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Report on follow-up visit technical exchange program Malaysian sugar industry 15 to 31 January 1983

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FOLLOW-UP REPORT
TECHNICAL EXCHANGE PROGRAM
MALAYSIAN SUGAR INDUSTRY
(15TH JANUARY TO 31ST JANUARY 1983)

LAND USE AND SOIL CONSERVATION

BY
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Technical Exchange Program
Malaysian Sugar Industry
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R.M. Stephens

Soil Conservation Branch
May 1983
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1.0 SUMMARY AND RECOMMENDATIONS

The program of soil and water conservation on Perlis, Felda and Padang Terap sugar plantations commenced following the visit of Queensland soil conservationists in February/March 1982. Field management staff of the plantations participated in a workshop which studied the situation and devised measures for the protection and improvement of a pilot area selected because of its history of erosion and related problems.

The report provided after the visit outlined the problems and the solutions adopted as a result of the workshop. It also contained recommendations for the development of the water resources of the plantations and the integration of land use, erosion control and irrigation needs into overall catchment based plans that could be completed progressively over a five year period.

The present report covers the follow-up visit made in January 1983 to evaluate the measures employed in the pilot area and discuss modifications, improved techniques and programming needs with plantation managers.

Progress made since the initial visit was outstanding with almost 1,000 hectares protected by soil conservation measures and more than 20 new water storages completed. Management and staff have received encouragement in the form of a much improved harvest in 1983 as a result of improved techniques and a wider than usual rainfall distribution. Some problems exist with the stabilisation of waterways but on the whole the measures adopted have performed very well and all plantations are actively following programs of implementation.

Some modifications to techniques and design criteria are suggested and further recommendations are made. However the recommendations made in the initial report remain as basic requirements of a program of improvement and are repeated here for that reason.

Recommendations of the 1982 report:

1. That a 5 year program of erosion control and soil improvement be adopted on each plantation.

2. That surface water supplies be developed making use of low cost earth dams and weirs with grassed spillways.

3. That irrigation supplies and layouts be developed in close association with soil conservation work.

4. That priority be given to the treatment of better class land that will yield a higher return.

5. That unsuitable over-steep land be phased into another more appropriate use as this becomes feasible.

6. That staff be appointed to each plantation to carry out soil conservation and irrigation planning, design and supervision.
9. That opportunities be taken to take simple measurements of rainfall, runoff and water flow to validate and develop the criteria adopted for design purposes.

10. That use be made of concrete or metal structures to control overfalls where vegetative control is impracticable.

11. That following a familiarisation period, staff appointed in accordance with recommendation 6 of the 1982 report spend a suitable period in Queensland to widen their knowledge and experience.

12. That a further visit by Queensland soil and water conservation specialists be considered to consolidate the progress that has been made.

2.0 INTRODUCTION

The soil and water conservation program commenced in February 1982 with a five week visit by two officers of the Soil Conservation Branch of the Queensland Department of Primary Industries. This program comprised an assessment of the problems on the plantations followed by a course of instruction for field managers on land use planning, land management and soil conservation. The course was held on Perlis Plantation and featured field exercises in which the participants analysed the problems and, under the guidance of the Queensland Soil Conservationists, worked out solutions. It included the design, layout and construction of runoff control measures within overall catchment plans on selected pilot areas on Perlis and Padang Terap Plantations. Land evaluation and the classification of land into units requiring similar treatment and management formed an important part of the program. Other aspects covered were improved cultivation and planting methods, soil improving practices and the potential place of irrigation in the industry. A report was prepared which contained an evaluation of the situation together with recommendations, design criteria and other information felt to be useful in the program of improvement that was suggested.

The initial program provided for a follow-up visit after a suitable interval to evaluate its effectiveness, modify recommendations in the light of experience with the pilot projects and provide such further assistance as appeared necessary. This visit was made between 15 and 31 January, 1983 and comprised the leader of the initial program, Mr R.M. Stephens and Mr J. Cantor of the Farm Water Supply Section of the Queensland Water Resources Commission. The inclusion of Mr Cantor resulted from a recommendation in the initial report that the follow-up should include an irrigation specialist able to advise on the conservation of water, its management as a resource and the most suitable methods of application.

2.1 Aims of the Follow-up

The aims of the follow-up were, first to evaluate the work carried out on the pilot areas, then to discuss with field managers their experiences with the project, its strengths and weaknesses and finally, to determine any need for modification of design criteria, construction methods, or layout design. Two days were spent on each
needs of land use planning have been kept in mind. Of the areas due for replanting, some have needed drainage, some require no special treatment, some have been treated with contour banks and some have been taken out of cane production because of unsuitable slopes and soils. Some of this land has been planted to rubber, mango and cashew nut trees and the prospects for macadamia nuts are under investigation.

Use has been made of an area of land beneath a high voltage powerline to establish a grass nursery as a source of planting material for waterways in future years. The preparation and grassing of waterways is a matter of particular importance in the program. Problems were experienced in the pilot area because the waterways were constructed far too late in the season and it appears that this could become a perennial problem unless particular attention is paid to it.

