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A Comparison of Irrigation Water Issue Options - Case Study from System H of Mahaweli Development Programme

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ABSTRACT. Water is the most precious resource in the Dry Zone of Sri Lanka and agriculture is the main livelihood of people living in the area. Therefore, all possible efforts need to be taken to optimize the water usage within the area. This study is an attempt to identify the present use of the water for irrigated cultivation in comparison with the guideline and recommendations of the Department of Irrigation. A system of field canals and a distributory canal in the Mahaweli System H was chosen for the study. System under the study consists of 26 field canals carrying 28 litres per second in each, while catering 177 field allotments of one hectare each. The study revealed that the present practice of rotational water issue consumes more water even with higher conveyance efficiencies than those in the guidelines and with early water issue terminations again different to that of the guidelines. The study also showed that the use of a challenging water issue schedule considering a rational grouping of canals and accounting for the change in crop water use with different growth stages could lead to a significant saving of water which could be much more than 33 cm per unit area during a Maha season. Results and comparisons indicate the need of critical evaluation of guidelines with the present practice to ensure the optimum yield from the water diverted to the water scarce Dry Zone.

INTRODUCTION

Mahaweli programme is the largest development programme undertaken by the government of Sri Lanka and Mahaweli Authority of Sri Lanka (MASL) is the organization in charge of the development activities. This programme harnesses water resources from the longest river of Sri Lanka and diverts some of the water to the water scarce Dry Zone in the North and East regions. The System H (Fig. 1) in the Kala oya basin is the first irrigation development system carried out by the MASL. It covers about 40,000 ha of irrigable land. System H received water from the Kalawewa, a reservoir which has a capacity of 123 mcm. Block 4 which is located close to Thambuttegama is fed by the branch canal 4 of the Kalawewa Right Bank main canal. Kalawewa right bank canal carries a discharge of 32.5 cumecs.

Thambuttegama is a small town in the System H and to the south of Anuradhapura, where water is the most precious resource. Agriculture is the main livelihood of people in the area and hence a reliable water supply for irrigation is considered as a must. Presently this area has been developed under the Mahaweli programme and is supplied with Mahaweli water received by the Kalawewa. Since water is diverted from river Mahaweli and transported over a long distance, it has been recognized that all possible efforts need to be taken to optimize the water use. Optimizing of water use indicates that more land could be cultivated. This could be achieved by improving the conveyance, distribution and use. Improving the conveyance could be done by proper canals and related structures. Distribution could be optimized by having suitable allocation methods either schedules or amounts. Optimizing water by proper usage needs to look at ways of which the farmer uses water for the crop, how controls are done at field level *etc.* The present work is on a selected distributory canal from the Block 404 comparing the quantity of water that is required under different distribution scenario.

