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Liberia

Evaluation of the Yandohun micro-hydro project

NRECA Small Decentralized Hydropower (SDH) Program

Liberia: Evaluation of the Yandohun micro-hydro project

by Allen Inversin and Walter Lawrence

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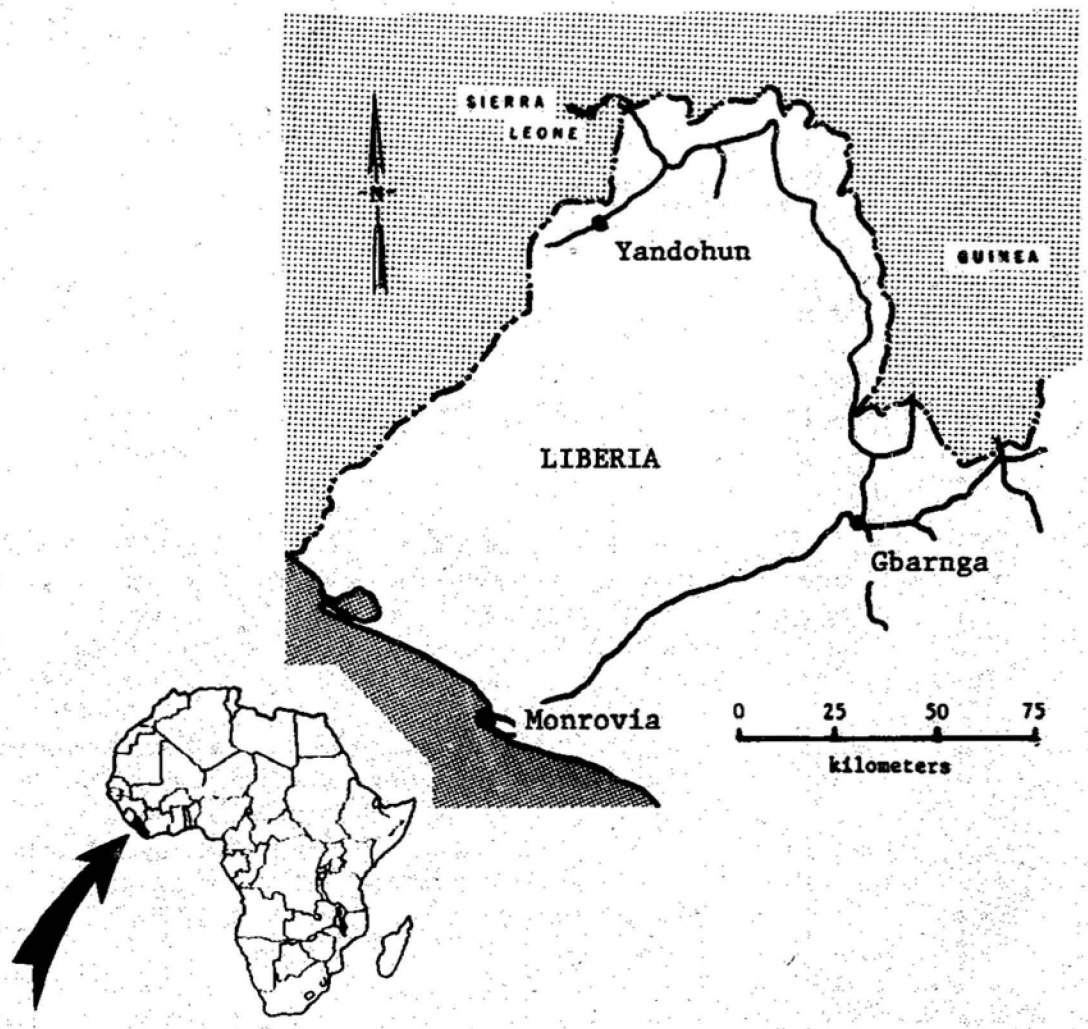
The possibility of undertaking a micro-hydro project near the village of Yandohun, Lofa County, Liberia, was first recognized by Peace Corps volunteer Gary Duncan in 1978 and the initial activity proposal was submitted in June 1979. Over the subsequent months, numerous questions of a technical, social, and economic nature were raised by David French (USAID AFR/DR/SDP), Gene Ellis (USAID), and others. Although the project review committee meeting in Washington in November 1979 was unable to approve the activity paper as presented, a slightly redrawn paper was approved by the committee in February of the following year. Work on the site and ordering of the turbogenerating equipment followed, but later in the year, questions concerning technical aspects of the project were raised.

Through its Cooperative Agreement with USAID ST/EY, NRECA was asked to send a team to address these questions. As a result of that request, a team comprised of Allen Inversin, Micro-Hydro Engineer with NRECA, and Walter Lawrence, consultant with NRECA, visited Liberia during the period February 17-26, 1982.

During the initial portion of the visit, discussions were held with Fred Hagel, ID, and Larry Donnelly, ENGR, of USAID/Monrovia. Mike Smith, Peace Corps volunteer, and Charles Martin, Director of Peace Corps/Liberia, Lionel Keller, Head of the Planning and Engineering Services Department of the Liberia Electricity Corporation (LEC), and Ian Yhap, Load Study Engineer, also with that department. Time was also spent reviewing the files dealing with the Yandohun micro-hydro project at USAID/Monrovia. No visit was made to the Ministry of Local Government, the Government of Liberia signatory to the memorandum of understanding for the project, since that ministry was being reorganized and it was still uncertain who, on the side of the Government of Liberia, would be responsible for this project. Because no cable announcing our arrival was received from USAID/W, the team was not able to arrange for a visit to the actual site until near the end of its stay. February 23-25, in the company of Larry Donnelly, the team visited the Yandohun micro-hydro site, accompanied by Mike Smith and Gary Duncan, who is still living in Yandohun. The team also had the opportunity to meet with Ron Drnjevic, a more recently arrived Peace Corps volunteer who eventually will take over from Mike Smith. Because of the delayed visit to the site, the team only had time to leave a brief draft summary of conclusions and recommendations with USAID/Monrovia.

