Land Resources Development Centre

NOTES ON SMALL SCALE IRRIGATION IN LOWER EMBU AND MERU DISTRICTS OF KENYA

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ABBREVIATIONS

SWCP - Soil and Water Conservation Project
MALD - Ministry of Agriculture and Livestock Development of the Kenya Government
SSI - Small Scale Irrigation
GOK - Government of Kenya

PREFACE

These notes form a supplement to a report prepared by Leo Silva, LRDC Miscellaneous Report 305, 'Report on a Visit to Kenya, 19th July to 11th August 1984' including the Technical Annexe and to the results of the socio-economic survey conducted by Elizabeth Hawksley 'Potential for Small-Scale irrigation in Kibung'a and Ruungu villages of Tharaka Division, Meru District, E Province, Kenya', August 1984, LRDC Report P-159.

These notes should be read in conjunction with the other two reports and together form a basis for future proposals for British government assistance to small scale irrigation in Embu and Meru.

The notes draw on experience gained during a tour of duty as Soil and Water Conservation Engineer with the EMI/SWCP Soil and Water Conservation Project from late 1982 to mid-1985. Attention is paid to the organisational and social aspects likely to influence irrigation development and also to the suitability of different irrigation techniques.

The question of assistance to the rehabilitation of the Ewaso-Nyiro cluster (Isiolo District) is not considered.

1. INTRODUCTION

The climate of lower Embu-Meru is characterised by low and intermittent rainfall varying between 650-800 mm divided between two rainy seasons. The resultant low crop yields and uncertainty in crop production make it surprising to the casual observer that there is almost no tradition of irrigation in the area.

The reasons for this are not clear. Certainly, simplistic assumptions about the lack of awareness of the potential benefits of irrigation do not explain its absence. As Hawksley showed in her survey many farmers are aware of other irrigation initiatives but have not made any attempts of their own, probably due to a lack of expertise, cash, and especially in the drier areas, a dependence on livestock sales for subsistence during hard times rather than agriculture.

It is against this background that plans for small scale irrigation (SSI) have to be considered. Clearly irrigation development on any scale is not a simple matter. Recent literature on the subject emphasises again and again the problems of water management and the failure of SSI to live up to expectations and also the social problems in the community concerned. Farmer participation is the vogue term and clearly development planners have finally woken up to the impossibility of successful implementation without bringing farmers into the decision process from the earliest stages.

The aim of these notes is to refine what has already been presented in the earlier reports as to where the EMI programme should be attempting to promote SSI and how.

2. BACKGROUND

In 1953, after initial trials by the then DAO Embu on rice growing on black cotton soil, the Mwea-Tebere rice irrigation scheme was started as a way of resettling Kikuyu released from detention camps after the end of the Emergency. This scheme has grown to some 5000 hectares and has become a showpiece for irrigation in Kenya. Mwea is important to the present study not because it bears any relation to future SSI developments but because it is a nearby success story which everyone knows of and refers to. Economically Mwea is a success but there is a temptation for district planners is to presume that Mwea is the only model for future irrigation schemes.

The only other irrigation initiatives of any scale in Lower Embu-Meru are privately run schemes. On the east bank of the Rupingazi close to the junction with the Thiba river there are two irrigated farms, one operated by an Asian farmer and the other by Yoder, a company specialising in the growing of plant buds for export. Another Asian irrigates by pumping from the Kuuru river on the northern side of Kiagu Forest in Lower Meru. The Yoder farm uses a locally made turbine driving a centrifugal pump similar to the mini-hydro lift described by Silva. The Yoder pump in turn is a copy of a now defunct power unit once fitted to a mill in Embu town. Apart from these private schemes Brother John operates a diesel driven pump for irrigating a few hectares of church land at Materi Catholic Mission (Tharaka) for famine relief. Here, families are allowed to cultivate a small plot for a given period and no charge is made for the water.

There is presently no other irrigation of any significance in the lowland areas of Embu-Meru. However, the idea of promoting irrigation in Embu-Meru is not a new one. In the mid 1970's a review of the area was undertaken on behalf of the TANA River Development Authority and a comprehensive report prepared. As a follow up to this Booker and Binnie undertook two feasibility studies, one for the Rupingazi valley below Embu town and the other for the Thanantu valley in Meru District. These two studies recommended the adoption of large scale development using overhead irrigation for the production of cash crops. Perhaps not surprisingly in view of the investment and running costs these plans did not attract donor interest.

A major new development which in part had its origins in the TARDA review is the Mitunguu Irrigation Scheme funded by German Aid. Silva refers to this Scheme in section 9 of his report and he notes the high investment cost per hectare for installation of irrigation works. The scheme is due to start operation in early 1986. The project has importance for the present study because it will be watched by planners to see how it progresses. Indicators are so far that costs are roughly within budget and expectations are high that results will be positive.

The 400 hectares to be irrigated within the scheme has all been adjudicated land. The irrigation system has been designed in such a way that water is piped underground to individual farms and the sprinkler lines are plugged in by way of a flexible coupling to the field outlet. The outlet itself has a buried flow regulating valve so that each farmer cannot exceed his water allowance. The equipment is expensive but has been installed in recognition of the past experience of irrigation in Kenya which has often been hampered by disputes between water users who seem unable to cooperate in when and how much water to extract. The solution adopted at Mitunguu may be fairly hi-tech but the problems it tries to circumvent are real and will have to be addressed in any irrigation where water sharing is required.

3. APPROACH TO IRRIGATION DEVELOPMENT

3.1 Planning

Recent literature on small scale irrigation (SSI) is unanimous in asserting that the majority of SSI projects in Africa are failures, that is that they produce results far below the original expectations. Obviously planning for successful irrigation development is not straightforward and therefore adequate time and care must be taken in drawing up the correct approach. The most general shift in emphasis (at least, in theory) has been away from the 'top-down' style of management, to the 'bottom-up' style, whereby the farmer is involved from the outset in planning the irrigation developments. Hawksley's report, in examining the socio-economic situation of farmers in Kibung'a and Ruungu provides the type of information on which a community oriented planning process should be based. This type of input is vital in the planning process.

One of the dangers in planning is the assumption that technical solutions to providing water for irrigation are the main requirement for successful implementation. Nothing could be further from the truth, especially in lower Embu-Meru. The approach taken by the government to farming communities in drawing up plans and putting them into effect, together with the degree of spontaneous interest in irrigation shown by those communities has far more influence on the ultimate success or failure of any initiative than providing water or other inputs.

The Kenya government planning is decidedly 'top-down' at present with the result that 'government' in general is often resented and the small farmer/livestock keeper is suspicious of government initiatives and nervous about the consequences of non-cooperation. For community based planning to be a success, therefore, and not just an expatriate buzz-phrase, a re-think is required at the district level planning of irrigation. The result will be a programme following a slow-moving, iterative, small scale development policy.

Clearly government cannot and should not be excluded from this process. There are many MALD officers especially at divisional level who are aware of the need for flexibility and responsiveness to community wishes. (This is because at divisional level they have not yet become divorced from the reality of the community.) There are committed officers in the divisional centres at Gachoka, Siakago and Chiakariga (Tharaka) who should be utilised.

The EMI Soil and Water Conservation Project was supposed to be largely an investigative project but under pressure from the authorities, in particular senior Kenyan agricultural staff, the emphasis of the project was changed to one where implementation was required for visible results. The Kenya Government is not interested in long drawn out investigative procedures, and therefore a balance has to be found between making sufficient investigation and assessment, so as not to miss the real needs of the supposed beneficiaries of the irrigation, but on the other hand not to waste undue time and money in the planning stage. The best approach seems to be to avoid exhaustive economic and physical surveys, but to start with pilot projects, small enough to be scrapped if they seem to be failures. There is already sufficient background information available to proceed. The combination of the 2 previous reports, the expertise of the staff in the MALD HQ and experience gained from other small scale irrigation projects in Kenya should provide a sufficient basis for the EMI programme to proceed with a pilot project.

Recent budget constraints imposed on the EMI programme due to MALD expenditure ceilings are likely to continue in the present economic climate. Therefore low cost technology and low cost development per hectare irrigated must be emphasised. But again sufficient funds need to be allocated so that something can be achieved in the field rather than just the investigational work that GOK is tired of.

Preference should be given to farmers who have requested help and have shown their willingness to work, for example those groups around the Kithenu river, (Section 5.4). Emphasis should be placed on finding those who have enthusiasm for, and a commitment to irrigation and who can back up that committment with their own labour for excavation, canal digging and so on rather than finding the suitable sites and the right technology first and then trying to persuade the community to participate.

3.2 Institutions

Experience from the SWCP has shown the need for proper and diplomatic integration with existing government bodies. Failure to involve the existing structures' results in opposition from government officials and politicians. The MALD already has personnel assigned to irrigation at National, Provincial and District levels.

a) National. The Ministry launched the Small Scale Irrigation Development Project (SSIDP) in 1977 with assistance from the Netherlands government. This in turn resulted in the creation of the Irrigation and Drainage Branch (IDB) within the Land Resource Development Division of the Ministry in 1979. At the same time, a start was made on the establishment of the Provincial Irrigation Units, including the one based in Embu to cover Eastern Province. The Small Scale Irrigation Unit in the MALD HQ currently has 4 expatriate staff in the unit. They seem understretched and should certainly be utilised in detailed planning of small scale irrigation sites, (which they take to be any development under 100 hectares of irrigated land).

The National Irrigation Board (a parastatal body) manages large scale irrigation schemes in the country, such as Mwea-Tebere rice scheme in Kirinyaga district south west of Embu town. The scale of the schemes and their style of management means that small scale irrigation under the EMI programme is unlikely to be directly involved with the NIB.

b) Provincial. The Provincial Irrigation Unit at the Provincial HQ in Embu was set up in 1979, and a member of the German Agricultural Team, Mr Peter Keuster was appointed the Provincial Irrigation Engineer from that time. (At first Mr Keuster divided his time 50/50 between Embu and Nairobi, but has now been placed in a coordinating role over the Mitunguu and Muka-Mukuu irrigation projects, and so is based fulltime in the Land Development Division at MALD HQ in Nairobi.) Both the Provincial Director of Agriculture, (presently, Mr Mwasya) and Mr Keuster readily admit that the output of the Provincial Irrigation unit has been poor in recent years and both are keen to revive it. ODA should consider the unit as the focus of its support. The temptation to set up any separate structure should be avoided.

c) District. Recently graduates have been taken into both the district agricultural offices in Embu and Meru as District Irrigation Officers. Mr Mbugu was posted to the DAO Embu's office in mid 1984, and there is also a District Irrigation Officer in place in Meru since mid 1985. Both have little field experience, and ODA assistance should be directed towards giving these and other MALD officers on the job training in irrigation management. (A list of possible projects for irrigation in Embu District was compiled by Mr Mbugu and is included in Appendix 8).

3.3 Farming Systems

Within the proposed area for irrigation development there is one farming system, with two variants. Those living at higher altitudes, eg. around Siakago, in Embu District and Mitunguu in Meru District, have generally better soils to cultivate, and slightly more reliable rainfall. There communities are basically farming communities, but also keep livestock. However, in the lower drier areas, livestock is of key importance, and farming is relegated to a secondary role. The division between these two groups is not clear, but roughly corresponds to the boundary between ecological zones 4 and 5 as defined by the Farm Management Handbook produced by the MALD in Nairobi.

The difference in emphasis between cultivation and livestock has implications for irrigation development. It can fairly be assumed that those with a stronger farming background are going to adapt themselves to the requirements of irrigated farming better than those who up to now have not taken cultivation so seriously. This might not however apply in individual or small group situations where farmers are not required to have a high degree of commitment and communal organisation. The degree of adaption required by farmers in zone 5 to cope with the demands of farming management in a formal irrigation scheme may make such initiatives unrealistic. Hawksley (page 30) has already voiced doubts in relation to Kibung'a and Ruungu. In zone 5, where soils and water availability permit, there is no reason why small groups should not be encouraged to attempt irrigation although, at first no significant investment in capital terms should be made, and no significant returns should be expected.

3.4 Land Tenure

Under present government policy the demarcation of land in Embu and Meru will continue until all of both districts have been parcelled off to individual ownership. In Embu district all of the locations have reached at least some stage in the adjudication process which is very lengthy. For example, in Thambu sublocation in lower Embu, it has already taken 6 years for the adjudication officers to finalise the farm boundaries, and there are still disputes going on. No demarcation has so far taken place in Tharaka division of lower Meru, although in many areas the local communities have carried out 'self demarcation' and have reached fair agreement on plot boundaries, although it would be over optimistic to assume that disputes will not surface again once formal adjudication begins.

All land which has not been officially demarcated is still technically Trust land and the State has the right to reclaim that land and to distribute it as it sees fit. If a 'formal' irrigation scheme is to be started in Tharaka Division therefore, the government can in theory reclaim the portion which is to be irrigated and remove those who are currently occupying the land. However the social and political implications of this action are such that this course of action should be entered on with extreme care. If British Government assistance is to be given to such schemes, then ODA will have to commit itself in the long term, as the process of closing off the area, removing the existing inhabitants, resurveying and reallocating plots to individuals, plus irrigation development is to be taken through, at least 6-8 years should be allowed before any significant production should be anticipated. If ODA is prepared to think in a 10 year timescale then such schemes could be considered but in view of the upheavals that the land issue will cause it might be best to wait for the land adjudication process to run its full course, perhaps with some encouragement in the right quarters to accelerate the process.

In the short term therefore it would make more sense to try to initiate irrigation on land which has already been adjudicated, and where land ownership is not a problem.

3.5 Irrigation Management

Disillusionment with large and small scale schemes in Africa has grown in recent years. Schemes have variously been described as 'failures', 'uneconomic', and so on. As such, any new initiative must examine not only the most suitable technology by the best system of management. The EMI programme working through the Kenya government, and through non-governmental organisations with which it can initiate small schemes, should be able to find the best management systems.

The current debate over irrigation management centres on whether there should be a 'formal' or 'informal' management. This does not necessarily have anything to do with scale. A 50 hectare scheme can be run just as much in a top-down autocratic style as a 2000 hectare scheme. However, the smaller the scale of the irrigation project the greater the chance for true farmer participation in planning and management. More importantly there must be a threshold below which no formal arrangements are necessary in terms of social organisation or water management. For example, 3 or 4 farmers grouped together to make use of the turbo pump as suggested in Silva's report would not require any formal agreement between themselves and the government and they should be able to handle the management of their irrigation together, by reaching concensus on water distribution. The threshold below which formal management is not required depends not so much on the area to be irrigated as the number of farmers who are to cooperate as a unit. Labour groups in Eastern Province, commonly have between 10 and 20 members and are able to organise their own activities with minimal government assistance. It seems possible that groups like this could also organise themselves when it comes to the management of small scale irrigation, even though they would have to be given technical assistance in the early stages, with installation of works and training in how to use the irrigation water.

The type of irrigation management which is best suited to any one area is influenced by the land tenure position, as explained above. In an area where land has already been adjudicated, the government can have little control over the activities of any one farmer in an irrigation scheme. Since the land is his own, he has the ultimate say over what takes place on that land even if irrigation water could be withheld. However, where a scheme has been set up on Trust Land, and plots are allocated to tenants, then more strict control of the crops to be grown and cropping practices is possible.

The supposed virtues of the community based approach to planning are spelt out by the proceedings of the workshop on small scale irrigation held in Kenya February 1983. The conclusions are given in Appendix 1. Apart from the necessary physical preconditions that would be expected, such as availability of water and soil suitability the 3 key recommendations are:

a) the farming community should be interested in water development

b) any land tenure problems in the project area should be solved... prior to final project acceptance

c) the project proposal should be based on full acceptance and participation of the rural population concerned.

For small scale informal group irrigation this is the approach now favoured by the SSIDP and the approach which should also be followed in the EMI programme. The case of the Ishiara irrigation scheme has already been raised in both previous reports, and although irrigation at Ishiara was originally a local initiative, in the expansion and development of the scheme conditions a,b and c above have been pushed into the background with consequent poor performance.

In finding the best style of management, the aim of irrigation development has first to be established. In lower Embu Meru, the priority is the stabilisation of food production. It would be best to allow participants in irrigation to grow food crops at least at first so that they can gain not only experience in irrigation management in the crops which they already know and understand, but also to give them the security to try unfamiliar cash crops.

3.6 Community Participation

The area under consideration does not have a strong tradition of communal labour participation. Both the Mbere and Tharaka peoples are strongly individualistic, and in recent years, this individualism has been emphasised by the growth of individual land ownership. The many disputes which take place during the demarcation process seem to harden the individualistic approach taken by the land owners. This seems to be especially true in lower Embu.

This does not, however, mean that community participation is impossible. There are a very large number of women's groups, and a few men's groups registered with the Ministry of Social Services. During the first phase of the EMI/SWCP inadequate contacts were established with this Ministry, which meant that the Project was not able to take as much advantage of these communal labour groups as it should have done.

In SSI, the same mistake should be avoided. It should be pointed out that many of the groups which are registered do not in fact undertake farming activities. In considering small scale irrigation however, these groups still remain the best initial point of focus.

3.7 Non-Governmental Organisations

NGO's are not particularly strong in the semi-arid areas but they should be used where possible. In particular places where they have had a continuous presence they may have extensive and quality local contacts so that they can gauge community reaction more quickly and accurately than government extension agents.

The only NGO's with any significant precence in lower Embu-Meru are:-

1. Catholic Diocese of Meru (covering Embu and Meru) Development Office, Meru. Contact Mr. Peter Mbero.
2. Anglican Diocese of Mount Kenya East. Community Services Office at Kerugoya.
3. CARE, Kenya. Contact Mr. Gakuta via District Social Development Offices at District HQ, Embu.
4. Foster Parents Plan International - Embu Office (operating in Gachoka Division, Embu and Igembe Division, Meru District).

4. IRRIGATION TECHNOLOGY

4.1 Mini Hydro Lift (MHL)

Silva has suggested the use of a MHL system for extraction of river water for irrigation around waterfall sites where energy can be harnessed for driving pumps. The arrangement he suggests is the hitching two standard pumps 'back to back' one acting as the delivery pump and the other acting as a turbine and providing the power to the first.

This is an established technique and an example of this system can be seen at Thika water supply sited below the Chania Falls. The installation was put in by Worthingtons and Appendix 7 has copies of letters from Worthington Pumping Systems Limited, Croydon regarding possible pump combinations for MHL.

At Ruungu most of the waterfalls marked on Text Map 1 have falls of 3 to 5 metres. Worthingtons were asked to provide possible solutions with a 4 m driving head. As they point out in their second letter the best approach is to consider what can be produced at any one site with standard equipment rather than decide on the quantity of water required and then find that a non standard, and hence highly expensive turbine pump set is required.

In their letter of 16.8.85 they give an example of a pump coupling which could produce 23 litres per second from a 4 m driving head delivering to 6 metres above the pump inlet. The price of this set would be £2,180 which is very reasonable when compared to the cost of a locally made turbine such as the one at the Yoder farm in Embu. Wigglesworth in Nairobi estimate that they could make up a similar pump for 60-80,000/-. The Worthington price is F.O.B. but the pump should not attract import duty on entering Kenya and so that additional costs would be for transport and handling. Further advantages of the Worthington set would be durability (in comparison with the locally made set) and the absence of any gearing.

If a greater discharge is required, say 100 litres per second (for irrigating 40-50 hectares) then it would be best to use multiples of the smaller set rather than to have one large pumping set. The letter of 19th July shows that for the same head conditions a set designed to produce 100 litres/sec would cost £29,750 F.O.B. of which about £20,000 is the cost of an axial flow pump which would act as the turbine. The optimal arrangement is to have both turbine and pump standard centrifugal types which are far cheaper than either purpose built turbines or axial or mixed flow pumps used in reverse.

