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Survey of irrigation efficiencies on horticultural properties in the Peel-Harvey catchment

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Survey of Irrigation Efficiencies on Horticultural Properties in the Peel-Harvey Catchment

S. Milani

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Disclaimer

The contents of this report were based on the best available information at the time of publication. It is based in part on various assumptions and predictions. Conditions may change over time and conclusions should be interpreted in the light of the latest information available.

Summary

The objectives of this survey were to evaluate the efficiencies of irrigation systems on horticultural properties in the Peel-Harvey catchment and to identify possible improvements which could benefit the growers and reduce pollution in the Peel-Harvey estuary.

A detailed efficiency survey of about 30 per cent of the irrigated horticultural area in the Peel-Harvey catchment revealed that only two out of 20 growers operated at the recommended efficiency levels. In addition it was found that the expenses associated with inefficiency were such that 12 out of 18 farmers would be able to recover improvement costs within one year of operation.

This survey revealed the extent of the inefficiency problem, the benefits available to growers who upgrade their systems and indicated the potential for improving the environmental sustainability of irrigated horticulture.

Efficient design and management of irrigation systems should be promoted for the benefit of both growers and the environment.

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1. Introduction

As a result of the agricultural activities in the Peel-Harvey catchment the Peel-Harvey estuary has suffered extensive algal blooms over recent years. The high levels of phosphorus found in the inflows to the estuary have been identified as the main cause of pollution.

In order to remedy this problem the Department of Agriculture is actively encouraging the implementing of catchment management strategies to reduce phosphorus input.

In an attempt to evaluate the contribution of fertilizer leaching from horticultural properties the Department of Agriculture is concurrently conducting research on phosphorus retention of soils and undertaking surveys on soil types, fertilizer application and irrigation efficiencies.

This survey was carried out to determine the efficiency of irrigation systems on horticultural properties in the Peel-Harvey catchment and to identify improvements which could benefit the growers and reduce environmental damage in the Peel-Harvey estuary.

2. Materials And Methods

2.1 Farm Selection

From the 1989 Water Authority of Western Australia's (WAWA) listing of all the farmers operating in the metropolitan area, 43 horticultural properties were identified to be located within the Peel-Harvey catchment boundaries (Figure 1).

Selection of the 20 farms included in the survey was based upon the following criteria:

i) The size of the property (not less than 4 hectares);

ii) Willingness to participate;

iii) Use of sprinkler irrigation;

iv) Location of the property within the catchment.

(This was to provide a geographically diversified sample).

The total area covered by the survey represents about 30 per cent of the sprinkler irrigated horticultural land found in the Peel-Harvey catchment.

2.2 Tests Conducted

The survey was conducted by two officers of the Department of Agriculture, required three to five hours per property, and included the following tests.

2.2.1 Distribution Pattern

The distribution pattern of the water drops was determined by measuring the amount of water caught in small cans laid out on a grid pattern (1 or 2 metres) between a set of sprinklers.

The tests ran for the same amount of time as a regular irrigation would during a hot summer day.

To help assess the performance of the system, wind gusts during the tests were recorded using an anemometer.

2.2.2 Design Evaluation

To evaluate the design of the irrigation systems, a sketch of the pipe network for each of the 20 properties was made. Pressure variations along laterals and throughout the property were obtained using a pressure gauge and a pitot tube.

Additional information about the system's performance was obtained by measuring the discharge of two sprinklers operating at different pressures and comparing the results to the manufacturers specification.

IRRICAD, a computer design package developed by the Agricultural Engineering Institute of New Zealand, was used to analyse two existing systems and provide a more efficient and economical alternative.

2.2.3 Efficiency of the Pump Units

The overall system's water delivery and total dynamic head were calculated using results from the sprinkler discharge/pressure tests and the information on the pipe network layout. The horsepower generated by the pump unit was then calculated and compared to the rating provided by the manufacturer.