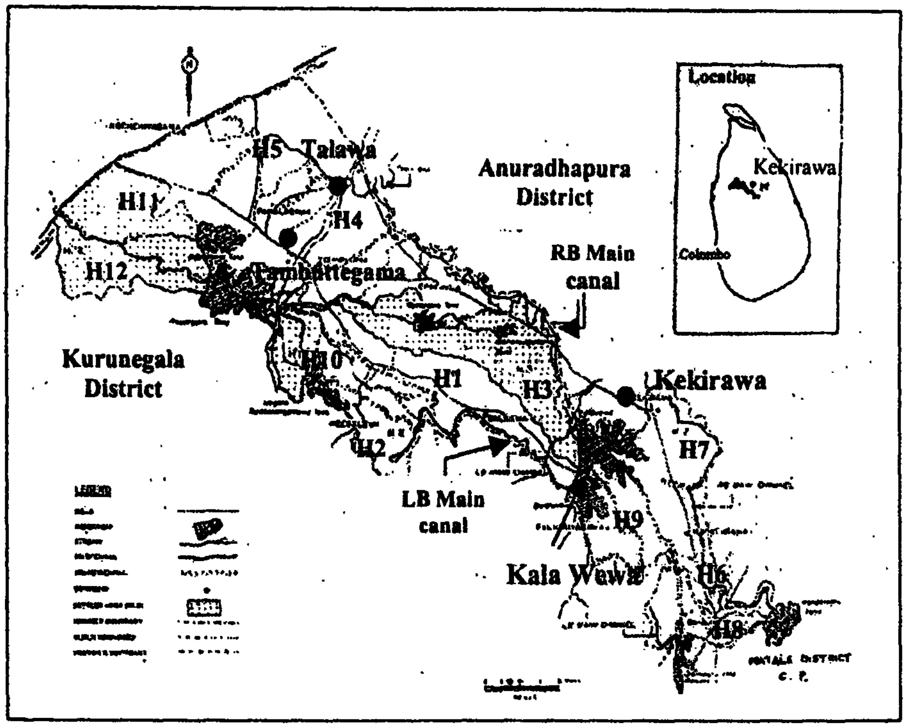

Fig. 1. System H under Mahaweli development programme.

MATERIALS AND METHODS

Study area

Annual rainfall of the Kalawewa is about 1275 mm and annual pan evaporation measured at Anuradhapura is about 1500 mm (ID, 1998). Water issues from the canal system developed under the Mahaweli programme has been going on for nearly two seasons. Block 404 was one of the early blocks developed under the System H4 for pilot studies. The distributory canal D2 of Block 404 (D2/404) feeds 177 allotments consisting of one hectare in each allotment. A schematic diagram of the canal network is shown in Fig. 2. D2/404 canal which has a design capacity of 1.8 cusecs, feeds 26 field canals. Rice is the main crop cultivated in both *Yala* and *Maha* seasons. Usually various types of rice varieties are cultivated in these allotments. In *Yala* season either 90 or 105 day paddy are grown by all farmers. According to the officials in MASL only 50% of the total irrigable area is cultivated during this season. In the *Maha* season about 25% of the farmers who are closer to the head end of canal cultivate shorter duration (90 or 105 day) paddy while the further downstream farmers opt for longer duration (120 or 135 day) varieties. Site visits revealed that the reason to this is that allotments which are further away receive drainage water and hence in a position to cultivate longer duration paddy.

