STRATFORD/AVON RIVER ENVIRONMENTAL MANAGEMENT PROJECT

EVALUATION OF TILLAGE DEMONSTRATION USING SEDIMENT TRAPS

Technical Report R-14

Prepared by:

Andrew Graham and
Gerald Knight
Rural Sub-Committee

PREFACE

This report is one of a series of technical reports resulting from work undertaken as part of the Stratford/Avon River Environmental Management Project (SAREMP) and the Thames River Implementation Committee (TRIC).

SAREMP was initiated in April 1980, at the request of the City of Stratford. It was funded by the Ontario Ministry of the Environment. The purpose of the project is to provide a comprehensive water quality management strategy for the Avon River basin. In order to accomplish this considerable investigation, monitoring and analysis has taken place. The outcome of these investigations and field demonstrations will be a documented strategy outlining the program and implementation mechanisms most effective in resolving the water quality problems now facing the residents of the basin. The project is assessing urban, rural and in-stream management mechanisms for improving water quality.

TRIC was formed in 1976 in response to a recommendation of the Thames River Basin Water Management Study carried out by the Ontario Ministries of Environment and Natural Resources. In 1980, these ministries committed funding for a three year work program to address the specific recommendations of the Water Management Study regarding both flood control and water quality issues. Ninety-five percent of the $788,000 three-year budget was directed at improving agricultural land management in an effort to reduce the adverse water quality impacts of rural diffuse sources.

This report results directly from the aforementioned investigations. It is meant to be technical in nature and not a statement of policy or program direction. Observations and conclusions are those of the authors and do not necessarily reflect the attitudes or philosophies of agencies or individuals affiliated with SAREMP and TRIC. In certain cases, results are interim in nature and should not be taken as definitive until such time as additional support data is collected.

Enquiries with respect to this report should be directed to the author or to:

Upper Thames River Conservation Authority
P.O. Box 6278, Station 'D'
London, Ontario N5W 5S1
(519) 451-2800

ABSTRACT

In order to demonstrate the erosion rate differentials of conservation tillage compared to conventional tillage, a series of four soil traps were constructed on sloping fields in the upper Avon River basin. On two separate five-acre plots, a moldboard plow was used, which buried the crop residues and exposed the soil surface to sheet and rill erosion. Adjacent plots were plowed with a mulch tiller, which left a greater percentage of residue on or near the surface. This residue gave greater protection against erosion while increasing infiltration of runoff. Soil collected from the moldboard-tilled plots versus the mulch-tilled plots revealed an average 5:1 soil loss ratio, with greater differences following intense periods of rainfall.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

The primary concerns of the Rural Sub-Committee of the Stratford/Avon River Environmental Management Project are non-point source sediment and phosphorus loadings to the Avon River and related watercourses. Efforts were made in 1981 and 1982 to demonstrate a variety of soil erosion and water quality control projects within a selected 'demonstration' sub-watershed, a 2-square mile area of the upper Avon River basin. Through the Stratford/Avon Project and the Thames River Implementation Committee, co-operative ventures were arranged with several landowners to determine the applicability of conservation tillage to agricultural systems where conventional tillage practices predominated. In order to demonstrate potential reductions of soil erosion where minimum tillage practices were implemented, adjacent plots were fall-tilled with a conventional moldboard plow and a mulch tiller, respectively. A series of 8-foot by 70-foot sediment traps were installed to measure relative rates of soil movement off the slope where the plots were located.

One of the tillage trial demonstration sites was selected for the installation and monitoring of a set of soil traps. The landowner, Mr. Robert Lantz, was co-operative, allowing project staff to carry out the demonstration in his field in 1981 and 1982. Slopes in the upper part of the field where the traps were located are 10-15%, and the soil represents a sandy loam with 63% sand, 29% silt and 8% clay. This field had been in continuous corn production for a number of years.

A second site was approved in the spring of 1982 on the property of Mr. Ron Hyde. Here relative soil movement would be measured in a field planted to spring grain following corn. Again two tillage plots were fall moldboard-plowed and fall mulch-tilled, respectively. Similar soil traps were installed and monitored over the 1982 season to provide additional data on relative soil movement under different field conditions. The soil type at the Hyde site represented a silt loam with 30% sand, 48% silt, and 22% clay. Slopes in this part of the field are 8-10%.