If this project is to continue, there are a number of technical points that will have to be resolved. However, because of the team's desire to address the primary questions posed by USAID/ Monrovia with the minimum delay, we have generally not attempted to address at this time those technical points in detail.

Figure 1 Location of Yandohun



Should the decision be made to continue with the project, NRECA can provide the necessary assistance upon approval from ST/EY. William Kitching of Small Hydroelectric Systems and Equipment (SHSE), who supplied the turbogenerating and control equipment and PVC pipe for the project, has indicated that he does not see his work completed until the system is on-line and his client satisfied. Assistance both from him and from NRECA can be coordinated through NRECA.

* In reviewing the scope of the Yandohun micro-hydro project, it is apparent that the project is only in its initial stage. But it is also apparent that commitments have been made, commitments on which it would be difficult to renege. If USAID/Monrovia and the Peace Corps, after being made aware of the magnitude of the work that remains and of the funds which have yet to be found, are still committed to the completion of this project, every effort must be made to ensure that any expertise required to complement that existing in-country be provided and that important issues be resolved as they arise and not be delayed.

* On the order of $25,000 has been set aside in the revised budget for electrical components for the distribution to, and within, Yandohun and Dungalahun. Their actual cost is estimated to be near $50,000, exclusive of labor. Consequently, assuming that the recommendations for the distribution system made in this report are adopted, approximately an additional $25,000 in funds will have to be found. The costs for additional pipe and bends required for the penstock, as well as tools, timber and sheet steel for the flume, etc. can probably be covered by the existing balance.

* Because the productivity of the villagers implementing the scheme is unknown and variable, it is difficult to give any accurate idea of the magnitude of the work which remains. Given other demands on the villagers' time, it may well take another year before the civil works and installation of the powerplant are completed. An awareness that a significant amount of work remains to be done is essential because, throughout the duration of this project, continued inputs from the Peace Corps and USAID will be necessary.

* A proper survey needs to be undertaken as soon as possible. This survey is to be used (1) to determine the actual placement of the power canal and forebay before excavation can be undertaken and (2) to determine the profile of the penstock to be able to determine and order the necessary bends and possibly additional lengths of PVC pipe.

* It is frequently less frustrating (and possibly more effective on the short term) to undertake a project independently. However, given LEC's responsibilities for the generation, transmission, and distribution of electrical power in Liberia and their avowed interest in small hydropower undertakings, it is essential that they be more actively involved in the project. Their participation in various aspects of the project should not be assumed as seems to have been the case at times in the past.

* Beyond addressing the immediate questions posed by USAID, this report includes a cursory look at the technical aspects which will have to be covered in greater detail as work at the site proceeds. Because of the extent of further technical inputs which will be required, if NRECA is to provide assistance on an as-needed basis, it is necessary that such a role be formalized through ST/EY.

In the course of implementing the Yandohun micro-hydro project, questions arose concerning (1) the technical adequacy of the designs adopted and equipment purchased and (2) the apparent necessity for substantially increased additional funding. Both the USAID Mission in Monrovia as well as USAID/W were increasingly concerned about whether the project was technically sound and whether additional funding of the project was warranted. This concern was accentuated by a lack of necessary expertise to gauge the validity of the technical criticisms being leveled against the project.

Under its Cooperative Agreement with USAID ST/EY, NRECA, through its Small Decentralized Hydropower(SDH) Program, was asked to provide a team to look into the technical adequacy of the designs adopted, to define the extent of work yet required to complete the project, to estimate additional costs that would be involved, and to recommend a course of action.

This section includes mostly qualitative descriptions of the work done to date and that which is yet to be undertaken, conclusions drawn to date, and recommendations. As mentioned in the introduction to this report, more quantitative design details and procedures will follow in due course.

At the site of the Yandohun micro-hydro project, land has been cleared for the dam, reservoir, powerhouse, and along the alignment of the power canal and penstock; work on the dam has begun; the construction of roads for access to the major components of the scheme is well advanced; and the turbogenerating equipment has been delivered to the site. The last sections of penstock pipe were being transported to the site. On the budgetary front, approximately half of USAID's present commitment ($70,000) has been obligated (Table 1). Although an impressive start has been made on the project, much work remains to be done and additional funding will be needed to complete the project. The villagers seem committed to completing the project and have made contributions in terms of both labor and financing. The Peace Corps and USAID/Monrovia also seem committed to completing of the project and feel that termination at this point would seriously affect their credibility. Since no compelling arguments have been advanced for terminating of the project, this appears to be an unrealistic option.

If, after realizing the scale of work which remains to be done, USAID and the Peace Corps feel that they are still committed to completing this project, every effort should be made to ensure that subsequent work is

An improvised A-frame support used by the villagers to lift the turbogenerating package off the truck.

* Especially since this is a prototype project, there is a need to fulfill commitments made in the activity paper concerning a thorough and well-planned evaluation of the method of implementation of this project and its impact on the rural communities involved.

