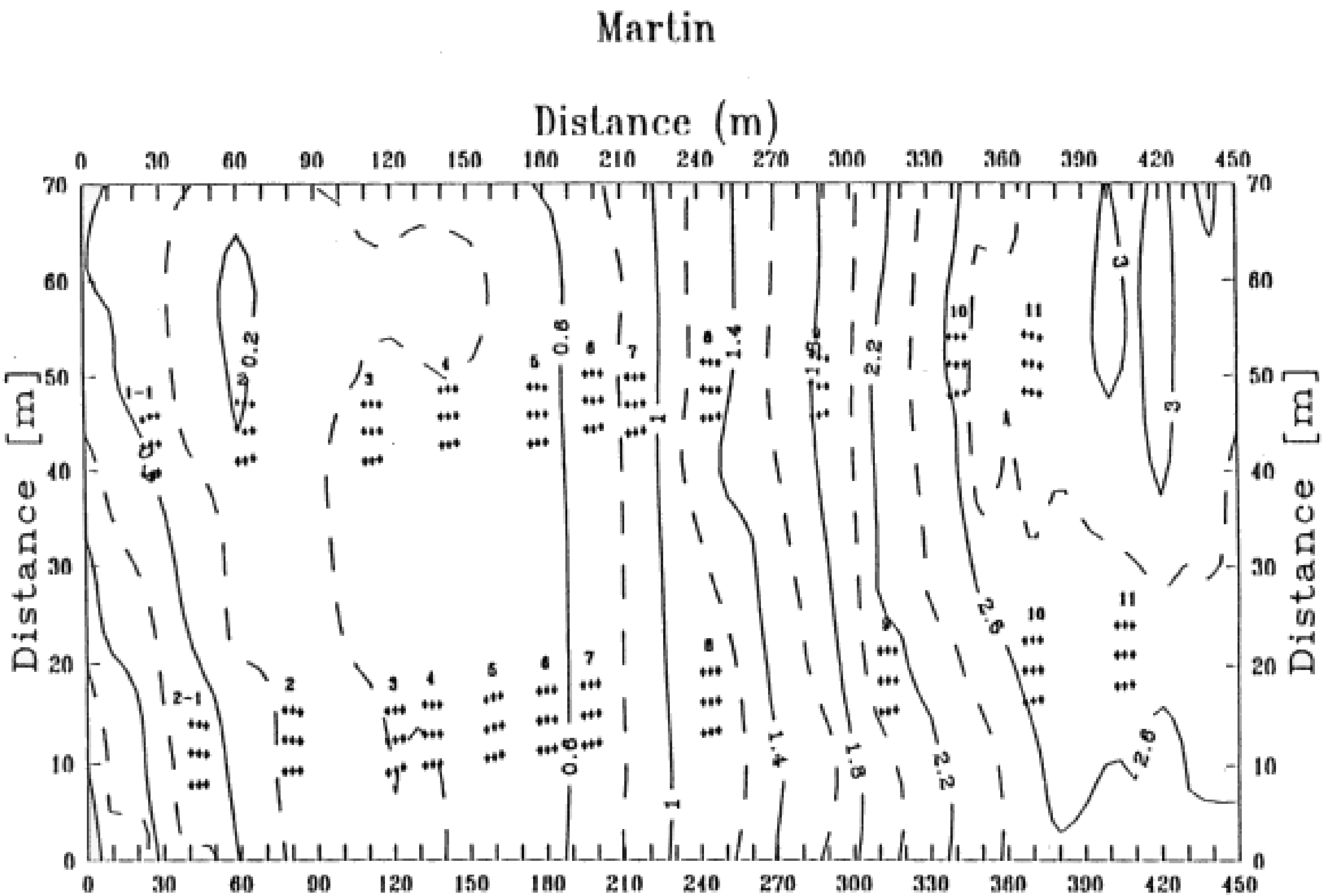

Figure IV.17: Martin Tillage-2000 field site elevation contour map showing benchmark positions.

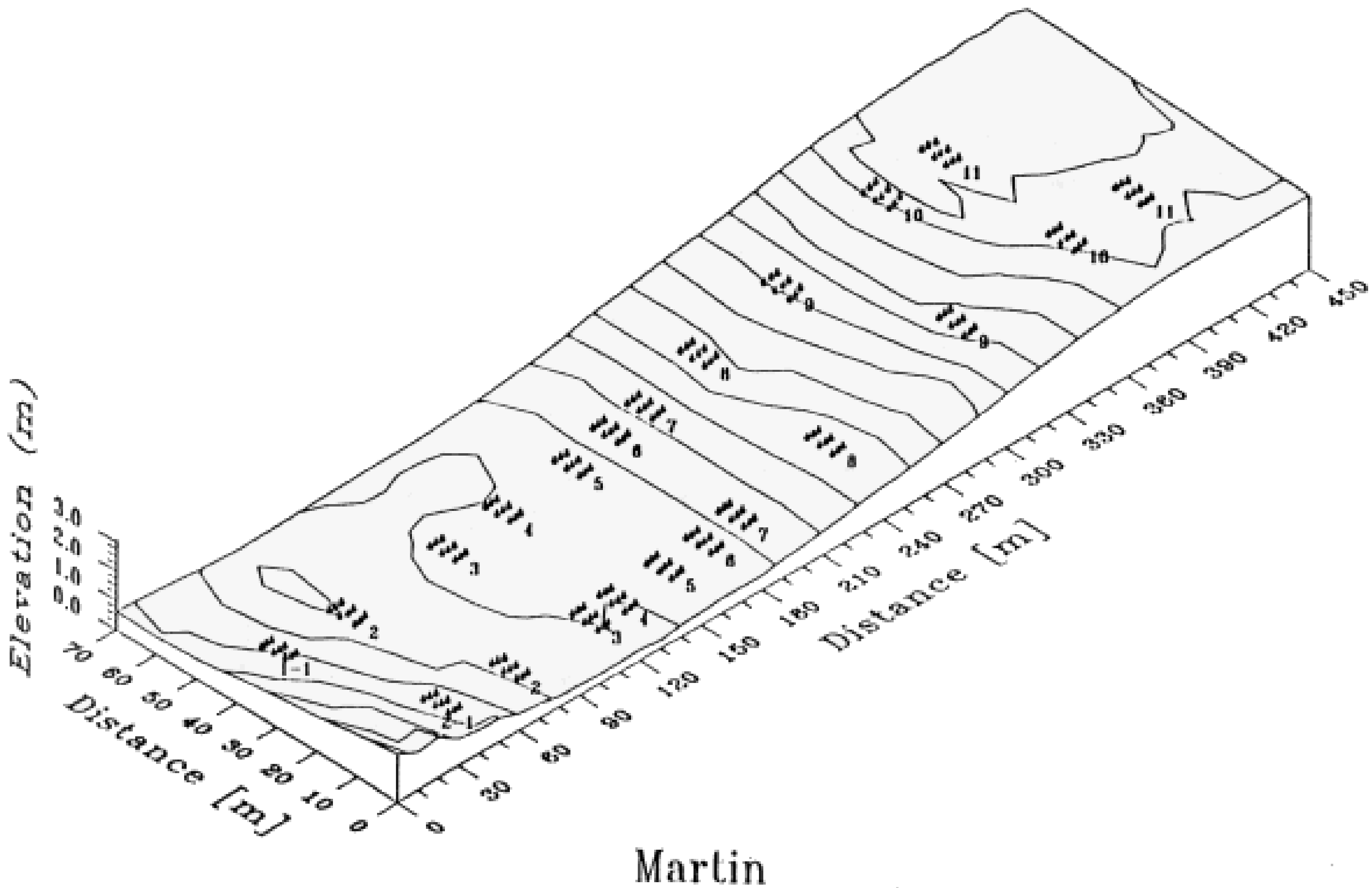

Figure IV.18: Martin Tillage-2000 field site 3D relief map.

Table IV.10: Murrell Tillage-2000 Field Site Cesium-137 Data

	1987					1990						1990-1987			
BENCH	Avg.2 Depth cm	Bulk Density g/cm^3	Mass g	Cesium Bq/kg	Bq/m^2	Avg.2 Depth cm	Bulk Density g/cm^3	Mass g	Cesium Bq/kg	Bq/m2	Bq/m2	Avg Depth cm	Bulk Density g/cm^3	Mass g	Delta Bq/m^2
TREATMENT 1															
Mu_1_01	23	1.1	26	7.1	1848	27	1.4	37	5.8	2226	378	25	1.2	31	-326
Mu_1_02	25	1.1	28	8.5	2405	26	1.3	32	8.0	2715	310	25	1.2	30	-17
Mu_1_03	23	1.1	26	9.1	2397	24	1.2	30	8.3	2618	221	24	1.2	28	-85
Mu_1_04	24	1.1	27	10.1	2687	25	1.2	31	9.2	2995	308	25	1.2	29	-109
Mu_1_05	23	1.2	28	7.4	2062	26	1.3	35	6.6	2404	343	25	1.3	31	-148
Mu_1_06	21	1.2	25	8.7	2200	23	1.2	27	7.8	2229	30	22	1.2	26	-136
Mu_1_07	24	1.1	27	11.2	3008	28	1.2	33	8.4	2907	-101	26	1.1	30	-706
Mu_1_08	28	1.1	30	10.0	3002	29	1.2	34	8.4	3035	33	28	1.1	32	-348
Mu_1_09	24	1.2	29	7.5	2186	24	1.2	30	6.2	1933	-253	24	1.2	30	-301
Avg	24	1.1	27	8.8	2422	26	1.2	32	7.6	2563	141	25	1.2	30	-242
TREATMENT 2															
Mu_2_01	31	0.9	27	8.7	2305	27	1.3	36	7.9	2979	674	29	1.1	31	-113
Mu_2_02	24	1.0	25	8.2	2045	24	1.2	30	7i	2345	299	24	L1	27	-102
Mu_2_03	30	1.2	35	7.5	2616	24	1.4	33	7.1	2418	-198	27	13	34	-32
Mu_2_04	30	0.9	27	8.6	2356	25	1.2	31	8.6	2828	471	28	1.1	29	127
Mu_2_05	27	1.0	27	9.2	2462	26	1.2	30	8.4	2685	223	26	1.1	29	-115
Mu_2_06	23	1.0	24	9.0	2155	26	1.2	32				25	1.1	28	
Mu_2_07	19	1.3	24	5.7	1382	19	1.2	24	6.9	1750	368	19	1.3	24	370
Mu_2_08	37	1.0	37	8.7	3209	29	1.3	37	7.5	2945	-264	33	1.1	37	-272
Mu_2_09	27	0.9	25	7.4	1863	25	1.1	28	7.1	2080	218	26	1.0	27	5
Avg	28	1.0	28	8.1	2266	25	1.2	31	7.6	2504	224	26	1.1	30	-16