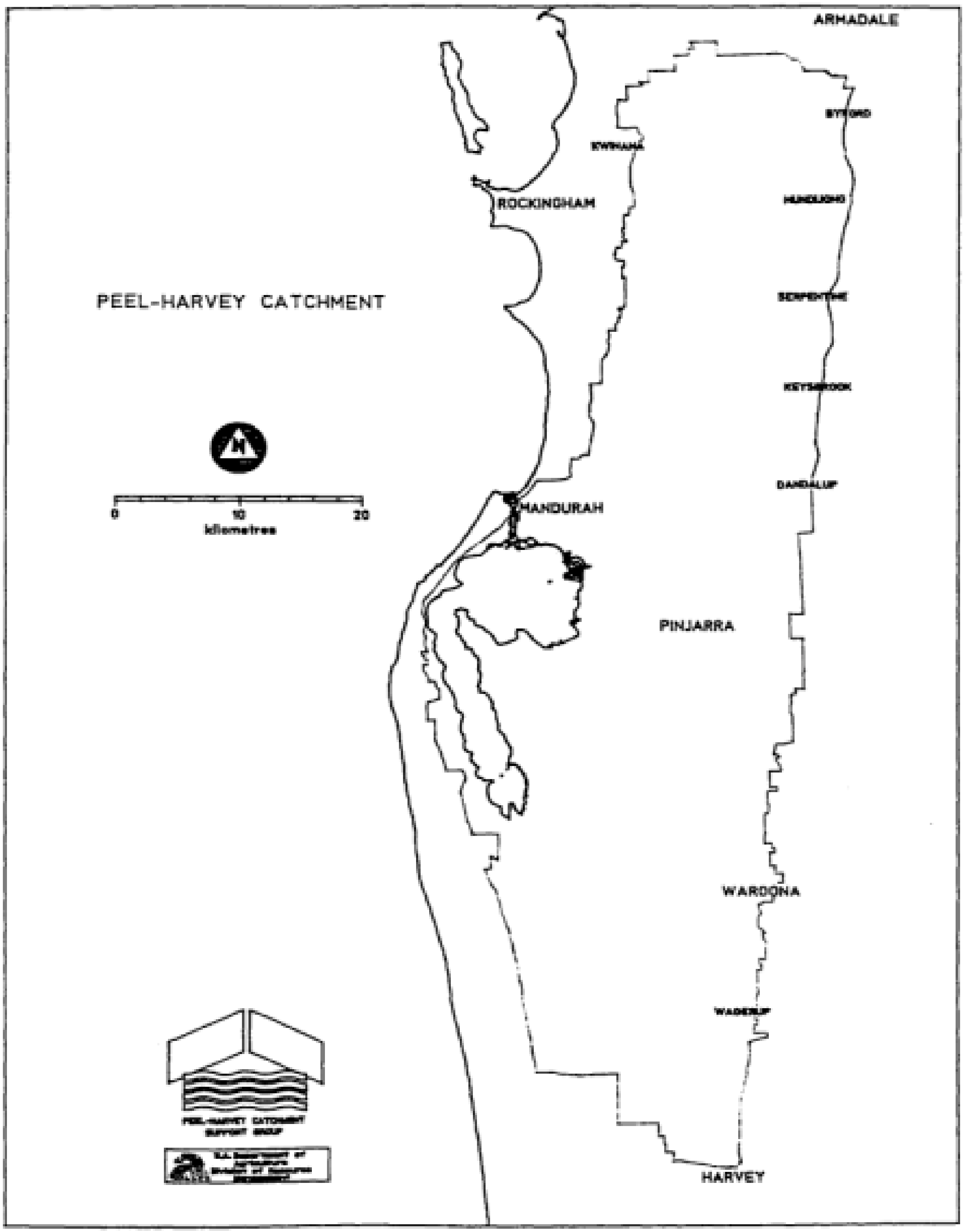

Figure 1. *Peel-Harvey Catchment area as defined for the irrigation efficiency survey.*

Table 1 List Of The Properties Surveyed

Property No.	Location	Area Irrigated (Hectares)	Type Of Crop
1	Anketell	4	Vegetables & Citrus
2	Baldivis	5	Vegetables
3	Anketell	8	Vegetables
4	Baldivis	8	Vegetables
5	Baldivis	8	Vegetables
6	Mandogalup	28	Vegetables
7	Mandogalup	12	Vegetables
8	Baldivis	6	Vegetables
9	Mandogalup	40	Vegetables
10	Wellard	12	Orchard (Kiwi, Avocado, Custard Apple, Etc)
11	Wellard	8	Vegetables
12	Serpentine	14	Orchard (Citrus, Apples, Pears, Stonefruit)
13	Anketell	4	Vegetables
14	Forresdale	12	Vegetables
15	Mandogalup	30	Vegetables
16	Mandogalup	9	Vegetables
17	Mandurah	9	Vegetables
18	Wellard	14	Vegetables
19	Serpentine	2	Flowers (Roses)
20	Mundijong	5	Turf
TOTAL AREA SURVEYED		238	

This method, although based on approximate figures, provides a reasonably good estimate of the working efficiency of a pump unit.

Estimation of the total dynamic head was more accurately calculated where a pressure gauge could be located near the pump.

2.3 Data Analysis

2.3.1 Distribution Pattern

Data from the collection cans was expressed in terms of coefficient of uniformity (CU) (Christiansen 1942) and distribution uniformity (DU) (US Soil Conservation Service 1960).

DU = [({x/n)/({X/N)] 100 with	x = low quarter can catch;
	n = number of low quarter can catch;
	X = can catch;
CU = [1-({(X-M)/{N)] 100	M = mean catch;
	N = number of can catch.

In order to assess the uniformity of the water pattern, the CUs and DU5 obtained were compared to the internationally accepted standards of 85 per cent and 75 per cent respectively (ASAB Yearbook 1979). With consideration to the wind conditions the following classifications were devised in order to rate the 20 systems tested:

CU > 85% or DU > 78%	- acceptable;
81 < CU < 85% with 72% < DU < 78%	- marginal;
60% < CU < 81% with DU < 72%	- poor;
CU < 60%	- very poor.

To satisfy the water needs of the crops on drier areas, partial overwatering is necessary.

To illustrate the crop yield response to various water application levels under a range of uniformity conditions, Warrick et al. (1987) developed a series of independent models. These models were based on a statistical expression of the water distribution pattern developed by Bralts et al. (1987), called the coefficient of variation (CV) and expressed as follows:

CV = 0.667 [(Qus – Q1s)/(Qus + Q1s)]

Where Qus = the sum of the upper one-sixth catch;

Qls = the sum of the lower one-sixth catch.

The following equation relating the coefficient of variation to the water application factor (W) was derived from the Warrick et al. (1987) model which assumes a constant crop yield of a 100 per cent. The equation was used to quantify the amount of water required in order to compensate for the uneven water distribution pattern:

$$W = [-0.54545 (CV^2)] + (2.25636 (CV)] + 0.99$$

The extra water application factor (V) was developed as an adjustment to the water application factor (W) in order to cater for a more realistic value of an optimum coefficient of variation equivalent to a CU of 85 per cent.

$$V = W/1.3$$

Extra costs were based on the additional operating time required to supplement the irrigation application to the level indicated by the extra water application factor (V).

2.3.2 Design Evaluation

The standard adopted in order to evaluate the irrigation designs was based upon the maximum allowable pressure drop along a lateral of 10 per cent. The rating “Good” was attributed to systems conforming to this standard. Rating “Poor” was selected to describe systems where maximum head loss throughout a station exceeded 10 per cent of the operating pressure.

2.3.3 Efficiency of the Pump Units

With consideration to the recommendations provided by R.A. Longenbaugh (1980), and in order to rate the efficiency of the electrical pump units the following classification was devised:

Pump efficiency = Pf >59% - acceptable;

40%< Pf <59% - poor;

Pf <40% - very poor.

When a pump unit was found to operate below 59 per cent efficiency, its duty points were matched to a replacement pump working at peak efficiency. Extra costs incurred due to the inefficiency of the pump unit was then calculated by comparing actual to potential time of operation.

In the case of the diesel units, operating costs were compared to the requirements of an electric pump.

3. Results

Results obtained on all properties were summarized and sent to the growers. A sample form of the summary sheets as sent to the farmer is presented in Appendix A.

3.1 Uniformity Test

Results of the uniformity tests are presented in Table 2.

Out of 17 systems tested for water distribution uniformity, only two were up to internationally accepted standards, five were classified marginal, nine were considered poor, and one very poor.

In 67 per cent of the cases poor distribution was due to incorrect spacing and poor selection of the sprinkler. Poor operating pressures were to blame for the remaining 33 per cent.

Only one of the seven double jet systems tested was able to achieve a marginal rating in the uniformity test. The single jet sprinklers performed better with one acceptable and three marginal.

Extra electricity costs were quantified and estimations show that on average a farmer loses $149 per hectare per year as a result of poor distribution. The losses attributed to poor uniformity, ranged from $0 to a maximum of $400 per hectare per year.