From these demonstrations, the anticipation was that measurements of relative rates of soil movement from the moldboard plots versus the mulch tilled plots would provide a basis for comparison of the effects of primary tillage on soil movement under actual field conditions. The demonstrations would be highly visible to local landowners while attracting significant attention from other farmers and professionals. Although a limited amount of data would be collected in the two-year study period, results from field monitoring and the actual soil collections could provide background information for recommendations on the application of conservation tillage to the lighter soils of the Avon River basin where erosion is a problem.

2.0 METHODS

The boundaries and collection units of the soil traps at the Lantz site were first installed in late winter of 1981 to monitor spring runoff. The control plot was located on an 11% convex slope; the conservation plot on a 14% concave slope. The slopes at the Hyde site where traps were installed in the summer of 1982 were 10% and uniform. The capacity of the collection units for handling expected flows and the manageability of the collected soil were the main considerations in determining plot dimensions. The plots also had to be long enough to duplicate the cumulative effect of runoff down the slope. For these reasons, and in order to isolate the runoff within the plot from that of the surrounding field, boundaries 8-feet in width by 70-feet in length were constructed of metal sheeting measuring 1-foot by 2-feet (Lantz site), and 8-inch by 8-foot strips of ¾-inch plywood (Hyde site), implanted 4-6 inches deep.

The collection units consisted of a trough for channelling runoff and a storage facility for each trap. The troughs are fabricated wi th 18-gauge galvanized sheet metal and run the full 8-foot width of the plots. Storage of captured materials was done by sinking galvanized 20-gallon containers below the outlets of the troughs and lining them with synthetic filter sacks which would trap sediment while allowing water to drain off through

