STRATFORD / AVON RIVER ENVIRONMENTAL MANAGEMENT PROJECT

GULLY EROSION CONTROL DEMONSTRATION PROJECT

Technical Report R-16

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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).

This two-year project was initiated in April 1980, at the request of the City of Stratford. The S.A.R.E.M.P. is funded entirely 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. Considerable effort involving field investigations, monitoring, and demonstration of remedial measures has been involved in the project analysis has taken place. The resulting strategy will outline the program and implementation mechanisms most effective in resolving the water quality problems now facing residents of the basin. Urban, rural and in-stream management mechanisms for improving water quality have been assessed to provide a basis for determining optimum restorative measures.

This report results directly from the rural demonstration efforts. 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 philosophy of all agencies and individuals affiliated with the project. In certain cases the results presented are interim in nature and should not be taken as definitive until such time as additional support data is collected.

Reference to equipment, brand names or supplies in this publication is not to be interpreted as an endorsement of that particular product or supplier.

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ABSTRACT

- Stratford/Avon River Environmental Management Project
- Rural Sub-Committee
- Gully Erosion Control Demonstration

Two demonstrations of gully erosion control were carried out on a co-operator's property in the demonstration sub-watershed of the Avon River during 1981. The construction of a rock chute and the installation of a drop-inlet structure with tile outlet protection served to demonstrate two both simple and economical means of controlling a common erosion problem. Such methods of stabilizing the gullies proved quite acceptable to the landowner while providing a future reduction of sediment contributions to the private drain receiving the discharge.

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1.0 INTRODUCTION

Although gully erosion is often not as serious or significant as sheet and rill erosion in reducing agricultural production or in contributing sediment to streams, it is more noticeable and presents a major local problem if left unchecked. Any concentration of surface runoff is a potential source of gullying. Channelling of runoff can be initiated by dead furrows, livestock trails, or other wall depressions on sloping land[1]. Once a gully starts, the erosion is nearly always self-perpetuating as the gully head cuts back upland, increasing in size as soil is eroded by the waterfall action of runoff. In cases where the repair of gullies does not directly affect agricultural production, it may be necessary to control the erosion for reasons other than the obvious loss of land. Downstream effects of sediment contributions, such as sedimentation of drainage channels and a lowering of water quality, must be considered as serious impacts of gully erosion[2].

The first consideration in gully erosion control is the reduction of runoff from the surrounding cropland through land management practices such as conservation tillage, contouring, stripcropping, and the use of cover crops. Where conservation measures are not applied on unprotected slopes, increased sheet and rill erosion may result in gullying either on the field or in surface drains and natural depressions in the land surface. Gullies occurring in such in-field drainage courses may be stabilized with grassed waterways and check dams, or with other vegetation such as trees and shrubs where the gully need not be shaped to permit operation of farm implements.

The present report concerns gully erosion which results when surface runoff reaches an outlet where there is an abrupt change in channel gradient. The resulting erosion of the drain banks and of agricultural land requires the stabilization of the gully by permanent structural means. Conservation water control structures, such as drop spillways, earth berms, and drop inlets, or chute spillways, may be used to dissipate the energy of the falling water and reduce velocities to non-erosive levels.

Two gully erosion sites were identified alongside a private drain on the property of Jim Horne. The Stratford/Avon Project staff approached the landowner with technical and

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1 Schwab, G.O., Frevert *et. al.* Soil and Water Engineering, N.Y.: Wiley and Sons, 1971, p. 140

2 Hudson, N., Soil Conservation, Ithaca, N.Y.: Cornell University Press, 1971, p. 216.

financial assistance towards implementing erosion, control measures on these sites. Economical means of controlling this common problem were demonstrated through the installation of drop structures on this property.

2.0 STUDY AREA AND METHODS

2.1 Description of Study Area

The first gully site on Mr. Horne's property, was approximately 4 feet deep and 3 feet wide. A small depression above this gully drained some 5 acres of pasture. Surface runoff entering the private drain through this depression was primarily responsible for the gullying, although a 4-inch diameter clay field tile also entered the drain at this point. The lack of a proper tile outlet caused the tile sections to be undercut one by one. This contributed to a lengthening and deepening of the gully, which had cut some 6 feet into the field.