3.2 Design Evaluation

Only two of the 20 growers had plans for their irrigation system. None of the farmers had any record of the operating specifications associated with their system.

Results of the designs evaluation tests are presented in Table 3.

Poor design due to excess head loss in the laterals was observed in 10 out of the 20 systems tested. In seven cases, incorrect sizing of the pipes resulted from a total disregard of the existing topographical variations. The remaining three faulty designs were the result of improper sizing of the pipes on flat land.

3.3 Efficiency Test of Pump Units

Results of the pump efficiency tests are presented in Table 4.

Only 30 per cent of the pump units tested were found to be operating at an acceptable efficiency. Six of the remaining 12 systems were found to be operating at a “Very Poor” rating, where almost half of the electrical bill was lost to inefficiency.

The survey estimated that due to pump inefficiencies, farmers pay on average $115 per hectare per year in extra electricity charges.

Extra costs attributed to pump inefficiency ranged from $0 to $380 per hectare per year.

3.4 Overall Costs Due to Poor Efficiencies

From the costs comparison results presented in Table 5 we can see that accumulated electricity charges vary from $0 to a maximum $590 per hectare per year. Only three growers could claim to achieve $0 loss when six others are found to pay more than $340 per hectare per year due to poor efficiencies.

Table 2 Results of the Distribution Uniformity Test (Conducted on 17 properties)

Property No	Type Of Irrigation System	Operating Pressures	Sprinkler Spacing	Distribution Uniformity		Extra Cost $/Ha/Year	Overall Rating	Cause For Poor Dist.
				CU %	Rating			
1	Micro-sprinkler	Accept	Accept	82.6	Marg	25		
2	Butterfly	Very poor	Marg	80.2	Poor	125	Poor	Pressure
3	Single knocker	Accept	Poor	70.4	Poor	229	Poor	Spacing
4	Double knocker	Accept	Poor	81.6	Poor	99	Poor	Spacing
5	Butterfly	Marg	Accept	85	Accept	0	Accept	
6	Single knocker	Accept	Poor	76.7	Poor	123	Poor	Spacing
7	Single knocker	Poor	Marg	84.4	Marg	47	Poor	Pressure
8	Double knocker	Accept	Poor	84.4	Marg	61	Poor	Spacing
9	Double knocker	Accept	Poor	81.1	Poor	103	Poor	Spacing
10	Micro sprinklers	Accept	Accept	-	NT	-	Accept	
11	Double knocker	Accept	Poor	76.6	Poor	370	Poor	Spacing
12	Micro sprinklers	Poor	Accept	-	NT	-	Poor	Pressure
13	Single knocker	Accept	Marg	83.9	Marg	98	Marg	
14	Butterfly	Accept	Marg	74.0	Poor	167	Poor	Pressure

Property No	Type Of Irrigation System	Operating Pressures	Sprinkler Spacing	Distribution Uniformity		Extra Cost $/Ha/Year	Overall Rating	Cause For Poor Dist.
15	Single knocker	Accept	Marg	84.0	Marg	90	Marg	
16	Double knocker	Accept	Poor	43.8	V Poor	400	V Poor	Spacing
17	Single knocker	Accept	Accept	85.5	Accept	0	Accept	
18	Double knocker	Accept	Poor	80.0	Poor	113	Poor	Spacing
19	Micro sprinkler	Accept	Accept	-	NT	-	Accept	
20	Double knocker	Poor	Poor	70.8	Poor	358	Poor	Pressure

	DISTRIBUTION				
	Very Poor	**Poor**	**Marg**	**Accept**	**Total**
Double knockers	1	5	1		7
Single knockers		2	3	1	6
Butterfly		2		1	3
Micro Sprinkler			1		1
	1	9	5	2	17 systems tested for uniformity

NT = Not tested

Table 3 Results of the Irrigation Design Evaluation Tests (Conducted on all properties)

Property No	Area Under Irrigation (Ha)	Headloss In Lateral (M)	Percent Headloss In Lateral %		Topocraphy	Overall Rating	Reasons For Poor Design
1	4	1	10	Good	Gentle	Good	
2	5	1.4	25	Poor	Steep	Poor	Topo
3	8	4	16	Poor	Gentle	Poor	Topo
4	8	1.8	10	Good	Gentle	Good	
5	8	.6	10	Good	Flat	Good	
6	28	3	12.5	Poor	Steep	Good	
7	12	5	22	Poor	Steep	Poor	Topo
8	6	5	22	Poor	Steep	Poor	Topo
9	40	4.2	17	Poor	Flat	Poor	Pipe
10	12	3	20	Poor	Steep	Poor	Topo
11	8	1.2	10	Good	Steep	Good	
12	14	4	19	Poor	Flat	Poor	Pipe
13	4	2.1	10	Good	Steep	Good	
14	12	2.8	25	Poor	Flat	Poor	Pipe

Property No	Area Under Irrigation	Headloss In Lateral (M)	Percent Headloss In Lateral %		Topography	Overall Rating	Reasons For Poor Design
15	3	2.5	10	Good	Steep	Good	
16	9	1	10	Good	Steep	Good	
17	9	3.9	10	Good	Flat	Good	
18	14	7	28	Poor	Steep	Poor	Topo
19	2	.7	10	Good	Flat	Good	
20	5	2.1	12	Poor	Gentle	Poor	Topo
Total Area	238		14.4% average				

Topo = Topography not accounted for

Pipe = Poor sizing of pipes

Table 4 Results of the Pump Unit Efficiency Tests (Conducted on 17 properties)

Property No	Pump Description	Pump Efficiency (%)	Pump & Motor Efficiency (%)	Extra Cost $/Ha/Year	Rating
1	15 hp submersible (grunfos)	55.5	47.5	38	Poor
2	40 hp turbine (stalker)	37	31	380	Very poor
3	30 hp turbine (stalker)	39	33	340	Very poor
4	25 hp centrifugal (southern cross)	65	55	0	Good
5	200 hp diesel engine - 125 hp turbine (randolph)	60	21	0	Good
6	40 hp turbine (stalker)	69	58	0	Good
7	25 hp turbine (southern cross)	55	47	82	Poor
8	75 hp centrifugal (southern cross)	56	48	121	Poor
9	40 hp turbine (southern cross)	57	49	82	Poor
10	7.5 + 5.5 hp centrifugal (stalker)	30	25	120	Very Poor
11	30 hp submersible (meocalf)	59	50	70	Good
13	25 hp turbine (stalker)	39	33	250	Very poor
14	80 hp diesel engine - 62 hp (castleman) centrifugal	54	19	74	Poor