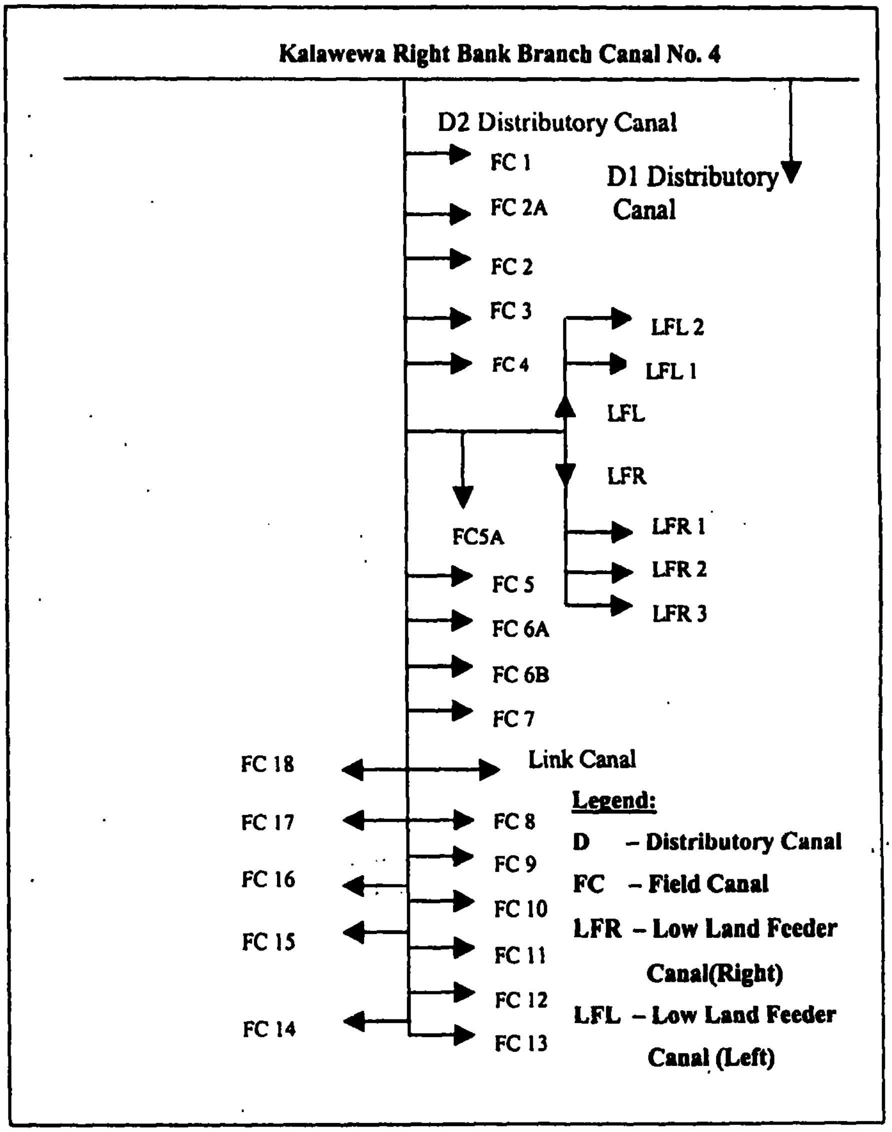

Fig. 2. **Canal network system for D2/404.**

Present water issue

Water issues for land preparation and irrigation is done jointly by the MASL officers and farmers in each turnout. Prior to each season officers of MASL and farmers summon a meeting known as "*Kanna*" meeting to decide on the type of crops, extent and quantity of water to be issued. Based on these discussions, the irrigation schedule is prepared by the Block Irrigation Engineer and further modifications if any, are done subsequent to these discussions but in consultation with farmers. According to the rotation schedule presently used by the MASL, field canal water issues are rotated in a cycle of 7 days in *Maha* season and 7-10 days in *Yala*. Field canals carry 1 cusec (28.3 l/s) and generally feed two allotments simultaneously. Presently each allotment is fed with 0.5 cusec (28 l/s) for 24 h during the land preparation period and 0.5 cusec for 12 h during different crop growth stages. Water is rotated to the next set of the allotments at each 24 h interval and at each 12 h interval during the land preparation and during the crop growth stages respectively. The rotation plan for the 3-8 week period during *Maha* for D2/404 is in Table 1. In the land preparation period the MASL releases water 24 h continuously for each allotment once a week and for 3 weeks. Water for land preparation is released for both *Maha* and *Yala* seasons.

Water issue scheduling

Rotation interval and application period

Irrigation Department guidelines (ID, 1988) indicate that for unlined network of primary, secondary and tertiary canals, the conveyance efficiency could be taken as 70%. Also the land preparation requirement is 150 mm for 15 days and the crop water requirement changes according to four crop growth stages. For paddy crop the effective root zone is taken as 22.5 cm and the Irrigation Department (ID) recommends an allowable moisture level depletion of 30%. However, during field visits it was revealed that the present water issue scheduling of MASL assumes a conveyance efficiency of 95% for field canals and 85% for distributory canals.

Water issue scheduling for optimum use, needs to consider the temporal water needs for each crop cultivated and the spatial distribution of allotment or turnout areas. Temporal water needs are straightforward calculations once the crop type, respective crop coefficients, reference crop evapotranspiration for each month of the year expected, effective rainfall and the canal efficiencies are known. A calculation of field irrigation requirement according to ID guidelines showed that the requisite rotation interval for an allowable depletion of 30% is 7 days. This rotation interval is the same interval presently practiced in D2/404. Considering guideline recommendations the requisite application period per week vary between 11-18 h. This is not same as the present water issue by MASL which is 12 h per week during the entire growing season. MASL water issues span over 21 weeks but the guideline recommendations for the same crop covers a period of 22 weeks. The irrigation water requirement for each week varies due to the crop water requirement and the receipt of rainfall. Variation of water supply duration computed under these consideration for *Maha* season is shown in Table 2.

Table 1. Present water distribution pattern in D2/404 during the growth stages in *Maha* season.