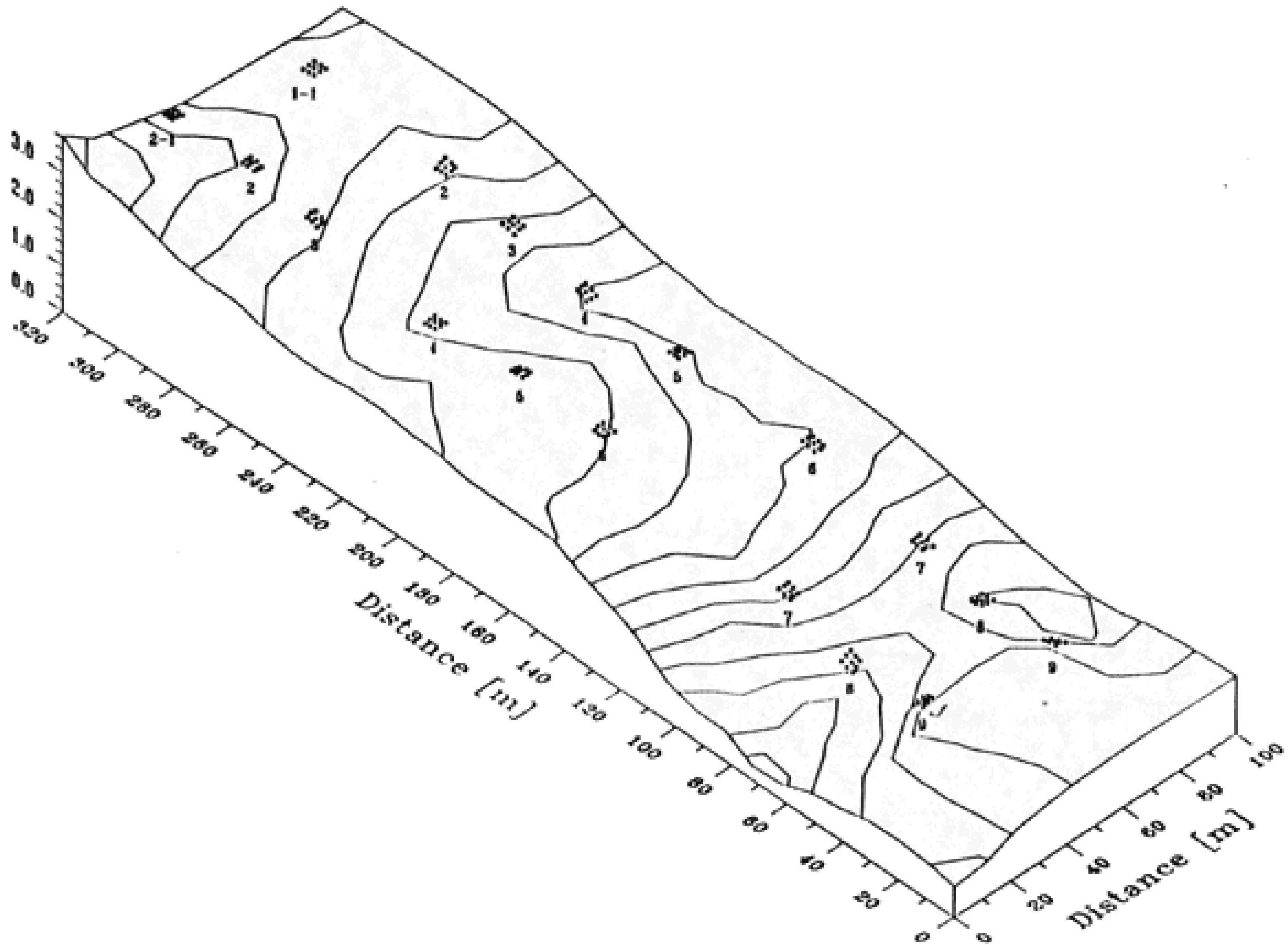

Figure IV.19: Murrell Tillage-2000 field site elevation contour map showing benchmark positions.

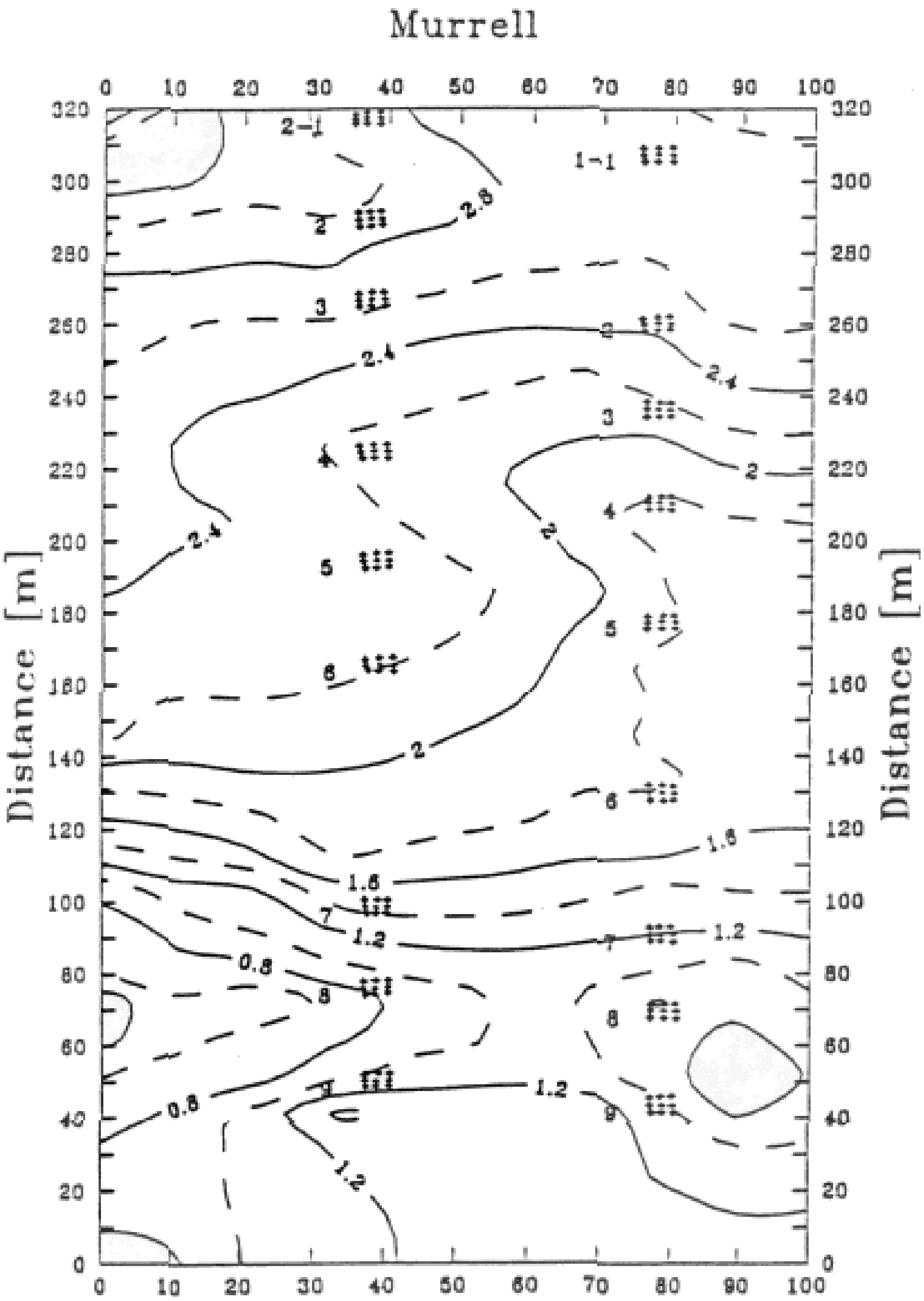

Figure IV.20: Murrell Tillage-2000 field site 3D relief map.