* Calculations indicate that the dam should be safe from failure from either sliding or overturning. However, though this might change at some later date, there is at this time no way of justifying the construction of a dam. It is recommended that the base of the dam be built up so that it serves as a weir and not for storage as originally envisioned. This will permit a chance to determine the suitability of a dam at the site and permit at the same time minimum delay until power is available to the villagers. The dam could be completed at some later date if this is then deemed advisable.

* With the possible exception of a generator main breaker, the control and protection functions of the powerplant itself are provided for. Protection of the primary distribution (2.4 kV or 7.2 kV) lines was not provided for initially but is included in relevant alternative distribution schemes.

* Alternative C (7.2/12.5 kV wood pole line to the village) appears to be the lower cost alternative. LEC uses this REA-type standard and could employ local labor to clear jungle, dig holes, and set poles. Skilled labor would be necessary for transformer and line termination, stringing, tie wiring, and such. On the basis of a rough cost estimate, $50,000 should be allowed.

* General recommendations for specific design aspects of the civil works can be found in the appropriate sections in the chapter, "Present status and future directions."

* If one is concerned with future projects which have a chance of being reproduced, a more honest attempt should be made to address critics of these projects from the outset and incorporate revisions in the project. In the case of Yandohun, the die has been cast and one has to make the best of the given situation, even though this project may not be as appropriate as it might have been.

properly planned and executed. The Peace Corps should realize the technical nature of such an undertaking and provide its volunteers with the necessary technical back-up. This fact is even truer in the development of a prototype project where new problems are encountered for the first time. Such a project may well encourage or discourage other similar undertakings in Liberia or outside, irrespective of the true merits of the technology. Exposing its volunteers to "appropriate technology training" at Fallones Institute should not be viewed as adequate preparation for the task at hand. The Peace Corps volunteers who have been, or are now, involved with this project seem dedicated to the project. The team recommends that these volunteers must be provided with whatever expertise is necessary to complement that which they already possess.

If the Peace Corps is to have substantial responsibility for implementating a number of such projects in the future, specific and specialized training on small hydro projects must be undertaken. Separation of projects into reconnaisance and construction phases with different volunteers trained for each phase would enable the volunteers to acquire the necessary skills for each phase and still comply with their normal two year tours.

Table 1
Budget for the Yandohun Micro-Hydro Project

	Revised Budget 2/19/81	Obligated* 2/18/82	Balance 2/18/82
USAID contributions			
Turbo-generation package and penstock	US $32,500	27,905.00	4,595.00
Shipping and insurance	9,000	1,931.03	7,068.97
Transformers and electrical distribution equipment	7,000		7,000.00
Shipping and insurance	2,000		2,000.00
Cement	5,600	2,270.20	3,329.80
Socio-economic survey	4,000		4,000.00
Training	3,000		3,000.00
Hand tools	1,000	693.61	306.39
Steel reinforcing	1,000		1,000.00
Miscellaneous	1,000	1,000.00	
Contingency and inflation	3,900	89.00	3,811.00
Sub-Total	US $70,000	33,888.84	36,111.16
Community contributions			
Chain saw	US $1,000	1,000.00	
Hand tools	1,000	1,000.00	
Gas and oil for saw	23		23.00
Chain saw operator	100		100.00
Concrete culverts	263	263.00	
Transportation (materials and labor)	650	650.00	
Rice mill	3,000		3,000.00
Coffee mill	2,000		2,000.00
Local labor	3,999	1,000.00	2,999.00
Local indigenous materials			
Wood for forms	3,000		3,000.00
Sand and rock	2,000	472.28	1,527.72
Sub-Total	US $17,035	4,385.28	12,649.72
Gov't of Liberia contributions			
Technical assistance	US $1,000		1,000.00
Ministry vehicle and support	4,000	1,834.15	2,165.85
Cable	15,000		15,000.00
Sub-Total	US $20,000	1,834.15	18,165.85
TOTAL	US $107,035	40,108.27	66,926.73

* as per records kept by Mike Smith, Peace Corps volunteer, Yandohun, Liberia

Civil aspects

Dam. To date, a large area around the dam and proposed reservoir has been cleared of trees and brush, and areas at each end of the proposed dam have been excavated into the banks. At present, the base of the dam rises an average of one to two feet above the bedrock foundation. The spillway portion, totaling 107 feet long, ultimately could be built to a height of approximately seven feet with the portions near the abutments rising an additional five feet from a wider base if the decision is made to provide regulating storage.

Composite view of dam site and right bank.

In the letter of September 21, 1981, from Harry T. Yuan, Managing Director of LEC, to USAID/Monrovia (see Appendix), concern about inadequate anchoring of the dam was expressed. In placing concrete on the bedrock foundation, care to properly clean the bedrock was exercised before laying the first layer of concrete and a good bond should have resulted. Calculations (including those found in the LEC report "The Yandohun/Dungalahun Mini Hydro Project - A Visit Report") indicate that the dam would be secure against failure by either sliding or overturning.