Many of the practices recommended in 1982 have been carried into effect, in particular, trash retention and the cultivation of land at a suitable moisture content. The use of irrigation to wet the soil before ploughing has also been tried with some success. Planting procedures have been revised and there is a noticeable improvement in cane establishment. Field managers at Perlis have been able to improve overall performance by using varieties which perform better in special soil and slope situations. The program has assisted this by fostering a greater appreciation of the significance of landform and soil features that distinguish the different land units.

Crops on the plantation look very good, in marked contrast to the previous year. Most of the standing cane is still actively growing and production will be significantly higher than last year.

3.2 Felda Plantation

On Felda Plantation priority has been given to the development of water resources and nine new dams have been built. These provide the capacity to irrigate a significant proportion of plant cane and some ratoons on Class II land which is capable of producing higher yields as a result. The supply of irrigation equipment by manufacturers has been slow and this situation needs to be remedied in time to take advantage of the water storage available. Problems exist with some of the water storages constructed and Mr Cantor was able to advise on the best measures to overcome them. The advantages and disadvantages of completing water storages ahead of soil conservation planning and design are covered in section 4.4.

No contour layouts were planned or implemented last year but work was commenced on a 150 hectare section prior to the current visit. Some difficulties were experienced in achieving satisfactory parallel layouts as the area selected was of difficult topography. The follow-up visit was therefore opportune. Assistance with this project provided a refresher course in planning, layout and construction methods and included staff who had not been involved previously.
Because of the number of streams with large catchments running through this plantation the risk of overtopping or bywash failure is higher here than on Perlis or Felda. However the potential water resource is also greater, so, providing the advice given by Mr Cantor can be followed effectively, the provision of irrigation to most of the plantation can be assured. Unfortunately the slow supply of aluminium piping has prevented full utilisation of the available water resources.

Yields from the areas treated with soil conservation measures last year are expected to be higher than those from similar areas which have not yet been treated. This remains to be confirmed by the harvest.

Land preparation and planting techniques have improved, and, provided supplies of improved cane varieties can be obtained, the number of ratoon crops and overall yields should also improve. The main limiting factors to production will then be water and soil. Water can be provided through irrigation but soil improvement will require the adoption of practices that will improve soil structure by adding organic matter and minimising the damaging effects of cultivation. Improvements in methods of handling cane trash are needed so that fertiliser can be applied to ratoon crops without burning.

The laying out of contour systems has proceeded well and surveyors have become competent in marking out parallel systems within the ranges of gradient specified. While no contour maps of the plantation are available, there appears to be sufficient back up in drafting services to enable maps to be prepared and topographic data plotted as required.

Planting material of grasses suitable for establishment in waterways is not readily available so a nursery area is desirable to ensure adequate supply.

4.0 EVALUATION OF THE PROGRAM

The program appears to have been highly successful, but care must be taken not to be influenced by improvements that have resulted from a favourable growing season.

Soil Conservation is far more than the design and construction of efficient systems of contour banks and waterways — it includes the proper selection of land and the adoption of management practices that will prevent erosion and maintain fertility, while improving the capacity of the soil to absorb and hold moisture.

The runoff control systems appear to have performed very well — only one breakage was observed and that was in a situation where the planners yielded to the temptation to take water across a hollow so as to avoid shifting an access road. Damage occurred to waterways in pilot areas on both plantations, because the work was carried out too close to the wet season to allow grass to establish properly. This was unavoidable if the whole of the demonstration project was to be completed, while the damage
kind of damage planting should be kept back from waterway edges and grass allowed to grow well up along the side batters of the waterways.

Overtopping occurred in only one location, where banks had been carried through a hollow on G.P.T. to a waterway constructed beside a road. Siltation in the hollow caused the failure of the top bank and subsequent breaking of others down the hollow. This emphasises the importance of placing waterways in depressions and avoiding 'perched' locations.

Apart from these small problems, which demonstrate the need for attention to detail, the contour bank systems performed extremely well. Plantation managers confidently expected that yields will be better on these areas than on untreated land.

4.2 Grassed Waterways

Waterways planted before the main part of the pilot project was completed, suffered noticeably less damage than those planted later. There was also less damage where catchments were smaller and slopes more gentle. Two waterways were found to be narrower than the design specification. This appeared to be due to planting having been carried through too far into the channels. These waterways were not planted until late in the season and all the topsoil, together with the grass that had been planted, was washed out of the channels. Fairly severe gullying developed towards the lower ends of the larger waterways and one of these has the additional problem of an unstable entry into a main watercourse.

A particular problem exists where fine white Tampoi soils are found at the lower ends of long slopes. Severe gullying occurred where this situation was encountered in the pilot area and special treatment will be needed to achieve stability.

Couch Grass (*Cynodon dactylon*) was the main species planted but the survival rate was poor and most of the grasses in the waterways at the moment appear to be annuals or short lived perennials. These will not produce the dense mat of intertwined stems and roots which is needed to withstand concentrated flows. This emphasises the importance of nursery areas from which supplies of suitable planting material can be obtained.

4.3 Soil Improving Practices

These practices aim to increase the amount of organic material added to the soil. This initially has a protective effect, covering the soil surface and protecting it from the erosive effects of high intensity rainfall. It also reduces runoff by increasing infiltration into the soil and slows water flow across the land. As organic material decays it leads to an improvement in soil structure which further aids infiltration, improves aeration, resists compaction and improves the capacity of the soil to supply nutrients.
Contour Banks

The maximum length of contour banks flowing in one direction of 300 metres has proved satisfactory and it would not appear desirable to extend this limit. However, all layouts are a compromise between factors of varying importance and it may be better in some circumstances to accept two or three banks extending beyond this limit than to have an additional waterway running through an area. If this is done gradients should be kept below the maximum specified.