Property No	Pump Description	Pump Efficiency (%)	Pump & Motor Efficiency (%)	Extra Cost $/Ha/Year	Rating
16	30 hp centrifugal (southern cross)	32	27	190	Very poor
17	40 hp centrifugal (stalker)	66	56	0	Good
18	40 hp centrifugal (southern cross)	57	48	106	Poor
19	3 hp centrifugal (stalker)	25	21	95	Very poor
	Average			115	

Table 5 Cost table Showing Extra Costs due to Inefficiencies

Property No	Costs Due To Poor Uniformity $/Ha/Year	Costs Due To Pump Inefficiency $/Ha/Year	Total Extra Costs $/Ha/Year	Area Under Irrigation (Ha)	Total Costs $/Year
1	25	38	63	4	252
2	129	380	509	5	2,545
3	229	340	569	8	4,552
4	99	0	99	8	792
5	0	0	0	8	0
6	123	0	123	28	3,444
7	49	82	131	12	1,572
8	61	121	182	6	1,092
9	103	82	185	40	7,400
10	NT	120	120	12	1,440
11	370	70	440	8	3,520
12 *	0	0	0	14	0*
13	98	250	348	4	1,392
14	167	74	241	12	2,892

Property No	Costs Due To Poor Uniformity $/Ha/Year	Costs Due To Pump Inefficiency $/Ha/Year	Total Extra Costs $/Ha/Year	Area Under Irrigation (Ha)	Total Costs $/Year
15	90	Nt	90	30	1,790
16	400	190	590	9	5,310
17	0	0	0	9	0
18	113	106	219	14	3,066
19	NT	95	95	2	190
20	358	NT	358	5	1,790
		Total		238	43,949
		Average	218	12	2,198

NT = not tested

* = Gravity fed therefore no pumping costs

4. Discussion

4.1 Common Faults Observed

The following faults in irrigation design and practice were commonly encountered during the survey.

4.1.1 Use Of The Double Jet Sprinklers

Double jet sprinklers perform well under low wind conditions. Under Western Australia's conditions, the high wind velocities disperse the small back jet's output in a very uneven manner. From distribution tests carried throughout the years on the coastal plain in Western Australia, the single jet systems have proved to give far better results than the double jets. The results obtained through this survey confirm the above observation.

4.1.2 Poor Sprinkler Layout

The results show that more than 70 per cent of the designs combine incorrect spacing and operating pressure.

Figure 2 shows that a change in pressure can considerably improve the performance of a sprinkler. Also, as shown in Figure 3, the spacing is of the utmost importance when dealing with water distribution pattern. Spacing sprinklers further apart than recommended can result in lower distribution uniformity.

Most sprinklers can provide a good distribution uniformity under a specific spacing and pressure condition. The proper combination between sprinkler type, wind conditions, spacing and pressure can now be simulated using the latest computer technology. This method supersedes the 60 per cent radius overlap traditionally used in irrigation designs. To alter the spacing of an existing system is an expensive and impractical solution. Figures 2, 4, 5 and 6 show that improvements in uniformity can be achieved by simpler means such as blocking a backjet, increasing a nozzle size, or operating at a higher pressure. Whether these changes can be of value in a particular instance should be determined by an experienced, qualified irrigation designer.

4.1.3 Topographical Variations Not Accounted For In Designs

The survey shows that in too many cases topographical variations within a property are not considered in the designs.

Most designers find it more convenient to visually estimate the variations in elevations. This inaccurate method, although acceptable on relatively flat lands, is found to be the major cause of problems associated with uneven distribution.

One of the remedies too often used in order to correct this situation is substitution to a smaller nozzle size in lower areas. This solution, although impressive at first glance, does not resolve the variation in application rate and pattern caused by uneven pressure distribution throughout the property.

The correct solution lies in the proper sizing of the pipes so that extra head gained from topographical variations can be utilized as head loss in a smaller diameter pipe.

4.1.4 Irrigating Under Windy Conditions

The survey found that most farmers were aware of the detrimental effects of wind on the operating efficiency of their sprinklers. Most however, regard over-watering as the most practical method to minimize the effect of poor distribution on crop yields.

For many years the butterfly sprinklers were used extensively to mitigate against the effects of the wind. Although the butterfly distribution is less wind-affected due to its big droplet size, high application rates lead to fertilizer leaching under the present poor management/scheduling conditions.

Growers should consider using properly designed wind-breaks to overcome the adverse effect of wind on water distribution.

4.1.5 Poor Irrigation Scheduling

There was no evidence of any proper irrigation scheduling on most horticultural properties surveyed.

The approximate time based scheduling method used by most farmers is inadequate and could be a big factor contributing to pollution. Some farmers based their irrigation on the previous day evaporation figures. This method, although more up to date, still requires proper management in order to be effective on the very porous sandy soils found in the coastal plains.

4.2 Costs

Due to a lack of research data and an inability to measure the amount of fertilizer lost through leaching, the estimated extra costs presented in this report do not account for extra fertilizer expenses.

Excessive pressure variation along laterals means large variation in distribution patterns throughout the property which in turn causes extra water application and fertilizer loss through leaching. Due to the complexity of obtaining relevant data, the extra electrical and fertilizer costs associated with improper designs were not quantified.

The cost of poor efficiency on crop yields have not been quantified either. From early trial work it appears that there are substantial yield benefits to be gained from attaining good system uniformities.

From the results obtained, we can observe that 12 out of 18 growers could recover the costs of a system upgrade within the first year of operation. This result points out the potential savings and benefits associated with efficient irrigation practices.

Too few farmers are aware of the true expenses associated with poor distribution, improper designs and inefficient pumping systems.