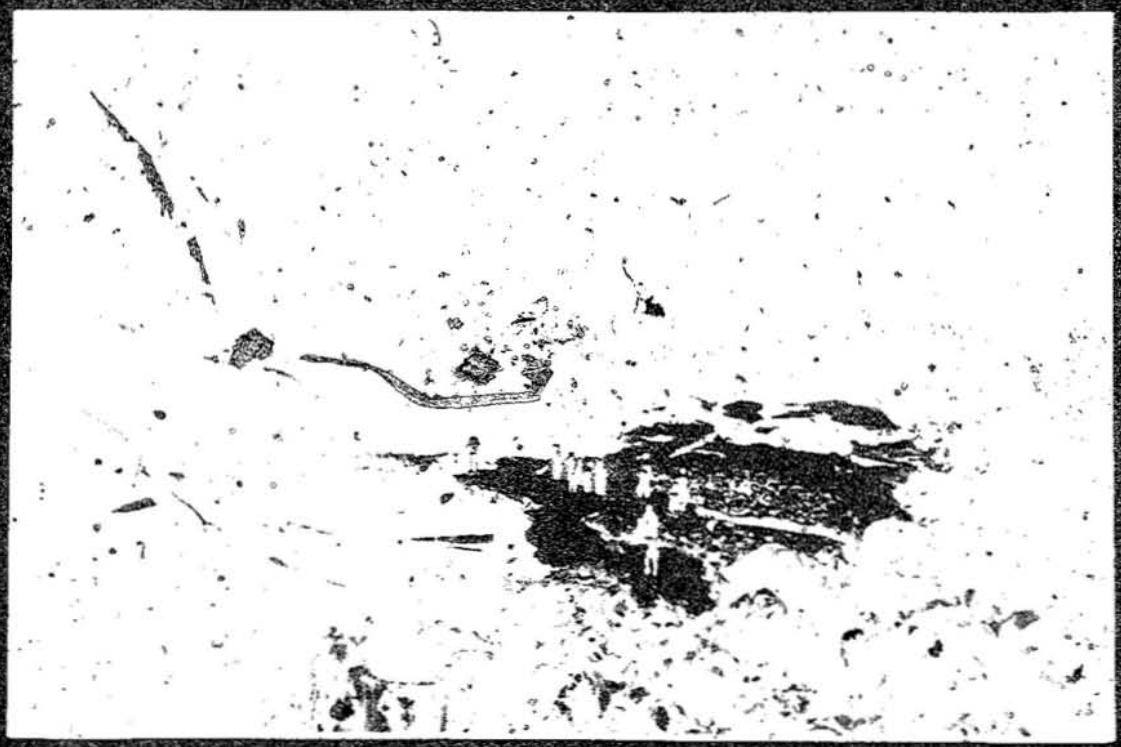
For a variety of reasons, an attempt is usually made to avoid incorporating dams in micro-hydro schemes unless they are essential. One should not assume (as was done in one of the engineering studies for Yandohun) that, since the flows may go below the "required" 200 cfm, a dam "is therefore justified." As was correctly noted in the IRT activity proposal, another alternative is to run the turbine at a lower flow and power output. Because of the substantially increased input of materials, financing, expertise, and labor in the design and construction of a dam, a final decision on the need for a dam requires a knowledge of both power requirements and flow duration data. In the case of Yandohun, the former would be largely

conjecture and the latter is not available. One is, therefore, really not in a position to make a case for a dam.

In the case of Yandohun, there seem to be several other reasons for not including a dam. One is that, at least in one bank, there is no firm rock against which the dam might abut. In addition, the presence of water flowing through the soil/rock bank behind the proposed abutment implies that piping around the dam may occur and eventually cause erosion around the dam, thereby rendering it useless. In addition, dams, especially in tropical areas, are susceptible to rapid silting and the storage capacity for which they were designed is then rendered increasingly useless. Silt bypasses or scouring gates merely permit sediment in the immediate vicinity of the gate (where the velocities of the water would be the highest) to be removed. Removal of the remainder of the silt, boulders, and accumulated debris could be a recurring, time-consuming and labor-intensive task.

Finally, in the case of Yandohun, based on the projected design, 10-20% of the volume of the dam has been completed. The process is laborious, involving hand mixing of the concrete, hand transport of the materials, and fracture of the rock for aggregate as well as for stones to be inserted into the mass of the dam using fire and hammers. Completing the dam would therefore still require considerable time.

Rather than completing the entire dam as envisioned, it is recommended that, at least initially, a weir be constructed rather than a dam. To most effectively do this, the spillway portion of the dam should be built only to a



View of the dam site and left bank where piping around the proposed dam abutment might be encountered.

height of about two feet, sufficient for it to act as a weir and to divert water through the intake. The abutments should be raised sufficiently to prevent flood flows from eroding the abutments. The intake and settling area should also be protected from flood flows. In this manner, full power could still be generated for at least 85% of the year when flows are claimed to exceed 180 cfm and half power for probably another 5-10% of the year when flows fall between 90 and 180 cfm. In its present configuration, the turbine cannot make use of flows below 90 cfm (though this can be changed, see discussion on p. 19). Initially replacing the dam with a weir permits:

(1) the shortest delay until the plant is on-line (and the villagers see the fruits of their labor);
(2) a chance to determine the presence of any piping around the abutments; and,
(3) a chance to record actual low flows and the extent of sediment deposition behind the weir to determine the advisability of increasing the height of the dam.