Generally speaking there are more advantages to be gained in canefields from having contour banks parallel, than there are from having longer runs and fewer waterways but non parallel banks.

The contour bank gradients recommended in the 1982 report appear to be satisfactory. Some erosion was noticeable at the outlets of banks with gradients within these limits but this was judged to result from overfall conditions at the ends of the fields due to gullying in the waterways, and not from the gradients of the banks themselves.

Waterways

The location of waterways in natural hollows is a principle that should be followed wherever practicable. This enables layouts to be made parallel with greater ease and is the main reason for the lack of problems with the contour system. Should rain be received that is beyond the designed capacity of the system these waterways will overflow temporarily without loss of control of flow direction and if contour banks overtop the water will still flow towards the waterways. Where there are main access roads at the edges of fields, waterways should be located beside them only if the water from contour banks and cane rows can discharge freely into them.

The waterways beside the main access road in the pilot area on Perlis Plantation scoured out chiefly because of the lack of an effective grass cover. The size of the areas draining into them was not the cause and there should be fewer problems when these waterways are properly formed and grassed.

It would have been possible to have directed part of the runoff from this area away from the road, but this would have made impossible the straight and parallel layout which is a valuable feature of the area. If this had been done the greater concentration of water would have been in the centre of the field and any damage would have occurred there.

Observations of waterways in the pilot area suggest that with the grass species currently available there could be advantage in reducing the designed water velocities in the more critical areas and on the more erodible soils. An amended table has been included in the appendix in which lower velocities are suggested for each of the main soil types and different categories of slope are used. This more clearly delineates critical areas. Simplified design tables which incorporate the suggested water velocities have also been included in the appendix.
Communication should be established between the plantations on a regular basis to enable the sharing of ideas, experiences and improvements in techniques that are developed.

5.0 SOLUTIONS TO TECHNICAL PROBLEMS

Following experience with the pilot areas it has been possible to identify problems more positively and to refine some of the design standards and methods of approach which were suggested in the 1982 report.

Most of the problems are associated with waterways and water disposal systems, though some refinements of measures and practices employed on productive lands are also suggested. This section contains recommendations on technical approaches to problem solving and practical hints on the management and maintenance of contour drainage systems.

5.1 Waterway Grass Establishment

Waterways are designed to carry the peak flows expected from their catchments on a 1 in 10 year frequency without suffering damage. The velocity is controlled and kept to a level which the grass can withstand by varying the widths of the channels. By making the channels wider the depth of flow is reduced and with it the water velocity, and vice versa. However, if the bed of a waterway is not level or if water is admitted before the grass cover is adequate and erosion occurs, the water will run faster in the area of greatest depth and scouring will occur, becoming worse as the flow concentrates and deepens.

THE CHANNEL OF A WATERWAY MUST BE LEVEL ACROSS ITS BED.

The grass in a waterway should provide a dense cover of intertwining stems and roots which protect the soil and bind it together. This can only be achieved by having a good depth of topsoil and a subsoil into which roots can penetrate to obtain moisture. When waterways are constructed it is usual to remove the topsoil and stockpile it to one side. The channel is excavated to the depth required and the spoil used to form a crowned road beside the waterway or for filling in low places in the field.

Irrigation of the site before construction takes place will improve soil conditions for earthmoving and assist construction. If subsoil is compacted it should be loosened by ripping before replacing topsoil.

After excavation the topsoil is replaced and trimmed to bring the waterway cross section to the designed specification. About 10 cm of good topsoil is necessary to achieve a satisfactory grass cover.

Fertiliser or filtercake is spread evenly over the bottom and side batters and disced into the soil.

Seed is distributed evenly over the surface and the soil compacted by rolling with a rubber tyred tractor. The lugs of the tractor tyres
### TABLE 1. Strategies for Waterway Grass Establishment