The Ikwa site near Kibung'a has a drop of some 15 metres and an example to suit these conditions is considered in Worthington's letter of 16-8-85. Again the water is required at 6 m head above the pump inlet (total lift of 21 metres) and 62.5 litres/sec discharge is possible with a set costing £1,903 F.O.B.

Every site for MHL development would have to be considered on its own merits. Also accurate measurements must be made of driving head available, delivery head required because of the sensitivity of such a reverse pump turbine to changes in driving head. This point should also be born in mind when training pump operators so that they know when the pump set is not performing properly and what adjustments to make.

4.2 The Turbo-Pump (T-P)

The turbo pump and its possible application for irrigation is discussed by Silva in the technical annexe pages 12-14.

The turbo pump is built by Ndume Engineering at Gilgil and is modelled on the 'platter' pump, originally a New Zealand Design. The pump has, as already indicated by Silva practically zero running cost.

The turbo pump was not designed to be used for irrigation. The turbo fan connected to a cam produces the reciprocating action of the pump which drives two 3" diameter piston pumps with a stroke of about 2½". The result is a high head low volume output whereas the requirement for surface irrigation is large volume with low head.

Ndume Engineering say that the pump cannot easily be adapted to produce high volume with low head because this would entail a complete design change to a long stroke pump with a gear box, and this would put the price up dramatically. They are in any case not prepared to engage in a complete new design and development.

Ndume have agreed however that if they receive a written request from the EMI Programme, they would be prepared to try 4" cylinder to give a higher discharge at low heads. Judging by the performance charts for the 2½" and 3" diameter cylinders (see Appendix 3) the increase in discharge with a 4" cylinder would not be proportional to the increase in cylinder capacity, but certainly 20 - 30% extra discharge might be expected for the same driving throughput.

A turbo pump was installed in the Kathita river bordering the Goat and Sheep Project ranch at Marimanti in 1983. Two years use of that pump has given valuable lessons from which the following points have emerged:

1. The pump operates satisfactorily during the dry season when there is no chance of flood damage or siltation of the inlet channel to the pump.

2. There have been frequent breakdowns. These have been due either to excessive wear on the main bearing or flood damage, or occasionally children throwing stones down the inlet barrel causing damage to the turbo fan.

3. The efficiency of the turbo pump is very low. Using approximate measurements the turbo pump at Marimanti delivers 1.5 litres/sec to the fishponds at a net pumping head of about 5 metres. The throughput of the turbine when this measurement was made was 150 litres/sec and there is approximately a 1 litre fall on the pump. By comparing the output and the throughput this gives an overall efficiency of about 5%. However, when the pump is pushing water up to the housing station buildings on top of the hill at a total head of about 40 metres the efficiency is much higher, probably 20% or more.

4. Without effective maintenance, the pump cannot be operated for any sustained period. When all is well, a little additional lubrication for the sealed bearing is all that is required, but when a breakdown does occur, the pump or part of its has to be taken all the way to Gilgil for repair. Marimanti station has a trained mechanic who is able to cope with these repairs, but without him the pump might have fallen into disrepair some time ago.

5. Problems of wear to the main bearings probably occur when water is pumped at low heads, for example, to the fish ponds near the pumping installation. Under these circumstances there is insufficient back pressure on the pistons pumps which means that the turbo fan is allowed to overrun. Ndume engineering recommends that the turbo fan should be spinning at 40-50 revs/minute maximum where as on a visit to Marimanti in April 1985 the fan speed was recorded at 110 rpm while pumping to the fish ponds.

6. The surge chamber mounted on the top of the pump is vulnerable to flood damage, this can easily be solved by moving the surge chamber further up the pipe away from the main river flow.

The turbo pump is not cheap. Presently it is marketed at shs. 18,000/- by Ndume. This is well above the actual production cost, a point which Ndume concede while pointing out that they have incurred considerable development costs in producing the pump in its present form. The actual production cost probably does not exceed 10-12 000 shs. Ndume have applied for a patent as the T-P, so another workshop could not set up in production even if this could not set up in production even if this could be arranged. Also, the level of machinery and skills required for the production of the crucial sealed bearing assemblys on the turbo fan is not to be underestimated.

Apart from the cost of the pump, the turbo pump can only be used in a limited number of suitable riverside sites where a solid structure is required to anchor the pump barrel in place. Also provision has to be made to raise the river level above the pump to give some driving head through the barrel, or it has to be sited at a natural waterfall. Silva considers the probably total installation cost to be a minimum of approx. £1,400 or shs 28,000.

The Marimanti installation is probably putting too much strain on the pump, and especially on the sealed bearing so that frequent maintenance is required. The turbo pump at Mutouga Forest Nursery has been more reliable but then it has a much smaller throughput and correspondingly smaller discharge. The pump is set almost flat in the river and a small head through the pump is created by deflecting some of the river flow towards the pump. This installation is more sensible both in terms of what a small group of farmers might be able to manage, ie. minimal concrete work, and also because the pump rotor is spinning slowly and without excessive wear.

As Silva points out the T-P has the advantage that it provides a small continuous flow which could be stored at night or at times when irrigation is not going on. At Marimanti the T-P was connected to three sprinklers, the sprinklers being some 60 m. away from the pump and 6-7 metres above the pump. The T-P was able to operate all three sprinklers (although the sprinklers were not selected to suit the conditions). The use of sprinklers, although involving extra cost might have advantage:

1. Less labour and management skill requirement than surface (eg. furrow) irrigation. Farm labour is presently a major constraint to production.

2. More suited to high infiltration rates of most soils (not vertisols) of the project area.

3. Irrigation could be done at night when air tempertures are low, so reducing evaporation. Furthermore, the high P/low Q characteristic of the turbo pump would allow a reasonable discharge through the sprinklers even with the higher operating pressure at the sprinkler head. Tests with different sprinklers should be conducted to find the best pump/sprinkler combinations.

Foster Parent Plan International is providing assistance to Gachuriri women's group which plans to irrigate two hectares on heavy soils to the east of the Rupingazi river. (The farm to be irrigated is about 1 km south of the Yoder chrysanthemum farm).

FPPI are to install three turbo pumps plus a weir on a site about 1 km from the farm, and water will be piped to a concrete storage tank at a high point in the farm. The project is being supervised by a Dutch volunteer with FPPI in Embu.

The T-P cannot be left in place during times of flood or danger of flood. There may be a very limited number of points on the major rivers where nature has provided natural protection such that flood damage is not a threat to a pump installed at that site. However, in considering general application, the T-P will be out of use for the period mid October to end November and mid March to mid May. There are the times when supplementary irrigation is required. The only real solution to avoiding damage by flood is for the pump operator to be trained to remove the pump after <u>every</u> irrigation so that only the barrel remains in place. With the present pump design this would be very inconvenient however, and would also negate the advantage of a slow by continuous day and night discharge.

The pump could be used to extend the grazing season after the flood period is over and before harvest. This would apply particularly in the lower areas where rainfall is not only highly intermittant but may fall within a concentrated period which finishes well before crops, particularly grains, have matured. Also water application before the first rains could soften the soil for easier tillage, planting and early germination of seeds.

The suggestion by Silva of using the turbo pump on seasonal streams, although theoretically attractive, has practical limitations due to the extreme seasonality of the 'dry' streams of the area and the flash floods which are a feature of their regions.

There are very few streams which flow for more than two to three days after rain. Any installation in such a stream would be very costly as it would have to be able to withstand flood flows which rival those of the large permanant streams. The pump would have to be put in position after the flood so as to use the residual flow, which in any case falls to a trickle within hours.

There are a few streams which although seasonal do have some flow for several months of the year. One such stream is the Itabua crossed on the Embu to Siakago road. Such streams are very few and far between although the smaller streams at higher altitudes (1,000m - 1,250,) have more even flow regimes and would be more suitable.

T-P seems best suited for total irrigation during the long dry season June - September when the river flows are even and there is no danger of flood damage. Climatic conditions at this time are also favourable as lower temperatures mean an evaporation demand. The area which could be covered under total irrigation is small, probably one hectare using one pump.

At 18,000/- per pump and a minimum of 10,000/- for installation and flood protection, there are very few individual farmers who can afford such equipment. Even a small group of farmers or a labour group would be very hard pressed to raise these funds and until the pump and its potential benefits are proven, few of these groups would be prepared to commit themselves in any case.

In the early stages of an EMI Programme input into SSI, the pumps would have to be purchased by the programme with 2 or 3 pumps purchased for each of the two districts, it would then be up to the MALD and TC staff together to identify farmers who were interested in irrigation and whose land is close to suitable sites for T-P installations. The pump would then be operated by the Ministry, monitoring the performance and maintenance of the pump while the farmer would cultivate as directed, although his reaction to the new technology and management techniques should mould the irrigation methods advocated by the MALD staff.

The capital outlay required for the Mini Hydro installations would be divided between a limited number of sites, and the cost would be born by the project. However the turbo pump which can only serve a small area will only be popularised if farmers can afford the cost of the pump and its installation, given that credit finance on any scale is highly risky when given to farmers used to a precarious subsistence lifestyle. If the pump became popular, the price per unit would drop to say 12,000/- which would still not put the pump within the reach of many.

4.3 Irrigation Tank Method

This method is detailed in Silva's technical annexe, pages 15-20. It is the most costly of the techniques per site, estimated at £130,000 and most costly on a per hectare installation cost basis.

It is the experience of government in Embu/Meru that once a government sponsored development project of any scale is introduced attempts to use Harambee (self-help) labour in the initial development and in the subsequent maintenance periods normally fail. This is one reason why the national Rural Access Road programme eventually proceeded on the basis of payment of labour for road construction and maintenance.

It would be unrealistic to expect any significant cost reduction through the use of self-help labour. Even with paid labour, the difficulty will be to find sufficient labour, especially at agricultural labour demand peaks.

As Silva has indicated the number of sites where the tank irrigation technique could be used is limited. The major limitations are in finding land which is:

1. Fairly flat and therefore suitable for surface irrigation

2. Fertile enough to justify the initial capital expenditure

3. Adjudicated and with settled agriculture (ie. not in the transition from semi-pastoralism).

and has

4. Streams with a low sediment load during times of flood

5. Streams which are semi-permanent and not subject to flash flooding.

Of the above, numbers 4 and 5 are the most limiting.

4.4 Alternative Technologies

An input by ODA into SSI provides an ideal opportunity for testing simple technology for water extraction and distribution. One possibility would be to establish a formal contact with UK institutions investigating suitable technologies such as ITDG - Intermediate Technology Development Group and to act as a field testing unit for eg. Simple pumps.

The use of simple technologies would be especially advantageous if it could enable farmers with plots along the banks of permanent or semi-permanent streams to irrigate. A certain amount can be done lifting water with a bucket and this should be encouraged where possible.

The permanent rivers running off Mount Kenya and the Nyambeni Hills are incised and a lift of 3 metres is the minimum required to cover any substantial area of riverside land. Simple lifting devices are therefore essential.

4.4.1 Rower Pump

A simple and cheap pump which might be adapted for riverside irrigation is the 'Rower Pump' originally designed for irrigation from shallow wells in Bangladash where it has become popular (Figure 1). Details of an improved version are shown in Figure 2 and Appendix 4. Made of tough PVC pipe and operating with a simple plunger, the 'Rower' can work effectively up to 3.5 m lift (or nearer 3m allowing for high air temperatures and 1000m elevation because of the reduction ie. atmosphoric pressure). The limit of the 3m lift obviously places restrictions on the number of sites where the pump can be used.

The modified Rower has only recently come on to the market and is being marketed at the high price of £100, dropping to £65 per unit for 100 units (prices FOB). The pump can operate by fitting a flexible hose which runs directly into the river or it can be attached to a short length of well screen buried beside a river or in saturated sand for extraction of clean water for drinking. The total cost including pump, filter and hose would then be £140 approximately.

The Rower pump is tough and requires very little maintenance. It might be especially suited to supplementary irrigation of riverside plots and would be within the price range of a farmers group who could share the pump. The amount of work required to operate the pump for a sustained period should not be underestimated.

Here again the manufacturer (SWS) would almost certainly be interested in cooperating with the EMI Programme in further testing and adaptation of the pump. A useful modification would be to allow the pump to discharge through a pipe with same delivery head to eliminate the head lost in water pouring out of the end of the pump.

4.4.2 Petrol Driven Centrifugal Pumps

A portable self priming petrol driven centrifugal pump has many advantages over the turbo pump.

1. It can be placed anywhere along a river bank for pumping
2. It can be stored safely when not in use because it is portable
3. It has a much higher output which means that no arrangement for water storage is required.
4. Initial investment cost is lower.
5. It can be used for supplementary irrigation.
6. It can be easily transported to Meru/Embu/Nairobi for repair.

There are some disadvantages.

1. Running costs are considerable while those of the turbo pump are almost zero.
2. Inconvenience of fuel transport and storage of petrol.
3. Petrol can be dangerous if handled improperly.

The advantage numbers 1 and 5 make the petrol driven pump far more attractive for small scale river bank irrigation than the T-P. The example given below illustrates the advantages:

Pump:	Honda WB 20 x 2" (See Brochure Appendix 8)
Price:	Approximately 12,000/- off the shelf in Nairobi complete with suction pipe. (mid 1985 prices)
Discharge:	7.5 litres/sec at 5 m total head
Power Consumption:	1.2 HP assuming low pumping efficiency of 40% at 5 m head.
Fuel Consumption:	230 grams/HP/hour = 0.3 litres per hour
Oil Consumption:	1 litre per month (1 oil change)
Maintenance Cost:	Assume 1000/- per annum.
Area to be irrigated:	Assume 1 hectare supplementary. (Rain to irrigation water ratio 50:50)

FIG 2

ROWER PUMP

PROPOSED MODIFICATION FOR PUMPED DELIVERY

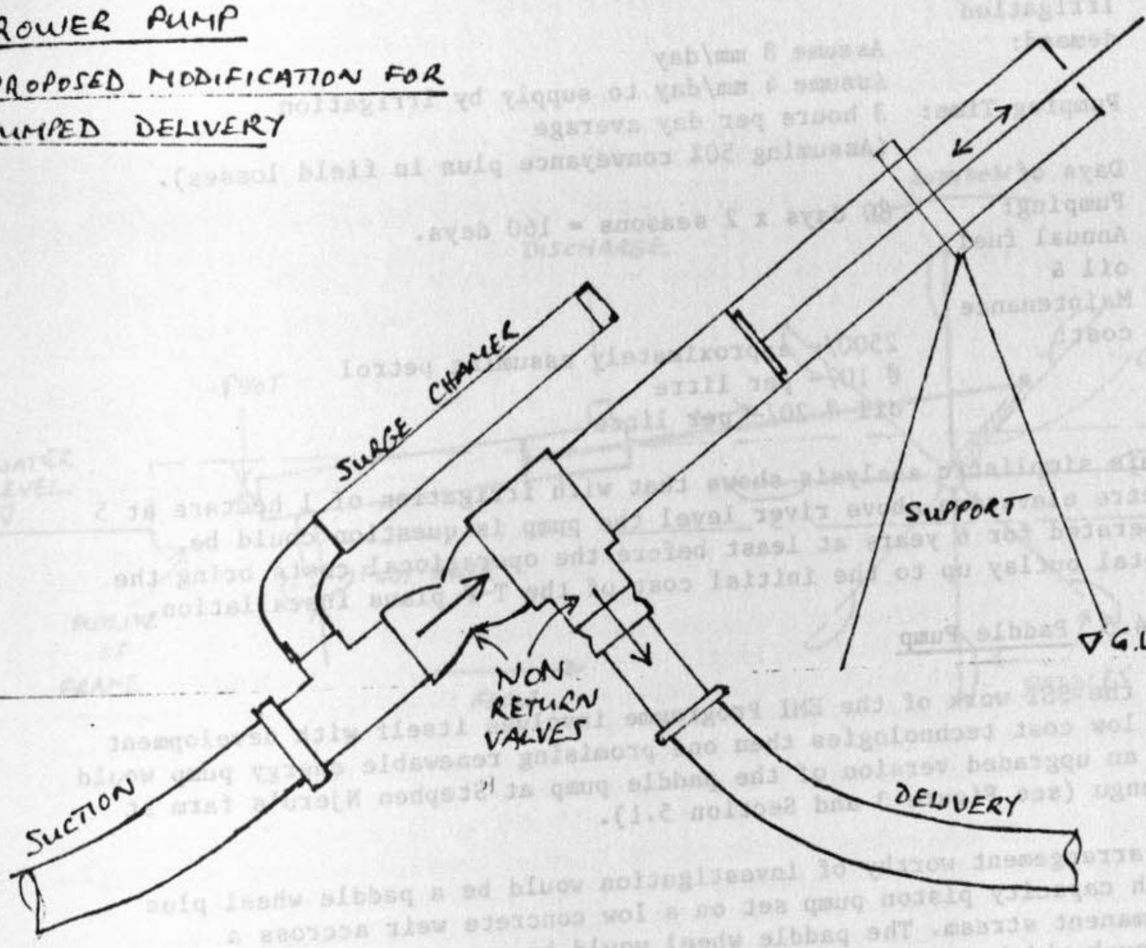
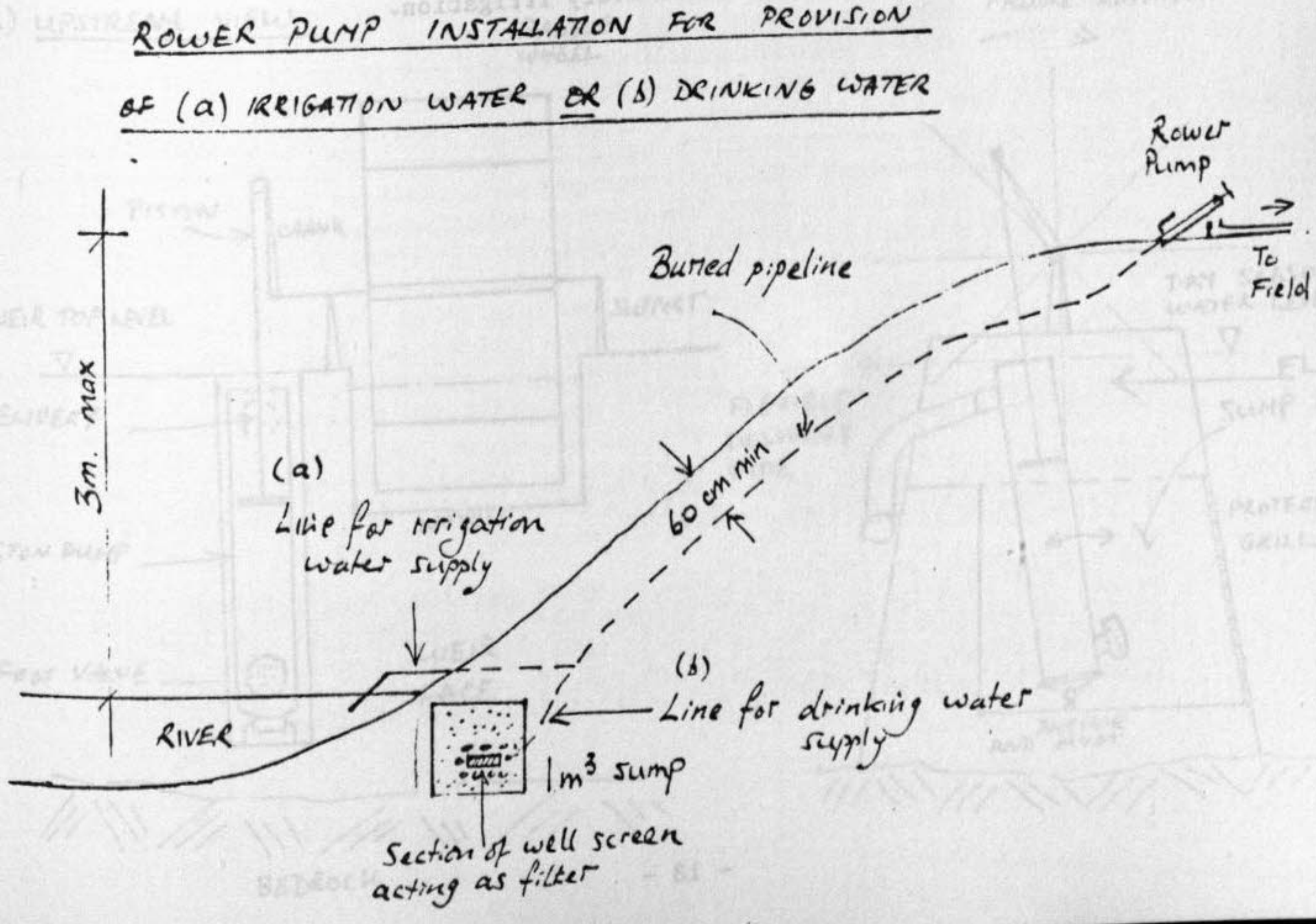


FIG 1

ROWER PUMP INSTALLATION FOR PROVISION OF (a) IRRIGATION WATER OR (b) DRINKING WATER



Irrigation demand:	Assume 8 mm/day Assume 4 mm/day to supply by irrigation
Pumping Time:	3 hours per day average (Assuming 50% conveyance plus in field losses).
Days of Pumping:	80 days x 2 seasons = 160 days.
Annual fuel, oil & Maintenance cost:	2500/- approximately assuming petrol @ 10/- per litre oil @ 20/- per litre

This simplistic analysis shows that with irrigation of 1 hectare at 5 metre elevation above river level the pump is question could be operated for 6 years at least before the operational costs bring the total outlay up to the initial cost of the T-P plans installation.