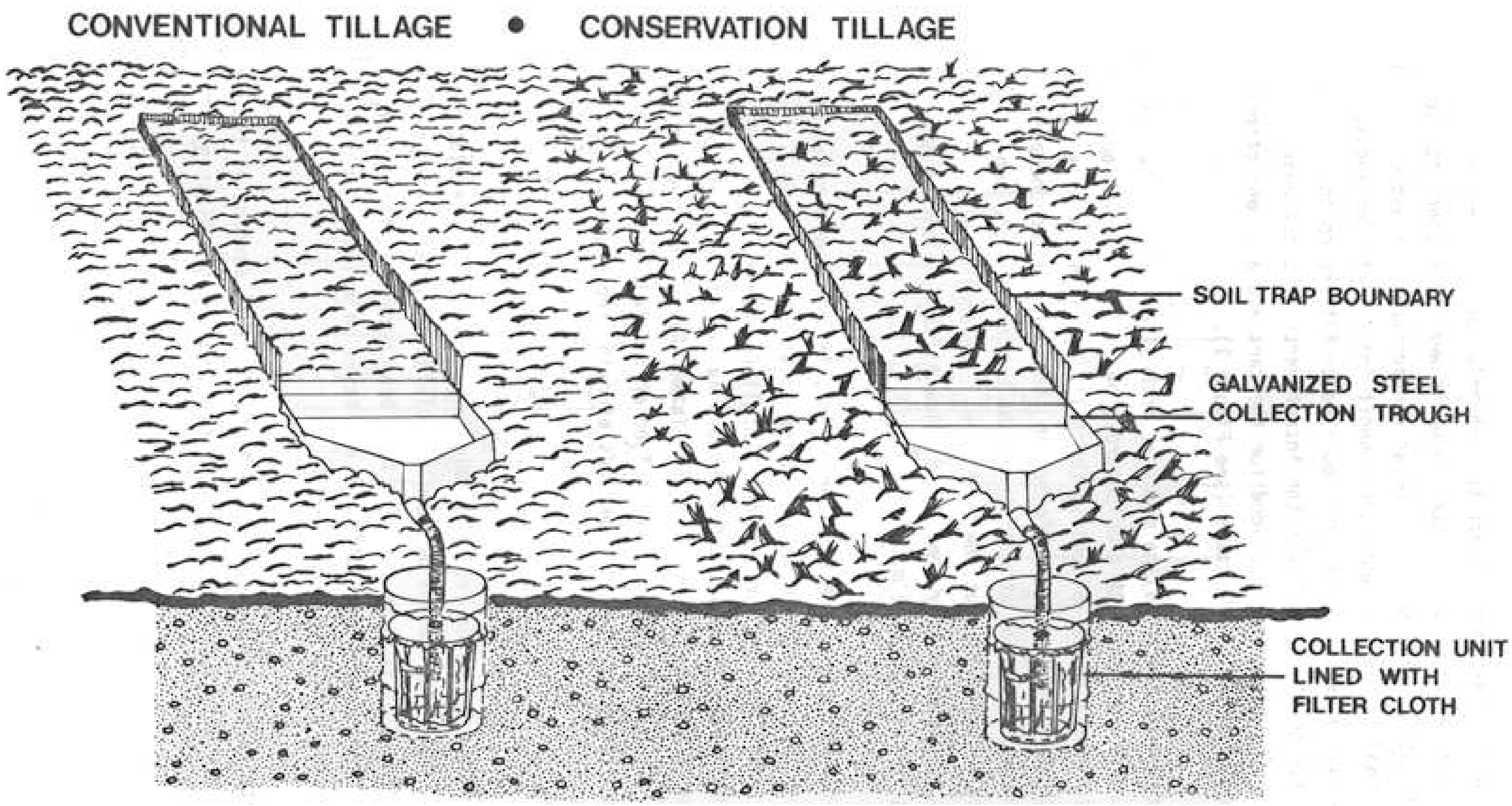

FIGURE 1: Soil Traps Plan View

holes drilled in the bottom of the containers. The storage units were then connected to the trough outlets with 6-inch diameter non-perforated plastic tubing to conduct the sediment-laden runoff into the filter sacks. Fifty-five gallon steel drums were modified to fit around the storage units and thus eliminate the interference of extraneous surface runoff. Lids were provided for the cans and all connections were secured with wire and stakes (see Figure 1).

The 5-acre conventional tillage plots at both sites were treated in the fall using one pass with a moldboard plow. The conservation tillage plots were chisel-plowed in the fall, again in a single pass. Secondary tillage was performed in the spring using one pass with a tandem disc/harrow attachment at the Lantz site, and two passes with a tandem disc at the Hyde site. The soil trap boundaries were temporarily removed to allow tillage, planting and harvesting operations to be made.

Daily rainfall data over the two-year period, 1981-82, were obtained by project staff from a rain gauge station located on the Hyde property. Additional information on rainfall for the spring runoff periods was gathered from a rainfall-recording station located south of Shakespeare and operated by the Upper Thames River Conservation Authority. This data enabled a comparison of rainfall and soil collections made after intensive periods of rain (see Table 1).

3.0 RESULTS

The data on soil collected from the four sediment traps is tabulated in Table 1. Soil-loss ratios between associated traps and extrapolations of this loss to tons per acre have been made and also appear in Table 1. Note that these estimates are based on a limited number of runoff events over a two-year period.

In field observations made by project staff, the soil surface of the moldboard plots was reported bare and nearly level by the planting date. As the season progressed, small rills