Table IV.11: Pottruff Tillage-2000 Field Site Cesium-137 Data

	1987					1990					1990-1987				
BENCH	Avg.2 Depth cm	Bulk Density g/cm^3	Mass g	Cesium Bq/kg	Bq/m^2	Avg.2 Depth cm	Bulk Density g/cm^3	Mass g	Cesium Bq/kg	Bq/m2	Bq/m2	Avg Depth cm	Bulk Density g/cm^3	Mass g	Delta Bq/m^2
TREATMENT 1															
Po_1_01	25	1.3	33	9.1	3038	25	1.4	35	7.294	2713	-324	25	1.4	34	-483
Po_1_02	23	1.3	30	6.9	2108	22	1.4	31	7.792	2571	463	23	1.4	31	393
Po_1_03	26	1.3	34	8.0	2678	23	1.4	36	6.402	2396	-282	26	1.4	35	-432
Po_1_04	24	1.2	29	9.0	2580	22	1.3	30	9.061	2873	294	23	1.3	29	165
Po_1_05	22	1.3	27	8.3	2225	22	1.4	30	6.759	2117	-108	22	1.3	28	-339
Po_1_06	37	1.3	48	7.4	3594	34	1.4	49	6.123	3148	-447	35	1.4	49	-467
Po_1_07	22	1.3	28	8.1	2309	17	1.5	25	6.770	1787	-523	19	1.4	27	-283
Po_1_08	22	1.3	28	7.8	2178	22	1.3	29	6.298	1907	-271	22	1.3	28	-340
Po_1_09	25	1.4	34	10.4	3501	26	1.5	40	9.016	3829	328	26	1.4	37	-314
Po_1_10	23	1.4	31	6.0	1823	20	1.5	29	5.498	1684	-139	21	1.4	30	-68
Po_1_11	30	1.3	39	10.3	404-4	27	1.5	40	7.748	3278	-766	28	1.4	40	-848
Po_1_12	26	1.2	30	6.6	1980	19	1.4	28	5.611	1635	-345	22	1.3	29	-207
Po_1_13	20	1.3	26	7.0	1791	23	1.3	30	6.006	1903	113	21	1.3	28	-196
Po_1_14	20	1.2	25	5.3	1312	18	1.5	27	5.212	1456	144	19	1.4	26	19
Po_1_15	30	1.4	43	7.2	3120	30	1.6	47	6.810	3408	288	30	1.5	45	-7
Po_1_16	28	1.3	36	8.7	3132	29	1.4	40	7.599	3238	106	28	1.4	38	-257
Avg	25	1.3	33	7.9	2588	24	1.4	34	6.9	2496	-92	24	1.4	33	-229
TREATMENT 2															
Po_2_01	23	1.2	28	9.0	2489	24	1.5	35	7.300	2727	238	23	1.3	32	-423
Po_2_02	22	1.2	27	9.8	2398	25	1.5	37	6.800	2669	71	24	1.3	32	-834
Po_2_03	19	1.2	23	9.8	2244	23	1.4	32	7.782	2591	347	21	1.3	27	-442
Po_2_04	25	1.2	30	10.7	3200	25	1.4	35	9.714	3599	399	25	1.3	33	-126
Po_2_05	19	1.2	23	8.9	2040	19	1.4	26	7.983	2218	178	19	1.3	25	-124
Po_2_06	26	1.2	32	10.1	3256	32	1.4	45	7.733	3659	403	29	1.3	38	-741
Po_2_07	30	1.5	45	7.1	3239	29	1.6	46	4.286	2076	-1163	30	1.5	46	-1208
Po_2_08	25	1.3	33	8.1	2637	33	1.4	45	6.455	3081	444	29	1.3	39	-504
Po_2_09	14	1.2	17	7.8	1318	16	1.5	23	6.801	1656	338	15	1.3	20	-147
Po_2_10	17	1.2	21	7.7	1590	28	1.4	39	4.490	1847	257	22	1.3	30	-914
Po_2_11	28	1.3	35	9.4	3293	31	1.4	45	6.576	3115	-178	30	1.4	40	-977
Po_2_12	20	1.3	26	7.7	1993	29	1.2	35	6.354	2363	370	23	1.3	31	-321
Po_2_13	20	1.2	25	7.5	1884	27	1.4	39	5.159	2125	241	24	1.3	*32*	677
Po_2_14	16	1.2	20	7.6	1515	23	1.3	30	5.670	1794	279	20	1.3	23	418
Po_2_15	28	1.3	38	7.6	2874	35	1.4	49	4.755	2467	-407	31	1.4	44	-1142
Po_2_16	27	1.2	33	8.6	2841	29	1.4	42	6.420	2816	-25	28	1.3	37	-678
Avg	22	1.3	28	8.6	2438	27	1.4	38	6.5	2550	112	25	1.3	33	605

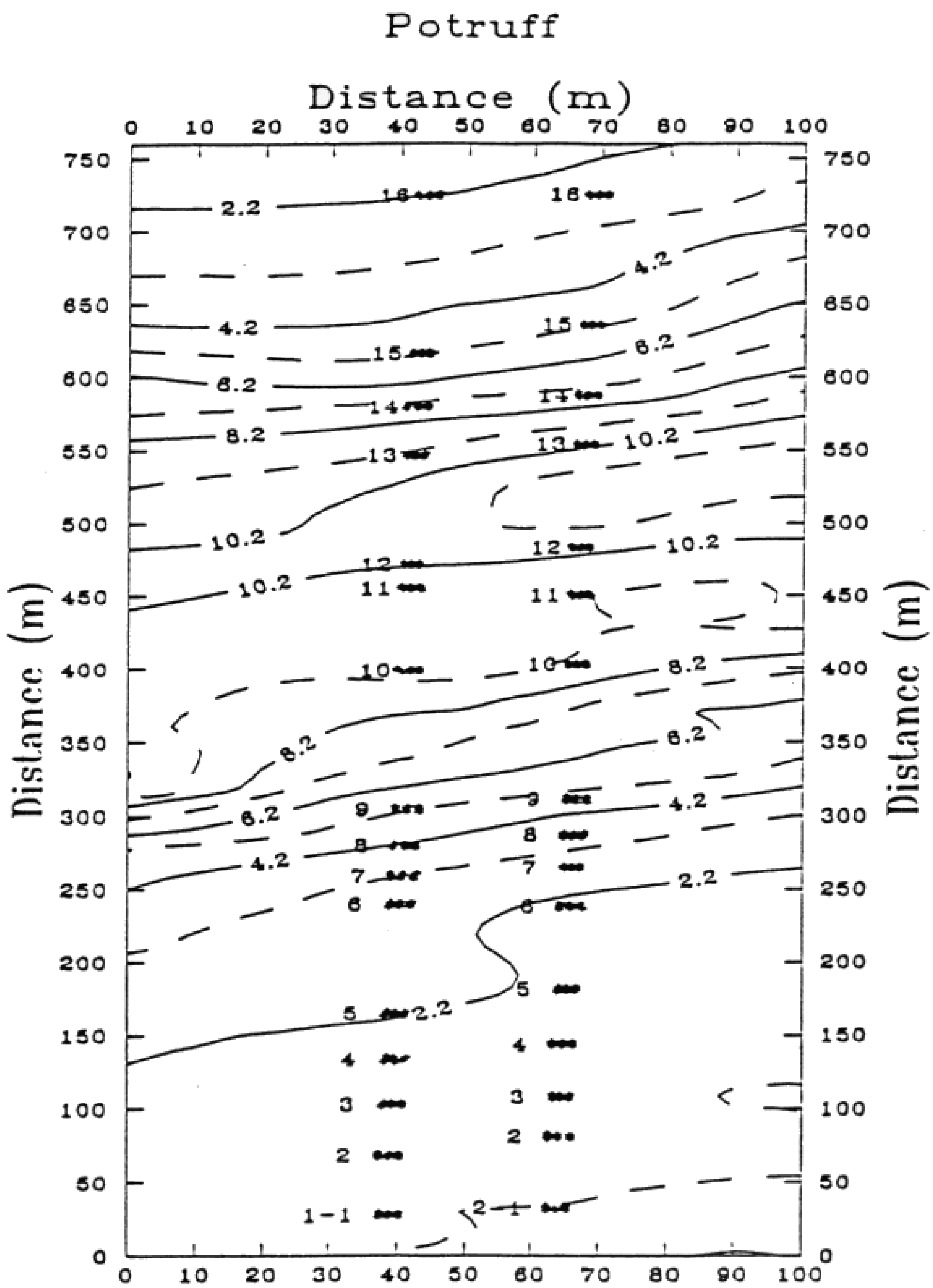

Figure IV.21: Pottruff Tillage-2000 field site elevation contour map showing benchmark positions.