4.4.3 Paddle Pump

If the SSI work of the EMI Programme involves itself with development of low cost technologies then one promising renewable energy pump would be an upgraded version of the paddle pump at Stephen Njeru's farm at Ruungu (see Figure 3 and Section 5.1).

An arrangement worthy of investigation would be a paddle wheel plus high capacity piston pump set on a low concrete weir accross a permanent stream. The paddle wheel would be set to rotate in a notch through which the majority of the flow would pass during the dry season (Figure 4). During the rains the weir would be flooded and during times of heavy flood the paddle wheel would have to be removed. For flexibility the wheel could be arranged so that it could be unhitched easily for storage after every irrigation.

FIG 3 PADDLE PUMP AS AT STEPHEN NJERU'S FARM, RUUNGU (SIMPLIFIED SKETCH)

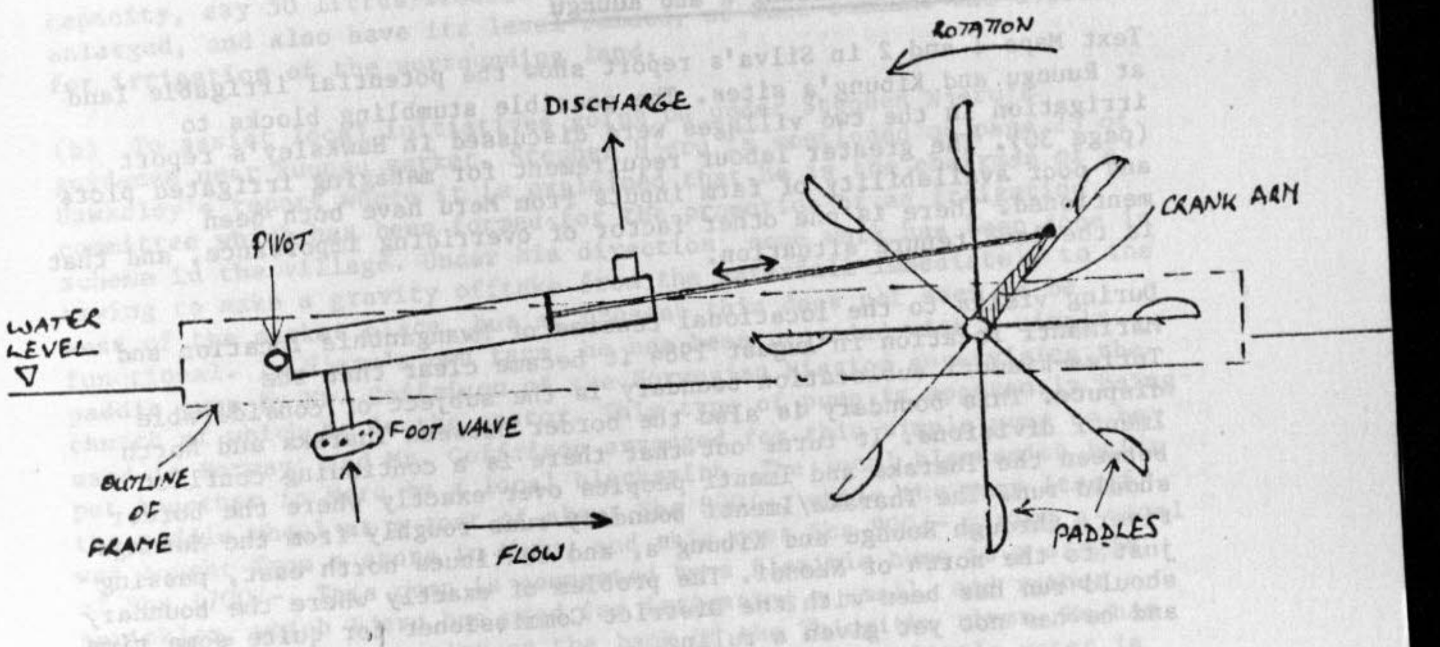
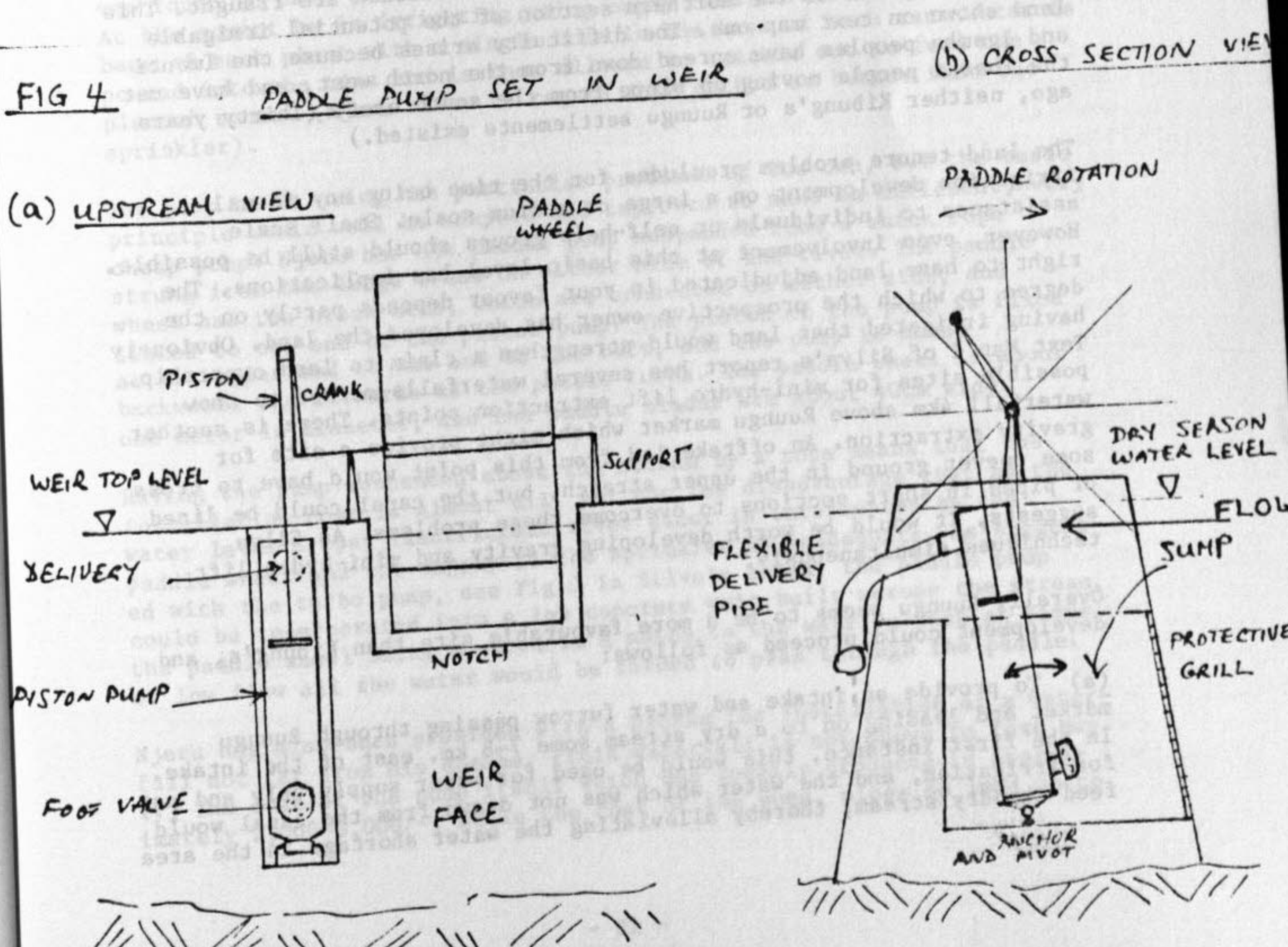


FIG 4 PADDLE PUMP SET IN WEIR



5. POSSIBLE IRRIGATION SITES

5.1 Irrigation in Kibung'a and Ruungu

Text Maps 1 and 2 in Silva's report show the potential irrigable land at Ruungu and Kibung'a sites. The possible stumbling blocks to irrigation in the two villages were discussed in Hawksley's report (page 30). The greater labour requirement for managing irrigated plots and poor availability of farm inputs from Meru have both been mentioned. There is one other factor of overriding importance, and that is the land tenure situation.

During visits to the locational centres of Mwanganthia location and Marimanti location in August 1984 it became clear that the Turima-Kiamuri sublocation boundary is the subject of considerable dispute. This boundary is also the border between Tharaka and North Imenti divisions. It turns out that there is a continuing conflict between the Tharaka and Imenti peoples over exactly where the border should run. The Tharaka/Imenti boundary runs roughly from the Mutonga river, through Ruungu and Kibung'a, and continues north east, passing just to the north of Nkondi. The problem of exactly where the boundary should run has been with the District Commissioner for quite some time, and he has not yet given a ruling.

The Adjudication officer camped at Kiamuri confirms that attempts to adjudicate the south eastern part of the sublocation are fraught. This area corresponds to the northern section of the potential irrigable land shown on text map one. The difficulty arises because the Imenti and Igembe peoples have spread down from the north west, and have met the Tharka people moving up slope from the south east. (Thirty years ago, neither Kibung'a or Ruungu settlements existed.)

The land tenure problem precludes for the time being any formal irrigation development on a large or medium scale. Small scale assistance to individuals or self-help groups should still be possible. However, even involvement at this basic level has implications. The right to have land adjudicated in your favour depends partly on the degree to which the prospective owner has developed the land. Obviously having irrigated that land would strengthen a claim to land ownership. Text Map 1 of Silva's report has several waterfalls marked to show possible sites for mini-hydro lift extraction points. There is another waterfall 4km above Ruungu market which might provide a site for gravity extraction. An offtake led from this point would have to cross some uneven ground in the upper stretch, but the canal could be lined or piped in short sections to overcome these problems. As Silva suggests, it would be worth developing gravity and mini-hydro lift techniques simultaneously.

Overall, Ruungu seems to be a more favourable site than Kibung'a, and development could proceed as follows:

(a) To provide an intake and water furrow passing through Ruungu market and leading on to a dry stream some 7-8 km. east of the intake. In the first instance, this would be used for water supply only and not for irrigation, and the water which was not drawn from the canal would feed the dry stream, thereby alleviating the water shortage in the area between Ruungu and the Marimanti-Mitunguu Road. In the first instance the channel could be made so that the water level was below ground level, ie. water could only be extracted by pumping or by drawing with karai or bucket. This canal could be dug by the local community who are likely to be motivated and in the first instance need not have a large capacity, say 50 litres/second. At a later stage the canal could be enlarged, and also have its level raised, so that command was available for irrigation of the surrounding land.

(b) To assist local initiatives going on under Stephen Njeru's guidance near Ruungu market. Stephen Njeru is mentioned on page 23 of Hawksley's report where it is explained that he is the chairman of a committee which has been formed for the promotion of an irrigation scheme in the village. Under his direction, some work has been done in trying to make a gravity offtake from the waterfall immediately to the west of the market place, but at present this does not seem to be functional. In Njeru's own farm, he has been provided with a simple paddle pump by Mr. Goffrison of the Norwegian Mission supervising the church of which he is the pastor. This type of pump is apparently being used in Norway, and Mr. Goffrison arranged for this simple pump to be put together in Meru by a local blacksmith. The local blacksmith built the paddle wheel at a cost of about Shs 800/-, while the pump itself was bought from a store in Meru, and this cost Shs 900/- giving a total of Shs 1700/-. This pump is connected by a flexible hose to a single sprinkler, which Njeru has used for irrigating a small, and rather unpromising ¼ hectare plot on the bank of the Thingithu river. He has not been very encouraged by the results because very little water is pumped when the river level is low, and on visiting the farm the pump was found to have broken down and had been taken into Meru for repairs. At the moment he is irrigating using empty cans burried next to the base of each plant with a single hole in the base of each can. Water is poured into the tins and is then allowed to trickle out to feed the plants' roots. (Njeru seems to regard this method as better than the sprinkler).

The pump he is using has particular problems of its own, but the basic principle would well be adapted and improved to make an efficient, very cheap pump. Njeru has his paddle pump suspended from a thick rope strung from two large trees on either side of the river. The paddle wheel has two crank arms, which are connected on either side, and linked to one end of the piston pump. The piston of the pump is fixed at its upper end to one end of the raft, and the pump is moved backwards and forwards as the paddle turns. The paddle wheel is about one meter in diameter, and the paddle blades are about 40cm wide.

Having the pump suspended above the stream by a rope means that the installation cost is almost nil, but has the disadvantage that as the water level drops, insufficient river water is intercepted by the paddle wheel and the supply to the sprinkler is inadequate. As suggested with the turbo pump, see Fig.3 in Silva's annex, the paddle pump could be incorporated into a low concrete weir built across the stream, the paddle wheel being mounted in a notch in the weir so that at times of low flow all the water would be forced to pass through the paddle.

Njeru has also been provided with a hydram for installation at a waterfall not far from his shamba. (This waterfall is not shown in Text Map 1.) The cost of the pump itself which was locally produced is approximately 2,000-3,000/-, while the cost of the pump, pipes to lead up to a storage tank near his house, and installation including simple works at the waterfall site is 9000/-. The committee of which Njeru is chairman has 8 members, and there are 100 people belonging to the group. So far they have collected 3,700/- which went towards the cost of the piping.

Such local initiatives should be strongly supported. If the EMI program decides to go ahead with small scale irrigation development it would also be worth making contact with blacksmiths such as the one mentioned in the case of Njeru's paddle pump. (His name is Githingi and he works for Meru Young Engineers, in Meru town). Such small engineering works should also be supported and made use of in producing simple equipment for irrigation where possible.

The potentially irrigable land around Kibung'a generally does not seem to be so favourable for irrigation development. Soils are more variable (with considerable stretches of black cotton soil) and the soil structure is not as good as that of the soils at Ruungu. The area is sparsely populated despite being a slightly older settlement area. The potentially irrigable land shown on the left bank of Silva's text map 2 is fairly inaccessible, and has not yet been visited for inspection.

Ikwa waterfall near Kibung'a is the largest of its kind close to irrigable land within the area, as such it has the greatest potential for the mini-hydro lift technique in terms of the energy available for driving a turbine. Given that resources for irrigation development within the EMI programme will not be limitless, it seems that with Ruungu only 15 km. away from the Ikwa site, using the MHL technique in two areas so close may not be justified.

Water development in the Kibung'a area is a key issue, and Ministry of Water development has surveyed the area in the past, with a view to providing piped water supplies. As shown in Text Map 2, (Ikwa site) there is another waterfall above Ikwa, and on visiting the site it was found not to be an ideal place for the construction of a weir. There is, however, a third waterfall further up Kathita river where it would be easy to install a weir but any offtake would have to feed into pipes for the first 200-300 meters because of the rocky and uneven terrain on the right hand bank. About 6 km. of pipeline would be required to lead water up to Kibung'a market. Ikwa waterfall, on the other hand is less than 2km from the market and therefore a worthwhile comparison could be made between provision of a gravity supply from the upstream waterfall, which is known as Kwamukwiro, and a small mini-hydro lift plant placed below the Ikwa falls. There is a rock bar running across the Kathita some 30-40 metres above Ikwa falls. A low weir, only 30cm high constructed on the bar would allow an offtake on the left bank to an MHL unit (access). The supply pipe from the pump would have to cross back over the stream to supply Kibung'a and beyond. The pipe could be strapped to the weir.

Irrigation by gravity on the right bank from an offtake at the same weir is also a possibility.

In conclusion, any irrigation activity in either Kibung'a or Ruungu should be informal and limited in scope before land tenure problems have been solved.

5.2 Mukothima

The small market of Mukothima can be reached by road, either from Meru or via Gatunga turning off through Gachiongo, leaving the road going to Meru National Park. The area around Mukothima market is part of that within the Thanantu valley development plan which was investigated by Booker and Binnie in 1978/9. In their report they proposed a large scale development of 5,000 hectares using sprinkler irrigation. There would be 18 pumping stations, for pressurisation of the sprinklers. No donor has so far taken up this proposal but since that time other proposals have been made. The Catholic diocese of Meru is now actively investigating the possibility of starting irrigation using water from the Thanantu river boosted with water from the Kathita. The Kathita is much larger and during drought the Thanantu almost dries up. A survey and proposal have been drawn up by a volunteer group from Italy called Sinerga, on behalf of CDM, and their plans should, by the time of writing, be ready. In principle, the project has been given the blessing of the District Development Committee but as yet, Mr. Peter Mbero, Development Coordinator of the Catholic Diocese of Meru Development Office is not sure where the funds for development will come from. There is also a proposal drawn up by Mr. Peter Keuster, of the German Agricultural Team, for a development of 700 hectares in three blocks (including Nkondi) on the same lines as Mitunguu.

In 1976, the Catholic Diocese of Meru tried to initiate irrigation by building a diversion weir across Thanantu valley which fed Gachiongo furrow, which was dug by the community. Unfortunately, due to a design fault in the weir, it only lasted 7 months before being washed away and has not been repaired since that time. The site used for the weir was not particularly good, but there is no other superior site nearby which could be connected up to the old line of the furrow. The furrow itself has mostly fallen into disrepair although local inhabitants insist that they will repair the furrow if water is again made available.

Just to the north of the Mukothima marketplace there is a small permanent stream called Akothima. From this stream water a pipeline is run to the Catholic church. A youth self-help group in the village is based on the church. From having 15 members in 1979, it has now grown to 45. They are cultivating communally a plot of about 1 hectare. They have received grants from the catholic diocese and from oxfam in order to buy oxen and a plough for cultivation. In cooperation with the Diocese this group could be encouraged to start irrigation on their communal plot.