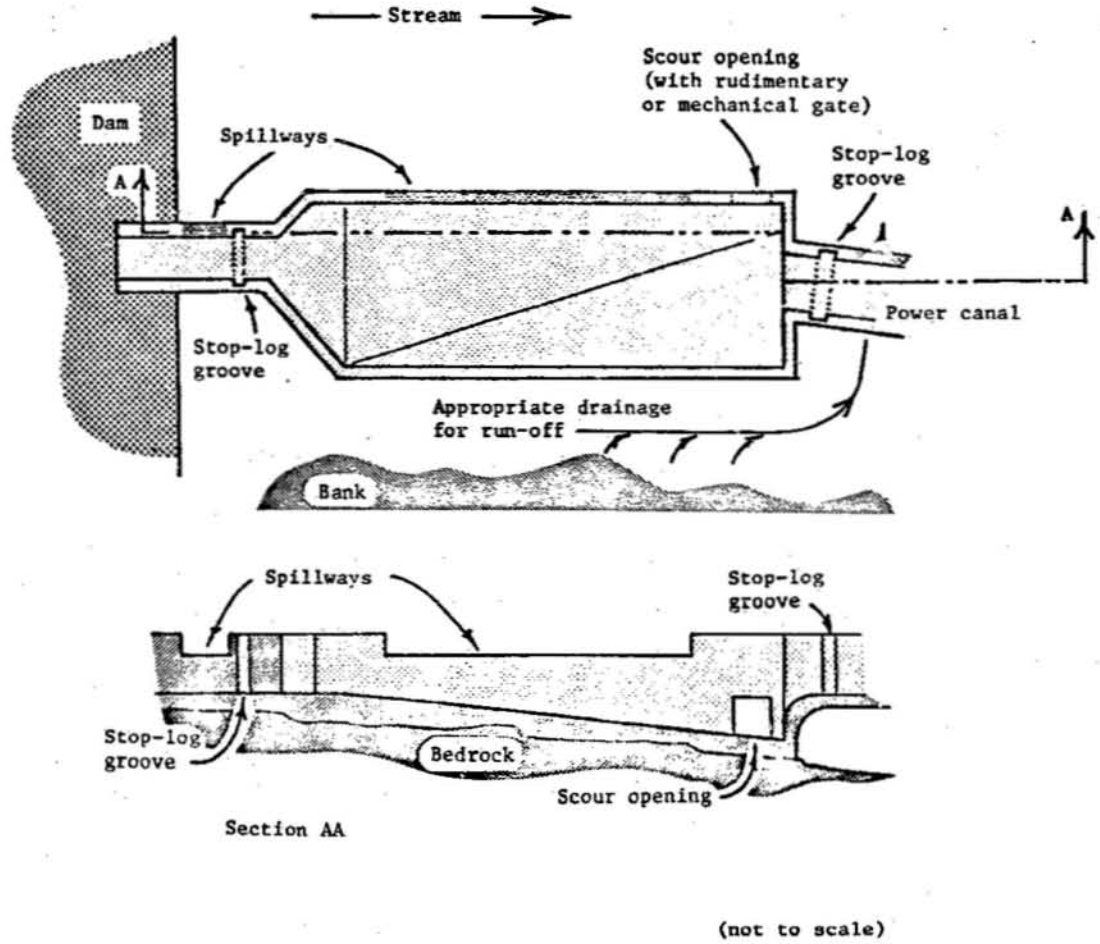
It is recommended that more thought be given to the design of the intake structure in the dam which leads water to the settling area just downstream of the dam. Any gates to control flow are generally incorporated on the upstream side of the dam, not downstream as indicated in some of the preliminary drawings and reports. This permits water pressure to more effectively seal the opening and allows free access to the entire length of the intake for any repair and maintenance work. Though the height of the intake opening is set as three feet, it must be noted that, for the flows required, the actual gate opening there will never even approach this value. The principal advantage of the large intake indicated is that the possibility of debris lodging itself in this portion is thereby non-existent. On the other hand, if the dam is constructed as envisioned, operating the gate would require an inordinately large force when the reservoir is full since the water pressure would act virtually on the whole area of the gate (about nine square feet). An opening of reduced size might, therefore, be considered. Constrictions and bends along the "silt bypass" should be avoided to maximize the velocity of the water and to facilitate the removal of any debris or boulders which might become lodged in this bypass. Though a larger cross-sectional area for the silt bypass might have been advisable, since it has already been incorporated in the dam, this is no longer a real possibility.

Settling area. To date, construction of the civil works has not proceeded beyond the base for the dam. There is, however, adequate space on the sloping bedrock forming the bed of the Yando Creek at this point to include a settling area.

A settling area serves to remove any sediment that might otherwise settle in the power canal as the water is led to the forebay, sediment which would eventually render the canal ineffective until its entire length is cleaned out by hand. A settling area can only be omitted if either (1) the water carries no sediment year-round or (2) labor is available to clean out the power