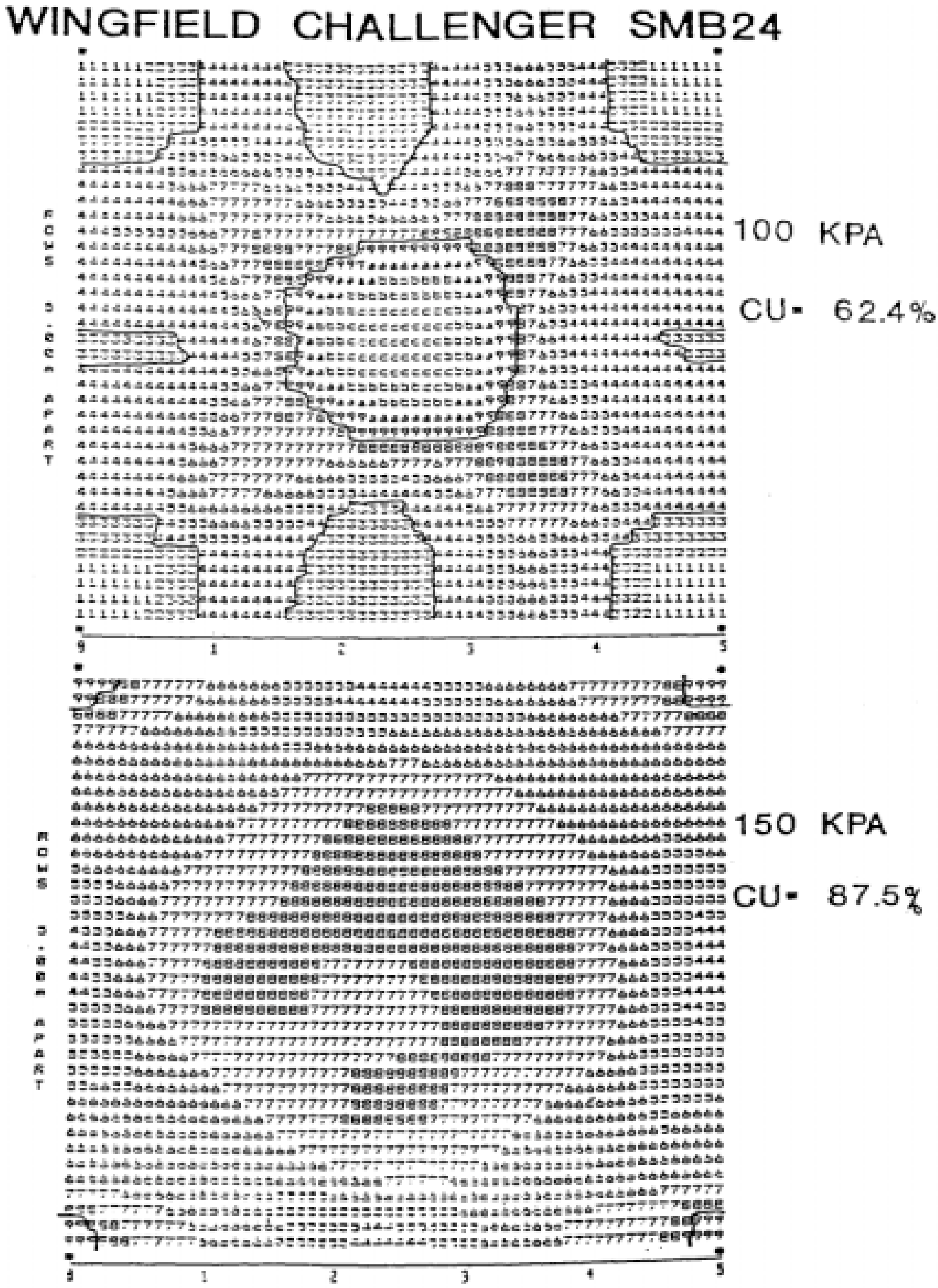

Figure 2. Computer simulations of the water distribution pattern showing improvements in CU for a Wingfield Challenger SME24 micro-sprinkler when the operating pressure is increased from 100 Kpa to the recommended level of 150 KPa.