Mr. Wekesa, the Technical Assistant responsible for the location, noted that during the time of drought in 1984, when the village was particularly hard hit by food shortage and by cholera, only 3 people in the location were able to undertake irrigation, drawing water by bucket from Thanantu with which to grow a few vegetables along the river bank.

5.3 Nkondi

Like Mukothima, Nkondi has a large, flat, fertile land area which has been used as a settlement scheme from the 1950's. Most of the present inhabitants moved in during the 1950's and 60's and were given 10 acre plots. Although the land 'belongs' to the present occupants no title deeds have ever been issued. The land is highly prized and many Tharakans try to save enough to buy a piece of land in Nkondi. Even without the title deeds there is no confusion over farm boundaries and this gives Nkondi an advantage over Ruunga/Kibung'a when considering SSI.

There is a water furrow which passes through Nkondi and feeds, amongst other places, the tree nursery near the market place. The furrow was first constructed pre-independence, and had two sources. Water is drawn from Thanantu river, and also from the Kuuru river (although this is not a permanent stream). After the furrow had been made, five secondary channels were dug off the main channel in order to provide water for irrigation in the area. However irrigation has been banned by the local authorities because the furrow leads water to the Gatunga secondary school and also to the Gatunga catholic mission and when the flow has been interrupted by those trying to irrigate both of these institutions have been deprived of water. For many years, therefore the people of Nkondi, have not been able to irrigate, officially at least. A most useful informant in Nkondi is the former Technical Assistant, now retired, Mr. John Livingstone. During all the time which he has been in the area, Mr. Livingstone says that he only knows of 8 people who have ever consistently tried to irrigate. There are certainly more who would try if there was not a prohibition on the diversion of water from the main channel.

Shortage of water results in part from a malfunction at the intake on Thanantu river. When the intake was originally constructed, there was no concrete weir crossing the river. After a while the river shifted so that the simple riverside intake no longer received water.

In order to assist the flow of water into the furrow, a wall was built across the stream but it does not reach to the far bank. After some years, the river shifted again to the far side of the wall and cut down its channel so that when the water level drops during the dry season in August-September no water enters this arm of the furrow at all. It is also the time when the Kuuru river tends to dry. As a result, during the 1984 drought, the furrow dried up completely. This could easily be rectified by extending the wall right across the stream to the left hand bank. Also there is a lot of sedimentation in the furrow but, despite repeated requests and orders from the local chief, people have not been willing to attempt desilting of the channel. What is more, some farmers are keen to cultivate in the furrow itself and plant bananas and other crops in such a way that the water flow is impeded. Certainly the furrow has become a source of conflict between the authorities and the local community.

If the furrow was repaired and the intake improved, there should be enough water for some irrigation and also to ensure a constant supply to the mission and the school further down the furrow. However any attempts to organise irrigation at Nkondi will first have to solve the local bad feeling over the use and maintenance of the furrow.

5.4 Kithenu

On Text Map 3 of Silva's report the Kithenu river can be seen running from north west to south east of the map where it joins with the Mutonga river. The Kithenu is one of the several permanent rivers coming off Mount Kenya and in keeping with the others is deeply incised into its own channel apart from a short section some 2 to 3 km. to the south west of Mitunguu.

The Thingithu river, just to the north west of Mitunguu, is the source for the Mitunguu-Tunyai furrow, which was constructed in the 1940's and from which farmers have been drawing water for quite some time for their own irrigation especially for vegetables which are marketed in Mitunguu and Meru. The farmers of this area, then, have some experience of irrigation and it is the area between the so called Mate Road (Mitungu to Ishaira), the Mitunguu-Nkubu road and the Kithenu river which is the area now designated for irrigation under the German aided Mitunguu irrigation scheme.

In 1976, the chief organised the people of this location to dig a furrow to serve the land on the eastern bank of the Kithenu river to the south of the land now in the Mitunguu scheme. The furrow takes water out of the Kithenu, at a point some 2½ km. southwest of Mitunguu market. There is no permanent weir for this furrow, and the water is diverted by building a temporary weir of debris each season, which raises the water level sufficiently to put the water into the furrow. The weir is then washed away during each rainy season and is rebuilt again. This so called Kithenu furrow has two arms. The furrow divides about 1 km. from the source and the right hand arm runs south about 2 km. parallel to the river. The left hand arm should have been about 4 km. long in all, reaching up to Mamuru but the furrow does not reach this point because of waterlogging problems in a particular farm where the owner insisted that the water should not pass through his farm because of a bog which was allegedly caused by the furrow. The farmers who get water from the furrow are irrigating maize, cotton and vegetable crops with some success, although they are aware that improvements in water distribution and water use are required. This is exactly the type of initiative which should be supported by the EMI programme.

This same furrow was supposed to run all the way down to Matere Mission, but the furrow presently does not pass the boundary of Mitungu and South Tharaka locations. This is the boundary between South Imenti and Tharaka divisions, which is in dispute. It is symptomatic of the lack of cooperation between the inhabitants of the 2 divisions that the furrow was never completed up to Matere, presumably because those in Tharaka believe that the water from the furrow would be interfered with before reaching them.

On the western bank of the Kithenu there is potentially irrigable land as shown in Text Map 3. between Kithenu and Mutonga rivers there is a group called the Ngu'uru-Gakirwe Water Association with 100 families belonging who have embarked on a water project to bring water down from an offtake on the western bank of the Kithenu river, the offtake not being far below that for the furrow on the eastern side. They have already dug a line for pipes to be laid but they have also expressed an interest in having water by furrow because they don't have the funds for the pipes nor for the construction work required at the intake. It is clear, however, that the members of the group are willing to give their labour and again this is an effort which is worthy of support. At present, CARE Kenya are also considering giving assistance. Mr. Gakuta is the Officer in charge of CARE in Eastern Province, and can be contacted through the District Social Development Officer in Embu town. The chairman of the water association is Mr. Simon Nyaga.

The reason that the water association has decided to put in a pipeline is that they fear interference with the water by the Mitunguu people through whose land a furrow would have to run.

One key point about the area on both sides of the Kitenu river, is that it has been adjudicated. The land was demarcated under the Mitunguu-Tunyai Settlement scheme, which divided up the land in the period 1962-66. This means that there will be no land ownership disputes.

6. CONCLUSIONS

From the above the following main conclusions are drawn about small scale irrigation development in lower Embu and Meru under the EMI Programme.

1. Only groups or individuals who show a genuine interest in irrigation should be involved. Strong links should be established with NGO's and the Ministry of Culture and Social Services to allow identification of and proper communication with the relevant farmers. 'Formal' projects should be managed by the community involved in cooperation with government.

2. The first 2-3 year phase of a proposed project should concentrate on assessing the potential for irrigation at specific sites and finding motivated farmers while starting pilot schemes for demarcation and trial purposes.

3. Water for irrigation should be extracted by gravity wherever possible in preference to any of the pumping or storage techniques mentioned even if initial costs are slightly higher.

4. Meru district has a high potential for SSI from the standpoint of water and soils. Embu district has very limited potential.

5. Irrigation on an informal small group or individual basis should be the main concern using the simplest technology possible especially for irrigation beside permanent rivers.

6. Where formal organised schemes are started they should concentrate on adjudicated land owned by settled agriculturalists. If semi-pastoralists are to be involved ODA should consider a 10 year committment to allow for farmer training needs and settlement of adjudication matters.

7. Any irrigation initiative should be based in the Provincial Irrigation Unit which should be revitalised and provision should be made for on-the-job training of field staff.

8. For projects of 10-50 hectares the Mini-Hydro lift extraction technique seems feasible and economic. The tank technique is also a possibility but the number of suitable sites will be very limited because of topography and sedimentation considerations.

9. At present prices the turbo pump is not appropriate and portable fuel driven pumps should be considered as an alternative.

10. The initial aim of irrigation is to stabilise the production of food crops.

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APPENDICES

APPENDIX 1

Guidelines from the Summary Report of the Workshop on Small Scale Irrigation in Kenya February 1983

The following criteria were distilled from the introductory presentations, the Case studies and from the conclusions of the discussion groups.

1. The farmers community should be interested in water development.
   The best indications of real interest are farmers' own initiatives to have some form of water controle, however simple, and a request by themselves for assistance. They must be willing, - and give proof of that -, to contribute in free labour. Ideal would be if they would only ask for advice ('Where and how can the canal best be dug?!) or for actual assistance for something beyond their physical possibilities (e.g. blowing a rock between a suitable water supply site and the command area). Further project plans can then be developed together with the farmers.
   Farmers' interest may, however, be based on irrealistic expectations, usually the result of wrong information or idle promises. These should then first be scaled down in open dialogue with the farmers and the remaining interest be re-appraised.

2. In areas where the prevalent farming system(s) do not have a traditional wetland cropping component, however simple, the option of water resources development should be very carefully weighed against other development options.
   In many a situation improvement of, for example, livestock systems (in the arid zones), dryland cropping (in the semi-humid and humid zones), fishing (along lakes and water courses), and so on, might offer better scope for lasting self-sustained productivity increase and lowering of risks than irrigation.

3. In areas were the prevalent farming system(s) do have a traditional wetland cropping component or, if not, where water resources development appears the best development option, the best project proposal- (or worked-out plan) is the one with the lowest

recurrent-cost prospects, no need for imposed management by outsiders, and minimal dependence on outside institutions and facilities and supplies.

This means that the project should be adapted to the means, know-how, and management capabilities of the farmers on the one hand, and to the national and local infrastructure, institutional and economic possibilities on the other hand, as those possibilities are now.

Projects that trade upon possible improvements in an indefinite future invariably turn out to be not feasible in spite of whatever promising the original (conventionally estimated) I.R.R. might have been. The key-word should be 'Appropriate Technology' or 'Phased Land and Water Development'.

4. The water development project should fit in the existing farming system, especially with regard to the available family labour and the existing (already heavy) work load of women as well as the latter's traditional land use rights ('Women fields'). The project should be compatible with the risk-spreading range of the different subsistence activities of the traditional farming systems which is of time-proven value.

5. The project should also be compatible with the (expected future) water requirements of down-stream and upstream villages.

   The changing regime of the Ewaso River in Isiolo District and the increasing constraint of available water due to water development up-stream of the Kore Area in Nyanza Province are examples of the need for a river basin approach. The key-word here should be Water Rights for equal development opportunities.

6. Land and water development for one socio-cultural group should not be at the expense of the 'farming system' of another section of the local population.

   Projects for the benefit of, for instance, sedentary farmers in areas that are used by pastoralists as dry-season and emergency grazing grounds, should be discouraged unless the pastoralists can be integrated in the scheme or become target group of parallel livestock intensification programmes.

7. The quality (suitability) of the natural resources Land and Water should not pose particular problems.
An initial 'Rapid Survey' will suffice to ascertain that. Natural vegetation (e.g. grass species) and, on cultivated land, growth performance of, in particular, maize are effective soil quality indicators. In case of doubts, for example when the plant cover is 'patchy', the Rapid Survey should be followed by a Site Evaluation. The wet season is the best Rapid Survey period, also to appraise soil-structural aspects.

8. Topography, soils and hydrography should be such that water supply by gravity and basin irrigation is feasible at low cost.
Experiences with pumped water supply suggest that, - awaiting the development of alternative water-lifting devices (with low investment and running costs, not depending on uncertain and expensive fuel supplies, with a long working life, locally made and locally maintainable) -, the only viable option for water supply is by gravity. On the other hand, experiences in developing countries elsewhere in the world show that, even on sloping land, paddy-type fields are the best suitable for smallholders irrigation: construction, land preparation and levelling, as well as water application are, provided that fields are small, comparatively simple and do not require (anyhow unfeasible) machinery.

9. The solliciting farmers group should accept à priori that also other villagers or other users of the proposed project site are free to join the project, such as landless community members, families headed by women, and local pastoralists, even if this would have to result in smaller plots than was foreseen.
Increasing the lead of a few enterprising villagers by excluding the large majority of those who are most in need of development opportunities is planting the seed for larger problems than would be caused by rejecting the project all-together.

10. Closely related to the above: any land tenure problems in the proposed project area should be solved, within the village and

between the segments of the population concerned, and endorsed by the offical land authorities, prior to final project acceptance. Land disputes and harassment of scheme farmers by other people who claim older land use rights once the project is operational, make scheme management impossible and undermine any prospect for project viability.

11. Last but not least: the project proposal should be based on full partnership and participation of the rural population concerned. Techno-economical feasibility estimates lose all sense if planning and implementation is done for but without the intended beneficiaries. For the chance of project success depends primarily on the active involvement of the farmers themselves in all stages of project development.
The key-theme behind all discussion on small-scale irrigation is that 'the local people should feel that they control the system and that it is theirs'.

APPENDIX 2

Example of tenancy regulations in Mwea-Tebere Rice irrigation scheme

Once an area has been gazetted for irrigation under the Rules, no person may reside in, carry on business in, or occupy any part of it, nor graze any stock within the area, unless he holds a special license to do so (Rule 4). In accepting such a license from the Manager, a tenant becomes subject on pain of offence to a number of restrictions, including (Rule 8):

- agreement to devote full time to his cultivation and the improvement of his holding, without being absent for more than a month unless he has prior approval in writing from the Manager.
- a prohibition on hiring stock or machinery other than the Scheme's without prior written approval.
- the maintenance to the Manager's satisfaction of all irrigation channels and works on or serving his holding.
- the observation of all instructions concerning crop rotations and husbandry as stipulated by the Manager.

In addition, the tenant may be allocated a house by the Manager, must maintain his house (whether given to him or not) to the Manager's satisfaction and must repair it as instructed, may not occupy any other house or build any structure or works without prior approval in writing – and will even be liable to repay the Manager for demolishing any structure constructed without consent (Rule 10). He cannot keep any livestock other than those specified in his license (Rule 16); he cannot have a vehicle driven over any part of the Scheme except on the public roads (Rule 21); he cannot take irrigation water "out of turn or otherwise" (Rule 26); and he holds his tenancy under an annual license which can be terminated at any time if the Manager gives on instruction of the Minister 12 months' notice in writing (Rule 25).

APPENDIX 3

Example of Draft Agreement between Ministry of Agriculture, Nyanza province and Kore irrigation scheme land users.

DRAFT 28-0.3

AGREEMENT

This agreement is made the .... day of March one thousand nine hundred and eighty three between

the Government of the Republic of Kenya, represented herein by the Ministry of Agriculture, Land Resources Development Division, Provincial Irrigation Unit in Nyanza Province (hereinafter called "MOA") of the one part

and

the farmers, that is the land-users, of the so-called KORE scheme located within North East Kano Location, Nyando Division, Kisumu District, Nyanza Province, represented herein by a Farmers Committee (hereinafter called the "farmers") of the other part

WHEREAS

A. the MOA is willing to assist the farmers in the improvement of the rice production under a programme called "Smallholder Rice Rehabilitation Programme" and agrees:

A 1. to inform and consult the farmers about necessary improvements.

A 2. to discuss modifications of designs and adopt these modifications as long as these are technically and financially feasible.

A 3. to provide additional agricultural staff at the scheme during the implementation to explain and guide the farmers concerning the works required and their participation.

A 4. to provide all necessary designs for infrastructural works and in-field improvements including modifications, if any, of these designs in accordance with clause A2 mentioned before.

A 5. to supervise all works to be constructed in accordance with the designs.

A 6. to <u>assist</u> the farmers with the construction of all structural works.

A 7. to negotiate contracts for the execution of the works with the farmers based on rates in use by the Government.

A 8. to provide specialist rice extension staff to improve agricultural practices.

A 9. to provide agricultural inputs during one season to assist the farmers in establishing a revolving fund.

A 10. to <u>assist</u>, together with other relevant Government institutions, the farmers in the strengthening of their organization.

A 11. to liaise with the Scheme-Committee and Steering Committee to arrange for the assistance of other institutions if necessary.

B: the farmers are desirous to improve the rice production and agree:

B 1. to <u>reinforce</u> their organization with the help of MOA and the <u>Ministry of Social Services</u>, register their organization and draw up by-laws.

B 2. to co-operate with the agricultural extension service to improve agricultural practises.

B 3 to provide free labour (HARAMBEE) for the execution of the infra-structural works to the amount of 40 days per year for every landuser cultivating an area of one acre or less within the scheme while every landuser cultivating an area in excess of one acre within the scheme will provide an additional 10 days for every half acre or part thereof, whereby a day's work is set for either 7 hours or 2 cubic metre of earthworks.

B 4. to provide storage facilities for keeping project tools and materials.

B 5. to provide free of charge the land for roads, dikes, canals and drains with appurtenant structures, borrow-pits and stores, that is land permanently withdrawn from agricultural use; and land for temporary access-roads, working sites and temporary soil-dumps, that is land temporary with drawn from agricultural use.

B 6. to execute and organize all in-field improvements free of charge.

B 7. to operate and maintain the scheme on their own after completion of the works.

all subject to the following terms and conditions:

I: This agreement will take effect upon signature and will terminate after a period of three and a half years, unless terminated sooner in accordance with the provisions of this agreement.

II: Any disputes or differences arising out of this agreement shall be put before the Scheme Committee.

III: The farmers accept the authority of the Scheme-Committee and of the Provincial Steering-Committee.

IV: The farmers accept that in case settlement of disputes or differences in accordance with Clause II, mentioned before, is not adhered to the MOA will pull out and this agreement becomes null and void.

V: This agreement is made in an English and a Dholuo version of which the English version will be binding.

Signed on behalf of the said Government, in the presence of:

District Agricultural Officer, Kisumu District.

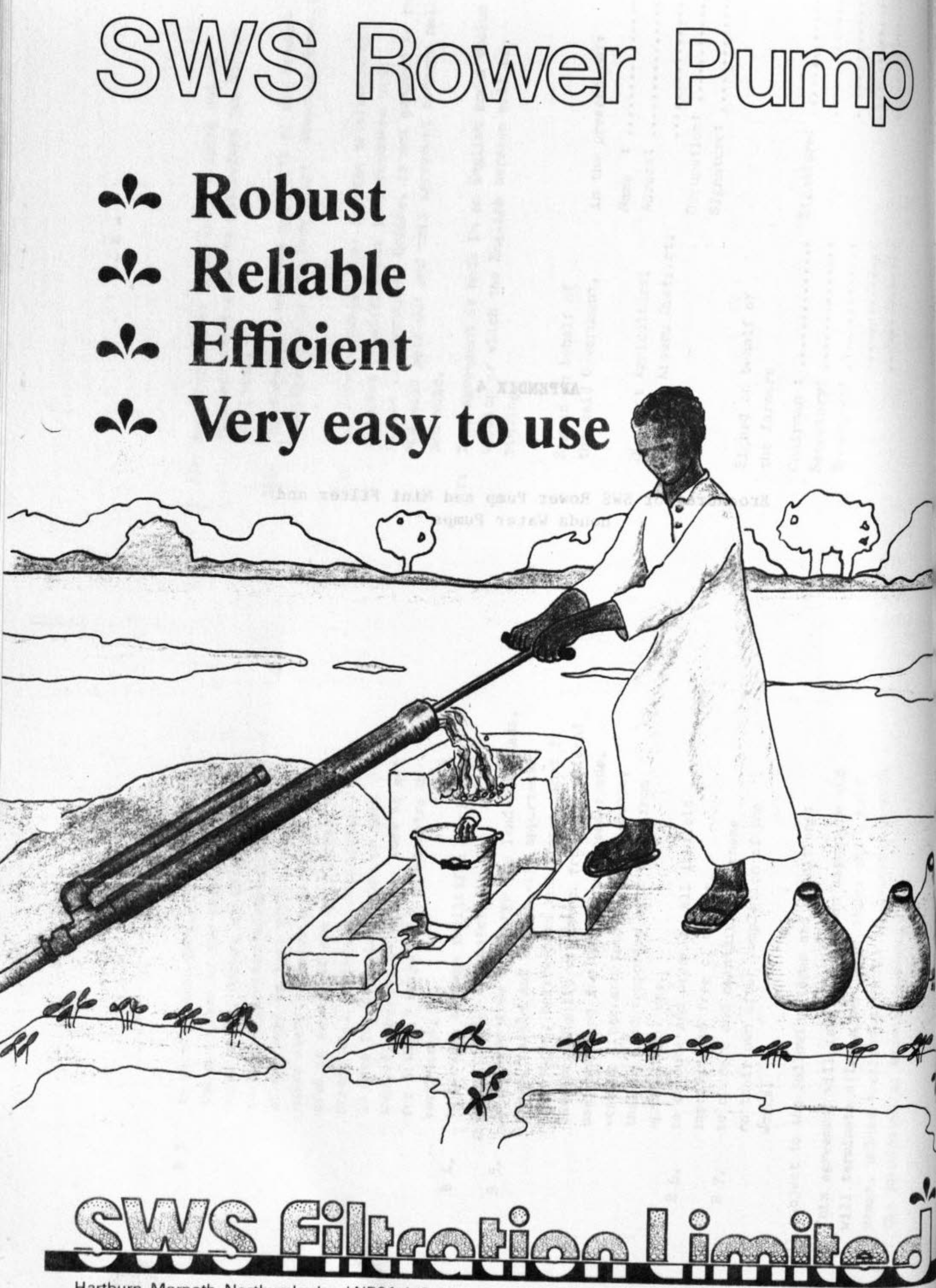
Name : ....
Adress: ....
....
Occupation: ....
Signature: ....