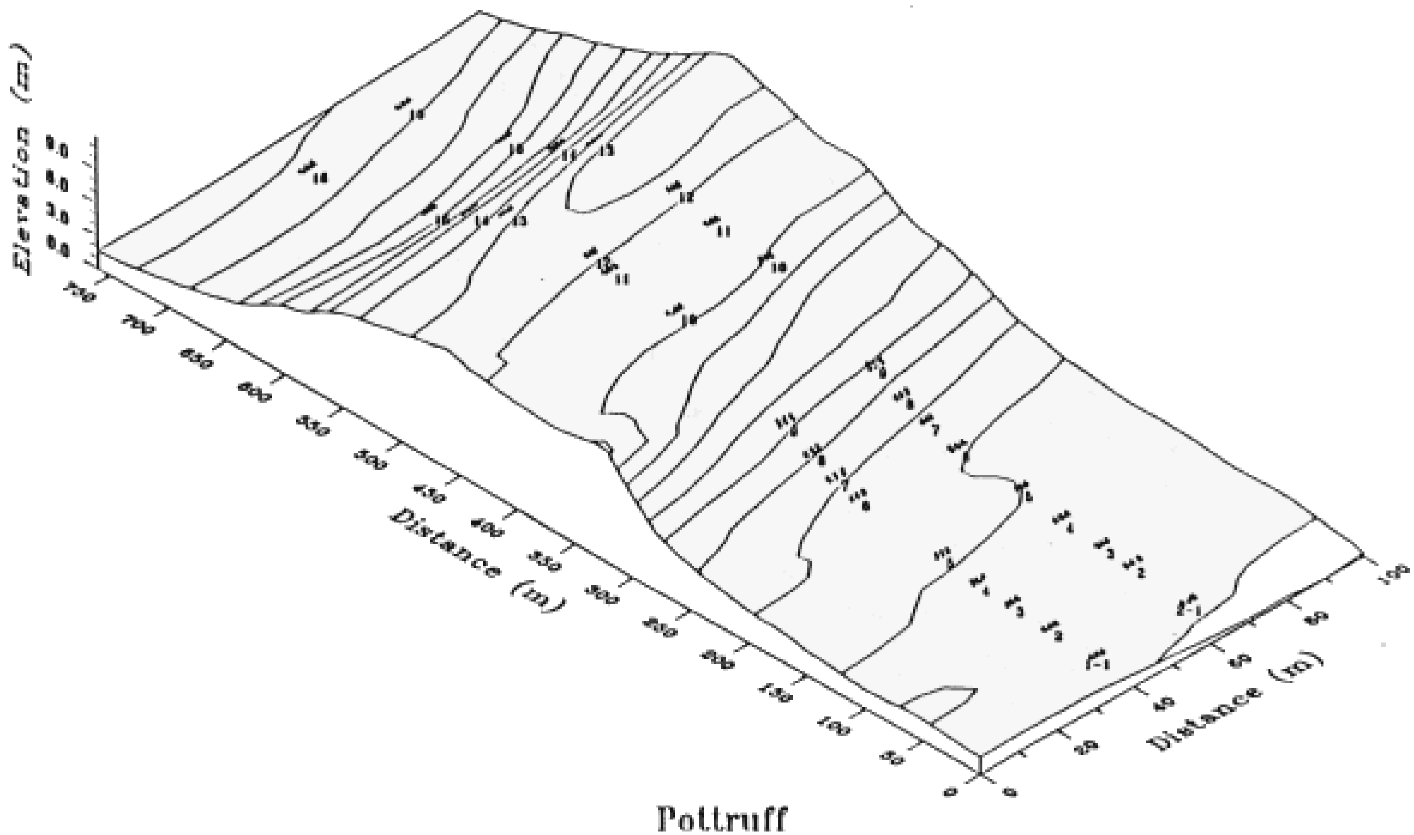

Figure IV.22: Pottruff Tillage-2000 field site 3D relief map.

Table IV.12: Smith Tillage-2000 Field Site Cesium-137 Data

BENCH	1987 Avg.2 Depth cm	1987 Bulk Density g/cm^3	1987 Mass g	1987 Cesium Bq/kg	1987 Bq/m^2	1990 Avg.2 Depth cm	1990 Bulk Density g/cm^3	1990 Mass g	1990 Cesium Bq/kg	1990 Bq/m2	1990 Bq/m2	1990-1987 Avg Depth cm	1990-1987 Bulk Density g/cm^3	1990-1987 Mass g	1990-1987 Delta Bq/m^2
TREATMENT 1															
Sm_1_01	22	1.0	23	7.5	1739	22	1.2	26	7.0	1895	156	22	1.1	24	-43
Sm_1_02	22	1.0	21	7.2	1551	19	1.1	21	6.3	1365	-186	21	1.0	21	-144
Sm_1_03	20	1.0	20	6.7	1359	19	1.2	23	6.2	1501	142	19	1.1	22	60
Sm_1_04	25	1.0	25	7.2	1800	24	1.4	33	5.8	1976	176	24	1.2	29	-337
Sm_1_05	23	0.9	20	6.6	1333	20	1.2	25	6.6	1707	375	21	1.1	22	46
Sm_1_06	24	1.1	26	6.8	1781	23	1.2	28	5.8	1683	-98	24	1.1	27	-190
Sm_1_07	22	0.9	20	9.5	1948	22	0.7	15	8.8	1399	-550	22	0.8	18	-70
Sm_1_08	21	1.0	21	8.0	1690	20	1.2	24	8.4	2143	453	21	1.1	23	188
Avg	22	1.0	22	7.5	1650	21	1.1	24	6.9	1709	59	22	1.1	23	-76
TREATMENT 2															
Sm_2_01	24	1.1	2.5	6.8	1739	21	1.3	28	6.9	1995	256	22	1.2	27	95
Sm_2_02	23	1.1	25	7.4	1840	22	1.4	30	7.5	2362	522	23	1.2	27	132
Sm_2_03	24	1.2	29	7.7	2221	25	1.3	32	6.5	2201	-20	25	1.2	31	-271
Sm_2_04	24	1.1	28	7.0	1959	23	1.2	28	6.8	2017	58	24	1.2	28	45
Sm_2_05	22	1.2	27	7.2	1935	21	1.3	27	6.4	1792	-144	21	1.3	27	-141
Sm_2_06	23	1.3	30	7.0	2130	2.3	1.4	32	6.5	2198	68	23	1.4	31	-82
Sm_2_07	24	1.6	39	7.5	2905	24	1.3	31	7.7	2538	-367	24	1.5	35	242
Sm_2_08	20	1.6	33	11.1	3622	24	1.2	28	11.7	3509	-113	22	1.4	31	404
Avg	23	1.3	29	7.7	2294	23	1.3	30	7.5	2326	33	23	1.3	30	53
TREATMENT 3															
Sm_3_01						26	1.4	35	5.1	1900					
Sm_3_02	18	1.4	2.5	5.8	1421	19	1.4	26	5.0	1349	-72	18	1.4	25	-152
Sm_3_03	21	1.3	26	6.4	1677	19	1.3	24	4.9	1201	-476	20	1.3	25	-340
Sm_3_04	22	1.2	26	5.9	1523	20	1.3	27	5.2	1458	-64	21	1.3	26	-119
Sm_3_05	19	1.1	22	7.4	1592	21	1.2	26	6.4	1723	132	20	1.2	24	-182
Sm_3_06	21	1.0	22	6.1	1345	19	1.2	23	5.4	1313	-32	20	1.1	23	-112
Sm_3_07	23	1.2	28	6.9	1913	23	1.2	27	5.5	1562	-352	23	1.2	27	-306
Sm_3_08	21	0.9	18	9.8	1750	21	1.1	23	8.9	2114	363	21	1.0	20	-96
Avg	21	1.2	24	6.9	1603	21	1.3	26	5.8	1577	-72	20	1.2	24	-187