Field Canal No.	Area (ha)	Discharge (l/s)	Days 1	2	3	4	5	6	7
1	5	28.3	—	—					
2A	2	28.3		—					
2	8	28.3			—	—	—		
3	7	28.3			—	—			
4	6.5	28.3	—	—					
5A	2	28.3	—						
5	4	28.3	—	—					
6A	7	28.3			—	—			
6B	10.5	28.3	—	—	—				
7	6.6	28.3			—	—			
8	12	28.3	—	—	—	—			
9	8	28.3	—	—	—				
10	10	28.3		—	—	—			
11 & 12	9	28.3		—	—	—			
13	3	28.3				—			
14	8	28.3		—	—	—			
15	11.5	28.3	—	—	—	—			
16	9	28.3		—	—	—			
17	11	28.3		—	—	—			
18	8	28.3		—	—	—			
LR(L)	11	28.3	—	—	—				
LR(R)	18	28.3	—	—	—	—	—		

Required Total Discharge (l/s) in D2/404 [with all losses]: 254.7, 254.7, 297.2, 382.1, 438.7, 424.5, 382.1, 339.6, 42.45, 28.3

	Days 1	2	3	4	5	6	7
Actual Total Discharge (l/s) in D2/404 [with all losses]	424.5	424.5	424.5	424.5	56.6		

———— Duration of water issue

Losses
Distributory Canal - 15%
Field Canals - 5%

Command area - 177 ha

Water issue sequence

Water requirement for irrigation rotations differ when the canal layout for water distribution is changed. This is because the extents cultivated under each canal vary depending on the topographical features. Since the extents that need to be supplied with water under each canal differ, it creates a variation of a water schedule once the canal grouping for water issue is changed. This is caused by the need to round off water releases to suitable time slots. Therefore, it is necessary to make an assessment of water requirement using a combination of canals to identify the best. This study used a computer spread sheet based trial and error approach to compute the water requirement for various canal grouping. The related parameters were varied over a wide range in order to ensure that the water usage reached a global minimum. Trial and error computations of a water requirement looked at the canals and the areas cultivated under each canal for grouping.

Table 2. Variation of water supply durations during *Maha* season.

Week of *Maha*	Growth stage	ID guideline (h)	Present practice (h)
1	LP	24	24
2	LP	24	24
3	LP	17	24
4	IS	15	12
5	IS	12	12
6	IS	11	12
7	IS	11	12
8	IS/CD	11	12
9	CD	12	12
10	CD	14	12
11	CD	14	12
12	CD	14	12
13	CD	14	12
14	MS	18	12
15	MS	18	12
16	MS	17	12
17	MS	17	12
18	MS	18	12
19	MS	18	12
20	MS/LS	17	12
21	LS	17	12
22	LS	17	0

LP - Land preparation MS - Mid season stage
CD - Crop development stage IS - Initial stage LS - Late stage

Scenario

In order to identify the present water usage and its comparison with the ID guidelines practice, a comparative analysis of the system with different water issue scenario was performed. Comparison of water issues assuming a constant conveyance loss for the entire canal system considered the following three scenario during a *Maha* season commencing 1st of October.

- Water use of present rotational system practiced in the D2/404 canal.
- Water use with issue arrangement in canals changed while maintaining the same water release pattern for each allotment as at present.
- Water use with issue arrangements in canals changed and the water release pattern also changed according to crop growth stages.

Table 3 shows a summary of the perspectives used in the study.

Table 3. Variation of water supply duration during *Maha* season.

Scenario	Selection of canals for water release	Water release pattern
1	Present practice	Present practice
2	Selection of best arrangement by trial and error	Present practice
3	Selection of best arrangement by trial and error	Changing to suit the crop growth requirement

The first scenario considered the same repetitive scheduling presently practiced by the farmers and the MASL throughout the season. The second scenario studied the grouping of canals to carry out simultaneous water releases. Water releases were similar to the presently practised system of repeating the same release pattern for each week till the end of the season. Trial and error computations were done to compute the combination of canals with a minimum water requirement. The third scenario considered the canal grouping and also the variation of water release duration (Table 2) to suit the requirements at each crop growth stage. A number was allocated to each canal and this number indicated the order in which water would be distributed to that particular canal. Different trials were carried out changing the order of water issue with ID guidelines recommended quantities.