Signed on behalf of the farmers

Chairman : .... Signature: ....
Secretary: ....
Treasurer: ....
....
....

APPENDIX 4

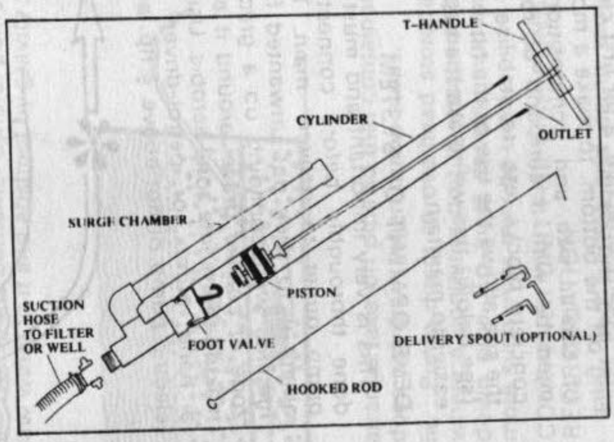
Brochures for SWS Rower Pump and Mini Filter and Honda Water Pumps


SWS Rower Pump
Robust
Reliable
Efficient
Very easy to use
SWS Filtration Limited
Hartburn, Morpeth, Northumberland NE61 4JB, U.K.
Telephone: (067072) 214 Telex: c/o 53182 ATLAIR G

SWS Rower Pump

The SWS Rower pump is a manually operated, suction piston pump used for drawing water from shallow wells, river bed filters and open water. **It is ideal for irrigation, village water supply and livestock watering.**

The original Rower pump, developed in Bangladesh by the Mennonite Central Committee and the Mirpur Agricultural Workshop and Training School, has become an outstandingly successful irrigation pump, used mainly by low income farmers. Now SWS Filtration Limited, with the encouragement of MCC and MAWTS, has produced the SWS Rower pump; a robust, low maintenance pump specially designed for rural communities where maintenance facilities are minimal.



Easy Operation

The pump is partly buried in the ground at an angle of about 30 degrees to the horizontal and is operated by pulling and pushing directly on the T-handle at the end of the piston rod.

Its easy 'rowing' action enables the operator to achieve a smooth pumping rhythm, in which the arms, legs and body all work together in natural harmony. Irrigation farmers find they can operate the SWS Rower pump for long periods without fatigue. This ease of operation is helped by the surge chamber, which steadies the flow of water to the pump.

Simple Maintenance

The SWS Rower pump is one of the simplest pumps to maintain.

The piston assembly may be freely withdrawn from the pump cylinder to check the rubber cup seals. They are hard-wearing and serve for many months but when necessary may be replaced in moments.

The foot valve lodges in a constriction at the base of the cylinder and can also be freely withdrawn, using the hooked rod provided. **No other tools are needed to service the pump.** New foot valve seals may be made from tyre inner tube.

Delivery Option

If the pump is used for domestic water supply it can be fitted with a special delivery spout allowing water to be collected without spillage and reducing the risk of contamination.

Pump Performance

The SWS Rower pump has a maximum suction lift of 5m (18ft), but operates best to lifts of 3.7m (12ft) at which an average healthy man can pump at least 1.4 lit/sec.

Women and children would pump less, but the large diameter cylinder (a pull of only 45cm discharges 1.5 litres) enables even a child pumping slowly to produce more water than from most other hand pumps.

Other Special Features

- Low cost – 'no pivot' design removes complications
- Lightweight – freight costs minimised
- Top quality stainless steel and robust modern plastics
- Pump need not be placed directly above water source
- Available in kit form for local assembly

In addition to the SWS Rower pump we supply a range of filters and well screens for intakes from canals, lakes, river beds, water holes and hillside springs.

Specifications

CAPACITY:	from 0.3 lit/sec (4 gal/min) at 17 strokes/min with 30 cm stroke to 1.4 lit/sec (18 gal/min) at 30 strokes/min with 84 cm stroke
CONSTRUCTION:	High pressure ABS plastic Pump Body Stainless Steel Piston Rod and Bell Mouth Valves injection-moulded in Polyacetal
DIMENSIONS:	Cylinder: 1200 mm x 65 mm i.d. Total Length: 1420 mm Suction Inlet: 1½" or 2" BSP Male thread
WEIGHT:	Single pump: 4 kg 2 pumps packed for export: 10 kg

For further information please contact:–

SWS Filtration Limited

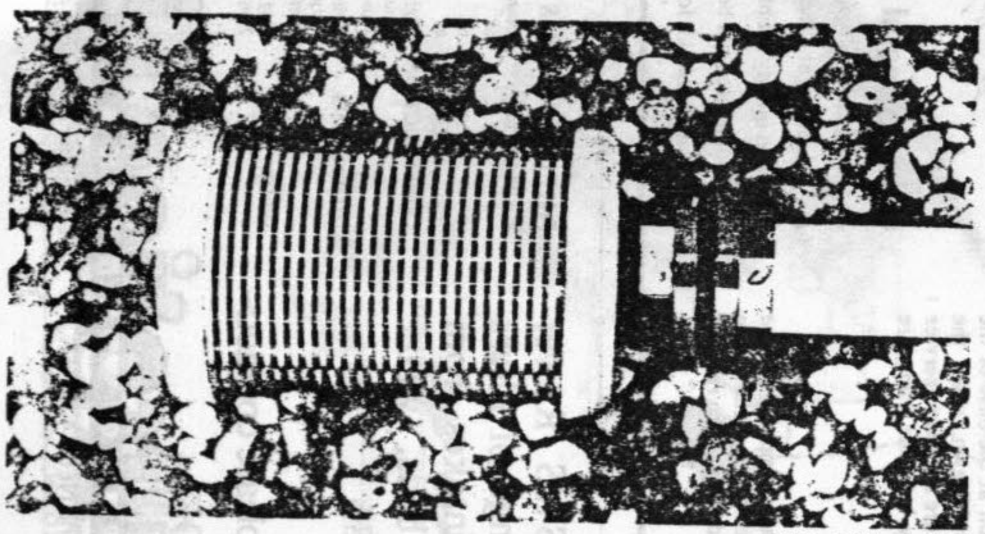
Hartburn, Morpeth, Northumberland NE61 4JB, U.K.

Telephone: (067072) 214 Telex: c/o 53182 ATLAIR G

Mini-Filter

S.W.S. FILTRATION LIMITED, HARTBURN, MORPETH, NORTHUMBERLAND, NE61 4JB. ENGLAND

Telephones:
Hartburn (067 072) 214 Saffron Walden (0799) 30274



HALF ACTUAL SIZE

Instructions For Use & Installation

The S.W.S. Mini-Filter, made of stainless steel and thermoplastic, has a capacity of up to 2 m³ (450 g)/h. It works on the same principle as the larger Village and Camp Units, using the sand or gravel of the river or lake bed as an effective *in situ* filter.

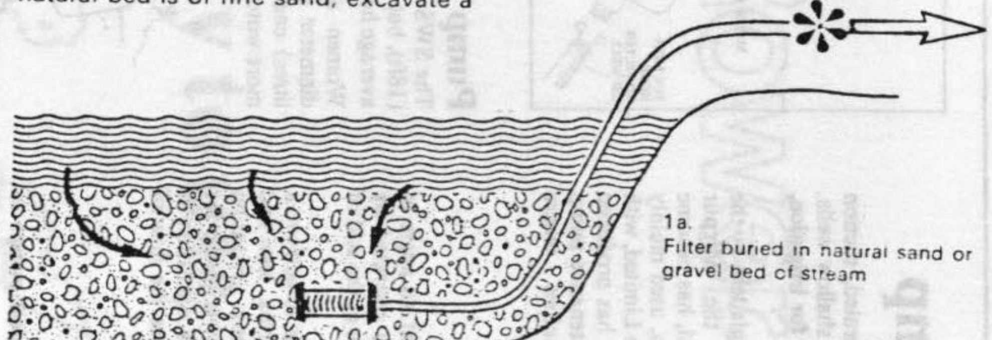
Installation is simple and requires no particular skills. The ideal bed has at least half the gravel between 1 and 5mm., and is covered by at least 20cm. (8") water. Where the bed is unsuitable for direct use it can often be modified by adding gravel or by excavating a hole and refilling with suitable fine gravel and coarse sand. Where this is not possible or convenient, the S.W.S. mini-filter can be used in a container of gravel standing on the bed or as an on-shore filter.

Note: The filtration occurs before the water reaches the mini-filter itself; the water is cleaned and purified as it passes into and through the sand/gravel bed.

I. FILTER INTAKES

Ia. *Mini-filter in natural bed.* Fork over an area of about 2m² (20ft²) i.e. about 1.5m x 1.5m (5 x 5ft) to a depth of about 40cm. (16"), letting the water wash out the silt and leaving the bed clean and permeable. Fasten the unit take-off securely to suction hose. Dig a hole in centre of prepared bed c. 30cm. (12") deep. Lay unit in hole and fill in, leaving surface mounded rather than hollow. Bury suction line in bed as far as bank.

Ib. *Mini-filter in improved bed.* If the natural bed is of fine sand, excavate a



1a.
Filter buried in natural sand or gravel bed of stream

hole 1m (3ft) diameter and 40cm. (16") deep. Obtain at least one sack pea gravel (2 — 4mm.) and put 12cm. (5") in the hole; attach unit to suction line and lay on gravel; pour in remainder of gravel and fill in with sand. Thoroughly fork over the area just around the hole. Bury suction line.

1c. *Mini-filter in artificial bed.* If the bottom is of clay, dig a hole c. 60 x 60cm. (24 x 24") and 40 cm. (16") deep. Put pea gravel to depth of 5cm. (2"), attach unit to suction line and lay in position. Pour in more gravel to within c. 5cm. (2") of top and fill remainder with coarse sand. In a dam, pond or sluggish stream it is easie[r] and equally effective, after first clear[ing] off the bottom, to make a moun[d] of similar size and composition, [if] need be with a surround of rock[s,] concrete blocks, etc. to stabilise it. [If] the site allows the use of the filter ma[...] (see below) this will make the syste[m] easier to maintain.

DEVELOPMENT OF SYSTEM

This is very important and must b[e] done thoroughly before connectin[g] pump outlet to delivery main. Th[e] object is to suck out unwanted fin[e] material while building up a grade[d] zone of coarser gravel around it an[d] making the whole zone aerobic. Using a hand pump, or petrol-driven o[r] electric pump of not above ½ hp. an[d] able to pass fine sand, pump at not above 2m³ (450 g)/h. until the water appears clean; this may take up to 30 minutes but mostly only 2 or 3 minutes. Then stop the pump briefly and re-start: the water becomes cloudy again but not for so long. Repeat the stop/start sequence until the water no longer becomes cloudy. Then pump to waste for at least one hour.

Note

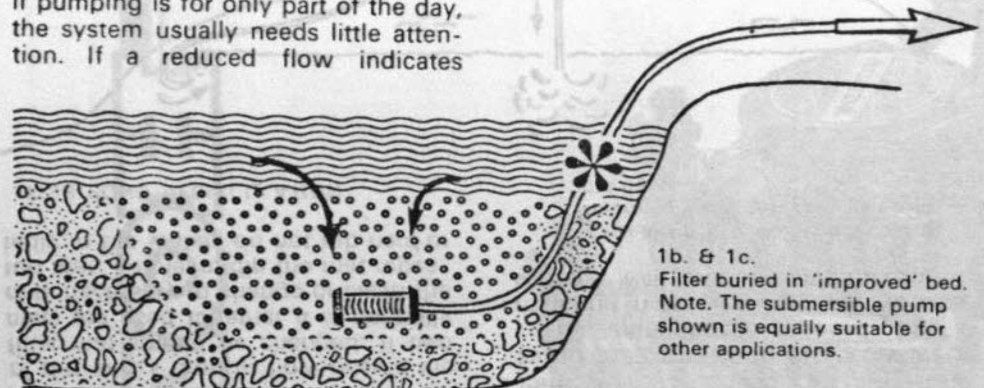
1. Development of an artificial bed is much more rapid, with little fine material to be removed.

2. A system in a bed with much fine sand may continue for some time

to pass grains immediately after re-starting; these settle out quickly in a sand trap or storage tank, or can be lost by pumping to waste for a few minutes after re-starting.

MAINTENANCE OF SYSTEM IN RIVER OR LAKE BED

At up to $2m^3$ (450 g)h, particularly if pumping is for only part of the day, the system usually needs little attention. If a reduced flow indicates



1b. & 1c.
Filter buried in 'improved' bed. Note. The submersible pump shown is equally suitable for other applications.

blockage in the bed, either or both of the following actions may be taken:—

i. Stop the pump. Rake or gently fork over the surface around the unit. Then redevelop briefly as above.

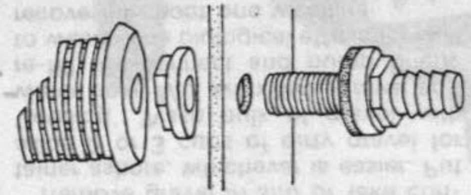
ii. Pump back briefly by changing over intake and delivery hoses. Or blow back briefly with an air pump such as is used for inflating air-beds, etc. For a short run it may be possible to do this by mouth. Then redevelop briefly.

Id. *Mini-filter in container of gravel.* This is proving useful in all sites except rivers subject to heavy spates. If convenient, the container is stood on the bottom but for stability or in shallow reaches it can be partly dug in, keeping the top well clear of a silty bottom and below the surface scum and floating algae in still water. A 20 l. (4 gal) plastic header tank (30 x 40 x 30cm) (12 x 16 x 12") is a useful size and shape for a flow of $0.5m^3$ (100 g)/h., but any container can be used, not smaller than the above and strong enough to hold the gravel. If possible use pea gravel.
Alternatively, sieve out 2—4mm gravel, washing thoroughly to remove all fine sand.

TO FIX MINI-FILTER INTO TANK

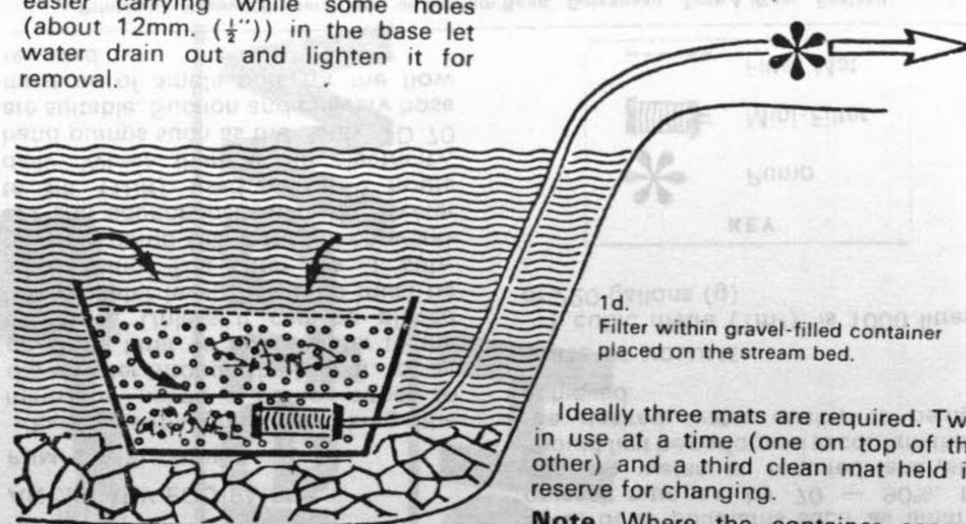
First cut ¾" (19mm.) hole near bottom of tank; a piece of pipe can be heated and used to burn a hole or used as a punch against a block of wood.

Connect hose to serrated end of fitting supplied. Warm hose briefly in boiling water and slip on while still soft. If necessary use a hose clip to secure the joint.



Remove one nut, pass screwed end of fitting through hole, replace nut and tighten. Finally screw Mini-filter to connector inside the tank.

It may be easier to part-fill with gravel on shore and complete filling when in position, but the above container can be handled by one man. Rope handles at each end make for easier carrying while some holes (about 12mm. (½")) in the base let water drain out and lighten it for removal.



1d.
Filter within gravel-filled container placed on the stream bed.

Finally the filter mat, which should overlap the top by about 2cm. (1") all round, is placed in position and held firmly by a wire grid, several stones, a layer of gravel, etc. so that the surface is sealed by it.

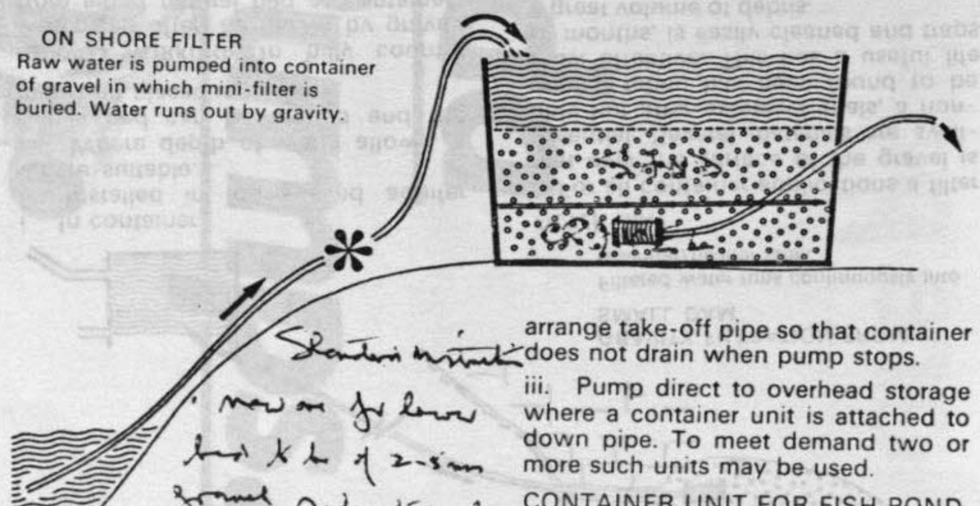
Ideally three mats are required. Two in use at a time (one on top of the other) and a third clean mat held in reserve for changing.