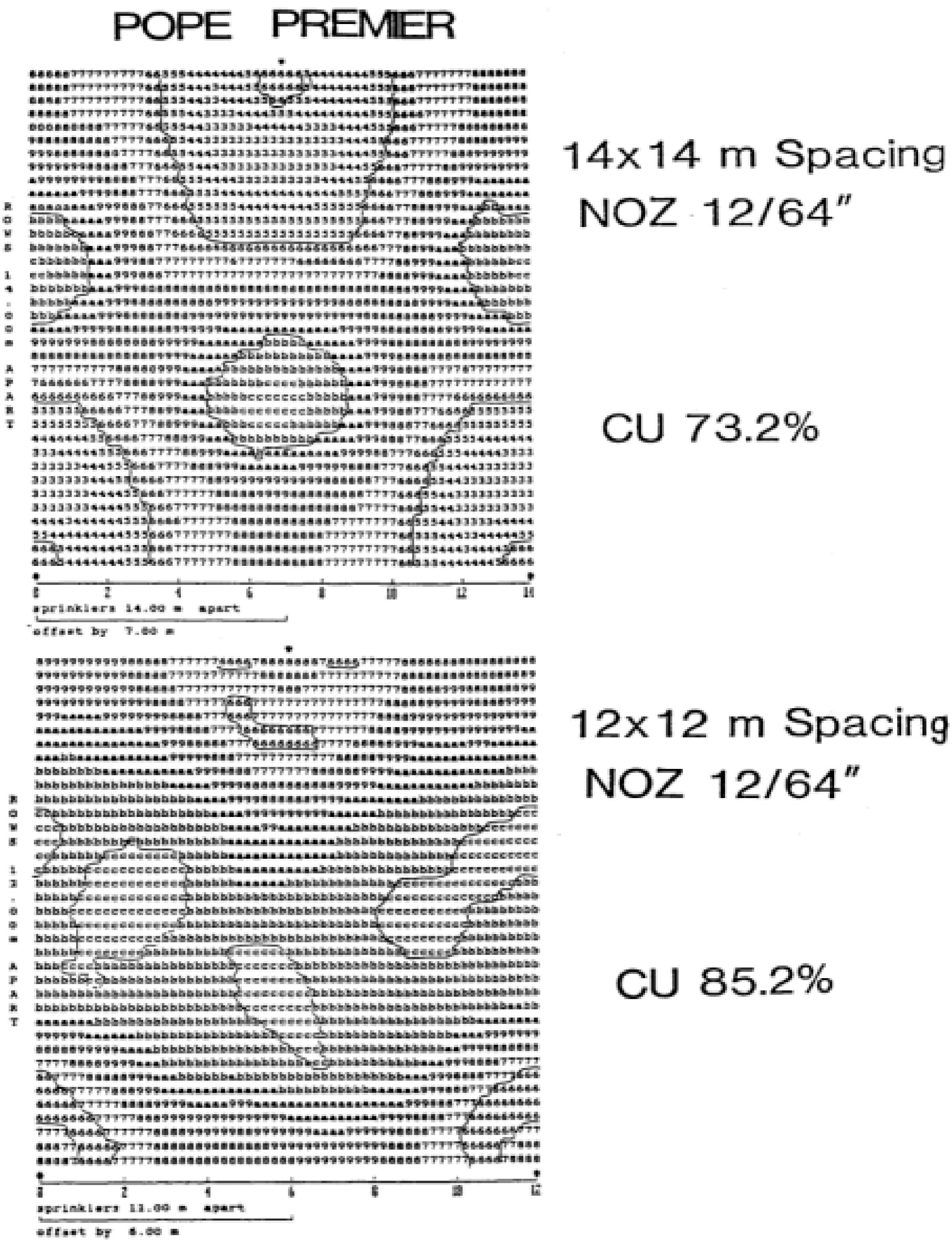

Figure 3. Computer simulations of the water distribution pattern showing improvements in CU for a Pope Premier sprinkler when spacing is reduced from 14x14 to 12x12 meters

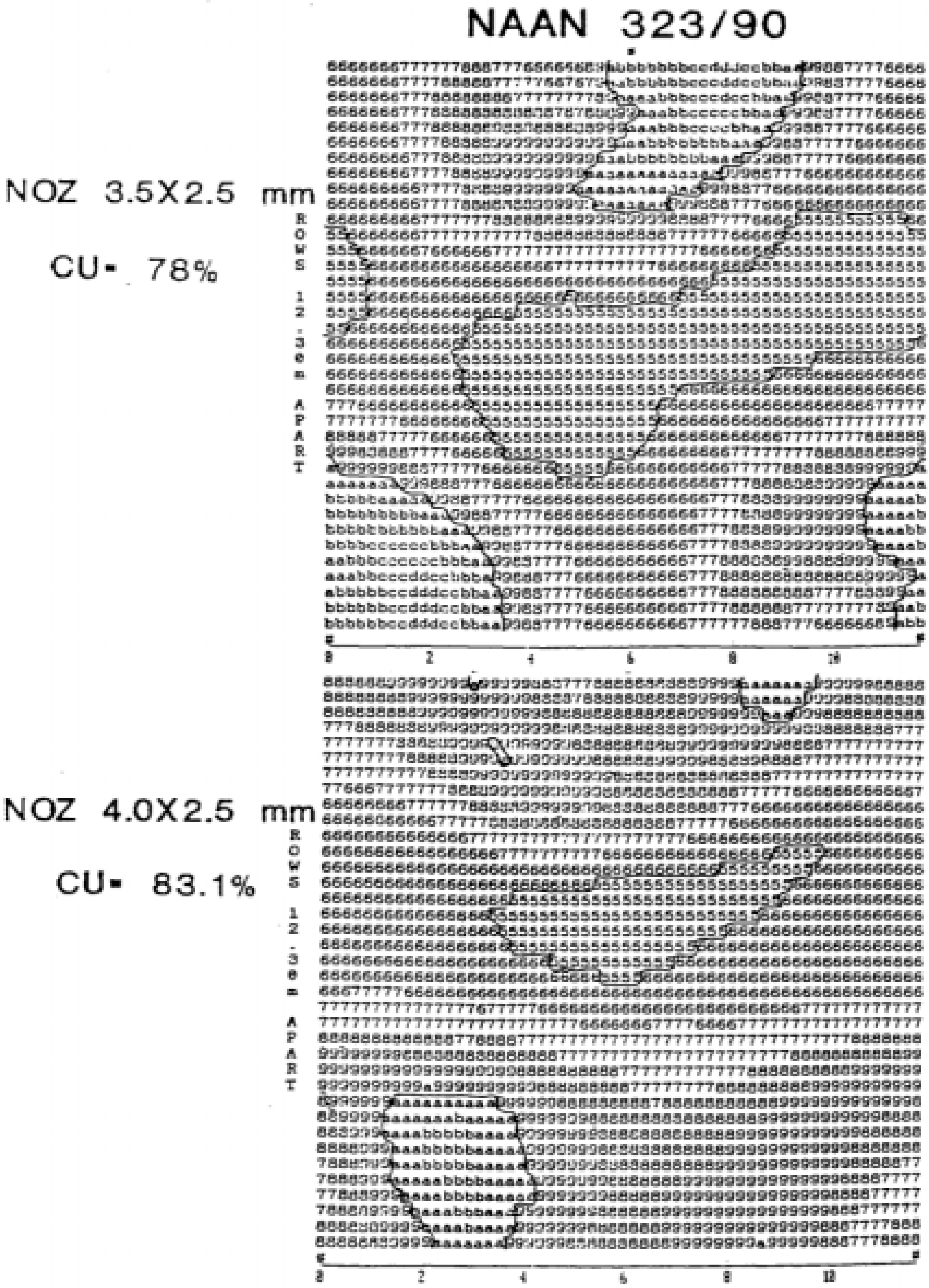

Figure 4. Computer simulations of the water distribution pattern showing improvements in CU for a Naan323/90 sprinkler when the front nozzle is increased from 3.5 to 4.0 mm