<table>
<thead>
<tr>
<th>Time before onset of wet season</th>
<th>Method of Grass Establishment</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 weeks</td>
<td></td>
</tr>
<tr>
<td><strong>Fertilise</strong></td>
<td>- 400 kg/ha mixed fertiliser</td>
</tr>
<tr>
<td><strong>Plant seed</strong></td>
<td>- 10 kg/ha Rhodes grass, signal grass or Bothriochloa with 2 kg/ha Japanese millet</td>
</tr>
<tr>
<td><strong>Mulch</strong></td>
<td>- Cane trash - bagasse - grass cutting</td>
</tr>
<tr>
<td><strong>Irrigation</strong></td>
<td>- Daily till up, twice weekly for 2 weeks, then weekly.</td>
</tr>
<tr>
<td>12 weeks</td>
<td></td>
</tr>
<tr>
<td><strong>Fertilise</strong></td>
<td>- 400 kg/ha mixed fertiliser</td>
</tr>
<tr>
<td><strong>Plant cuttings</strong></td>
<td>- Couch grass, Pangola or Carpet grass</td>
</tr>
<tr>
<td><strong>Mulch</strong></td>
<td>- Cane trash - bagasse - grass cutting</td>
</tr>
<tr>
<td><strong>Irrigation</strong></td>
<td>- Every 2 days for 2 weeks then weekly</td>
</tr>
<tr>
<td>8 weeks</td>
<td></td>
</tr>
<tr>
<td><strong>Fertilise</strong></td>
<td>- 400 kg/ha mixed fertiliser</td>
</tr>
<tr>
<td><strong>Plant sods</strong></td>
<td>- Couch grass, Pangola or Carpet grass</td>
</tr>
<tr>
<td><strong>Mulch</strong></td>
<td>- Cane trash - bagasse - grass cutting</td>
</tr>
<tr>
<td><strong>Irrigation</strong></td>
<td>- Every 2 days for 1 week then twice weekly</td>
</tr>
<tr>
<td>4 weeks</td>
<td></td>
</tr>
<tr>
<td><strong>Fertilise</strong></td>
<td>- 400 kg/ha mixed fertiliser</td>
</tr>
<tr>
<td><strong>Fully sod</strong></td>
<td>- Couch or Pangola</td>
</tr>
<tr>
<td><strong>Mulch</strong></td>
<td>- Cane trash - bagasse - grass cuttings and plastic mesh</td>
</tr>
<tr>
<td><strong>Irrigation</strong></td>
<td>- Every 2 days for 1 week then twice weekly</td>
</tr>
<tr>
<td>Nil</td>
<td>Build Temporary structure or use roadway. Plan to build waterway early next season.</td>
</tr>
</tbody>
</table>

Where insufficient time exists to establish a grass cover before the onset of the wet season a temporary waterway can be built beside the newly constructed and grassed channel. If possible a strip would be left unploughed and a bank built to prevent water running into the channel to be protected. Another alternative is to dispense with a waterway altogether and allow the water to flow through an unploughed hollow or down a road, with the intention of carrying out construction.
may cause turbulence. When this occurs an overfall may develop which will work its way back up the waterway or contour bank channel until flow ceases or something is encountered which halts progress. Because of this tendency grass should be encouraged to grow right up the side batters of waterways so that water from cane rows will flow into the grass before encountering the change in slope.

Contour bank outlets likewise should have grass growing back into the channel as far as the point where grade increases. If necessary sods of couch should be planted in a solid strip across the outlet at this point.

Waterway outlets do not usually encounter problems if they are in the natural hollow and are serving their natural catchment. Where this is not the case and a change in gradient is encountered, this should be taken as an indication that particular care is needed with grass establishment.

Where an overfall exists or an entry into a creek is unstable there are two alternatives:

(a) the sloping off of the gully head to a moderate slope, say 1:10, and designed width, and the establishment of a grass cover in exactly the same way as for a waterway; or

(b) the construction of a drop inlet structure which controls the flow of water as it drops down to the lower level and prevents it from doing any damage. These structures can be made of reinforced concrete, sheet steel, rock in wire baskets, cement filled jute bags, concrete pipe sections, or corrugated iron.

In the Malaysian situation there is considerable potential for the use of drop inlet structures, as the edges of streams and swamps are usually unstable. If the use of a corrugated iron structure is combined with the clearing of bamboo and establishment of grasses such as elephant grass and kikuyu there is a good chance that natural stability will be reached during the life of the structure.

Diagrams of typical drop inlet structures are contained in the appendix.

5.4 Construction Methods

Contour Banks

A large proportion of the contour banks made subsequent to the establishment of the pilot areas were of insufficient size and capacity. This was because the builders had concentrated on following a construction method instead of building the banks to the required dimensions.

It appears that the plough is likely to be the chief method of contour bank construction for some time to come as contractors with ploughs are more easily available than contractors with graders. Considerable time was therefore spent on all three plantations in developing
5.5 Design Modifications

Contour Banks

No modifications are suggested to the contour bank design provided. The range of gradients specified allows flexibility in design that will enable the great majority of layouts to be parallel. It will be up to the plantation staff to monitor soil movement in areas of maximum gradient to determine whether these limits are satisfactory in the long term, and to modify them in the light of experience. Diagrams of cross sections of a range of contour bank types are contained in the appendix.

Outlets, in particular, need special treatment as the velocities generated will cause erosion unless a wide flat section is constructed and a good grass cover established.

Waterways

Because of the erodible nature of the soils and the difficulty of achieving an effective grass cover in the short dry season, it is suggested that slightly lower water velocities be used in some situations. Table 3 of the 1982 report provides for a reduction in design velocity on slopes greater than 5%. On re-evaluating the situation in the light of experience gained in the pilot areas it is suggested that these slope categories be modified to commence reducing velocity at a lower gradient level, and that the upper limit for couch and pangola grasses be reduced. A modified table is included in the appendix.

Design Tables

A modelling exercise showed that there is a fairly strong linear relationship between runoff and catchment area for small contoured catchments of the type existing on the sugar plantations. On this basis design tables have been drawn up which will greatly simplify the task of waterway design. However, it is strongly advised that all waterways with catchment areas over 7 hectares and any that are not typical should be designed individually.

The design tables referred to are contained in the appendix.