A second gully site was located along the banks of the same drain . A dead furrow ran up and down the gentle slope and ended near a natural depression in the field. Here, runoff from the approximately 3-acre drainage area had broken through the lip of the ditchbanks, and had eroded the bank as it dropped into the drain. A small gully eventually formed, approximately 3 feet wide by 2 feet deep as it stretched back into the field. Again an 8-inch diameter clay tile without proper outlet protection was partially at fault for causing undercutting and gully erosion.

If left unchecked, these two problem areas would continue to erode, resulting in a loss of soil from the field, and contributions to downstream siltation problems. As the cost of repairing these two gullies would be relatively low and since the problems were of such a visible nature, the landowner had no hesitation in co-operating with project staff. Details of the 60% cost-sharing offered by the Stratford/Avon Project are given in the Engineering Practice Agreement (see Appendix), and were agreed to by the co-operator prior to construction.

2.2 Drop Inlet Structure Construction Methods

Since the characteristics of the two gullies differed, different methods were used to stabilize them and control erosion. The larger of the two gullies occurred where the banks of the drain were approximately 6 feet in height. Due to this abrupt change of grade it was decided that a drop inlet structure would be best suited to conduct runoff safely from the upland area into the drain.

A 4-foot section of 16-gauge corrugated steel pipe, 18 inches in diameter, was outfitted for this purpose. A 3-foot square piece of sheet metal was first welded to the bottom of the pipe to serve as a base for the structure, and a grate was fitted to the top of the inlet to keep debris from entering and clogging the pipe. A 5-inch hole was then cut one foot from the bottom of the pipe to accommodate the existing clay tile and to allow a percentage of suspended sediment to be trapped before it could enter the watercourse. This sediment would need to be cleaned out periodically. A section of 4-inch plastic tile was used to connect the clay tile to the drop inlet, and joints were sealed with a concrete mixture. A second hole was cut opposite and slightly below the tile inlet where a 10-foot outlet pipe of 20-gauge, 6-inch diameter corrugated steel was installed. This outlet pipe extended into the drain proper and was protected with stone rip-rap and a splash pad (see Figure 1).

With the completed structure in place, the bank of the drain was built up with field stone taken from adjacent fence rows, and earth fill transported from another part of the farm. This fill was then compacted and a small berm was built behind the inlet to contain surface flows and direct them into the drop inlet structure. Grass sod was laid over the surface of the berm, and rocks underlain with filter fabric were placed around the inlet to reduce scouring and local erosion.

2.3 Rock Chute Construction Methods

The smaller of the two gullies had formed further upstream where the banks of the drain were 2-3 feet high. Here the surface runoff did not drop abruptly into the drain as before, but had cut a channel through the bank which was in danger of becoming wider and deeper. An 8-inch diameter clay tile had been exposed by the gully erosion and would have to be protected.

To channel the surface runoff safely into the drain, and to provide proper outlet protection for the tile, a rock chute was planned for this site. Project staff had previous experience in assessing the need for such structures in protecting the outlets of grassed waterways, as well as in constructing them according to specific design criteria.

In this case a formal plan was not drawn up for the rock chute. The small drainage area involved and the existing gully size were indications of the rate and &mount of flow which could be anticipated entering the drain at this point. A 4:1 slope would be achieved using an 8-foot width and 15-foot length as dimensions for the chute.