Note Where the container cannot be placed in the actual stream the following may be possible:—

i. Dig out a small inlet not more than 1m x 1m (40 x 40") and deep enough to house the container.

ii. House the container ashore, pump raw water to it and abstract by gravity;

ON SHORE FILTER
Raw water is pumped into container of gravel in which mini-filter is buried. Water runs out by gravity.



arrange take-off pipe so that container does not drain when pump stops.

iii. Pump direct to overhead storage where a container unit is attached to down pipe. To meet demand two or more such units may be used.

CONTAINER UNIT FOR FISH POND RECIRCULATION

Filter bed surface and depth must be adequate and flow rates should not normally exceed 1 g/ft²/minute. Some aquarists aim at an hourly turnover and filter surface 25% of pool area but the highly efficient filter mat (see below) allows a much lower ratio. E.g. one pond of c. 2,200 g has a mini-unit in plastic tank 18 x 30 x 18", pumped for 6 — 8 hours daily from April to September. It is best for the filter to be placed near one end of pond and the filtrate returned to the far end by jetting or cascading to increase aeration. Ponds vary widely and the best pattern must be worked out in practice. For flows of above 2 m³ (450 g)/hour two or more mini-units should be used.

DEVELOPMENT OF CONTAINER SYSTEM

Because the container is filled with clean gravel only a brief stop/start sequence is needed to stabilise the system before pumping to waste for at least an hour.

MAINTENANCE OF CONTAINER SYSTEM

CLEANING THE MAT

When the mat surface appears full of dirt and a drop in flow occurs the filter mat should be changed. If two mats are used together it is normally only necessary to change or clean the top mat. To clean, dip the mat repeatedly in the water: do not rub hard or wring out. After changing the mats pump to waste for 10 minutes before using water. Experience will show how often mat changing is required.

Unless the water is very dirty it is likely to be weeks rather than days. Mats of the type supplied are likely to last more than six months.

The filter mat is so efficient that few particles reach the gravel and this should be washed only when obviously dirty, after not less than 6 months. Proceed as follows:—

Remove gravel *in situ* or take container ashore, whichever is easier. Put aside 2 or 3 cups of dirty gravel for 'seeding'. Wash bulk of gravel with water only. Mix with dirty gravel and re-fill. Re-connect and pump briefly to waste. The biological efficiency will recover in about one week.

OTHER APPLICATIONS OF MINI-FILTER

CONTAINER UNIT AS POLISHING FILTER

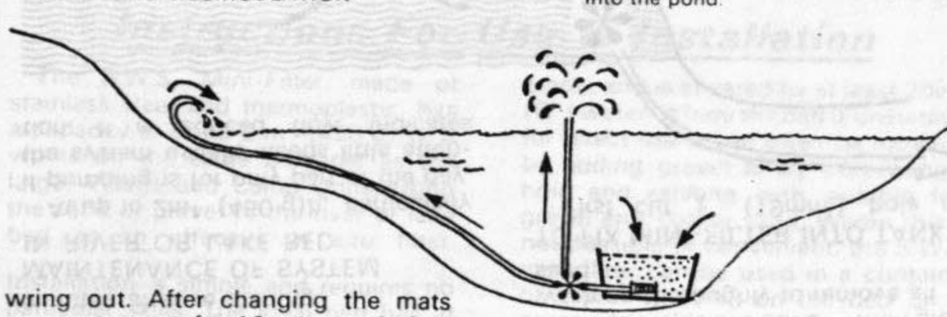
If water from an S.W.S. system, whether *in situ* or in container, is pumped to overhead storage, a further container unit placed in the reservoir and attached to the down pipe reduces any residual pollution to negligible figures.

MINI-FILTER INTAKE IN SHALLOW WELL

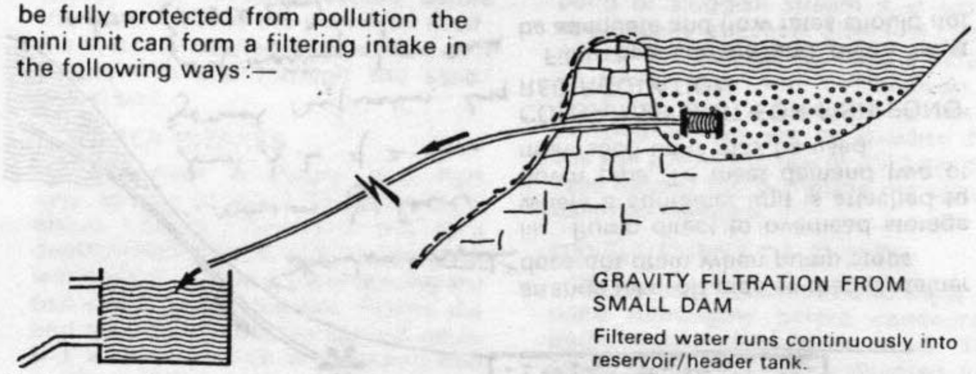
The extra head imposed by a mini unit in gravel is minimal. Where a shallow well that is pumped cannot be fully protected from pollution the mini unit can form a filtering intake in the following ways:—

i. In container.
ii. Installed in loose sand aquifer where suitable.
iii. Where depth of water allows, a gravel bed can be formed and the mini-unit placed in it.

FISH POND RECIRCULATION



Many alternative layouts possible. Returning water best cascaded back into the pond.



GRAVITY FILTRATION FROM SMALL DAM

Filtered water runs continuously into reservoir/header tank.

GRAVITY WORKING. In hilly country water can often be drawn by gravity from either natural bed or container; a fall of 2m. (6ft) is enough and a valve may be needed to restrict flow. For optimum filter performance allow water to run continuously into a header tank and thence to waste. Draw water from this header tank rather than directly from the mini filter. (See diagram).

ANCILLARY EQUIPMENT

PUMPS & PLUMBING

Except with gravity working the mini-filter needs a pump, either to draw water through the bed or, for an on-shore filter, to pump water to the container. Unless it can be placed below water level the pump must be self-priming. The Otter No. 1 submersible pump (90 watts) is convenient and economical for raising water to 3m. (10ft), used up to 12 hours daily. Where there is no electricity, hand pumps such as the Patay DD 70 are suitable. Suction and delivery hose must be of ample bore for the flow required.

FILTER MAT

For all container applications a filter mat over the surface of the gravel is essential. Several materials are available but after extensive trials, a non-woven fabric has been found to be most effective. This has a useful life of months, is easily cleaned and traps a great volume of debris.

QUALITY

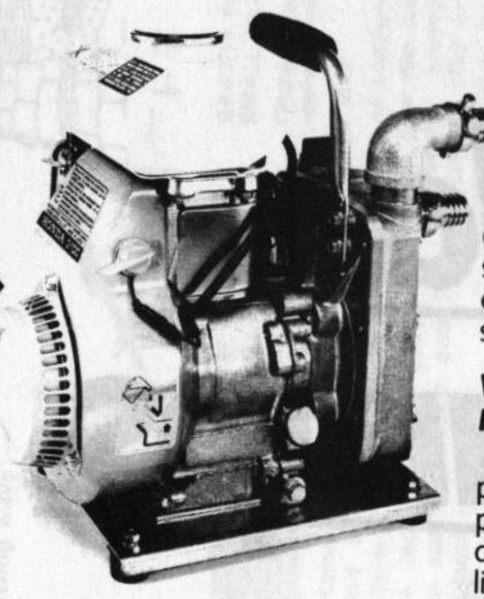
Water quality will depend on the depth and grade of sand, rate of pumping etc., but a system pumped continuously or for several hours daily should reduce suspended solids to c. 2 p.p.m. and all bacteria by above 95%; other pollutants such as ammoniacal nitrogen by 70 — 90%. If drinking water is required analysis should first be performed to confirm that the desired water quality is being achieved.

UNITS OF VOLUME

1 cubic metre (1m³), is 1000 litres or 220 gallons (g).

Printed by Vaseys (Printers) Ltd., 36 Durham Road, Gateshead, Tyne & Wear, England

More power, more refinement, more choice.



The heart of a Honda water pump is its engine. The superior Honda design provides smooth, even power with low noise levels.

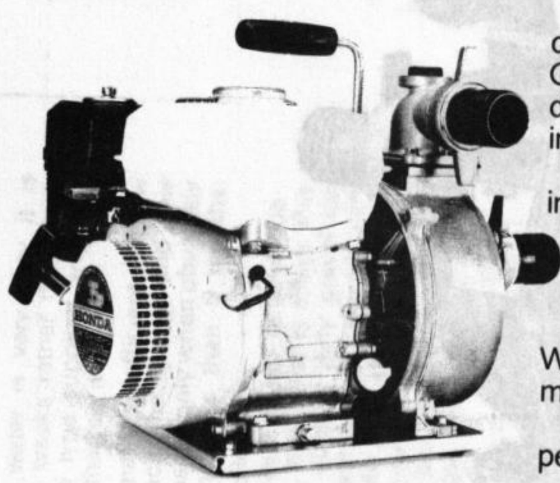
The engines also feature automatic mechanical decompression for easy-starting and low maintenance points-free ignition. Cast iron cylinder sleeve and valve guides, chrome-plated top piston ring and ball-bearing crankshaft all combine to ensure maximum durability.

Running economy is such that you can enjoy close to a 30% reduction in fuel consumption and a 50% reduction in oil consumption.

As for the actual pump performance, you can rely on Honda's design thoroughness to provide the optimum levels of total head, suction head and output capacity. Self-priming time is minimised and cast iron impellers and mechanical seals ensure a long, reliable service life.

WA10D 1inch diameter discharge aperture.
For basic water pumping requirements.

The smallest model in the Honda range, the WA10D provides performance which belies its size. The 76cc G100 engine is the reliab power source which enables the WA10D to achieve a maximum discharge capacity of 150 litres per minute. Total head and suction head lift maximums are 38m and 8m respectively.



WA20XD 2inch diameter discharge aperture.
For larger draining operations.

This model comprises all the advantages of the WA10D but is capable of even greater performance. The engine featured is the 144cc GX110 which powers a maximum pumping capacity through the 2inch diameter discharge of 600 litres per minute. Total fuel tank capacity is increased to 2.5 litres to enable longer running times.

The unit is spring-loaded to minimise vibration from the increased power.

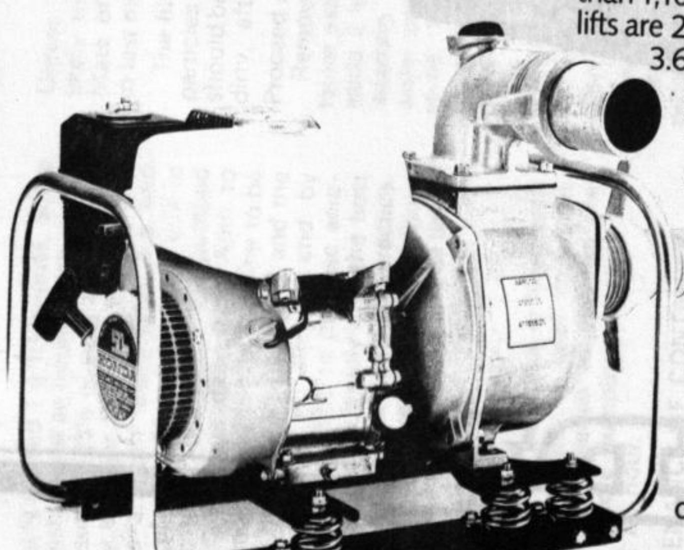
WA30XD 3inch diameter discharge aperture.
For heavy draining and irrigation purposes.

The largest model available in the current Honda range, the WA30XD features even more power to enable you to cope with the most demanding situation.

The engine is uprated to the GX140 delivering a useful 5HP performance.

Maximum pumping capacity is increased significantly to no less than 1,100 litres of water per minute, while total head and suction head lifts are 28m and 8.5m respectively. Fuel tank capacity is increased to 3.6 litres for even longer running periods.

Again the unit is spring-loaded to reduce vibration and a half-frame is fitted for further operator convenience.



WB20X 2inch diameter discharge aperture.
For added mobility and efficiency.

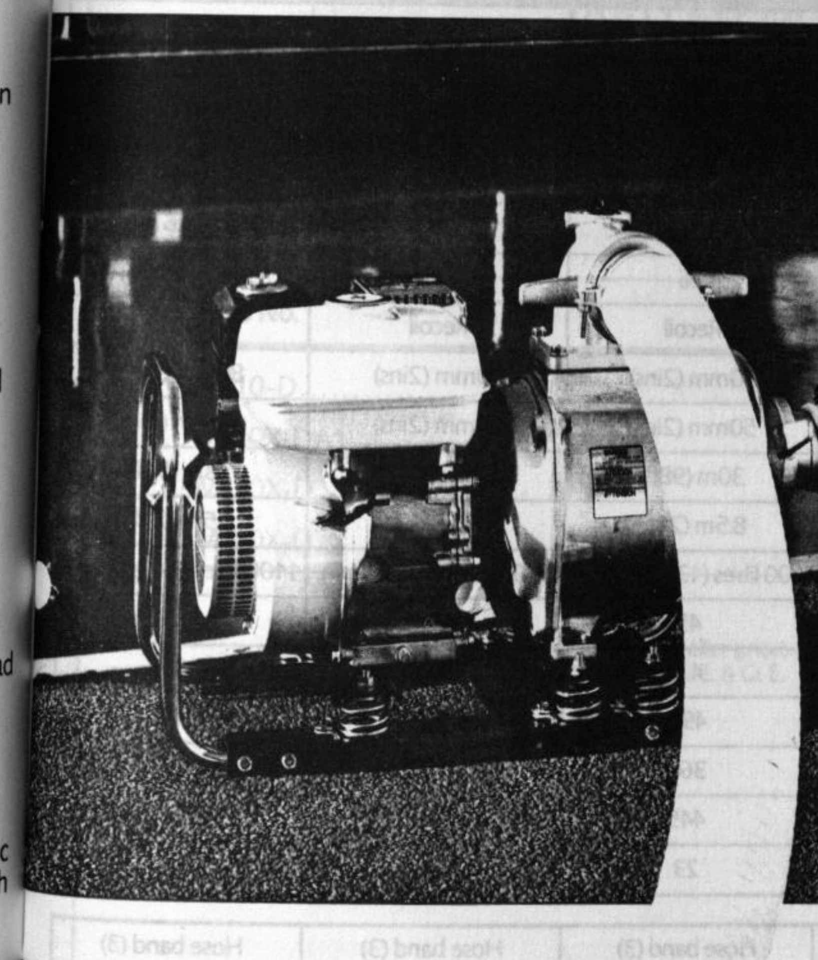
The amazingly compact WB20X weighs a mere 20 kilograms to give you real flexibility and mobility in the field.

Further refinements have been made to the pump unit to ensure that its performance is at least as good as pumps much less manoeuvrable.

The 3.5HP GX110 engine provides the power to pump 500 litres per minute.

Total head lift is 32m while suction head lift is a highly convenient 8m.

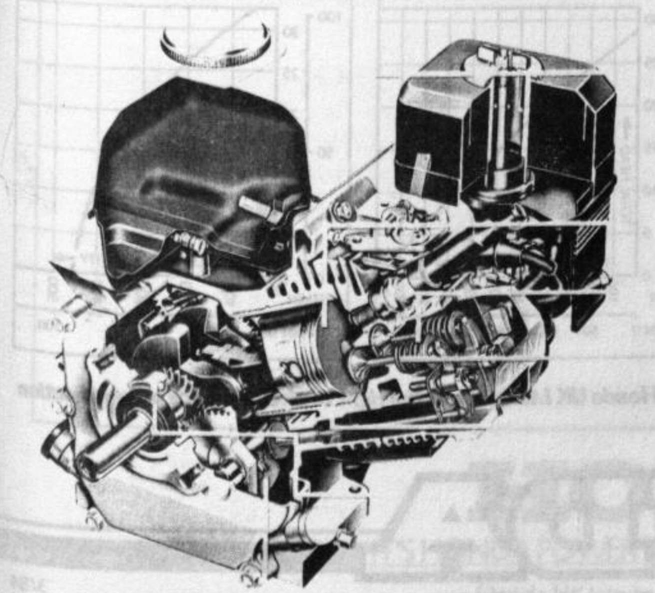
A cast iron impeller and mechanical seals are fitted to reduce maintenance requirements and prolong reliable service life.



The choice is yours.

Overleaf you will find a full list of specifica-ns to enable you to choose the Honda pump at's right for you.

Whichever you choose, you'll find that same Honda combination of reliability, performance and economy.



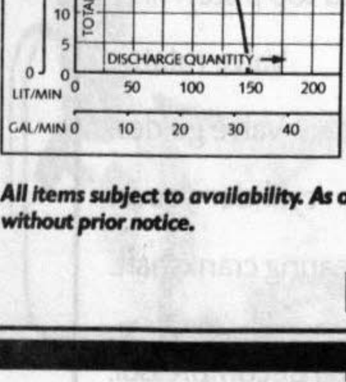
Specifications.

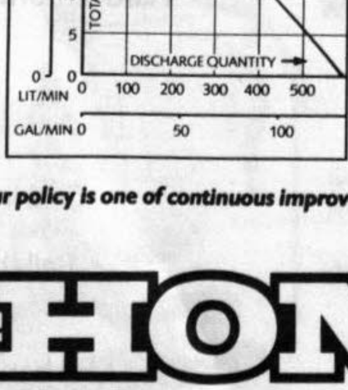
Model No.		WA10D	WA20X D	WB20X D	WA30X D
Engine	Engine type	G100	GX110	GX110	GX140
	Displacement (cc)	76	108	108	144
	Max. HP	2.0	3.5	3.5	5.0
	Max. RPM	4200	3600	3600	3600
	Fuel tank capacity (litres)	1.4	2.5	2.5	3.6
	Oil capacity (litres)	0.45	0.6	0.6	0.6
	Starter	Recoil	Recoil	Recoil	Recoil
Pump performance	Inlet dia.	25mm (1in)	50mm (2ins)	50mm (2ins)	80mm (3ins)
	Outlet dia.	25mm (1in)	50mm (2ins)	50mm (2ins)	80mm (3ins)
	Total head lift	38m (118ft)	30m (98ft)	32m (104ft)	28m (92ft)
	Suction head lift	8m (26ft)	8.5m (28ft)	8m (26ft)	8.5m (28ft)
	Max. discharge capacity	150 litres (33gal)/min	600 litres (132gal)/min.	500 litres (110gal)/min.	1100 litres (242gal)/min.
	Self-priming time at 5m (sec)	50	45	110	120
	Priming water capacity (litres)	1.4	4.3	2.8	6.2
Dimensions	Length (mm)	320	490	445	620
	Width (mm)	270	360	345	410
	Height (mm)	352	445	395	485
	Dry Weight (Kg)	12	23	20	35

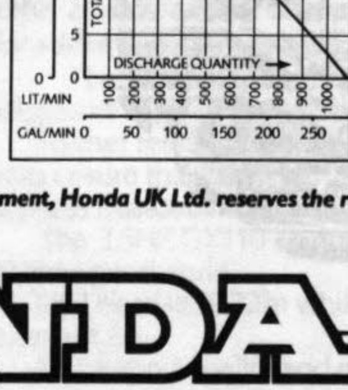
Standard parts	Hose band (3)	Hose band (3)	Hose band (3)	Hose band (3)
	Strainer (1)	Strainer (1)	Strainer (1)	Strainer (1)
	Strainer joint (1)	Strainer joint (1)	—	—
	Hose coupling (2)	—		—
	—	—	Mount rubber (4)	—

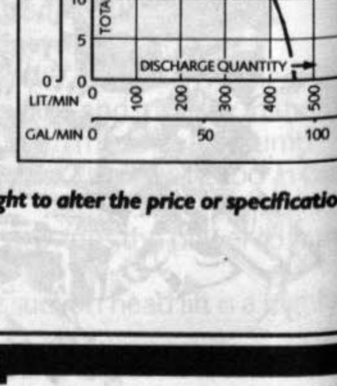
Performance curves.