RESULTS

Water requirement schedules were prepared for the above three scenarios assuming that water issues commence on 1st of October. Using the presently adopted practices as described in the water issue scheduling section, the total quantity of water requirement during the *Maha* season using 75% probable rainfall was 3585.82×10^3 m^3. This used the canal grouping as in Table 1. Second scenario computations attempted regrouping of canals for water releases and using a trial and error technique the best arrangement was decided. The optimum canal grouping for the scenario 2 is shown in Annex 1. Third scenario computed the water requirement for each growth stage of paddy as per ID guidelines. Seasonal water requirement was then computed for different canal grouping using a similar trial and error approach as in the scenario 2. The best grouping is shown in Annex 2. Computations pertaining to five out of many trials are shown in the Annex 3. In Annex 3 the numbers allocated for each field canal indicated the sequence of water issue to that particular field canal and it was the 1st, 2nd, 3rd, ... up to 7th day of the week considering the variation of requisite application period per week during different growth stages. This canal grouping and water issue showed an optimum water requirement of 3340.03×10^3 m^3. A comparison of total water requirement for each scenario is in Table 4. This planning exercise, used 75% probable rainfall as the most likely rain in the project area (ID, 1988) for all computations.

Table 4. Water requirement under different scenarios.

Scenario	Total quantity × 10^3 (m^3)	Quantity per unit area (m)
1	3585.82	2.02
2	3015.76	1.70
3	3340.03	1.89

Variation of weekly water usage (Fig. 3) indicates that the present system utilizes more water than requisite amounts according to guidelines. Since the canal efficiencies are assumed at very high levels, it is felt that the overall water management is high. It is important to note that if the same efficiencies recommended in the guidelines are used then the water requirement would be much more. The option of changing canal grouping for water distribution showed a water usage reduction of about 570.1×10^3 m^3 per season (≈ 33 cm) and that is about 16% of the present supply. This change follows the same pattern as the present system because this option has considered only a change in the canal grouping. Incorporation of rotation variation with crop growth and optimum canal grouping showed that water requirement could be lowered by approximately 245.8×10^3 m^3 than in the present system. Recommended water scheduling as per ID guidelines show a significant amount of more water is released in the present system during the latter part of the land preparation, during the latter part of initial crop growth stages and also during the initial part of crop development stage. Only during the 5th and 9th weeks the water requirement (according to ID guidelines) is same as the present issue and during the rest of the season the water requirement is more than the present issue. It is noted that presently the water issues are stopped two weeks prior to the ID recommended end season. Since the farmers agree at the *Kanna* meetings to stop water for two weeks prior to the ID recommendations, water use at the end of the 21st week of scenario 3 could be terminated. This shows that the rotational considerations with optimum grouping could be reduced to 3178.65×10^3 m^3.

DISCUSSION

Water requirement and usage comparisons indicated a significant difference between the present system and when the canal grouping was changed. The difference in quantity is about 33 cm per unit area and it is about 16% of the present supply.

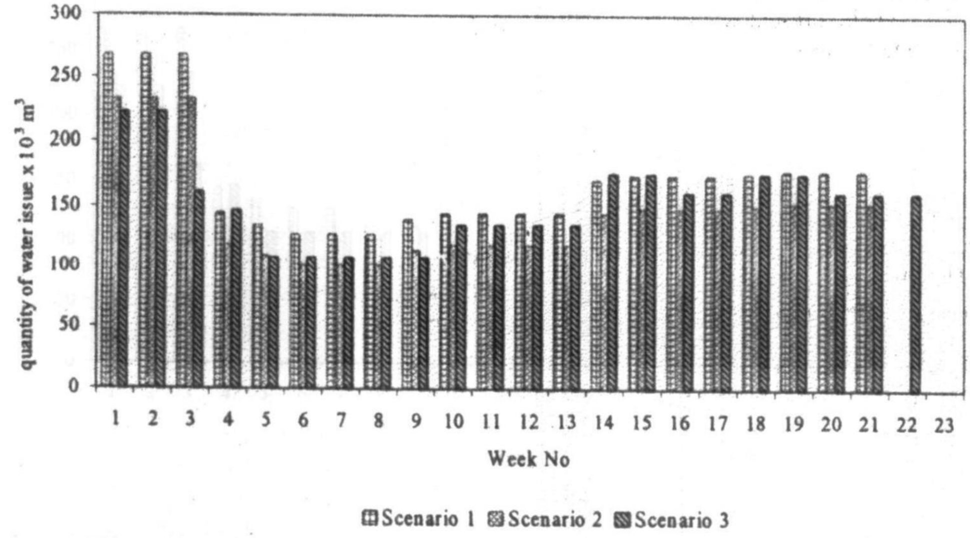

Fig. 3. Comparison of weekly water issue quantity.