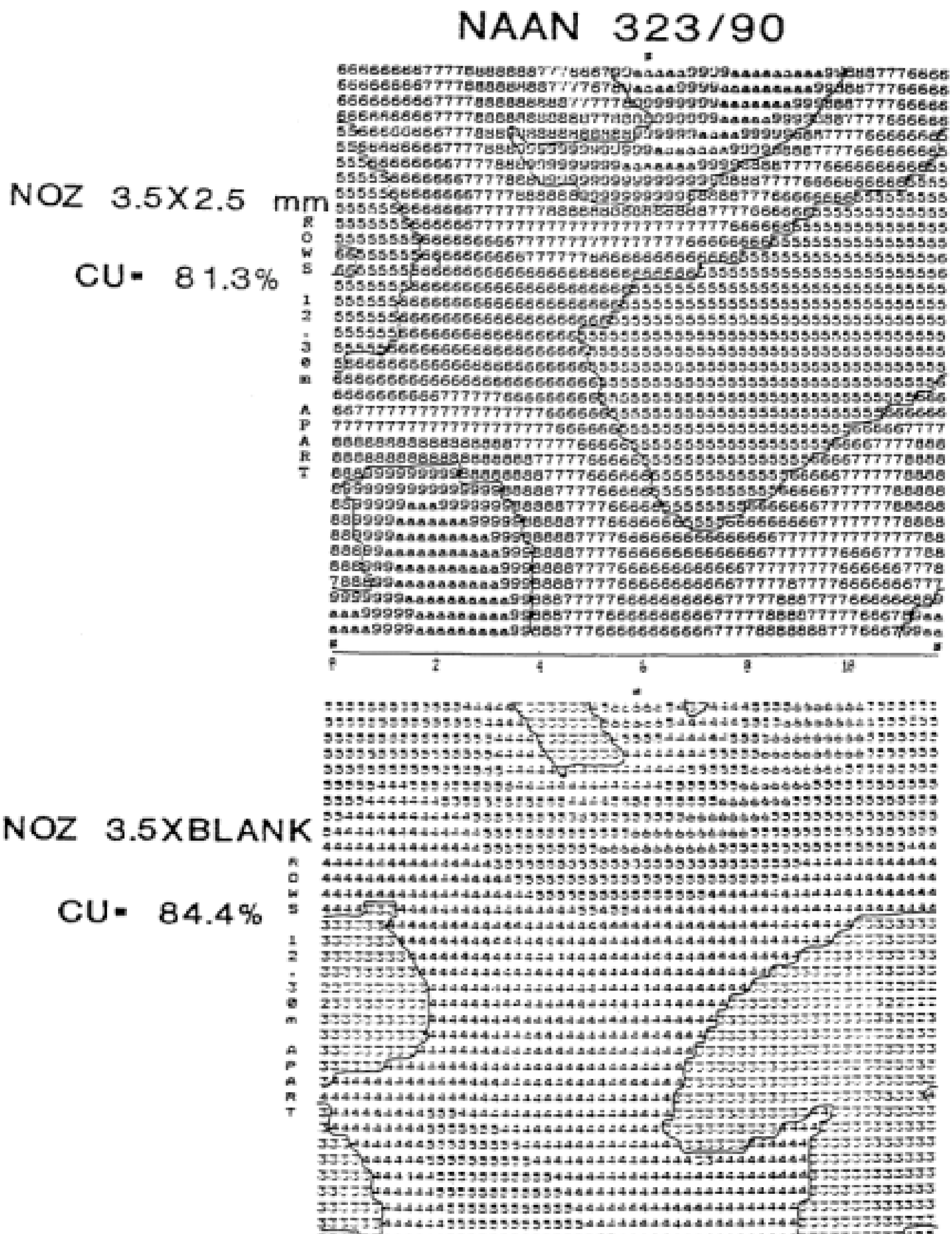

Figure 5. Computer simulations of the water distribution pattern showing improvements in CU for a Naan 323/90 sprinkler when the backjet is blocked

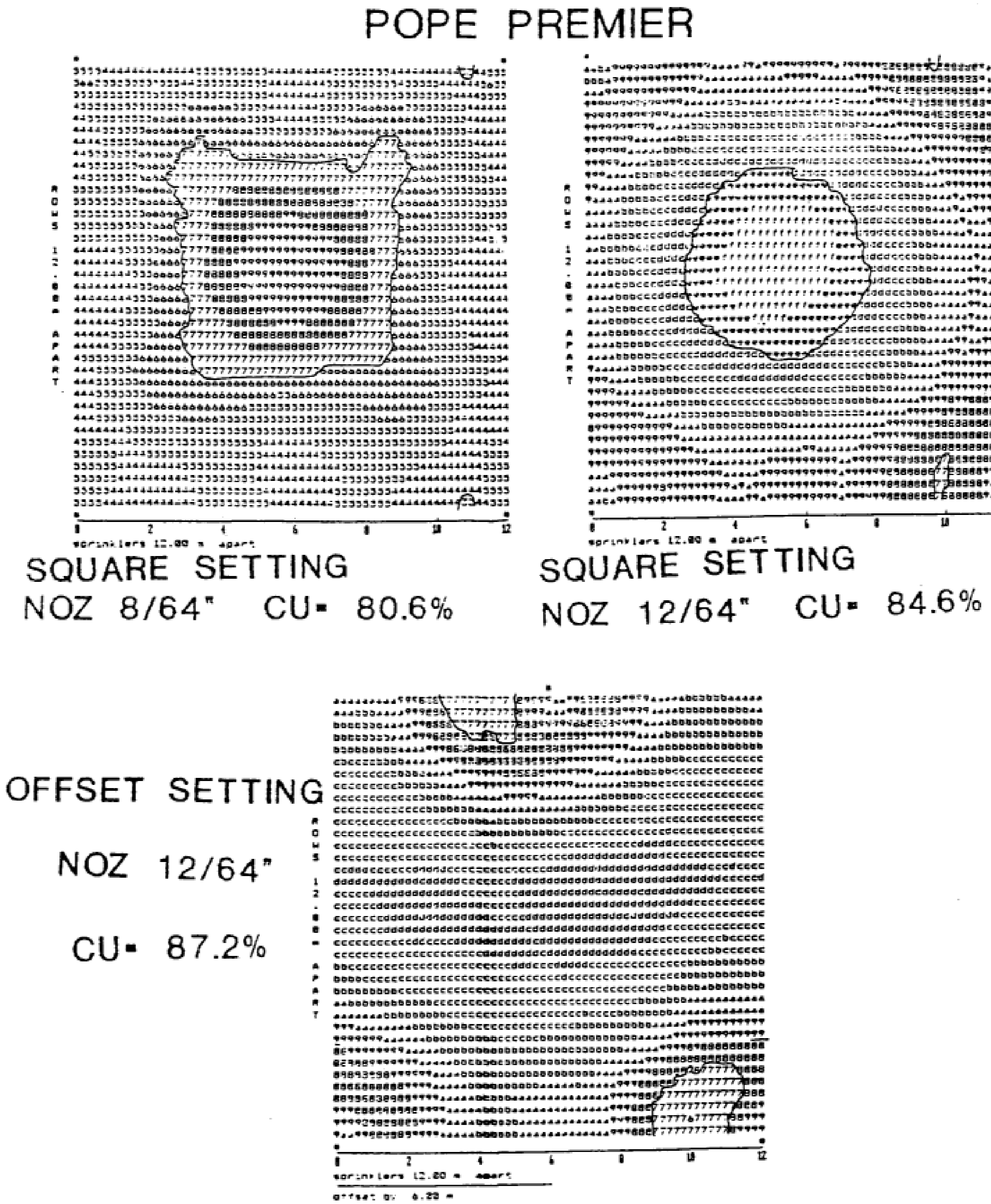

Figure 6. Computer simulations of the water distribution pattern showing improvements in CU for a Pope Premier sprinkler when the nozzle is increased and the set up is altered

4.3 Advice and Recommendations

4.3.1 Setting Up A New Irrigation System

Often, the money saved by farmers in initial designs and equipment, lead to later problems in inefficiency and increased operating expenses. A proper and accurate design is essential to efficient irrigation and can save the grower a considerable amount of money in operating and maintenance costs. All new irrigation designs should comply with the Irrigation Association of Australia (Western Australian Branch), Guidelines.