TABLE 1: SAREMP Soil Trap Data 1981-82

Collection Date	Site	Sediment Trapped		Soil Loss	Cumulative	Maximum Intensity
		Moldboard	Mulch Till	Ratio	Rainfall	Inches per hour
1981 RESULTS						
April 14	Lantz	12 lb. (0.5 T/A)	4 lb. (0.16 T/A)	3:1	1.27 in.*	0.17 iph*
April 24	Lantz	62 lb. (2.4 T/A)	6 lb. (0.2 T/A)	10:1	1.55 in.*	0.11 iph*
June 22	Lantz	4 lb. (0.16 T/A)	1.3 lb. (0.05 T/A)	3:1	1.57 in. (9 hrs. rain)	0.40 iph
September 9	Lantz	65 lb. (2.71 T/A)	1.2 lb. (0.05 T/A)	54:1	6.28 in. (24 hrs. rain)	0.57 iph
Cumulative Results - 1981	Lantz	143 lb. (5.6 T/A)	12.5 lb. (0.5 T/A)	11:1	10.67 in.	
					* U.T.R.C.A. wildwood data	
1982 RESULTS						
April 14	Lantz	36.5 lb.	24.6 lb.	1.1:1	0.4 in. (7 hrs. rain)	0.15 iph
June 8	Hyde	1.76 lb.	0.96 lb.	1.8:1	0.96 in. (14 hrs. rain)	0.16 iph
June 23	Lantz	23.0 lb.	8.2 lb.	3:1	1.68 in. (9 hrs. rain)	0.61 iph
	Hyde	7.33 lb.	1.14 lb.	7:1	1.68 in. (9 hrs. rain)	0.61 iph
July 21	Lantz	8.57 lb.	1.15 lb.	8:1	2.20 in. (3.5 hrs. rain)	0.73 iph
August 3	Lantz	6.49 lb.	1.63 lb.	4:1	1.12 in. (9 hrs. rain)	0.37 iph
Cumulative Results - 1982	Lantz	74.6 lb. (2.9 T/A)	35.6lb. (1.4 T/A)	2:1	5.4 in. (28 hrs. rain)	

began to form down these plots and sheet erosion was manifested by the silting-in of the furrows at the lower end of the soil traps. This effect was not visibly duplicated on the conservtion tillage plots where the crop residue stabilized the soil surface.

Staff working with the Thames River Implementation Committee on the tillage demonstrations, estimated percent residue covers for the different treatments. After 1981 primary tillage on the Lantz moldboard plot a 1% residue cover was reported, compared to a 25% cover on the conservation plot. After secondary tillage, residue covers were estimated at 0% and 22%, respectively. 1982 results on the same plots following primary tillage showed an increase to 6% cover for the moldboard plot and 46% for the conservation plot. After secondary tillage, residue covers were estimated at 8% and 42%, respectively. Residue covers for the Hyde plots were estimated as follows: after primary tillage using a moldboard plow, 3% cover; using a mulch tiller, 59% cover. After secondary tillage the results were 6% cover on the moldboard plot and 47% on the mulch tiller plot[1].

4.0 DISCUSSION

4.1 Residue Factors

The results from the soil traps suggest that residue cover may significantly reduce erosion on sloping lands. Erosion is a three-part process: 1) detachment of particles from the soil mass, 2) particle transport, and 3) deposition. Rainfall energy is the major factor influencing the detachment process. Crop residues absorb the kinetic energy of raindrops and thus prevent the breakdown and subsequent transport and deposition of soil particles. Residues left on or near the soil surface also reduce the velocity of runoff, while promoting infiltration, thus contributing to lower soil loss rates. Other factors influencing the erosion

1 J. Sadler-Richards, Thames River Implementation Committee, personal communication.

process are detailed in associated technical reports prepared on behalf of the Stratford/ Avon Project (Technical Reports R-4, R-5).

4.2 Soil Factors

4.2.1 Lantz Site

The soil found at the Lantz site is a Waterloo sandy loam. A particle size analysis of a representative sediment sample taken from a collection of trapped soil, revealed 54% sand, 44% silt and 2% gravel. The soil has a high permeability, particularly on the mulch tillage plot where the partially incorporated residues further increase infiltration rates. The soil surface of the moldboard test plot was free of residue cover in the spring of 1982 and the furrows had been levelled by the effects of rainfall and surface runoff. These conditions increase both the volume and velocity of runoff as it moves down-slope, with subsequent increases in sheet and rill erosion.

Other factors influencing the soil loss ratios of the Lantz sediment traps may be briefly stated. Antecedent moisture conditions may have caused the greater collected weight of sediment for the April 24 and September 9, 1981 runoff events (see Table 1). Dense growth of green foxtail may have interfered with the 1981 results on the mulch tillage plot where the grasses grew in at the upper and lower ends of the trap boundaries. According to the landowner, this section of the field had not been sprayed in the spring of 1981 as was the rest of the field.