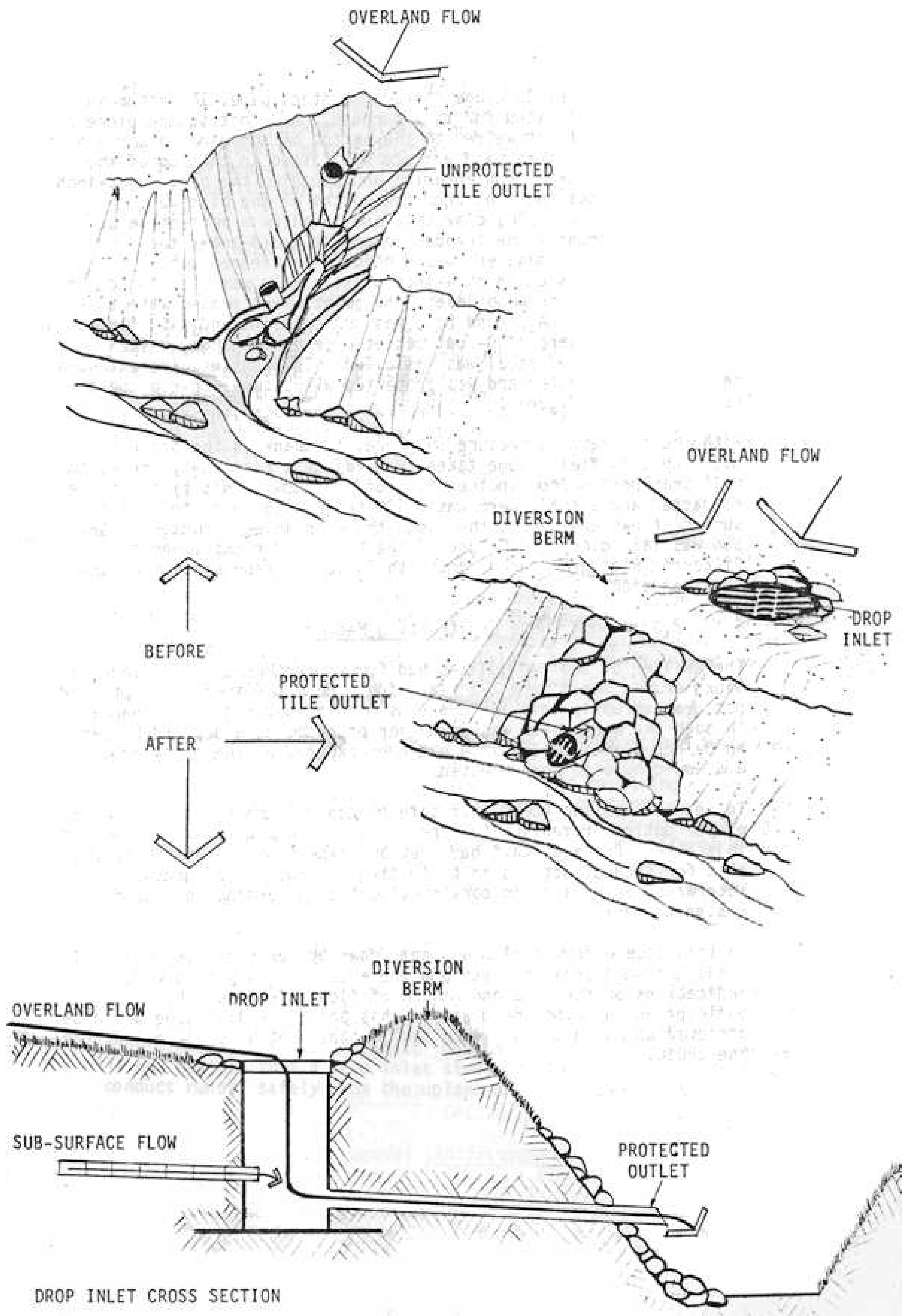

Figure 1: Drop Inlet Structure

The general trapezoidal shape of the chute was first excavated by hand with an 8-12 inch toe dug in above and below the chute. Synthetic filter cloth was then laid in place. This material would hold the soil in place and effectively prevent undermining of the structure by bank seepage and by water scouring beneath the rocks.