Rotational water use presently practiced in the area is lower than the calculated amount using the ID guidelines and hence in certain periods crops undergo a soil moisture depletion of more than 30%. This need to be locally investigated and if the yields are not affected by this practice then the guidelines need to be modified accordingly since a significant water saving could be achieved.

During some crop growth stages the present practice used more water compared to the ID guidelines practice and this also needs investigation for efficient water usage. Incorporation of rotation variation with crop growth and optimum canal grouping showed that water requirement could be lowered by approximately 245.8×10^3 m^3. This shows that flexible and challenging water issue rotations could optimize the water usage.

There was a significant difference between the conveyance efficiency values between the MASL and ID practices. This could lead to either a waste or the plants could be under moisture stress leading to reduced yields. Hence this needs further investigation, for meaningful, effective and flexible water scheduling.

Canal grouping combinations showed that there was a significant difference in water requirement between the options. This shows the need to consider the most practicable options to prepare suitable water release schedules. Canal grouping needs to consider the extent under each canal and the crop type proposed by farmers. The present study considering five options showed a variation of use by about 88.02×10^3 m^3 in *Maha* season.

The water release computations under each option showed the seasonal use under each option to vary between 1.89 m as per ID guidelines to 2.02 m according to present practice. However the present water use could be reduced to nearly 1.7 m if the canal grouping is changed as proposed.

CONCLUSIONS

Water issue scheduling with the consideration of water requirement change with growth stages, effective rainfall and proper canal grouping would enable optimum irrigation water use. The present water issues practiced by the block 404 appears to use more water than estimated by the ID guidelines even with higher conveyance efficiency values. Therefore, it is necessary to find out the possible ways to optimize the water usage.

Rotation interval of 7 days of the present issue is acceptable according to the calculations done with the ID guidelines but the weekly water requirement for the season varies between 11-18 h (during the crop growth) other than to the 12 h water issue at present. Present practice also indicates a possible early termination of water issues. This shows the need of a critical evaluation of available guidelines and present practices in relation to crop yields, in order to achieve a significant water saving.

Water requirement for irrigation rotations vary with the canal grouping and canal layout depending on the extents cultivated under each canal. Hence the water issue scheduling should be done with the best combination of canals.