Figure 2

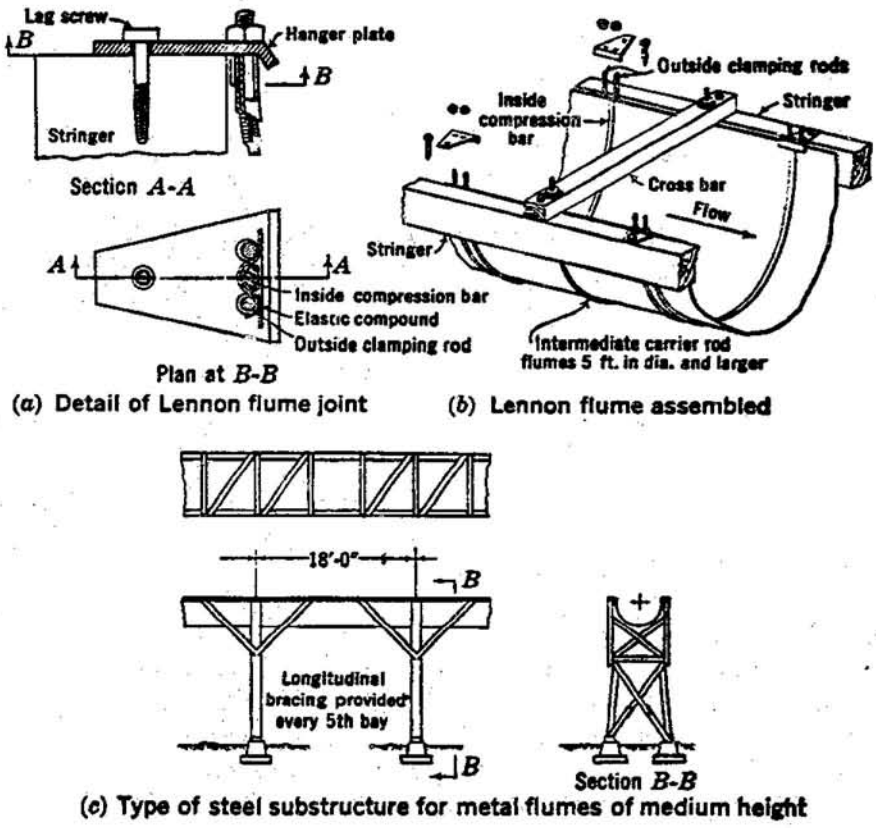
Drawing of a settling area showing the major components which should be included in its design



canal whenever necessary. In the case of the Yandohun site, the terrain can easily accomodate a settling area at the intake to the power canal. Though a "flume for sedimentation" was called for in the "Preliminary Engineering Analysis" (Fritz, 1980), it is recommended that this settling area be properly designed and include the components noted in Figure 2.

The dimensions of a settling area are established so that sufficient time is allowed for all sediment above a certain size to settle out of the flowing water. The cross-sectional area of a settling area is greater than that of the power canal to reduce the velocity of the flowing water. Though a settling area of nearly any shape is possible, it should be designed to facilitate flushing of the sediment. Its size is determined by the silt load in the water and the magnitude of the flow passing through this area. A settling area with small surface area would require more frequent cleaning out. A spillway must be incorporated in the wall of the settling area on the side of the river. This permits excess water, which might enter the settling

Figure 3
An example of a flume constructed of sheet steel

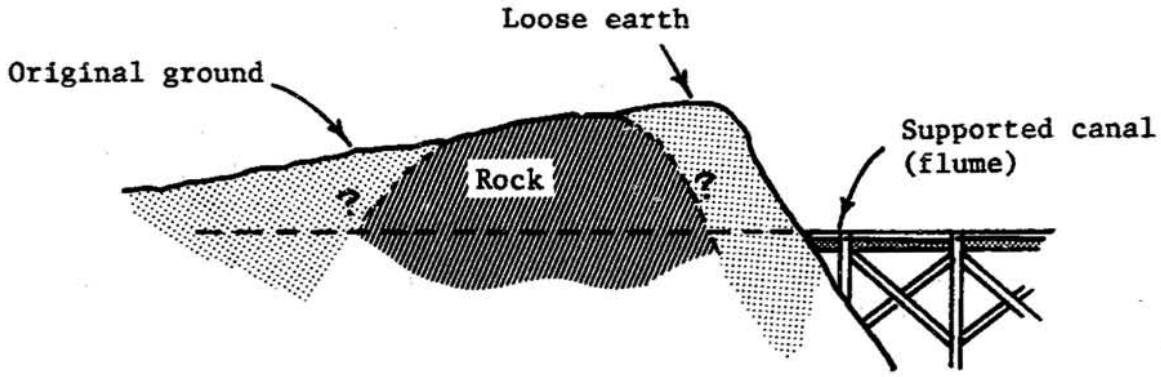


(Armco Drainage and Metal Products, *Handbook of Water Control*, 1946.)

area to be returned to the river and not diverted down the power canal. Excess water in the power canal might cause erosion along the canal or at the forebay.

Power canal. The function of the power canal is to convey water at the proper rate from the intake area on the stream to the forebay at the intake of the penstock. This canal may be open or closed and be constructed below or at ground level or supported above the ground. An open canal is generally preferred since it permits easy removal of sediment or other debris which might settle along its length. It may be made of earth or of a number of materials, including wood, concrete, and sheet metal, depending on the porosity of the soil, the nature of the terrain, and the availability of materials for its construction. Its dimensions, profile, and slope are determined by both the layout of the terrain it traverses, the flow to be accomodated, and economic factors. In designing the power canal, it must be kept in mind that, according to Mike Smith, eventually two 30 kW units might be installed in the powerhouse, requiring twice the flow initially envisioned.

Figure 4
Portion of the power canal requiring excavation



At Yandohun, the power canal would include two distinct portions, a flume suspended above the ground and a canal excavated in the earth and rock. Each portion is on the order of 200 feet long.

A variety of materials might be used to construct a flume. Two possibilities for the Yandohun site are wood or sheet metal. Whereas timber and chain saw attachments to cut planks are available locally, timber flumes are substantially heavier and require more labor inputs than sheet metal flumes. Without treatment they may require more frequent replacement.

Because of its relative ease of construction, it is recommended that a straight flume, using sheet metal to convey the water, be considered for the first section of the power canal. An illustration of a sheet metal flume in Figure 3 is included to give an idea of the construction that might be involved. These are designs used for flumes of larger dimensions than would be needed at Yandohun and therefore the actual dimensions and design adopted will differ from these.