When elevation variations exceed 2 to 3 metres, a topographic survey is strongly recommended. In most cases money spent on the survey represents less than 10 per cent of the initial investment and only a very small portion of the potential losses due to inefficient operation.

The key to the development of a proper irrigation design and management plan is the integration of a soil survey which defines the spatial variability of the soil within the boundaries of a property.

For future reference, it is also important to obtain and keep a plan of the pipe network and operating specifications as designed by the consultant.

After installation, pump and pressure tests are necessary and would help identify malfunctions.

Following the installation of the new system, pump and pressure tests should be conducted to identify malfunctions.

Irrigation scheduling advice matching crop requirements and soils and climatic conditions should be sought.

4.3.2 Improving Efficiencies Of Existing Systems

Efficiency tests can reveal a lot of information about the design, installation, operation and management requirements of an irrigation system. Farmers need to be aware of the following:

- Simple and cheap means of improving the uniformity of a sprinkler system may be available;
- With increasing age, pumps tend to decline in operating efficiency. This situation can cost farmers a considerable amount of money in operating costs. A simple inspection of the impeller may reveal that cavitation had occurred and that for the minimal price of a new impeller the original efficiency can be restored;
- The installation of a pressure gauge at the pump outlet is a very inexpensive and worthwhile exercise as it can often provide valuable information in an efficiency test. Flow meters have also been found to be very useful but are less common due to their relatively high cost;

- Regular evaluation of an irrigation system can prevent expensive problems from occurring at a later date. Farmers are strongly encouraged to evaluate their irrigation system on a regular basis.

4.3.3 Irrigating Under Western Australia's Windy Conditions

To minimize the adverse effects of winds on distribution uniformity the following adjustments are recommended:

- As a rule of thumb double jet sprinklers should be restricted to areas where average wind gusts do not exceed 8 to 10 km/hr;

- Where possible a north-south direction can be given to the laterals in order to compensate for the strong easterlies that dominate our summers;

- As a larger droplet size is less prone to wind interference, a combination of smaller spacings and lower operating pressures would be desirable;

- Use wind-breaks to reduce wind speed.

4.4 Other Observations

A comprehensive list of the horticultural growers operating in the Peel-Harvey catchment does not exist and needs to be compiled.

The lack of an accurate irrigation management and scheduling service needs to be addressed.

4.5 Farmer's Concerns

The following concerns were found to be common among growers found in the Peel-Harvey catchment:

- As cost of water and fertilizer is cheap, over-irrigating and over-fertilizing is perceived to be the cheapest way to secure good annual crop yields;

- With the extension of the metropolitan urban land into the rural areas, farmers have a bleak vision of their future and are consequently reluctant to undertake expensive changes or costly conversions to a better and more efficient irrigation system.

These concerns should be taken into account when any extension programme aimed at improving the efficiency of irrigation and fertilizer management is designed.

5. References

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6. Appendix A

Result Summary Of The Irrigation Investigation

Name:	Example only
Date of Investigation:	02/05/1990
Address:	
Telephone:	
Total Area Under Irrigation:	9 hectares
Soil Type:	Bassendean Sands
Crop:	Vegetables

Description		**Results**	
1.	**Pumping Plant**		
	Total head your pump has to work against	TDH	75m
	Maximum flow discharge from your pump	Q	8.1 L/SEC
	Water horsepower generated by your pump	WHP	8.0 HP
	Actual horsepower rating of your motor	EHP	30.0 HP
	Estimated efficiency of your electric motor	Efm	85%
	The efficiency of your pump	Efp	32%
	The overall efficiency of your pumping plant	Eft	27%
2.	**Pipe Network Analysis**		
	Pressure at which your sprinklers operate	H_s	35m
	Pressure variation along the laterals	H_v	1m < 10%
	Estimated head loss in main and submain	H_m	-
3.	**Water Distribution Pattern**		
	Wind conditions during distribution test	V_w	5-8 KM/HR
	Coefficient of uniformity obtained from test	Cu	43.8%
	Distribution uniformity obtained from test	Du	26.0%
	Coefficient of variation obtained from test	CV	.56
	Extra water required to achieve full yield	W	1.77
4.	**Additional Costs Incurred Due To Inefficiencies**		
	Extra electrical cost associated with pumping plant inefficiency	$ 1,680/year	
	Extra Electrical cost associated with poor distribution pattern	$ 3,600/year	
	TOTAL	$ 5,280/year	

Remarks And Recommendations - Example Only

1. Pumping Plant

The operating efficiency of your pump is well below its design performance. We suspect that this situation is caused by a corroded impeller which needs changing. However this can also be due to several other factors such as; leaks in the system, valve malfunction, insufficient water yield from the bore. We urge you to try to identify the cause of such inefficiency.

2. Pipe Network Analysis

The operating pressures and pressure variations along the laterals are adequate and up to good design standard. However your spacing does not match the capacity of your sprinklers. It is more economical for you to change your sprinklers rather than spacings.

3. Water Distribution Pattern

Your distribution pattern is very poor and is estimated to cost you an extra $3,600 each year in electricity expenses. With your 13.6 x 12.8 spacing at 200-300 KPA we believe that you will obtain a much better performance with a new sprinkler such as the Pope Monsoon Single Jet (5.2 mm nozzle).

4. Additional Costs Incurred Due To Inefficiencies

Your additional costs due to the inefficiencies in your system are high and need to be addressed urgently. The costs estimates are based on the following assumptions:

- 1900 mm/year application
- 6.7mm/hr application rate
- 9 Stations
- 2500 hrs of operation time per year
- $.18/KWH

5. Comments On Water Quality

From the results of the water analysis we believe that your bore water is suitable for irrigation of vegetable crops.

6. Final Recommendations

1. Need to change your sprinklers (See Recommended Model in 3)
2. Check your pump and change impeller if necessary.