Information on rainfall intensities is important when evaluating the performance of structures and it would be of considerable advantage if measurements could be made on the plantations. It is possible that actual intensities may vary slightly from those shown by the charts constructed from the information contained in Technical Guideline No. 2 of the Ministry of Agriculture. If this is the case the most critical period for waterways could well be the period towards the end of the wet season when the land is saturated and the runoff co-efficient as high as 0.9.
Access Roads Beside Waterways in Deep Hollows

These present a difficult problem. Usually, because of past siltation, the floors of these hollows are wide enough to contain both roads and waterways, while the edges slope very steeply into them.

When these areas are contoured the banks and cane rows bring water to the hollows and maximum flows occur just where the slope of the land is greatest, leading to erosion and siltation. Water will follow down the road in a concentrated flow and attempts to divert it into the waterway will result in either silting or erosion.

Figure 3 Erosion caused by planting cane on steep banks and cutting roads into the sides of hollows.

The most satisfactory approach to this problem is to grass the steep slope at the edge of the field if it is not possible to continue cane rows on a satisfactory gradient. In general any slope over 10 per cent should be grassed. The road must then be sloped towards the waterway so that water will run across it from the field into the waterway. Roads should not be cut into the sides of slopes in a way that increases that slope or causes an overfall and no drainage channels should be constructed.

Figure 4 Erosion controlled by grassing steep side slopes and sloping road so that water flows across into hollow.
5.7 Cultivation in Contour Bank Systems

All working should be carried out between contour banks and parallel to them so that tractors and implements are worked up to the crest of each bank from either side. Ploughing this way will help to maintain the banks and if necessary a few extra runs can be made to build them up.

It is important that ploughing, ripping or ridging should not be carried through into waterways. Implements should be lifted early enough and the tractor slowed down so as not to carry soil into waterway channels. Ridges should be carried through to the edge of waterway side batters but no further.

When ploughing it is important not to finish out in the same place each time so as to avoid a shallow strip developing along the centreline. Up and down working at the ends of bays should be avoided, as should the ploughing out of corners. It is better to make the first half dozen runs 'round and round' and then plough right to the ends of the bays and run up and down empty. The reversible plough is ideal for this purpose as no finish out furrows are made and there is no empty running.

Tractors and implements should never be run squarely along the tops of contour banks. Where 'double ridging' is carried out, the run which would take the tractor along the top of the bank should be omitted and ridging done on each side only. When commencing ridging it must be remembered that the tractor will be offset half a row width closer to the crest when cultivating the growing cane. The upper ridge should therefore be located half a row width down from the crest so that the tractor wheel will not go over the top of the bank when cultivating.

There is no quicker way to reduce the capacity of a contour bank then by cultivating along the top of it.

5.8 Maintenance

Soil conservation structures need periodic maintenance, as do the embankments of dams and their spillways. A regular inspection should be made so that problem areas are noticed and can be dealt with promptly. Neglect of a small scour can rapidly lead to a major gully and a low spot in a bank can result in the failure of a whole series.

Waterways

The grass cover in waterways should be mowed as often as necessary to keep it to the height allowed for in design procedures (5 cm to 15 cm).

Mowing also prevents weeds from taking over and shading out the couch and encourages grasses to spread and form a good cover.

Fertiliser should be used as found necessary to maintain a satisfactory cover. An invasion of weeds is often an indication of fertility decline.
Measurements of runoff and soil loss can be made but this involves instrumentation of catchments and is a matter more for government institutions than for commercial enterprises. Results of some Australian research work on these lines are included in the Appendix.

However, differences in yields obtained under different degrees of erosion control, and under different tillage and trash treatments, could provide information that would be useful in making management decisions on types of machinery to be purchased, numbers of cultivation operations to be carried out, etc.

Similarly with the use of irrigation it would be useful to know what application rates and what schedules give the best results.

Much of this information could be collected by field managers. Different contour bays could be used as plots which would be given different treatments, with carefully kept records of the tonnages harvested as the means of evaluation. However, it would require the co-operation and assistance of research personnel to set up the treatments, see that necessary observations and measurements were made and records kept, so that monitoring could continue and a meaningful analysis of data be achieved.

Random measurements of the bulk density of soils and determination of organic matter levels could provide an on going measurement of soil structure and the water holding capacity of soils.

On the engineering side there is a need to monitor the behaviour of structures so that modifications to design criteria may be made, e.g., gradients, water velocities, runoff co-efficients.

Rainfall intensities should be measured and observations taken of flows that occur in banks and waterways. There is no point in building structures larger than necessary or setting aside more land than necessary for waterways. On the other hand, to be under designed could result in serious damage and costly modifications.

A particularly important area is that of waterway grass selection and positive effort should be made to collect and assemble a range of potentially useful grasses so that they can be evaluated under field conditions. It cannot be stressed too emphatically that the waterways are the heart of the whole contour system. If not properly stabilised they will be a constant source of nuisance, unproductive time, extra maintenance and repair costs.

7.0 CONCLUSION

It has been said that once a problem has been recognised the solution has been partly achieved. While it is accepted that the 1982/83 season has been much more favourable to cane production than those experienced in the previous four or five years, there is nevertheless a big improvement in the appearance and growth of cane compared to the previous year.