A 10-foot length of 16-gauge, 10-inch diameter corrugated steel pipe with rodent guard was then connected to the clay tile to serve as a proper outlet. Various grades of rocks were brought to the site by the landowner using his own equipment. Project staff placed these in the chute at a minimum one-foot depth. A splash pad for the tile outlet was provided with some regrading at the upper end of the chute (see Figure 2).

2.4 Cost of Materials

A list of materials used and their associated costs is presented in Table 1, below. These figures represent the total used in calculating the 60% capital cost subsidy offered to the co-operator by the Stratford/Avon River Environmental Management Project, according to the Engineering Practice Agreement (Appendix). A breakdown of this sum gives approximate costs of the drop inlet structure and rock chute as: $77.56 and $97.24, respectively.

These costs do not include labour costs which were covered by SAREMP.

3.0 RESULTS

The drop structures were installed in mid-November of 1981, and although the soil was saturated by heavy rainfall, no surface runoff occurred which would test the structures for function and design.

It is expected that this runoff will occur principally in the spring during snowmelt, and as a result of intense summer storms or periods of wet weather. Given the characteristics of the two small drainage areas, the drop structures should operate virtually maintenance-free and effectively convey surface runoff to the drain.

Both structures were relatively simple to install by hand and did not incur high costs or require extensive materials. The 60% cost-sharing offered by the Stratford/Avon Project had some influence on the landowner's willingness to implement these erosion control measures. In this case, however, the low total material costs involved and the encouragement and technical advice of Project staff were perhaps of greater significance.