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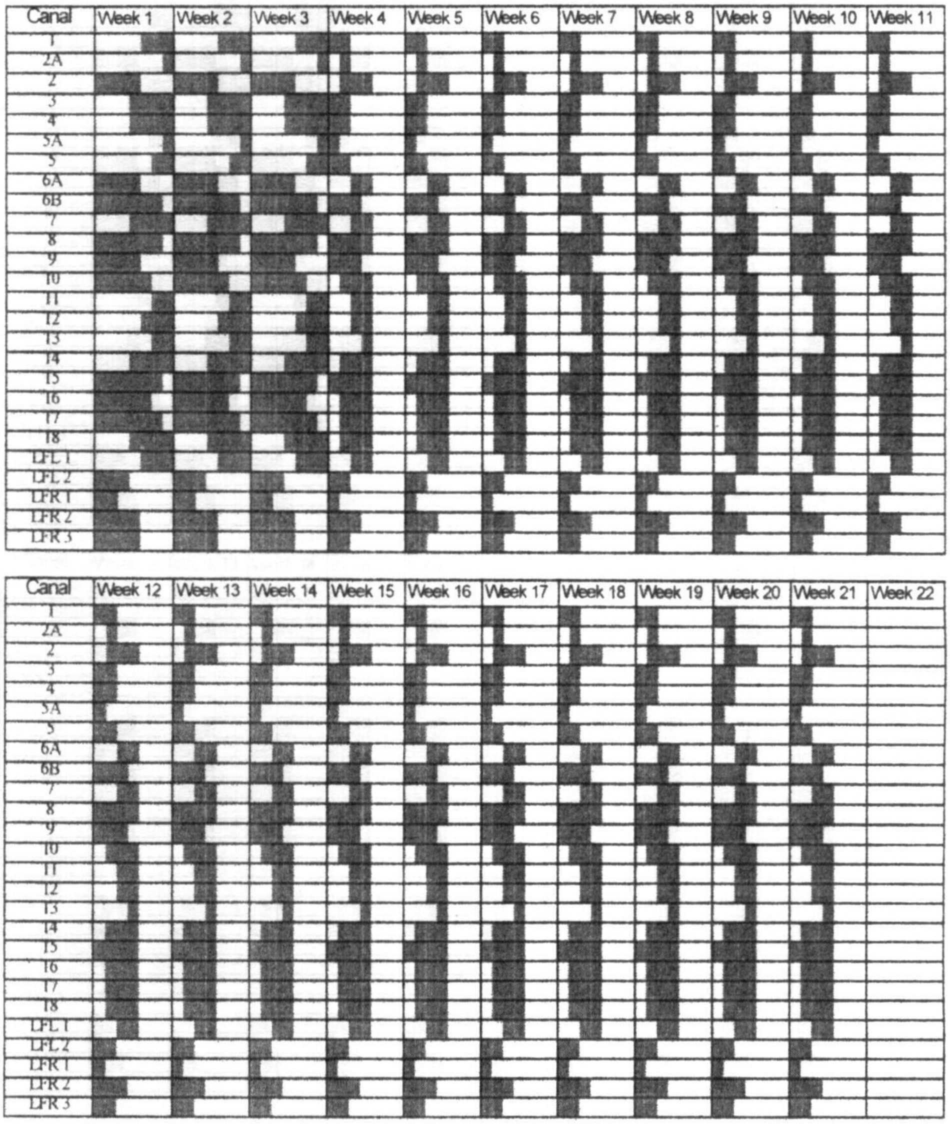
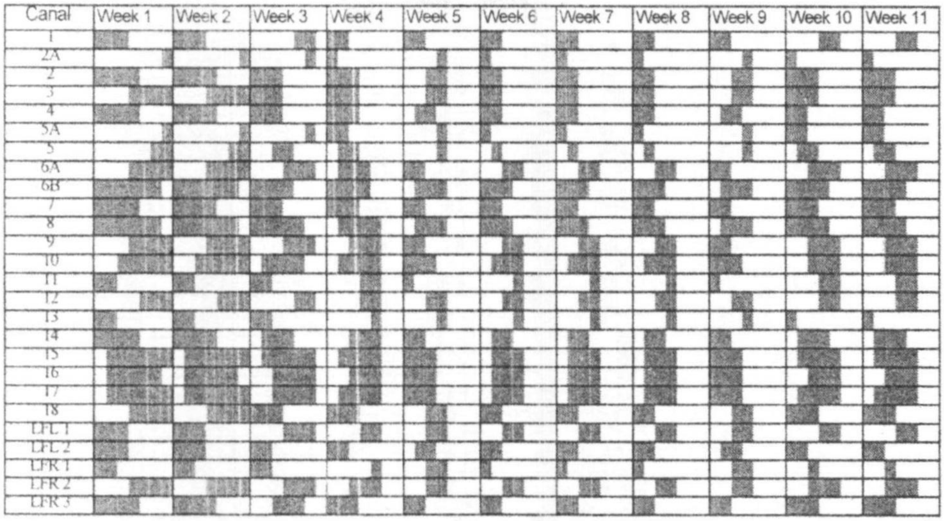
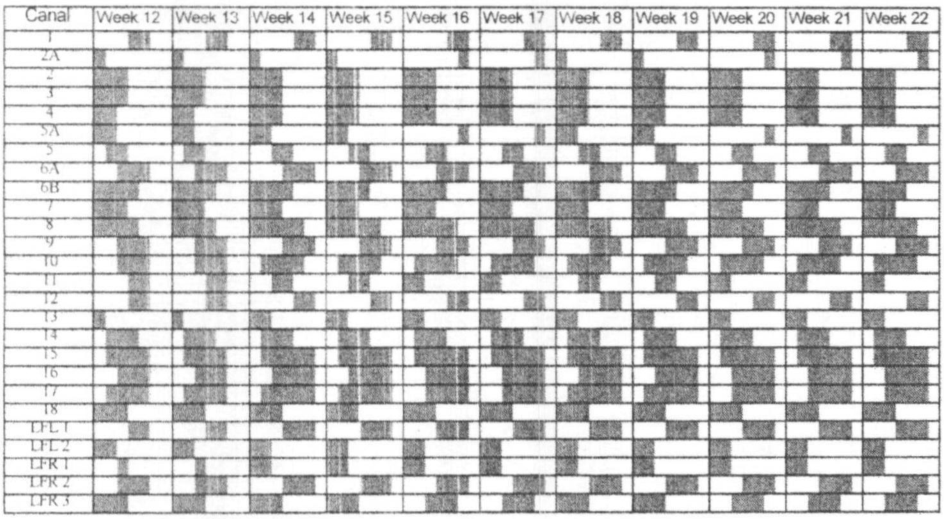
ANNEXES