Improved crop and soil husbandry has brought greater benefits from the use of better varieties and varieties more suited to different land types.
9.0 LIST OF REFERENCES


10.0 LIST OF APPENDICES

1. Itinerary and List of Program Participants.

2. Table of Waterway Velocities.
   Table of Contour Bank Gradients.

3. Waterway Grass Establishment - Alternatives.

4. Rubber Tyred Roller for Compacting Waterways.
   Sprinkler Attachment for Water Tanker.

5. Grass Chute for Stabilising Waterway Outlet.
   Grass Chute Design Table.

6. Drop Inlet Structures.


10. Runoff and Catchment Area Relationships.


12. Rainfall Intensity Diagrams.

PROGRAM DETAILS AND ITINERARY

Sunday, 16th January  Departed Brisbane by Quantas.
Monday, 17th January  Arrive at Felda Perlis.
                     Meet staff and visit pilot project.
Tuesday, 18th January  At Perlis Plantation.
                       a.m.  Evaluation of the performance of soil
                       p.m.  conservation and irrigation projects.
Wednesday, 19th January At Perlis Plantation.
                       Evaluation of technical aspects with field
                       managers.
Thursday, 20th January Discussion of broad scale planning and
                       programming aspects.
Friday, 21st January  Free.
Saturday, 22nd January At Felda Plantation.
                       Evaluation of Technical aspects with field
                       managers.
Sunday, 23rd January  Discussion of broad scale planning and
                       programming aspects.
Monday, 24th January  At Padang Terap Plantation.
                       Evaluation of projects with field managers.
Tuesday, 25th January  Discussion of broad scale planning and
                       programming aspects.
Wednesday, 26th January Felda/Perlis Conference Room.
                       Concluding discussion with staff of Felda and
                       Perlis on aspects of planning, design, and
                       future programming for soil conservation and
                       irrigation.
Thursday, 27th January At Padang Terap Plantation.
                       Discussion with staff of Padang Terap
                       Plantation on planning, design, and future
                       programming for soil conservation and
                       irrigation.
Friday, 28th January  Departed Alor Setar for Singapore via Kuala
                     Lumpur.
### TABLE 3. Maximum Water Velocities for Trapezoidal Channels Lined with Sod Forming Grass Species (m/sec)

<table>
<thead>
<tr>
<th>Grass Species</th>
<th>Channel Gradient (%)</th>
<th>Soil Type (Perlis Plantation)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Tampoi</td>
</tr>
<tr>
<td>Couch <em>Cynodon Spp.</em></td>
<td>0-2</td>
<td>1.1</td>
</tr>
<tr>
<td></td>
<td>2-6</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>6-10</td>
<td>1.0</td>
</tr>
<tr>
<td>Carpet grass <em>A. compressus</em></td>
<td>0-2</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>2-6</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>6-10</td>
<td>-</td>
</tr>
<tr>
<td>Rhodes grass <em>Chloris gayana</em></td>
<td>0-2</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>2-6</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>6-10</td>
<td>1.0</td>
</tr>
<tr>
<td>Pangola grass <em>Digitaria decumbens</em></td>
<td>0-2</td>
<td>1.2</td>
</tr>
<tr>
<td></td>
<td>2-6</td>
<td>1.1</td>
</tr>
<tr>
<td></td>
<td>6-10</td>
<td>1.0</td>
</tr>
</tbody>
</table>

### TABLE 4. Maximum and Minimum Gradients Permissible in Contour Banks in Parallel Layouts on Perlis Plantation Soils

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Gradient (%)</th>
<th>Distance along Contour Bank (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>LANGKAWI</td>
<td>Minimum</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>5.0</td>
</tr>
<tr>
<td></td>
<td>Max average</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>Whole bank</td>
<td></td>
</tr>
<tr>
<td>CHUPING</td>
<td>Minimum</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>Max average</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>Whole bank</td>
<td></td>
</tr>
<tr>
<td>TAMPOI</td>
<td>Minimum</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td>Max average</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>Whole bank</td>
<td></td>
</tr>
</tbody>
</table>
Figure Strategies to Obtain Satisfactory Grass Cover in Waterways

| PREPARATION   | TOPSOIL GRADE LEVEL FERTILIZE | TOPSOIL GRADE LEVEL FERTILIZE | TOPSOIL GRADE LEVEL FERTILIZE | TOPSOIL GRADE LEVEL FERTILIZE | DO NOT ATTEMPT TO USE WATERWAY, EITHER:
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Planting</td>
<td>Plant seed roll</td>
<td>Plant cuttings roll</td>
<td>Plant sods roll</td>
<td>Fully sod roll</td>
<td></td>
</tr>
<tr>
<td>Mulching</td>
<td>Trash, crop or bagasse</td>
<td>Trash, cut grass or bagasse</td>
<td>Trash, cut grass or bagasse</td>
<td>Trash, cut grass or bagasse</td>
<td></td>
</tr>
<tr>
<td>Irrigation</td>
<td>Daily till up then weekly</td>
<td>Every 2 days for 2 weeks then weekly</td>
<td>Every 2 days for 1 week then twice a week</td>
<td>Every 2 days for 1 week then twice a week</td>
<td></td>
</tr>
<tr>
<td>Special Protection</td>
<td>Shape and seed outlets with cutting</td>
<td>Plant outlets with cutting</td>
<td>Sod plant outlets</td>
<td>Sod plant outlets. Use plastic mesh.</td>
<td>Overfall Structures</td>
</tr>
</tbody>
</table>