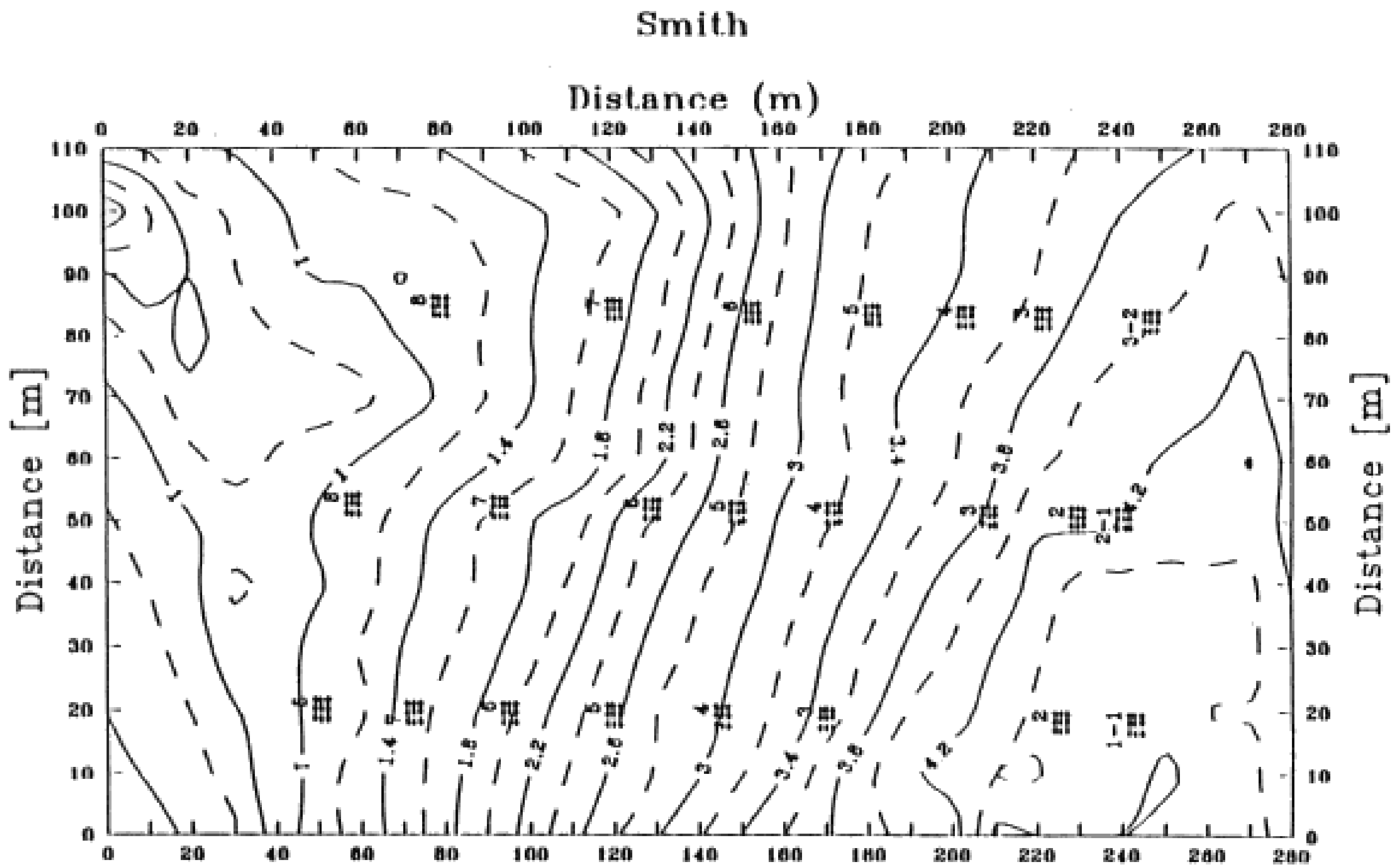

Figure IV.23: Smith Tillage-2000 field site elevation contour map showing benchmark positions.

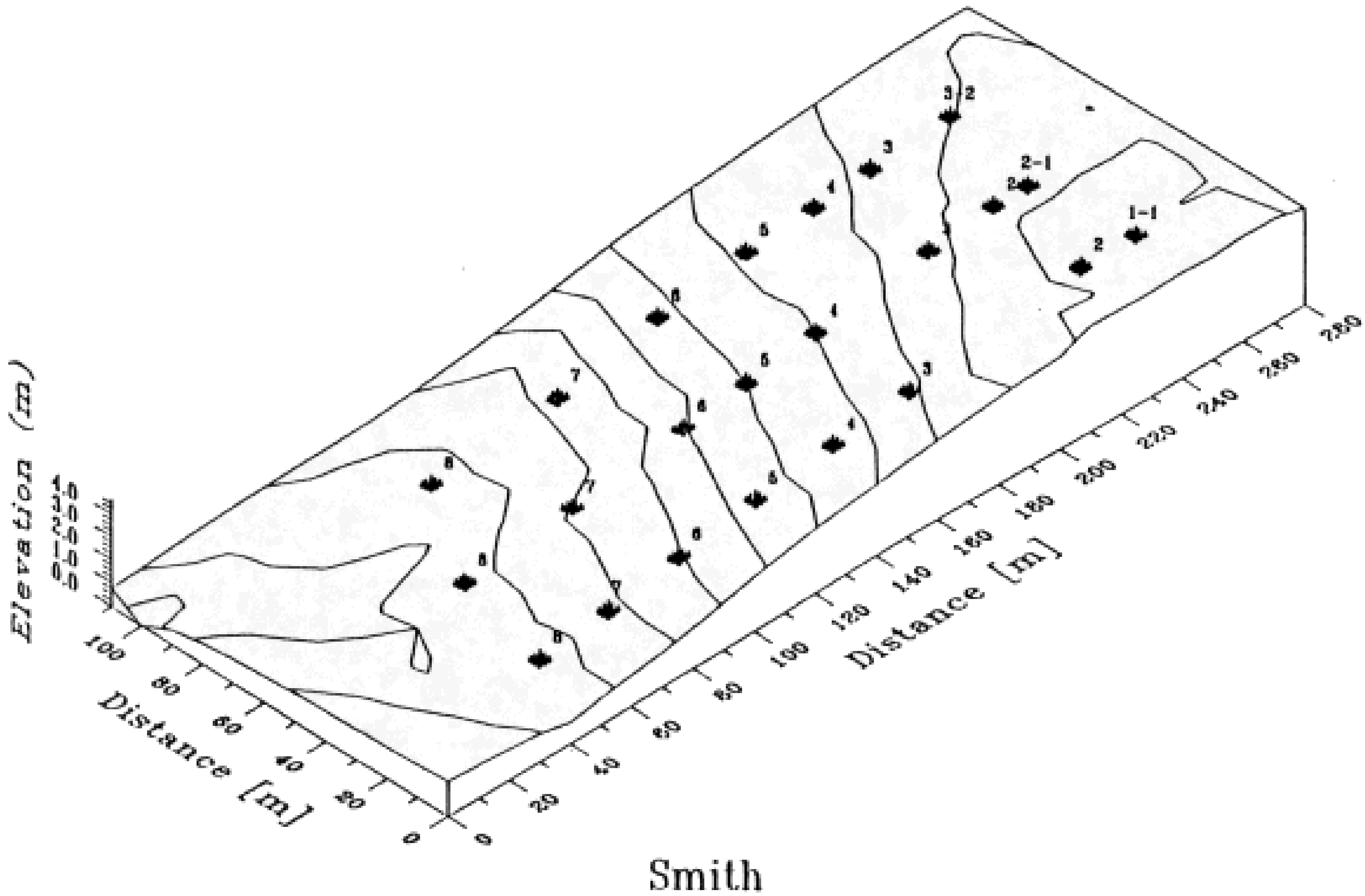

Figure IV.24: Smith Tillage-2000 field site 3D relief map.

Table IV.13: Steward Tillage-2000 Field Site Cesium-137 Data

	1987					1990						1990-1987			
BENCH	Avg.2 Depth cm	Bulk Density g/cm^3	Mass g	Cesium Bq/kg	Bq/m^2	Avg.2 Depth cm	Bulk Density g/cm^3	Mass g	Cesium Bq/kg	Bq/m2	Bq/m2	Avg Depth cm	Bulk Density g/cm^3	Mass g	Delta Bq/m^2
TREATMENT 1- Conv. Till															
Br_1_01	22	1.3	28	7.5	2140	22	1.3	29	8.1	2471	331	22	1.3	29	290
Br_1_02	20	1.4	28	6.4	1795	24	1.5	35	4.9	1811	16	22	1.4	32	-427
Br_1_03	28	13	37	8.2	3053	25	1.5	36	7.5	2868	-186	27	1.4	37	-114
Br_1_04	28	1.3	36	8.6	3062	27	1.4	37	7.5	2912	-150	27	13	36	-241
Br_1_05	22	1.2	26	10.3	2709	23	1.2	28	9.2	2730	21	22	1.2	27	-179
Br_1_06	24	1.2	28	8.1	2265	23	1.4	32	7.0	2331	65	24	1.3	30	-233
Br_1_07	25	1.3	32	8.8	2783	23	1.4	32	7.7	2588	-195	24	13	32	-227
Br_1_08	21	1.3	28	7.2	2016	24	1.2	29	6.2	1882	-134	23	1.3	28	-198
Avg	24	1.3	30	8.2	2478	24	1.3	32	7.3	2449	-29	24	1J	31	-166
TREATMENT 2 - No Till															
Br_2_01	32	1.4	44	9.5	4167	34	1.1	37	8.0	3127	-1040	33	1.2	40	-403
Br_2_02	27	1.4	38	8.5	3265	33	1.1	36	8.1	3067	-199	30	1.2	37	22
Br_2_03	24	1.3	31	9.4	2919	29	1.1	32	9.9	3315	395	26	1.2	31	315
Br_2_04	33	1.4	45	10.1	4516	38	1.1	42	8.3	3732	-784	35	1.2	44	-545
Br_2_05	30	1.3	38	12.5	4799	38	1.0	39	10.0	4149	450	34	1.2	39	-747
Br_2_06	39	1.4	52	8.9	4652	44	1.0	45	7.0	3316	-1336	41	1.2	48	-697
Br_2_07	33	1.3	41	9.2	3826	37	1.1	40	9.3	3911	85	35	1.2	41	254
Br_2_08	29	1.3	39	9.4	3639	35	1.1	37	8.6	3403	-236	32	1.2	38	-99
Avg	31	1.3	41	9.7	3972.9	36	1.1	38	8.7	3502	-471	33	1.2	40	-237