FUEL CONSUMPTION 230 g/HP/HR









All items subject to availability. As our policy is one of continuous improvement, Honda UK Ltd. reserves the right to alter the price or specification without prior notice.

HONDA

It's Honda power that makes the difference.

3/84

Honda UK Limited, Power Products Division, Power Road, Chiswick, London W4 5YT. Telephone: 01-747 1400.

HONDA POWER PRODUCTS RETAIL PRICE LIST

WATER PUMPS

EFFECTIVE FROM 6TH MAY 1985

Code No.	SRP ex. VAT (£)	SRP inc. VAT (£)
WB10-D	181.00	208.15
WB20X-DA1	200.00	230.00
WA20X-D	231.00	265.65
WA30X-D	283.00	325.45

Honda (UK) Ltd. reserve the right to alter prices or specifications without prior notice.
E. & O. E.

HONDA

IT'S HONDA POWER THAT MAKES THE DIFFERENCE

Honda UK Limited, Power Products Division,
Power Road, Chiswick, London W4 5YT. Telephone: 01-747 1400.

APPENDIX 5

The Ndume Turbo Water Pump Brochure including Performance chart

The pump and turbine are of very sturdy construction needing virtually no maintenance. Periodic greasing of the crankbush and removal of debris from the turbine housing screen in all that is required.

When after a long period of service, it becomes necessary to renew the piston leathers, the whole pump and turbine unit can be removed from the turbine housing by unscrewing only two nuts. Thus, the turbine housing can be left in situ without disturbing the dam or other installation arrangements.

The pump can be supplied with either 2½" or 3" diameter pump cylinders, the smaller diameter being preferred when pumping against a high head, or where the volume of drive water is restricted to 2-3 cusec.

EVEN IN FLOOD CONDITIONS, THE TURBO-PUMP WILL STILL OPERATE.

On sites where flooding is known to occur, the Turbo Pump should be placed on the inside of a corner away from the main flow or preferably in a diversion channel as shown in Figure 3.

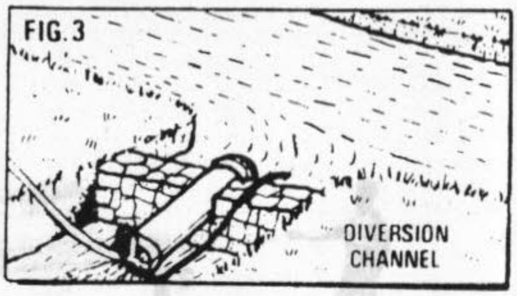


FIG. 3

Excess water will not damage the Turbo Pump and it will continue to operate. However, in areas where heavy debris is such as boulders and trees are brought downstream by floods, the Turbo Pump should be installed in a diversion channel to prevent damage.

The more fall that can be obtained through the turbine, the better — up to a recommended limit of 3 feet (915 mm). Therefore, a site with high banks upstream should be chosen to enable the dam to be built as high as possible. The site should be checked for flow and possible fall and, from the tables, check that the performance required is obtainable.

Once the site is chosen, it is necessary to prepare it for the installation of the turbine. In some cases, weirs and dams may already exist and these are ideal sites. Figure 4.

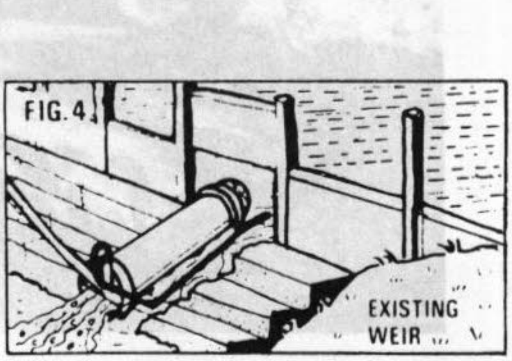


FIG. 4

Turbo Pumps may be installed in multiples as shown in Figure 5 and Figure 6 to increase output volume.

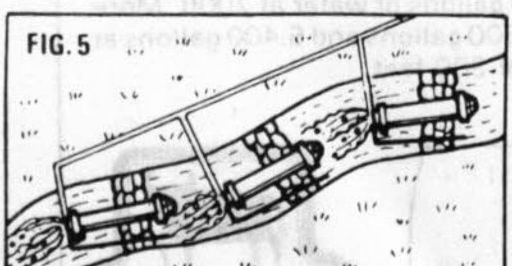


FIG. 5

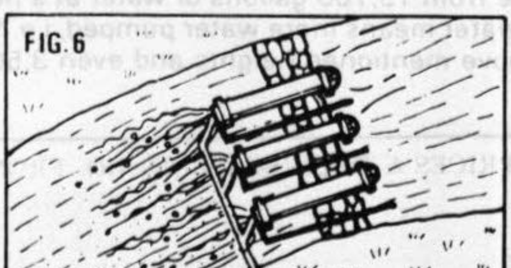
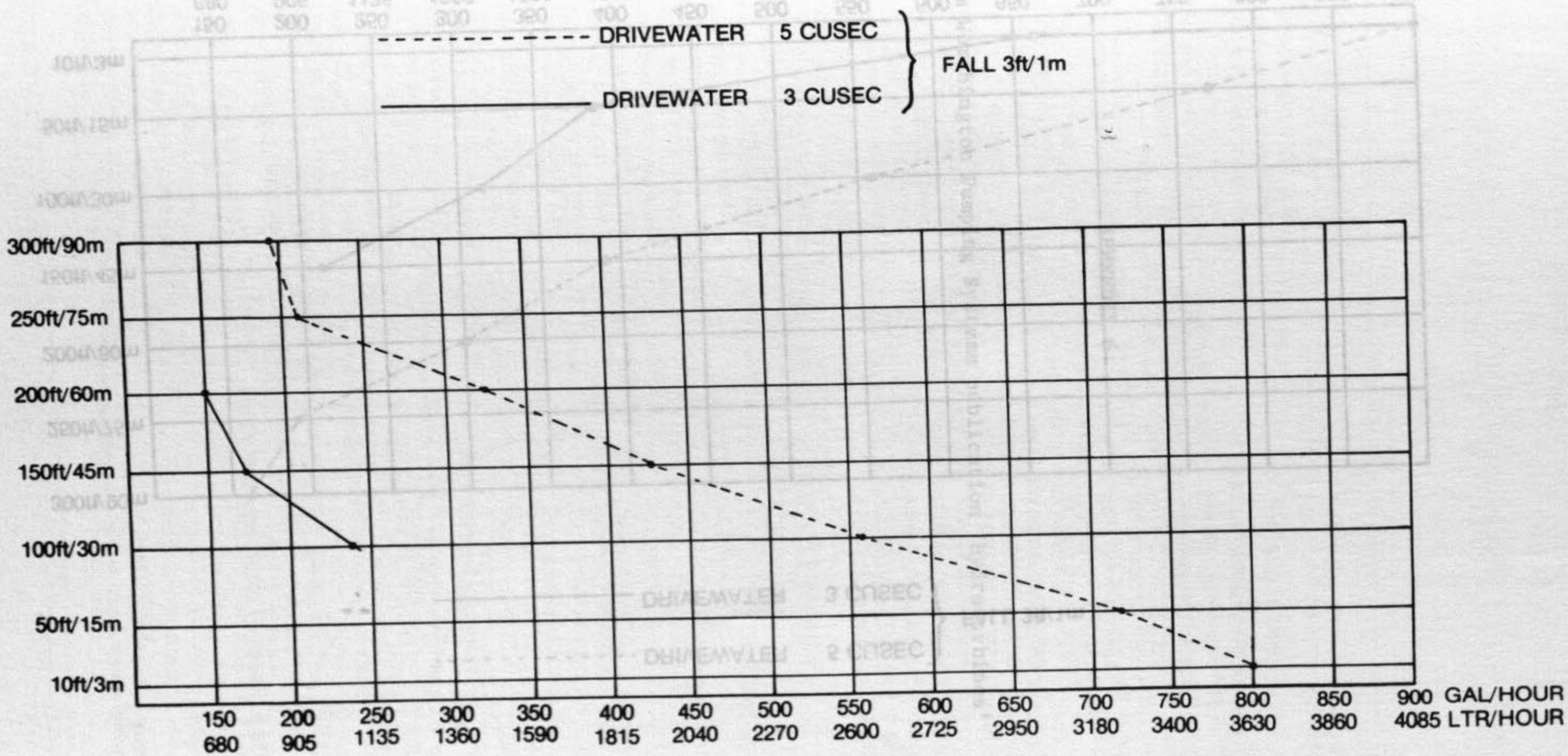
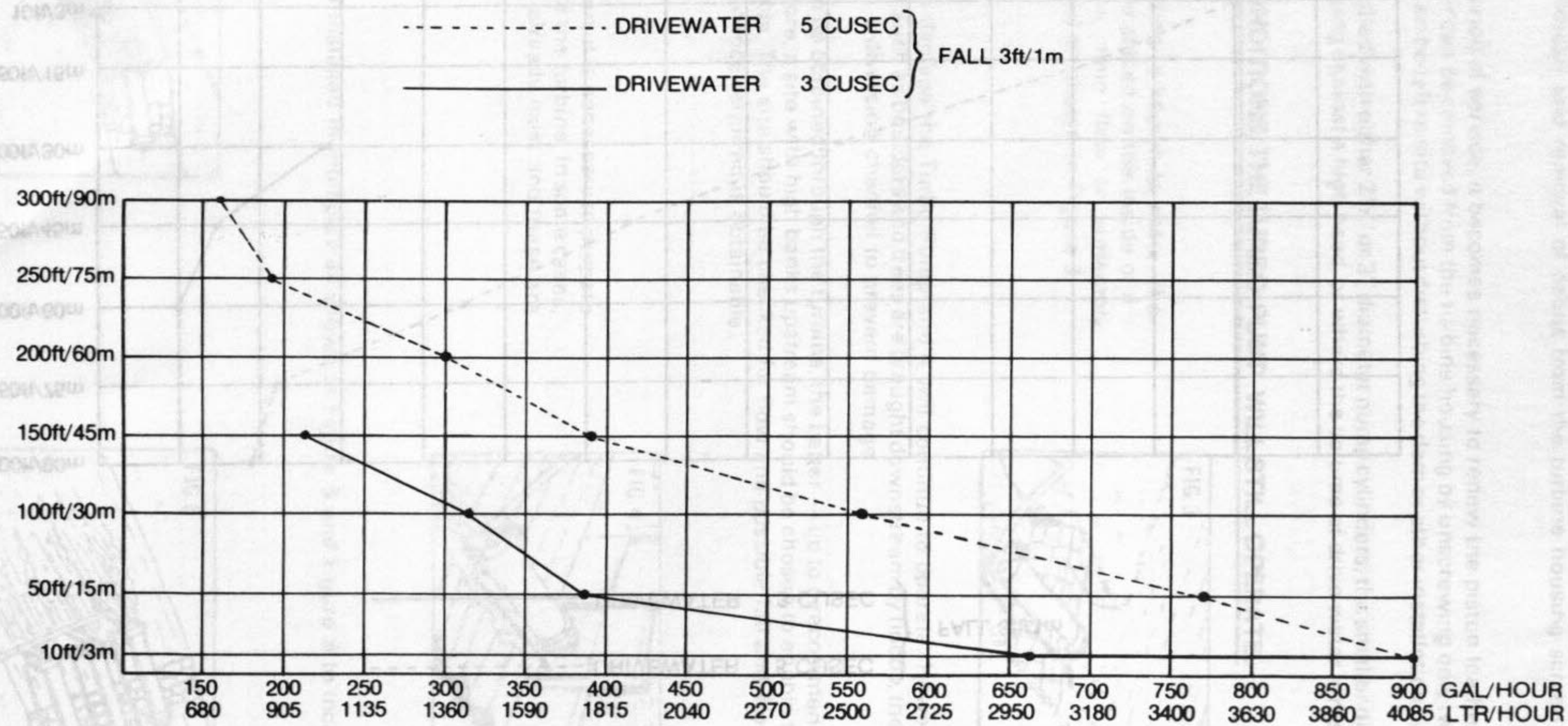


FIG. 6

PERFORMANCE WITH 2½" CYL



PERFORMANCE WITH 3" CYL



APPENDIX 6

Extract from Worthington Pumping Systems publication 'Hydroturbines'

operates as a turbine: its mechanical operation is smooth and quiet; its peak efficiency as a turbine is essentially the same as its peak efficiency as a pump; head and flow at the best efficiency point as a turbine are higher than they are as a pump; and the power output of the turbine at its best efficiency point is higher than the pump input power at its best efficiency point.

Dual capability predicted.

Centrifugal pumps from radial flow to the axial flow geometry can be operated in reverse and used as hydraulic turbines. This dual capability is not just happenstance, since turbomachinery theory predicts this capability. Furthermore, because this theory is applicable, a hydraulic turbine follows the same affinity relationships as do centrifugal pumps. Consequently, the performance of a turbine can be predicted accurately from one set of operating conditions to another, and new turbine designs can be "factored" from existing designs.

Over the years Worthington has tested many pumps as turbines. From these tests it has been observed that when a pump

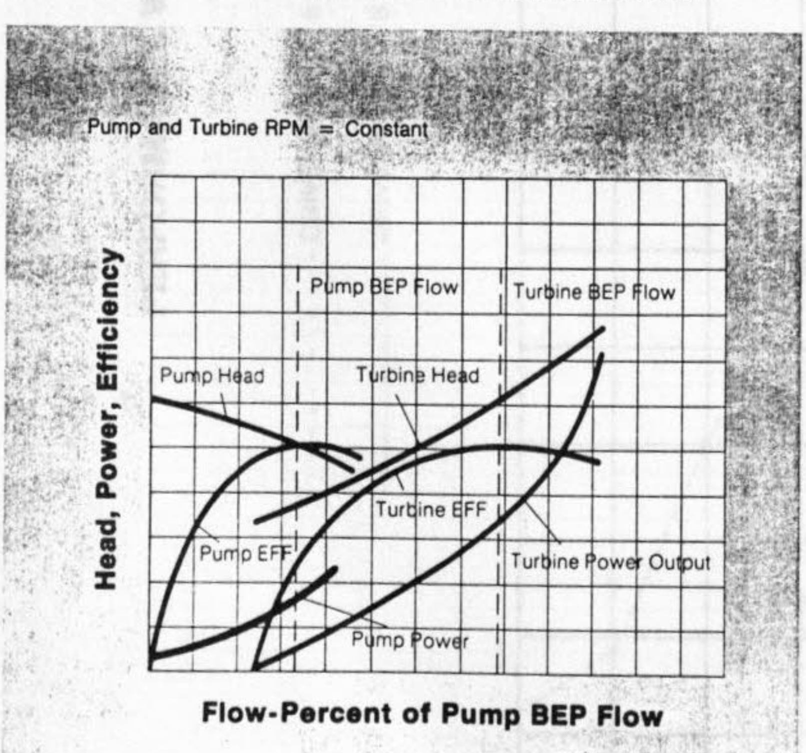


Figure 1—Normalized performance characteristics for a pump operating in the normal pump mode and in the turbine mode.

Typical performance characteristcs.

A comparison of the characteristics of normal pump operation with the characteristics of the same pump operated as a turbine at the same speed is shown in Figure 1. The curves are normalized by the values of head, flow, efficiency, and power at the pump BEP (best efficiency point). As mentioned previously, note that the location of the turbine BEP is at a higher flow and head than the pump BEP. The ratio of the turbine capacity and head at BEP to the pump capacity and head at BEP has been observed to vary with specific speed—ratios of 1.1 to 2.2 having been determined by test.

There are two other important characteristics of pumps operating as turbines shown in Figure 1. The first of these is that the turbine maximum efficiencies tend to occur over a wide range of capacity. Consequently, relatively wider ranges of turbine operating head can be accommodated without an adverse effect upon efficiency.

Secondly, note that there is a value of head at which the turbine power output is zero even though there is flow through the unit (this point is called the runaway speed). Further reduction in head below this value causes the turbine to begin absorbing power, assuming the connected load is capable of providing the power. The flow corresponding to the head at zero power varies from about 40 to 80 percent of the flow at turbine BEP, depending upon specific speed.

The turbine performance, or rating curve, normally supplied to a customer is either the one shown in Figure 2 or 3, whatever his preference. Figure 2 is a plot at constant speed with capacity as abscissa, while Figure 3 is a plot at constant head with speed as abscissa. Given the performance test in either

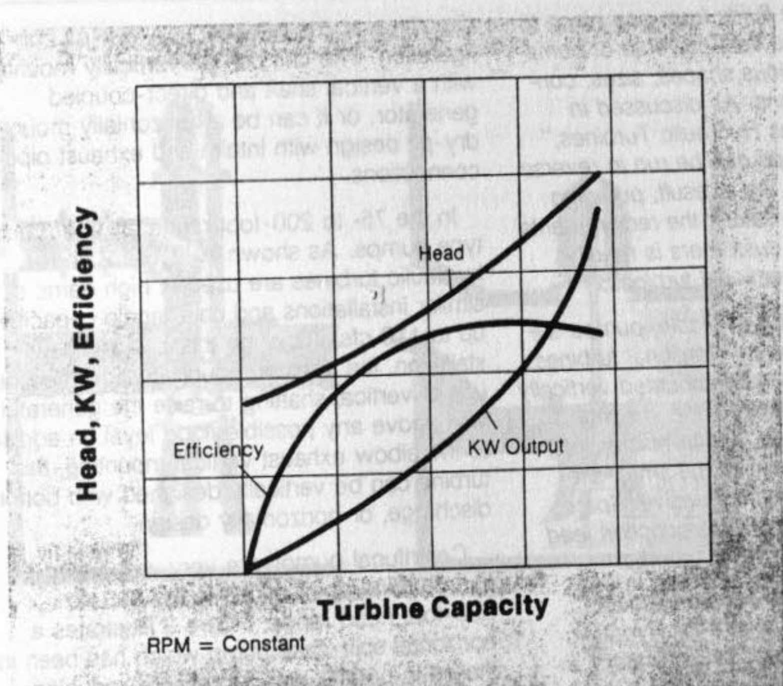


Figure 2—Typical turbine performance curve for constant speed operation.

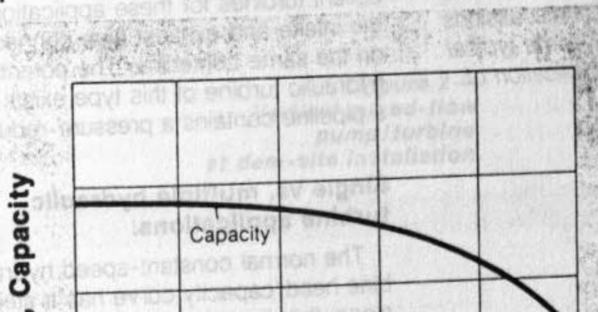


Figure 3—Typical turbine performance curve for constant head operation.

format, the other can easily be obtained by use of the affinity relationships.

Runaway speed.

Note that the runaway speed can be read directly from the curves of Figure 3. The runaway speed could also be calculated using Figure 2 and the affinity laws, i.e., by taking the product of the value of speed and the square root of the ratio of the head for which runaway needs to be determined to the head at zero power output.

As illustrated, the magnitude of the runaway speed can easily be determined for any operating condition, provided its value is known for a given condition. This is important data because the magnitude of the runaway speed could affect the structural integrity of the rotating equipment, making it necessary to incorporate overspeed protection in the control system.

Cavitation.