- Let water run on a strip of land left unploughed,
- Build temporary waterway, or,
- Temporarily run water on access road.
Appendix IV

Irrigation of waterways with water tanker

Add weights if necessary

A rubber tyre roller for waterways
Appendix V

Figure 12.1  Sections of a simple sod chute

Figure 12.2  Nomenclature for sod chute design
**Figure 12.1** Design Criteria for Sod Chutes with 1:2 Side Dinters (0 Retardance)

Adapted from Reference 12.4

<table>
<thead>
<tr>
<th>Chute Gradient</th>
<th>2% (1 in 50)</th>
<th>4% (1 in 25)</th>
<th>6% (1 in 17)</th>
<th>8% (1 in 12)</th>
<th>10% (1 in 10)</th>
<th>12% (1 in 8)</th>
<th>15% (1 in 6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Velocity</td>
<td>1.2 1.5 2.0 2.5</td>
<td>1.2 1.5 2.0 2.5</td>
<td>1.2 1.5 2.0 2.5</td>
<td>1.2 1.5 2.0 2.5</td>
<td>1.2 1.5 2.0 2.5</td>
<td>1.2 1.5 2.0 2.5</td>
<td>1.2 1.5 2.0 2.5</td>
</tr>
<tr>
<td>Entrance Depth</td>
<td>0.11 0.41 0.66 0.86</td>
<td>0.26 0.28 0.38 0.57</td>
<td>0.32 0.27 0.32 0.42</td>
<td>0.36 0.23 0.32 0.36</td>
<td>0.25 0.28 0.32 0.36</td>
<td>0.24 0.26 0.29 0.32</td>
<td>0.26 0.20 0.24 0.30</td>
</tr>
<tr>
<td>Chute Depth</td>
<td>0.23 0.3 0.4 0.5</td>
<td>0.16 0.18 0.23 0.32</td>
<td>0.13 0.16 0.18 0.23</td>
<td>0.11 0.13 0.16 0.23</td>
<td>0.11 0.13 0.16 0.23</td>
<td>0.11 0.13 0.15 0.09</td>
<td>0.12 0.12 0.13 0.13</td>
</tr>
</tbody>
</table>

**Capacity (Cubeces)**

<table>
<thead>
<tr>
<th>Bottom Width of Chute (Metres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3</td>
</tr>
<tr>
<td>0.4</td>
</tr>
<tr>
<td>0.6</td>
</tr>
<tr>
<td>1.0</td>
</tr>
<tr>
<td>1.5</td>
</tr>
<tr>
<td>2.0</td>
</tr>
<tr>
<td>2.5</td>
</tr>
<tr>
<td>3.0</td>
</tr>
<tr>
<td>5.0</td>
</tr>
<tr>
<td>7.0</td>
</tr>
<tr>
<td>10.0</td>
</tr>
<tr>
<td>15.0</td>
</tr>
</tbody>
</table>

**Note:** Velocity should be selected according to soil and grass cover expected. Chutes outside the range of this table should be designed individually.
Concrete drop overfall structure built on reinforced concrete apron. Holes in the concrete blocks are filled with concrete and 10mm steel rods inserted for reinforcing.
Appendix VII

BUILDING BROAD BASED BANKS WITH A GRADER

1. Plough 12m strip

2. Marking runs. Take shallow cut only. Keep blade flat with just enough angle for trash to flow.

3. Carry trash a second blade width down the slope.

4. Take about 1m cut with blade flat. Just enough soil to fill blade.

5. Place rill of soil alongside marking rill.

6. Go back and take another cut. (As in 3).

7. Place rill beside but separate to previous one.

8. Take another cut as in 3 and 5.

9. Carry across and place as before.


11. Use highest gear possible when carrying soil.

12. Cut from above channel. Dig heel down to get taper.

13. Carry soil across as before.

14. Add rill to the bank.

15. Plough deeper in centre of channel.

16. Toe of blade in channel. Sweep soil up to crest.

17. Heel down to shape channel.

18. Toe of blade in channel. Smooth face of bank.

19. Shape back slope of bank.

The finished bank should have a cross sectional area of 1.2 square metres.
CONTOUR BANK SPECIFICATION SHEET

LANDHOLDER ___________________________  ISSUED BY ______________  DATE __________

PROPERTY ___________________________________________________________

CROSS SECTIONS

TYPE A - BROAD BASED CONTOUR BANK

TYPE B - HALF BROAD BASED CONTOUR BANK

TYPE C - LONG BACKED CONTOUR BANK

TYPE D - NARROW BASED CONTOUR BANK

SPECIFICATIONS

<table>
<thead>
<tr>
<th>IDENTIFICATION</th>
<th>CHANNEL 'a'</th>
<th>BANK 'b'</th>
<th>BANK 'c'</th>
<th>BANK 'd'</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOCATION ON PLAN</td>
<td>TYPE CROSS SECTION</td>
<td>BACK SLOPE</td>
<td>FORE SLOPE</td>
<td>BACK SLOPE</td>
</tr>
</tbody>
</table>

NOTE: ALLOWANCE HAS BEEN MADE FOR FREEBOARD AND SETTLING.
CREST OF BANK SHOULD BE TRamped BEFORE TAKING HEIGHT MEASUREMENT.
QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES
SOIL CONSERVATION BRANCH