4.2.2 Hyde Site

The soil found at the Hyde site is a Perth silt loam. Particle sizes in a representative sample taken from the collection trough was determined by analysis to be 39% sand, 47% silt, and 14% clay. A lens of heavy clay approximately three feet below grade restricted sub-surface drainage at the sediment trap location, thus limiting the frequency of the 1982 collections. After major storm events the collection units often filled with runoff from the enclosed 560-square foot area and measurements could not be taken with accuracy.

4.3 Slope Factors

Erosion rates are sensitive to both the degree and shape of a slope. Erosion on convex slopes may be as much as five times greater than on uniform slopes, while rates on concave slopes are much less than those on uniform slopes[2]. In 1981, the sediment trap located in the moldboard plot of the Lantz site was on a convex 11% slope, with the mulch tillage trap on a concave 14% slope. Both primary tillage operations on the Lantz site were carried out up-and-down the slope. Secondary tillage in the spring and planting was done cross-slope. These differences in degree, aspect and shape should be considered in analyzing the 1981 results appearing in Table 1. The soil traps were relocated to a uniform 10.5% slope for the 1982 season. Over the 1982 collection period primary and secondary tillage operations and planting was carried out cross-slope.

To properly measure soil loss from an area using this trap method, plots are required which will allow replication of the cumulative effect of surface runoff as it flows downhill. The standard experimental plot used for these types of studies is 6-feet by 72.6-feet[3]. These dimensions were selected on the basis of anticipated runoff from a plot of this size, as well as on the feasibility of collecting the resulting sediment. Each soil trap constructed by the Stratford/Avon Project measured 8-feet by 70-feet, enclosing an area of 560-square feet. It is suggested that if the soil lost from a plot of 1076-square feet is measured to the nearest 0.1 pounds, this corresponds to an estimate of soil loss to the nearest 10 pounds per acre[4]. Extrapolations of the 1981 and 1982 results from the present work have been made in pounds of soil lost per acre and appear in Table 1.

---

2 Li, R.M., D.R. Carder, D.B. Simons, "Soil Erosion by Overland Flow", in Soil Erosion: Prediction and Control, S.C.S.A.: Ankeny, Iowa, 1977, p.210.

3 Hudson, N., Soil Conservation, Ithaca, N.Y.; Cornell University Press 1971, p.268.

4 Ibid. p .272

4.4 Alternate Methods

Alternate methods of soil loss measurements from trial plots have been in use at Canadian research stations for varying periods of time (e.g. Central Experiment Farm, Ottawa; Hydrology Station, University of Guelph). Quantitative measurements may be more accurately obtained from permanent plots such as these; however, the intent of the Stratford/Avon Project's sediment trap demonstration, with the use of temporary in-field plots, provides a direct measurement of soil loss under actual field conditions. Although these measurements are not as robust as those performed under the controlled conditions of a fixed experimental plot, the results may well suggest the order of magnitude of the soil loss on the comparative tillage plots.

Similar soil-loss study undertaken at the Hydrology Station, University of Guelph, involved chisel plowing and moldboard plowing on 7-9% slopes[5]. Two years of data have been collected from controlled runoff plots measuring 15 feet wide and 150 feet long. Flumes, continuous recorders and holding tanks were used to collect and store runoff over a three-month period beginning with seedbed preparation and ending once 100% canopy cover had been established. An average of 2 years data revealed a 4:1 soil loss ratio between conventional versus conservation tillage . Soil loss from the moldboard and chisel plows under secondary tillage were 7.5 tons per acre and 1.4 tons per acre respectively. Discounting the highest and lowest figures for the Stratford/Avon Project's work at the Lantz site (Table 1), the average soil loss ratio between the moldboard versus the mulch tillage plot was determined to be 5:1 (2 years data) . Estimations of soil loss in tons per acre per year based on the universal soil loss equation for the Lantz site, for the two year study period, are 4.5 tons per acre for the moldboard plot and 1.0 ton per acre for the mulch tillage plot.

---

[5] Vyn, T.J., T.B. Daynard, J.W. Ketcheson, J.H. Lee, "Progress in Tillage Research for Corn Production", Information for Industry Personnel, Guelph: O.M.A.F. Agdex 111/516, 1981.