Just as in a pump, at any point in the machine where the local pressure drops to the vapor pressure of the liquid, vapor is formed and cavitation damage can occur. Sufficient outlet or backpressure must be maintained to prevent cavitation, just as adequate suction pressure must be maintained on a pump. The value of the available backpressure is TAEH (total available exhaust head), and the value of the backpressure required for proper turbine operation is TREH (total required exhaust head).

Design changes.

In most instances no design changes or modification need to be made for a pump operating as a turbine. When a selection is made, a design review is required, however, because when operating as a turbine the rotation is reversed and operating heads and power output are generally higher. Consequently, a design review would include items such as: checking that threaded shaft components cannot loosen; evaluating the adequacy of the bearing design; shaft stress analysis; and checking the effect of increased pressure forces.

Pumps as turbines: Systems and applications.

The need to move fluids from one place to another has created a vast universe of pumping equipment of various shapes, sizes, configurations, and designs. As discussed in "Centrifugal Pumps as Hydraulic Turbines," most centrifugal pumps can be run in reverse as hydraulic turbines. As a result, pumping equipment needed to satisfy the requirements of small-hydropower customers is readily available, unlike conventional turbines.

Besides being readily available, pumps are also less complex than conventional turbines, more flexible—they can be mounted vertically or horizontally, wet pit, dry pit, and even submersible—can attain similar efficiencies, and, of prime importance to the small-site owner, are normally less expensive. Spare parts availability and shorter production lead times are also advantages for pumps.

Also discussed in the previous article "Comparing Control Systems for Hydraulic Turbines") were two kinds of generators, induction and synchronous, and their basic operating characteristics when employed in co-generation-type applications. This article expands on these two previous discussions with a detailed examination of some typical systems encountered in the application of pumps as hydraulic turbines.

An understanding of the specialized vocabulary and mathematical formulas which are applicable to pump applications as turbines will be useful to our discussion. Tables I and II on page 14 provides a glossary and a listing of relevant formulas.

Typical installations.

The first typical installation we will examine, as shown in Figure 1, is a wet-pit propeller or mixed-flow pump as a turbine. These units are generally low head, less than 75 feet, and high capacity, up to about 225 cfs. They lend themselves to small dams or naturally falling water where the turbine can be mounted directly over the tailwater in a wet-pit configuration. The unit can be vertically mounted with a vertical shaft and direct-coupled generator, or it can be a horizontally mounted, dry-pit design with intake and exhaust pipe connections.

In the 75- to 200-foot range are the Francis-type pumps. As shown in Figure 2, these hydraulic turbines are used at high dams or similar installations and can handle capacities up to 110 cfs. Although this is a dry-pit installation, the vertical mounting allows for the use of vertical shafting to raise the generator well above any possible flood level. In addition to the elbow exhaust vertical mounting, this turbine can be vertically designed with bottom discharge, or horizontally design.

Centrifugal pumps are very well suited for hydroturbine applications in the 200- to 500-foot head range. Figure 3 illustrates a horizontal split-case pump which has been installed in parallel with a pressure-reducing valve in a pipeline to recover wasted energy. Horizontal, dry-pit, split-case pumps make excellent turbines for these applications because the intake and exhaust pipe connections are on the same centerline. The potential for a hydraulic turbine of this type exists anywhere a pipeline contains a pressure-reducing valve.

Single vs. multiple hydraulic turbine applications.

The normal constant-speed hydraulic turbine head/capacity curve has a steep, positive slope; that is, at low flows the head is low, and to achieve higher flows, the head must be increased. This is suitable for many applications. For example, if a hydro developer has a dam site and wishes maximum capacity at the high-dam level with decreased capacity as the dam level is lowered, the normal single-pump installation is ideal. The curve in Figure 4 shows how a typical system of this type would operate.

Hydraulic turbine systems that have a broad range of flow requirements may require more control equipment; however, it does not have to be complicated. A simple timer may be incorporated into the control to automatically shut down the hydraulic turbine after a preset

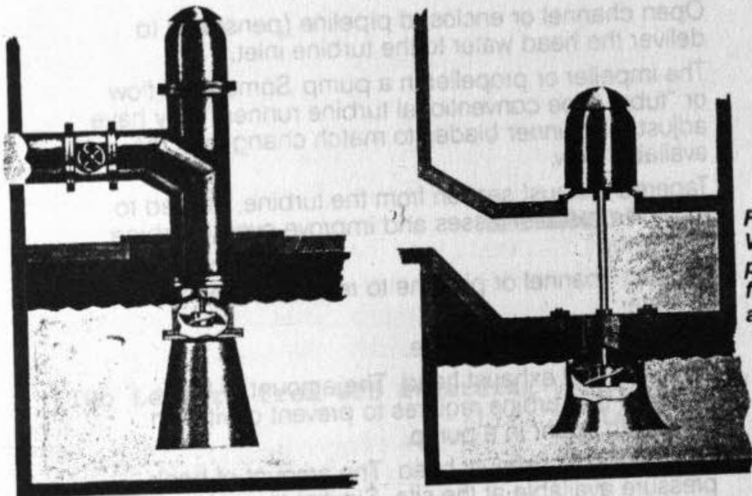


Figure 1 — Vertical propeller pump/turbine for wet-pit application.

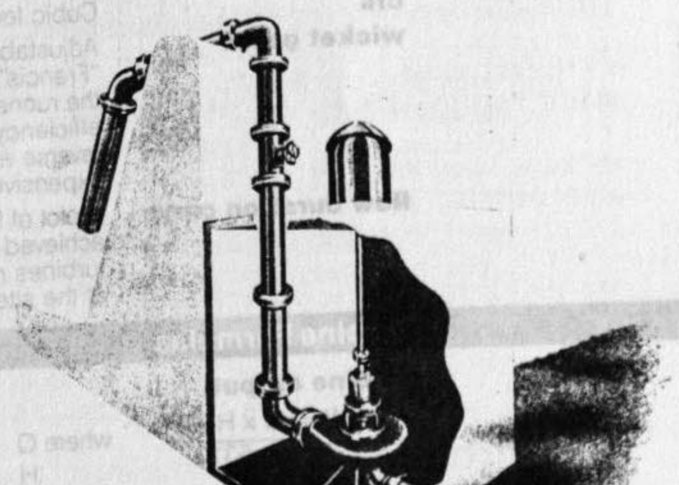


Figure 2 — Vertical mixed-flow pump/turbine at dam-site installation.

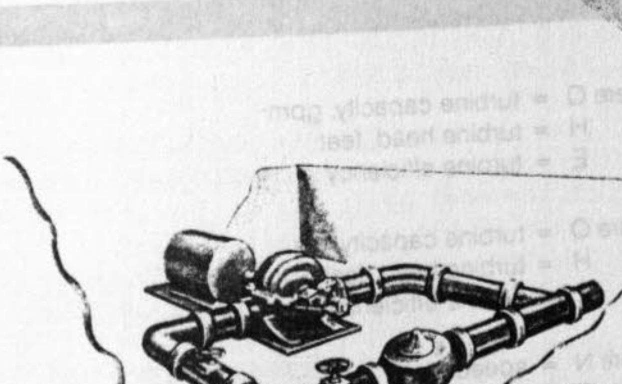


Figure 3 — Horizontal split-case pump/turbine installed in parallel with a pipeline pressure-reducing valve.

Turbine Nomenclature

head water	Source of water to power the turbine.
head race	Open channel or enclosed pipeline (penstock) to deliver the head water to the turbine inlet.
runner	The impeller or propeller in a pump. Some axial flow or "tube" type conventional turbine runners may have adjustable runner blades to match changes in the available flow.
draft tube	Tapered exhaust section from the turbine, utilized to minimize exhaust losses and improve overall turbine efficiency.
tailrace	Exhaust channel or pipeline to return flow to the tailwater.
tailwater	Exhaust water from turbine.
treh	Total required exhaust head. The amount of back pressure the turbine requires to prevent cavitation. Similiar to npshr in a pump.
taeh	Total available exhaust head. The amount of back pressure available at the site. Similiar to npsha in a pump.
cfs	Cubic feet per second (1 cfs = 448.8 gpm)
wicket gates	Adjustable "diffusers" in conventional radial flow or "Francis" turbines which change the angle of flow into the runner as a function of the capacity to improve efficiency. This design has not yet been applied to reverse running pumps because it is extremely expensive and complicated to operate.
flow duration curve	A plot of flow versus percent of time the flow is achieved. Useful in determining the number of turbines required to match the flow conditions at the site.

Turbine Formulas

Turbine output:

$$KW = \frac{Q \times H \times E}{5310}$$

where Q = turbine capacity, gpm
H = turbine head, feet
E = turbine efficiency

or

$$KW = \frac{Q \times H \times E}{11.83}$$

where Q = turbine capacity, cfs
H = turbine head, feet
E = turbine efficiency

Affinity laws:

$$\frac{N_1}{N_2} = \frac{Q_1}{Q_2} = \sqrt{\frac{H_1}{H_2}}$$

where N = speed
Q = capacity
H = head
1 = speed no. 1
2 = speed no. 2

Runaway Speed:

$$N_R = N\sqrt{H/H_z}$$

where N_R = runaway speed
N = normal speed
H = head at which runaway is calculated
H_z = head at zero torque, (at zero efficiency pt.)

APPENDIX 7

Two Letters from WPS regarding possible pump sites for Mini-Hydro Lift System.

WORTHINGTON

WORTHINGTON PUMPING SYSTEMS LTD.

CANTERBURY HOUSE
SYDENHAM ROAD
CROYDON CR9 3JX
SURREY. U.K.

TELEPHONE: 01-688 7733 TELEX: 24657

16th August 1985

Simon White
Land Resources Development Centre
54 York Street
CAMBRIDGE

Our ref W1349

Dear Mr White

I refer to our telephone conversations when we discussed our letter of 19th July and the alternatives you would like to be considered in order to achieve more economic solutions. Your idea was to look at smaller flow rates of say 25 and 50 l/sec.

While understanding your requirements we have taken a slightly different approach. This is based on the fact that the most economic solution would be to use standard production model pumps. We then looked carefully at these to see if sizes could be selected which would suit your limitations regarding motive water head and pumped water head.

We ascertained that a pump size 150WP-250 when fed with water at 4m head would require a flow of 215 m3/hr (60l/sec) to produce 1.8kw at 725 RPM.

We were then able to match this with a pump size 125WP-315 which at 725RPM when pumping against a differential head of 6m would deliver 85m3/hr (23.6 l/sec) and the power required would match the 1.8kw produced.

The price for one each of the above units, coupled together, mounted on a baseplate and packed and delivered F.O.B U.K port would be:-

£2180.00

I must stress however that theseselections are based on the nominal figures you have provided. While this arrangement is very definitely a practical proposition it is vital that the head available at the unit must be accurately calculated. For example if the head available was incorrect by only ¼ of a metre the discrepancy would amount to 6.25% the power produced would reduce accordingly and the speed would reduce by 2.5%.

At the same time the head required from the pump would increase from 6 to 6.25m which would require a speed increase of 2%. With only this slight change we would move from a good match to one which would not perform.

Cont'd... 2

Directors: J.M. Corker, A. Bocking, L.M. Teasdale, W.F. McBrien (U.S.A.) Secretary B.C. Squires

Registered in England 1420456. V. A. T. Reg. No. 344 6028 66

2

I would suggest that when the operating parameters are accurately assessed we should look at the selections again. It should then be possible to recommend one or more matched sets which would allow for small local variations.

Coming now to the situation of a waterfall with an elevation of 15m we find a much simpler situation because of the higher available head. In this case a size 125WP-225 running at 1500 RPM would take a flow of 225 m3/hr (62.5 l/sec) and produce 6.9kw. Coincidentally we could match this with a 125WP-250 which at 1500 RPM would deliver 225m3/hr (62.5 l/sec) against a differential head of 6m i.e a discharge head of 21m.

In the above situation the pump efficiency is quite low because of the low head required of 6m. We could improve this efficiency by running the pump at a lower speed. However, by the time we take into account the gearing losses and additional cost the small additional capacity would not be worth while.

The cast for a unit as above again packed and delivered F.O.B would be:

£1903.00

Details of the pumps we have offered both as turbines and pumps are given in the attached bulletin No. WS-5213B/8101. We would mention that this is the most extensive standardised range of pumps the world encompassing not only the bearing frame mounted type as illustrated but also Monobloc, Vertical In-Line and centre-line mounted high temperature versions all using standardised parts.

Finally we must apologise for not being able to enclose the Honda information you required. We have however been in touch with Honda and you should be receiving the necessary information direct.

We trust the above will enable you to complete your recommendations but if we can help you further please do not hesitate to contact us.

Yours faithfully
For Worthington Pumping Systems Ltd

A.Crosby
Senior Tendering Engineer

WORTHINGTON

WORTHINGTON PUMPING SYSTEMS LTD.

CANTERBURY HOUSE
SYDENHAM ROAD
CROYDON CR9 3JX
SURREY. U.K.

TELEPHONE: 01-688 7733 TELEX: 24657

Our Ref: W-1349

19th July 1985

Mr Simon White
Land Resources Development
Centre
54 York Street
CAMBRIDGE

Dear Sirs

With reference to our telecom of 17th July we have now had an opportunity of considering your requirements in more detail and have pleasure in giving our recommendations below.

We understand that you require to irregate at a rate of 100 l/sec and that the total head required to lift the water is 10 metres. We further understand that motive water is available from above a dam and the head available from this water is 4 m.

Assuming an overall efficiency of 50% this would mean that 5 volumes of motive water would be required to lift 1 volume of irrigation water. However, as the motive water would have to be piped to the turbine unit it would make sense to consider taking the irrigation water from the same source. With a 5:1 ratio the piping would not have to be much bigger.

This however, further improves the situation in that the irrigation water would already have 4 m of kinetic energy and would only require boosting by a further 6 m. Again assuming a 50% overall efficiency the relative volumes would be 3 of motive water to 1 of irrigation water.

Our recommendation therefore would be to pipe water from the top of the dam using ¾ of this as motive water and boosting the remaining ¼ through a pump driven from the water turbine.

So far as the irrigation pump is concerned this would most likely be a model 10LA-1 operating at 750 RPM to give 100 l/sec boosted from 4 m to 10 m. We have selected this low speed to try and obtain a speed match with the turbine. Because of the low motive head available this would have to be an axial flow design and it is just possible that this also could be selected at 750 RPM. However the parameters are such that we would need to look at exact levels and flow rates to get the best selection. In the worst case the turbine would run at approximately 500 RPM and require a speed increasing gearbox.

/Cont'd ....

Directors: J.M. Corker, A. Bocking, L.M. Teasdale, W.F. McBrien (U.S.A.) Secretary B.C. Squires

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WORTHINGTON PUMPING SYSTEMS LTD.

-2-

The LA type pump is shown on pages 9 and 10 of the attached publication while the axial flow pump to be used as the turbine is shown on pages 21 and 22. Our publication Worthington Hydroturbines may also interest you.

Coming to price we would stress that at this stage this can only be approximate. We would estimate however that a complete unit of hydraulic turbine, pump, coupling and baseplate would be in the region of £29,750.

We trust you will find this interesting and we would very much appreciate the opportunity of looking into this application in more detail.

Yours faithfully

A. CROSBY
Senior Proposals Engineer

APPENDIX 8

List of suggested irrigable areas in Embu district compiled by District Irrigation Officer, February 1985.

District Agricultural Office,
P.O. Box 32,
EMBU.

EBU/MEET/6/Vol.VIII/68

27th February, 1985

The District Agricultural Officer,
P.O. Box 32,
EMBU.

IDENTIFIED IRRIGABLE AREAS IN GACHOKA DIVISION

Various irrigation Projects have been forwarded to the DDC for discussion and funding. Such areas have been suggested by the farmers leaders and Agricultural Staff.

You directed me to investigate the sites to discover how feasible they were. Some of these sites require overhead irrigation method while others, surface flow is suitable.

Initial cost investments for fully sprinkler irrigation is between K.Shs.30,000 to 60,000 per hectare. Surface irrigation which depends very much on the topography of the area commands an initial cost estimate of about 7,000 to 24,000/= per hectare.

Any irrigation project requires high initial capital investment, but the secret in accomplishing them is by constructing in phases. In small scale irrigation units, the main idea is to bring water to the farmers to cover an area of about 50 to 100 ha. (125-250 acres). As such, the DDC could help the farmers best by slicing to them funds capable of developing an area in states.

Using a ceiling cost estimate of K.Shs.10,000/ha., following is a discussion of each site:-

MEKA.

This is the old meka sisal plantation which shoulders river Thiba. It is an area consisting of a flat ground of about 400 ha. in Mavuria Location. The area is irrigable but the stream sides are so steep that a furrow cannot easily be cut to convey water to the fields by gravity.

Feasible method of irrigating is surface but with a pump to elevate water to the field feeder canal. A crop of vegetables and beans could be grown. To irrigate effectively these 400 ha. would require about K.Shs.4 Million. However, such an area is no longer small scale, since total hectarage for small scale irrigation unit should be mostly less than 100 ha.

RIACHINA KIAMBERE:

This area is along river Tana and extends downwards upto Karura Primary School. The area which is very sparsely populated has a topography punctuated by small hills and valleys. Thick bushes cover this area and as such any agricultural operation would require lots of bush clearing and land levelling.

The type of irrigation feasible for this case is sprinklering with a pump placed next to the river bank.

Before Kiambere Dam is complete, no project can possibly be started along this area because Tana River Development Authority (TRDA) boundary line has to be noted so as not to trespass it.

The area size cannot ea easily be determined since few people live here and again some of the land is to be under TRDA.

MWEA MAKIMA

This area borders Masinga Dam. Some part of this site is feasible for gravity fed crop production of vegetables. Furrow irrigation to cover about 70 ha is possible. However, much of the area is only possible for sprinkling irrigation. Initial cost estimate are roughly 700,000/-.

MWEA EXTENSION

This area borders the Mwea Rice fields and extends into Wachoro, Karaba, Gategi and Riakanau Sub-Locations. The approximate area is about 360 ha. and about 5000 farmers live in the area. Surface Irrigation is possible in the Sub-Locations. Excess Water from the rice fields can be ponded in earthdams and later allowed to flow downwards to the fields. Water from the fields is wasted back to Tana River. The capacity of the streams flowing down to theriver is large enough to irrigate the area. All in all, there are many points at which the water can be directed to the fields from these streams.
Total cost to irrigate this area is around K.Shs.3.6 Million. However, the project can be operated in phases of about 50 ha per every DDC funds allocation.
The water to reach this site, would be from Kirinyaga District. Therefore, negotiations between the two District Agricultural offices would be very necessary.

To be contracted also, is the National Irrigation Board (NIB) for the old survey data they had taken of the same Project.

RUPINGAZI IRRIGATION

This one is in Mbeti Location and is feasible for surface irrigation. This is a big project and would require a high initial cost investments. It would however settle many farmers. TRDA has a report concerning this site.

None Governmental funded projects in Gachoka are not many. Förster Parents are aiding Gachuriri Women Group with about K.Shs.250,000/= to irrigate 4 ha. The type of system being overhead irrigation,

FARMERS PARTICIPATION AND ORGANISATION

In crop production in a irrigation scheme, individual farmers must note that they have to share the same irrigation facilities with others; irrigation crop production is a group affair based on group discipline.
Farmers should feel that the sheme is trully theirs by being involved in all planing and construction activities. Being the scheme beneficiaries farmers are the sole patrons and freely, they should offer mannual labour in the time of construction, and latter maintain the system.

(G.M. Mbugu)
IRRIGATION OFFICER, EMBU.

c.c. District Officer, Gachoka. The D.A.E.O., Gachoka.
P.I.O., EMBU. DDC. File.