WATERWAY SPECIFICATION SHEET
SUB SURFACE CHANNELS

LANDHOLDER ___________________________ ISSUED BY __________ DATE __________
PROPERTY DESCRIPTION ____________________________________________

CROSS SECTIONS

TYPE A
- SOIL SPREAD
- ORIGINAL GROUND LEVEL
- SOIL SPREAD

TYPE B
- ROADWAY
- ORIGINAL GROUND LEVEL

TYPE C
- ROADWAY
- ORIGINAL GROUND LEVEL

SPECIFICATIONS

<table>
<thead>
<tr>
<th>DESIGN POINT</th>
<th>TYPE CROSS SECTION</th>
<th>DEPTH $d$ (m)</th>
<th>BOTTOM WIDTH $b$ (m)</th>
<th>TOP WIDTH $t$ (m)</th>
<th>BANK BATTERS INSIDE</th>
<th>BANK BATTERS OUTSIDE</th>
<th>COMMENT</th>
</tr>
</thead>
</table>

NOTE: ALLOWANCE MUST BE MADE FOR DEPTH OF TOPSOIL TO BE REPLACED.
BOTTOM SHOULD BE LEVEL ACROSS FLOW DIRECTION.
Appendix X

Based on Rational Formula: \( Q = CIA \)

\[ Q = \text{Estimated Runoff (Cumecs).} \]
\[ C = \text{Runoff Co-efficient (estimated to be 0.7).} \]
\[ I = \text{Rainfall Intensity from Diagram prepared for Perlis Plantation.} \]
\[ A = \text{Catchment Area (Hectares)} \]

Estimated 1 in 10 year Runoff, (Cumecs).


Estimated 1 in 10 year Runoff for a Range of Runoff Co-efficients for Perlis Plantation.
Flow Capacity (Cumecs)

Flow Capacity (Cumecs) Chart

Waterway Design Chart

Retardance D

1:4 Side Slopes

Maximum Velocity 1.0 m/s

Maximum Depth 0.2 m

Appendix XI
WATERWAY DESIGN CHART

RETARDANCE D

4:1 SIDE SLOPES

MAXIMUM VELOCITY 1.1 m/s
MAXIMUM DEPTH 0.2 m

Flow (Cumecs)

Catchment Area (Hectares)

Slope (%) at Design Point

Depth

Bottom Width

Velocity

0.2

1.1

0.8

0.6

0.5

0.2

0.1

0.12

0.15

0.2

0.3

0.4

0.5

0.6

0.7

0.8

0.9

1.0

1.1

1.2

1.3

1.4

1.5

1.6

1.7

1.8

1.9

2.0

2.1

2.2

2.3

2.4

2.5

2.6

2.7

2.8

2.9

3.0

3.1

3.2

3.3

3.4

3.5

3.6

3.7

3.8

3.9

4.0

4.1

4.2

4.3

4.4

4.5

4.6

4.7

4.8

4.9

5.0

5.1

5.2

5.3

5.4

5.5

5.6

5.7

5.8

5.9

6.0

6.1

6.2

6.3

6.4

6.5

6.6

6.7

6.8

6.9

7.0

7.1

7.2

7.3

7.4

7.5

7.6

7.7

7.8

7.9

8.0

8.1

8.2

8.3

8.4

8.5

8.6

8.7

8.8

8.9

9.0

9.1

9.2

9.3

9.4

9.5

9.6

9.7

9.8

9.9

10.0
WATERWAY DESIGN CHART

RETARDANCE D

1:4 SIDE SLOPES

MAXIMUM VELOCITY 1.2 m/s

MAXIMUM DEPTH 0.25 m

Flow Capacity (Cumecs)

Catchment Area (Hectares) Perlis Plantation

Channel Slope (%) at Design Point

WATERWAY DESIGN CHART

RETARDANCE D

1:4 SIDE SLOPES

MAXIMUM VELOCITY 1.2 m/s

MAXIMUM DEPTH 0.25 m

Bottom Width Depth Velocity

Velocity 1.2 m/s

Depth 0.25 m
RAINFALL INTENSITY CHART
PADANG TERAP PLANTATION
FROM TECHNICAL GUIDELINE NO. 2
MINISTRY OF AGRICULTURE
KUALA LUMPUR
1981
RAINFALL INTENSITY CHART
PERLIS PLANTATION
FROM TECHNICAL GUIDELINE NO. 2
MINISTRY OF AGRICULTURE
KUALA LUMPUR
1981
ANNUAL RUNOFF AND SOIL LOSS 1976/77 - 1981/82
DARLING DOWNS QUEENSLAND

Black Earth - GREENMOUNT
Slope 6-7%
Slope Length 50m.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Runoff (mm)</th>
<th>Soil Loss (t/ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bare Fallow</td>
<td>59.7</td>
<td></td>
</tr>
<tr>
<td>Stubble Incorporated</td>
<td>39.8</td>
<td>14</td>
</tr>
<tr>
<td>Stubble Mulched</td>
<td>29.6</td>
<td>3</td>
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<tr>
<td>Zero Tillage</td>
<td>43</td>
<td>1</td>
</tr>
<tr>
<td>Summer Crop</td>
<td>35.1</td>
<td>29</td>
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</tbody>
</table>