Both the Guelph results and the USLE values compare favourably with cumulative results in Table 1. Differences arise since various parameters in the Guelph research differ from the Stratford/Avon approach: 1) slopes of 7-9% vs. 10-12%, 2) spring vs. fall primary tillage, 3) loam vs. sandy loam (Lantz site), 4) chisel plow vs. mulch tiller, 5) two discings vs. one discing, and 6) soil loss values averaged yearly over 4 months vs. 9 months. The ratios between the moldboard plot and the chisel plot point to similar reductions in soil loss when increased residue cover is maintained using conservation tillage practices.

5.0 CONCLUSIONS

Annual crops such as corn do not provide cover early in the season when the potential for soil erosion is high. Furthermore, conventional tillage practices bury most of the crop residues and leave the soil surface exposed to sheet and rill erosion. Residue management practices such as mulch tillage provide protective soil cover throughout the year while building soil structure and improving drainage. Based on the results to date, the sediment traps suggest that a significant reduction in erosion can result from conservation tillage .

STRATFORD-AVON RIVER ENVIRONMENTAL MANAGEMENT PROJECT
LIST OF TECHNICAL REPORTS

S-1 Impact of Stratford City Impoundments on Water Quality in the Avon River
S-2 Physical Characteristics of the Avon River
S-3 Water Quality Monitoring of the Avon River - 1980, 1981
S-4 Experimental Efforts to Inject Pure Oxygen into the Avon River
S-5 Experimental Efforts to Aerate the Avon River with Small In-stream Dams
S-6 Growth of Aquatic Plants in the Avon River
S-7 Alternative Methods of Reducing Aquatic Plant Growth in the Avon River
S-8 Dispersion of the Stratford Sewage Treatment Plant Effluent into the Avon River
S-9 Avon River In-stream Water Quality Modelling
S-10 Fisheries of the Avon River
S-11 Comparison of Avon River Water Quality During Wet and Dry Weather Conditions
S-12 Phosphorus Bioavailability of the Avon River
S-13 A Feasibility Study for Augmenting Avon River Flow by Ground Water
S-14 Experiments to Control Aquatic Plant Growth by Shading
S-15 Design of an Arboreal Shade Project to Control Aquatic Plant Growth

U-1 Urban Pollution Control Strategy for Stratford, Ontario - An Overview
U-2 Inflow/Infiltration Isolation Analysis
U-3 Characterization of Urban Dry Weather Loadings
U-4 Advanced Phosphorus Control at the Stratford WPCP
U-5 Municipal Experience in Inflow Control Through Removal of Household Roof Leaders
U-6 Analysis and Control of Wet Weather Sanitary Flows
U-7 Characterization and Control of Urban Runoff
U-8 Analysis of Disinfection Alternatives

R-1 Agricultural Impacts on the Avon River - An Overview
R-2 Earth Berms and Drop Inlet Structures
R-3 Demonstration of Improved Livestock and Manure Management Techniques in a Swine operation
R-4 Identification of Priority Management Areas in the Avon River
R-5 Occurrence and Control of Soil Erosion and Fluvial Sedimentation in Selected Basins of the Thames River Watershed
R-6 Open Drain Improvement
R-7 Grassed Waterway Demonstration Projects
R-8 The Controlled Access of Livestock to Open Water Courses
R-9 Physical Characteristics and Land Uses of the Avon River Drainage Basin
R-10 Strip cropping Demonstration Project
R-11 Water Quality Monitoring of Agricultural Diffuse Sources
R-12 Comparative Tillage Trials
R-13 Sediment Basin Demonstration Project
R-14 Evaluation of Tillage Demonstration Using Sediment Traps
R-15 Statistical Modelling of In-stream Phosphorus
R-16 Gully Erosion Control Demonstration Project
R-17 Institutional Framework for the Control of Diffuse Agricultural Sources of Water Pollution
R-18 Cropping-Income Impacts of Management Measures to Control Soil Loss
R-19 An Intensive Water Quality Survey of Stream Cattle Access Sites