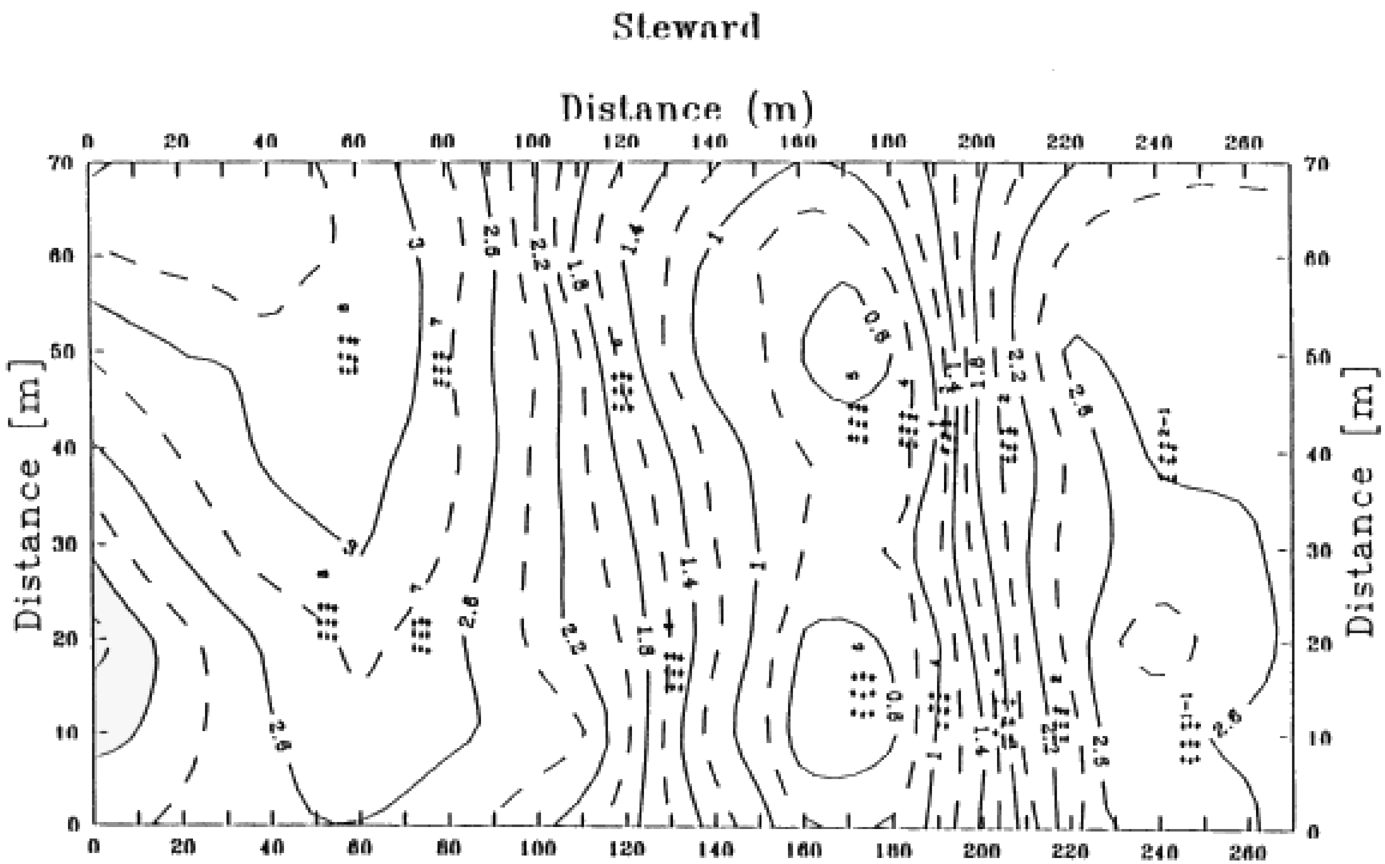

Figure IV.25: Steward Tillage-2000 field site elevation contour map showing benchmark positions.

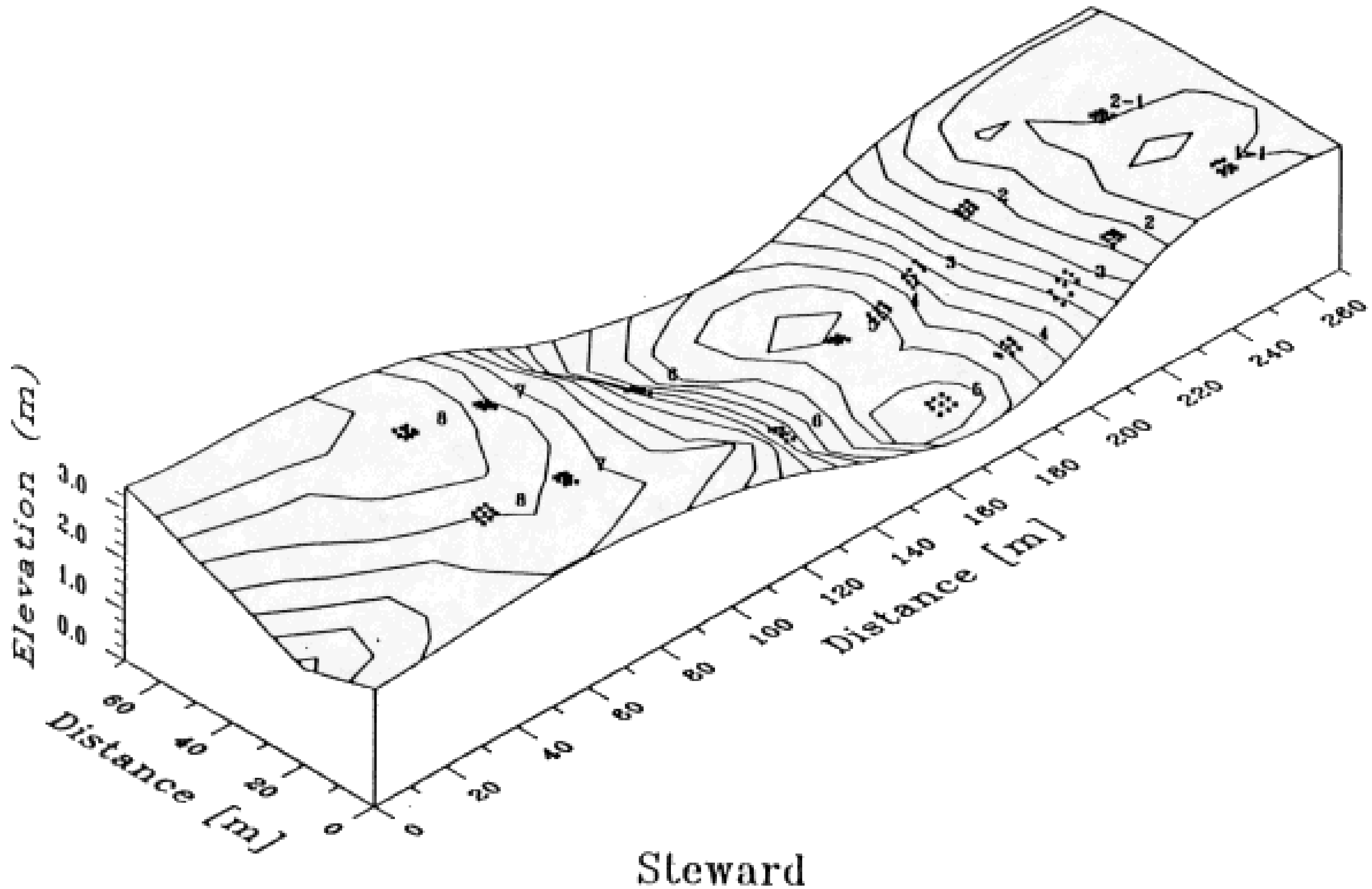

Figure IV.26: Steward Tillage-2000 field site 3D relief map.

Table IV.14: Strathmere Tillage-2000 Field Site Cesium-137 Data

	1987					1990						1990-1987			
BENCH	Avg.2 Depth cm	Bulk Density g/cm^3	Mass g	Cesium Bq/kg	Bq/m^2	Avg.2 Depth cm	Bulk Density g/cm^3	Mass g	Cesium Bq/kg	Bq/m2	Bq/m2	Avg Depth cm	Bulk Density g/cm^3	Mass g	Delta Bq/m^2
TREATMENT 1															
St_1_01	29	1.3	36	10.1	3665	33	1.3	43	9.2	4228	564	31	1.3	40	-145
St_1_02	31	1.4	44	8.1	3570	31	1.4	42	8.1	3564	-7	31	1.4	43	204
St_1_03	27	1.5	39	8.4	3232	28	1.3	38	7.5	2984	-248	27	1.4	38	-166
St_1_04	29	1.5	42	8.1	3421	30	1.4	42	7.3	3228	-193	29	1.4	42	-164
St_1_05	27	1.3	37	7.3	2684	30	1.5	43	7.8	3572	889	29	1.4	40	369
St_1_06	30	1.4	42	8.0	3330	30	1.4	42	8.4	3762	433	30	1.4	42	370
St_1_07	30	1.4	42	7.4	3098	29	1.3	38	7.9	3167	69	29	1.4	40	403
St_1_08	28	1.4	40	7.9	3139	30	1.4	42	8.0	3579	439	29	1.4	41	225
St_1_09	27	1.4	39	7.9	3104	27	1.4	39	7.5	3090	-14	27	1.4	39	-1
Avg	29	1.4	40	8.1	3249	30	1.4	41	8.0	3464	215	29	1.4	41	122
TREATMENT 2															
St_2_01	26	1.4	37	6.8	2480	29	1.4	39	5.4	2224	-256	28	1.4	38	-420
St_2_02	21	1.3	29	6.3	1826	25	1.3	33	5.3	1836	10	23	1.3	31	-242
St_2_03	23	1.3	30	6.5	1990	24	1.4	34	5.5	1971	-18	24	1.4	32	-245
St_2_04	22	1.4	30	6.8	2040	26	1.3	34	5.5	1945	-95	24	1.4	32	-340
St_2_05	19	1.4	26	6.8	1777	27	1.4	39	5.8	2337	560	23	1.4	32	-239
St_2_06	26	1.4	37	6.6	2426	28	1.3	36	5.3	1996	-429	27	1.3	36	-371
St_2_07	2.2	1.2	26	7.4	1903	25	1.5	37	5.9	2290	387	23	1.3	31	-382
St_2_08	22	1.2	27	6.5	1727	27	1.0	27	5.0	1392	-335	24	1.1	27	-338
St_2_09	23	1.5	34	6.0	2067	28	1.4	40	6.0	2507	439	25	1.5	37	99
Avg	23	1.3	31	6.6	2026	26	1.3	35	5.5	2055	29	25	13	33	-275