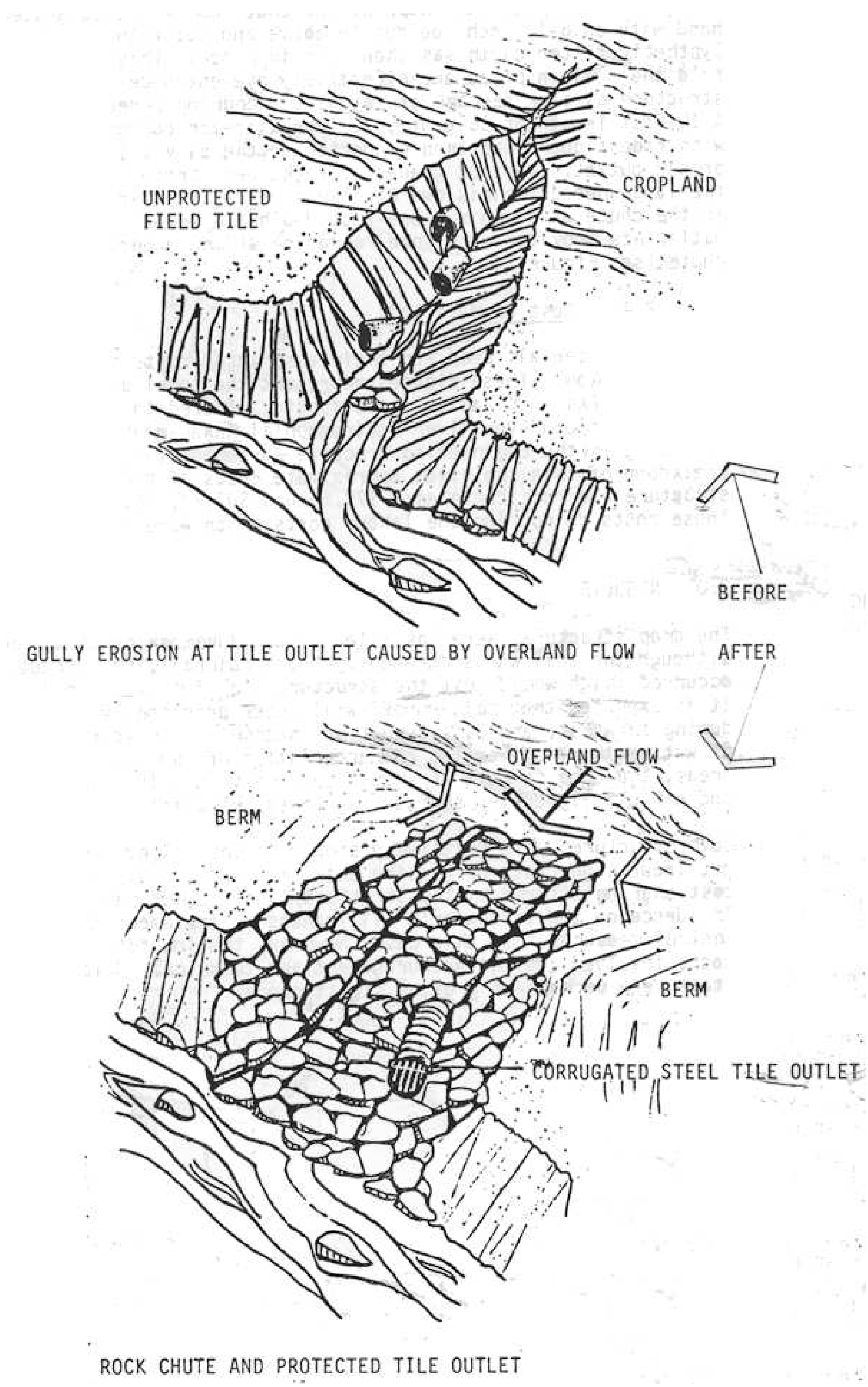

FIGURE 2: Rock Chute Structure

TABLE 1: Material And Equipment Costs

ITEM	UNIT COST	TOTAL COST
20 Gauge Corrugated Steel Tile Outlet, 15.2 cm x 3 m - 1	$32.00	$32.00
16 Gauge Corrugated Steel Tile Outlet, 50.8 cm x 3 m - 1	57.64	57.64
Corrugated Steel Drop Inlet with Steel Gate, 45.7 cm x 1.2 m	45.56	45.56
Nicolon 100-08 Synthetic Filter Material - 80 ft^2	0.22	39.60
TOTAL		174.80

4.0 DISCUSSION AND CONCLUSIONS

The delivery ratio of soil eroded from gullies is very high since that soil falls directly into the stream3. The intended impact of these gully erosion control demonstrations is to reduce the direct delivery of sediment to the drain by protecting the bank and by preventing the extension and enlargement of the gully into the field. In the case of smaller gullies such as these, it may be feasible to reclaim part of the gully for production by backfilling with topsoil once a stable outlet structure for containing surface runoff has been provided.

Many of the gully erosion problems observed in the Avon River basin are associated with erosion along drains and streambanks. These gullies may appear as little more than washouts where surface runoff has collected and subsequently broken through the bank of the drain. They impede the farmer's field work, reduce crop area and cause an impairment of water quality through sedimentation and associated nutrient loadings to the stream.

Erosion control structures are used to restore the balance which has been upset by natural and man-made causes. These are merely 'curative' measures, however, and if they are not combined with improved land management practices which will reduce the erosion potential of the land surface itself, the utility and lifespan of these structures may be reduced. Such conservation practices which could be applied on productive land might include the use of grassed waterways to control erosion in drainageways, conservation tillage to promote infiltration and reduce surface runoff velocity, and various cropping management techniques such as cross-slope farming, strip cropping, and the establishment of vegetated field borders along drains.

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[3] Ibid, p. 288

APPENDIX 1: ENGINEERING PRACTICE AGREEMENT

This agreement between:

Jim Horne, Co-operator

and

STRATFORD/AVON RIVER ENVIRONMENTAL MANAGEMENT PROJECT (SAREMP)

1. The Co-operator agrees to assist the **SAREMP** with implementation of the following soil conservation practices on his property as noted below:

- **Rock Chute Structure**
- **Drop Inlet Structure**
- **Both are to control gully erosion caused by surface and sub-surface flow entering an open drain at the same point.**

2. The Co-operator agrees that for the purposes of demonstration, practices shall be accessible for viewing by others, that photographs may be taken for documenting the success of the practice, and that a sign may be installed identifying the practice as part of a **SAREMP** Project.