Annex 1. Optimum canal grouping for scenario 2.



Annex 2. Optimum canal grouping for scenario 3.





Annex 3. Water issue sequence and water requirement for different canal combinations (scenario 3).

Field Canal No	Option 1							Option 2							Option 3							Option 4							Option 5						
	24hr/wk	18hr/wk	17hr/wk	15hr/wk	14hr/wk	12hr/wk	11hr/wk	24hr/wk	18hr/wk	17hr/wk	15hr/wk	14hr/wk	12hr/wk	11hr/wk	24hr/wk	18hr/wk	17hr/wk	15hr/wk	14hr/wk	12hr/wk	11hr/wk	24hr/wk	18hr/wk	17hr/wk	15hr/wk	14hr/wk	12hr/wk	11hr/wk	24hr/wk	18hr/wk	17hr/wk	15hr/wk	14hr/wk	12hr/wk	11hr/wk
1	1	5	5	1	4	1	1	1	5	5	1	4	1	1	1	5	5	1	4	1	1	1	5	5	1	4	1	1	1	5	5	1	1	1	1
2A	7	1	1	1	1	4	4	7	1	6	1	1	4	4	7	1	6	1	1	4	4	7	1	6	1	1	4	4	7	1	6	1	1	4	4
2	1	1	1	1	1	3	3	1	1	1	1	1	3	3	4	1	1	1	1	3	3	1	1	1	1	1	3	3	1	1	1	1	1	3	3
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6A	4	4	4	2	3	1	1	4	4	4	2	3	1	1	1	4	4	2	3	1	1	4	4	4	2	3	2	2	4	4	4	2	2	1	1
6B	1	1	1	1	1	2	2	1	1	1	1	1	2	2	1	1	1	1	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1	2	2
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9	4	4	4	3	3	[illegible]	1	4	4	4	3	3	1	1	1	4	4	3	3	1	1	4	4	4	3	3	1	1	4	4	4	3	3	1	1
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LFL 1	1	4	4	4	4	3	3	1	4	4	4	4	3	3	1	4	4	4	4	3	3	1	4	4	4	4	4	4	1	4	4	4	4	3	3
LFL 2	1	1	1	1	1	2	2	1	1	1	1	1	2	2	5	1	1	1	1	2	2	1	1	1	1	1	3	3	1	1	1	1	1	2	2
LFR 1	1	1	1	5	3	3	3	1	1	1	5	3	3	3	1	1	1	5	3	3	3	1	1	1	5	3	3	3	1	1	1	5	5	3	3
LFR 2	4	4	4	3	3	3	3	4	4	4	3	3	3	3	4	4	4	3	3	3	3	4	4	4	3	3	3	3	4	4	4	3	3	3	3
LFR 3	1	1	1	1	1	1	1	1	1	3	1	1	1	1	4	1	3	1	1	1	1	1	1	3	1	1	1	1	1	1	3	1	1	1	1
Total x 10^3 m^3	3428.65							3340.03							3374.25							3388.88							3388.95						