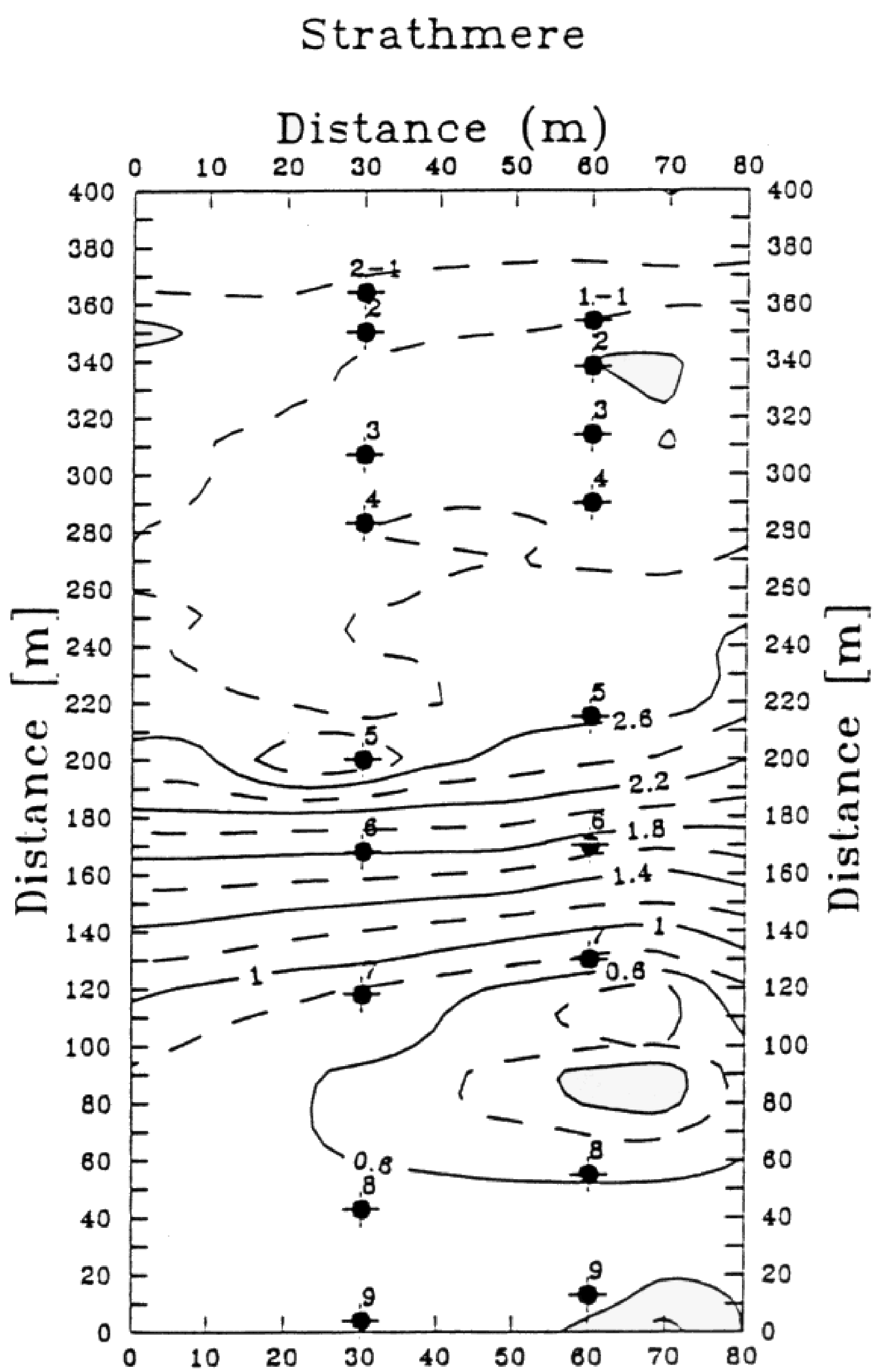

Figure IV.27: Strathmere Tillage-2000 field site elevation contour map showing benchmark positions.

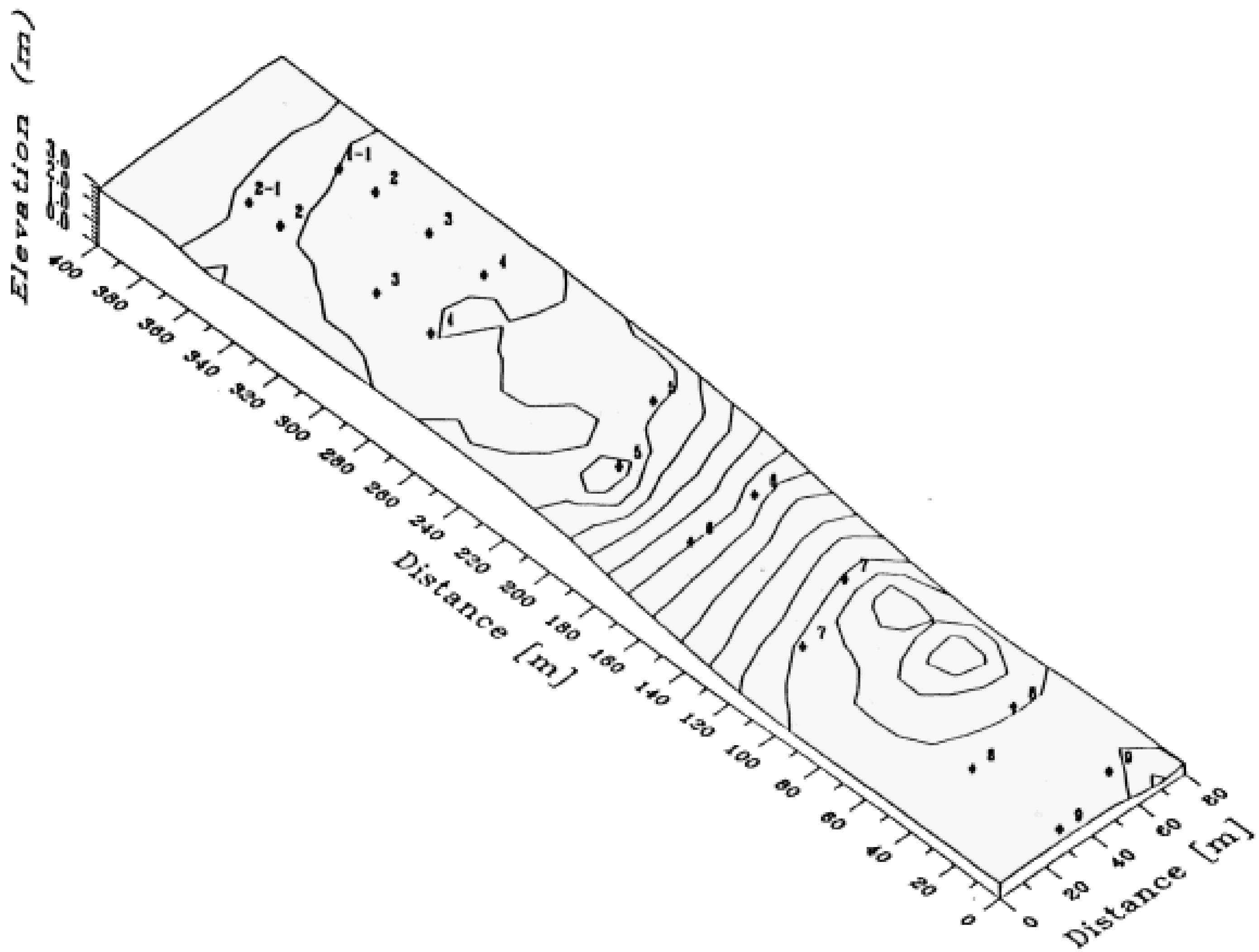

Figure IV.28: Strathmere Tillage-2000 field site 3D relief map.