To facilitate construction, a linear alignment from the settling area to the beginning of the excavated portion of the canal would be advisable and could be accomodated at the site. Adequate footings would be required on the steep slope.

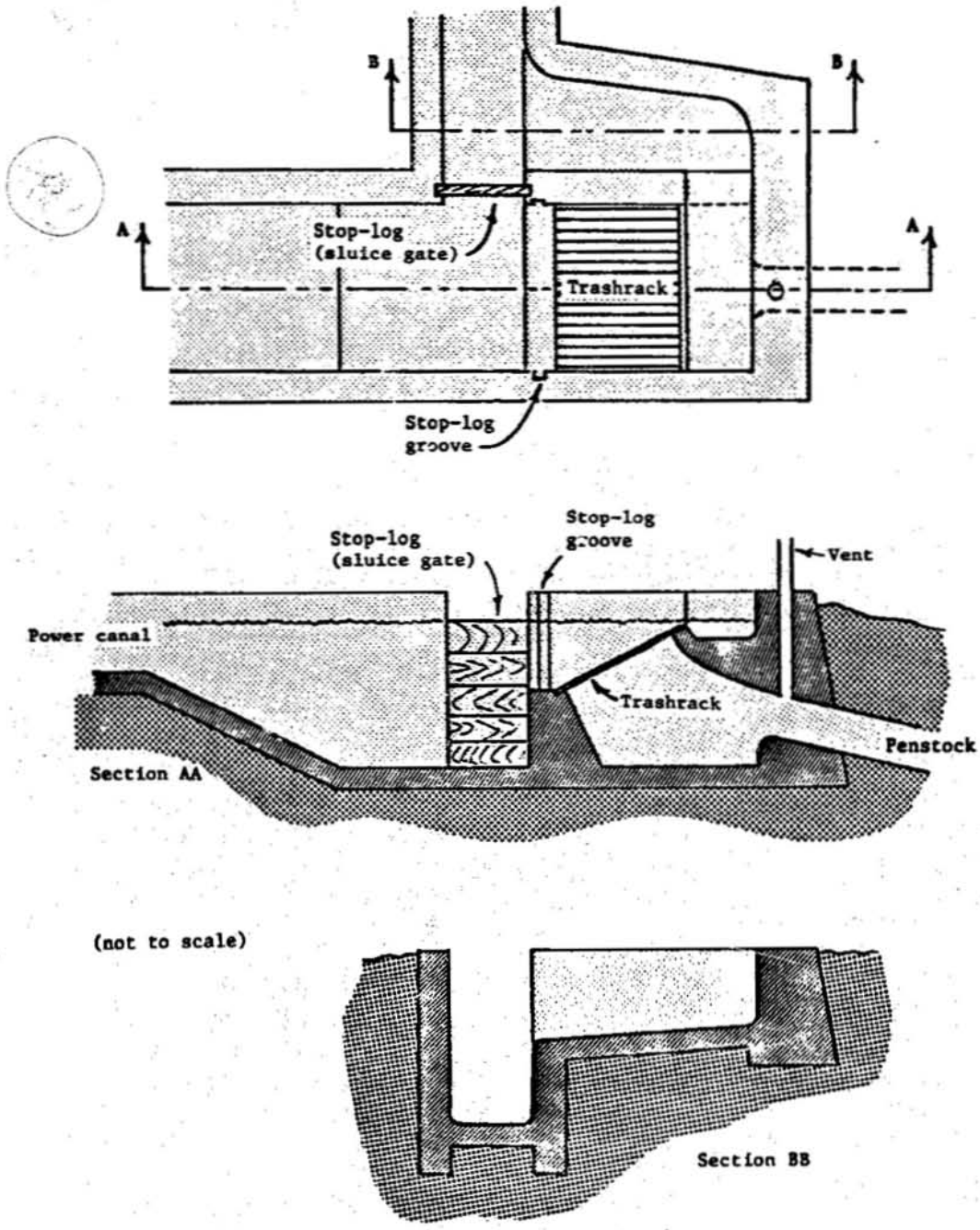
Given the nature of the soil at the site, the excavated portion of the canal need not be lined. Though a rough cut has already been made by a Caterpillar tractor along the alignment of the proposed power canal, the high point of this cut is still, according to Mike Smith, about 8 feet above the elevation of the proposed canal. At least a portion of this excavation is in rock which, though the rock is relatively soft, will be more time consuming than if done in earth. However, being of rock, the walls of the canal can essentially be vertical, thereby reducing the volume which has to be removed.

Before any further excavation, it is recommended that a survey of the final alignment of the power canal be undertaken to ensure that the canal is excavated in original earth rather than in backfill. In addition, as construction is undertaken, the various components described below should be included. Drainage canals on either side of the power canal should be included to remove any run-off during periods of rain and prevent soil and other debris from washing into the power canal. Depending on the actual design parameters, it might be necessary to include proper spillways along the canal to prevent overflowing of the canal either during times of unusually large flows or during times when the flow in the canal has been unexpectedly blocked and the water will back up in the canal. Water flowing over the spillways should be carefully led away from the canal so that no erosion can occur.