3. The **SAREMP** and the Co-operator jointly agree to undertake the above-noted demonstration in accordance with this Agreement and the plans and specifications attached hereto.

4. Modifications to the demonstration specifications and/or Agreement may be made in the future, subject to the approval of both Co-operator and **SAREMP**.

5. The **SAREMP** agrees to have a staff member or representative at the site to oversee the implementation of the demonstration, according to the demonstration specifications. If none are available, the Co-operator agrees to keep detailed records on all activities at the site during that period.

6. The Co-operator agrees to have at the demonstration site, in working order, those machines to be provided by him, as stated in the demonstration specifications. The Co-operator should be available to operate such tractors and/or machinery.

7. The **SAREMP** agrees to document changes in each project (eg. grass establishment on grassed waterways), throughout the life of the demonstration.

8. The Co-operator agrees to maintain the demonstration according to the specifications, for at least 3 years from the time of installation.

9. Should the **SAREMP** staff or the Co-operator note any problems that could jeopardize the success of the demonstration, both parties will be notified, and mutually acceptable, appropriate, corrective measures undertaken.

10. The Co-operator agrees not to undertake any cultural practices in the demonstration area without the consent of the **SAREMP** staff.

11. The **SAREMP** agrees to inform the Co-operator when a tour stop is to be made at the site, and will invite, on occasion, the Co-operator to attend the site while the tour is being conducted.

12. The **SAREMP** agrees to pay 60% of the total cost (exclusive of project staff and Co-operator labour), of the engineering practices noted above, subject to the satisfactory completion of the project and the provision of acceptable invoices.

13. Financial assistance will be made available by **SAREMP** in the following manner:

-100% of the cost will be paid initially by SAREMP

- 40% of the Total Capital Cost will be invoiced back to the Co-operator upon completion of the Demonstration Project

14. The Co-operator agrees to release the project, its staff and associated agencies from all liability which might arise as a result of the activity proposed.

____________________________	____________________________
Co-operator	Program Co-ordinator

Date: Nov. 16, 1981

APPENDIX 2

METRIC EQUIVALENTS

LENGTH

inch	= 2.54 cm	millimetre	= 0.039 in.
foot	= 0.3048 m	centimetre	= 0.394 in.
yard	= 0.914 m	decimetre	= 3.937 in.
mile	= 1.609 km	metre	= 3.28 ft

AREA

square inch	= 6.452 cm^2	cm^2	= 0.155 sq in.
square foot	= 0.093 m^2	m^2	= 1.196 sq yd
square yard	= 0.836 m^2	km^2	= 0.386 sq mile
square mile	= 2.59 km^2	ha	= 2.471ac

VOLUME (DRY)

cubic inch	= 16.387 cm^3	cm^3	= 0.061 cu in.
cubic foot	= 0.028 m^3	m^3	= 31.338 cu ft
cubic yard	= 0.765 m^3	hectolitre	= 2.8 bu
bushel	= 36.368 litres	m^3	= 1.308 cu yd
board foot	= 0.0024 m^3		

VOLUME(LIQUID)

fluid ounce(imp)	= 28.412 ml	litre	= 35.2 fluid oz
pint	= 0.568 litre	hectolitre	= 22 gal
gallon	= 4.546 litres		

WEIGHT

ounce	= 28.349 g	gram	= 0.035 oz avdp
pound	= 453.592g	kilogram	= 2.205 lb avdp
hundredweight(imp)	= 45.359 kg	tonne	= 1.102 short ton
ton	= 0.907 tonne		

PROPORTION

1 gal/acre	= 11.232 litres/ha	1 litre/ha	= 14.24 fluid oz/acre
1 lb/acre	= 1.120 kg/ha	1kg/ha	= 14.5 oz avdp/acre
1 lb/sq in.	= 0.0702 kg/cm^2	1 kg/cm^2	= 14.227lb/sq in.
1 bu/acre	= 0.898 hl/ha	1 hl/ha	= 1.112 bu/acre

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