Table IV.15: Templeman Tillage-2000 Field Site Cesium-137 Data

	1987					1990						1990-1987			
BENCH	Avg.2 Depth cm	Bulk Density g/cm^3	Mass g	Cesium Bq/kg	Bq/m^2	Avg.2 Depth cm	Bulk Density g/cm^3	Mass g	Cesium Bq/kg	Bq/m2	Bq/m2	Avg Depth cm	Bulk Density g/cm^3	Mass g	Delta Bq/m^2
TREATMENT 1															
Te_1_01	19	1.2	23	6.6	1505	20	1.1	22	6.9	1613	109	19	1.2	23	140
Te_1_02	27	0.9	25	9.0	2266	29	1.1	31							
Te_1_03	25	1.2	30	6.5	1954	15	1.2	18	5.5	994	-960	20	1.2	24	-208
Te_1_04	64	1.1	70	11.5	5035	57	1.2	68	6.0	4310	-725	61	1.1	69	-3528
Te_1_05	21	1.2	24	6.7	1624	24	1.3	31	6.7	2193	569	23	1.2	28	91
Te_1_06	24	1.1	26	9.3	2434	24	1.3	32	7.5	2.515	81	24	1.2	29	-405
Te_1_07	30	1.2	35	10.8	3729	35	1.1	39	9.2	3797	68	32	1.1	37	-384
Te_1_08	19	1.4	27	7.6	2023	19	1.1	21	8.0	1781	-242	19	1.3	24	192
Te_1_09	21	1.2	25	8.5	2090	19	1.2	23	7.8	1848	-242	20	1.2	24	-88
Avg	28	1.2	32	8.5	2518	27	1.2	32	7.2	2381	-168	27	1.2	32	-524
TREATMENT 2															
Te_2_01	24	0.9	22	8.2	1800	24	1.0	25	7.9	2049	249	24	1.0	23	15
Te_2_02	28	0.7	20	11.7	2383	20	1.0	20	6.6	1385	-999	24	0.9	20	-972
Te_2_03	20	0.8	16	5.8	943	22	1.1	25	7.6	1983	1040	21	1.0	21	421
Te_2_04	25	1.1	28	10.0	2829	26	1.1	27	7.3	2104	-725	25	1.1	28	-650
Te_2_05	19	1.0	19	8.4	1613	25	1.0	26	9.3	2520	906	22	1.0	23	311
Te_2_06	22	1.1	23	10.7	2516	27	1.0	28	8.1	2361	-154	25	1.0	26	-586
Te_2_07	25	1.0	25	9.9	2441	26	1.0	27	8.0	2257	-185	26	1.0	26	-399
Te_2_08	24	1.0	25	10.4	2563	23	1.1	24	6.7	1706	-857	24	1.0	24	-835
Te_2_09	23	1.0	22	7.5	1647	29	0.9	27	9.4	2678	1031	26	1.0	25	602
Avg	23	1.0	22	9.2	2082	25	1.0	25	7.9	2116	34	24	1.0	24	-233

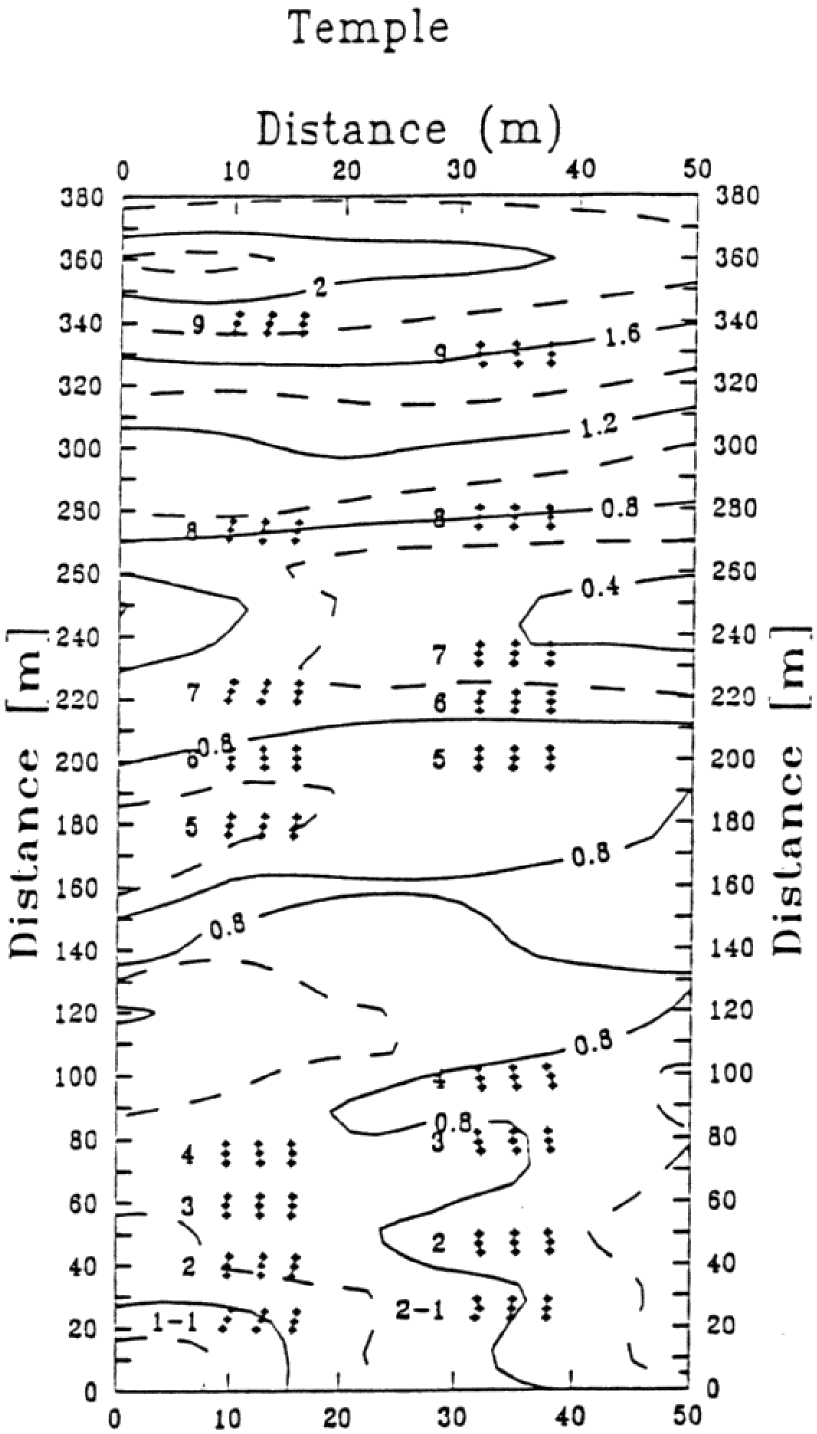

Figure IV.29: Templeman Tillage-2000 field site elevation contour map showing benchmark positions.

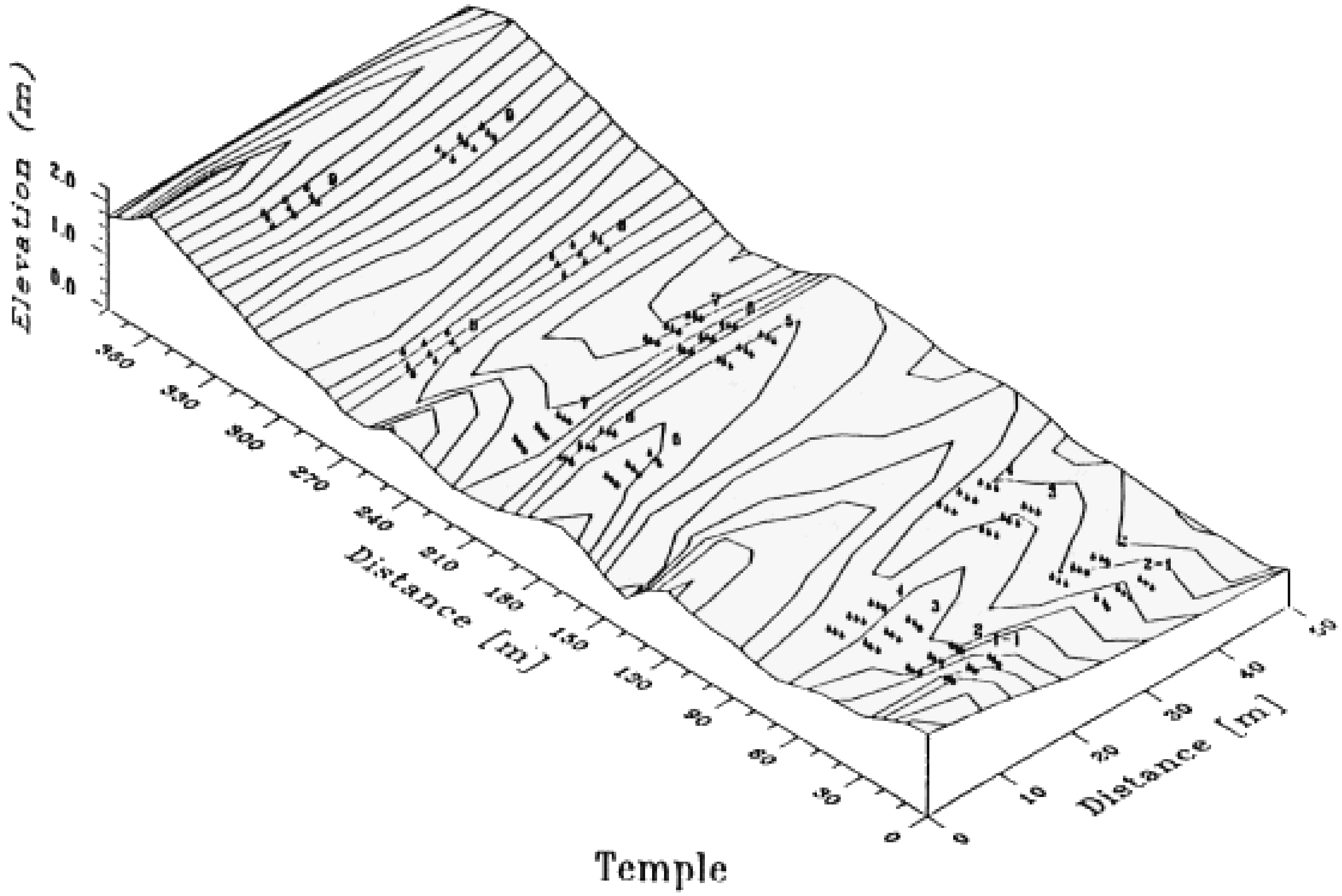

Figure IV.30: Templeman Tillage-2000 field site 3D relief map.