Forebay. Though any description of the forebay ("collection box") was omitted in the "Preliminary Engineering Analysis" and subsequent reports, it is recommended that a forebay, built with the components described in Figure 5, be incorporated to serve primarily as a secondary settling area. Because the nozzles incorporated in the turbine design are of fixed area, the function of the forebay at this site need not serve as storage to make up for transients occuring during times of increasing or decreasing penstock flows. It need be sized only to accept the anticipated sediment and to submerge the intake to the penstock sufficiently to avoid vortex formation and the entrainment of air into the penstock. Also to be incorporated with the forebay structure is a sluice gate to permit emptying out of the forebay to clean out accumulated sediment. It is also advisable to include a spillway as part of the forebay so that, in the event of unusually high canal flows, this water can be safely removed from the forebay. A waterway to convey the water from the spillway and sluice gate must be properly situated and constructed to avoid potential erosion which this water might cause and which might undermine the penstock, powerhouse, or forebay itself.

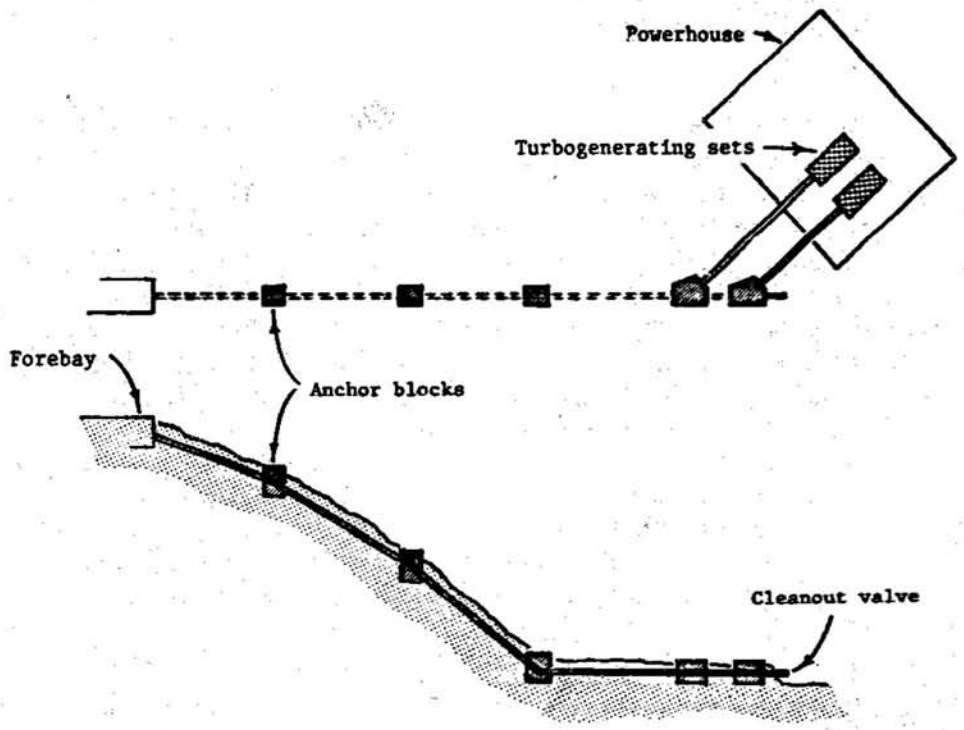
Penstock. The penstock route has been cleared partially and the major portion of the pipe is at the site. The PVC pipe tolerates only a slight curvature and even this requires considerable force to accomplish. Consequently, depending on the actual profile of the proposed penstock, the actual penstock will essentially be formed of several straight portions joined by appropriate steel bends. These latter can be supplied to order through the supplier of the turbogenerating equipment, Small Hydroelectric Systems and Equipment (SHSE), after specifications have been obtained. There is also a need for a transition piece between the 12-inch PVC pipe and the 8-inch flanged intake to the turbine. It is apparent that only sufficient pipe was ordered to cover the penstock length as originally envisioned. Depending on the actual profile, lengths of pipe may have to be cut and several additional lengths may have to be ordered along with the bends. An adequate supply of the lubricant for the assembly of the pipe also needs to be purchased. Approximate additional costs which would be incurred would be $700 dollars for the envisioned three bends (indicated in a drawing in the "Preliminary Engineering Analysis," one wye, and one adapter and $250 for each additional length of 12-inch PVC pipe.

Figure 5
An example of a forebay design, in common use for small hydropower plants, illustrating the basic components which should be included



A proper survey of the penstock routing should be undertaken. During this survey, an attempt should also be made to determine the depth of any bedrock below ground level along the proposed route of the penstock. A survey is needed to determine the magnitude of the bends necessary for the penstock as well as to determine the number of additional lengths of pipe

Figure 6
A possible layout for the turbogenerating equipment



which may have to be ordered. Later, the data obtained in the survey will be necessary to determine the size of the anchors to be used at the bends. Because of the delays which are incurred in ordering and shipping, it is recommended that this survey be undertaken as soon as possible so that the process can be initiated. Furthermore, in designing the penstock, the following components should be considered.

A vent pipe, just below the intake to the penstock, is often included to prevent collapse of the pipe should the intake be fully blocked during its operation. Since tapping the pipe would require special tools, another means should be incorporated in the forebay design to accomplish this end.

At each bend, the penstock must be appropriately secured by means of reinforced concrete anchors. These anchors secure the penstock against the forces due to both the weight of the filled penstock and the thrust due to changes in the direction of the flow.

The excavation of the penstock trench by hand will be a major task, even if no rock is encountered. Though the excavated volume is a function of the actual profile of the penstock route, it would be of the order of 200 cubic yards. The subsequent tasks of laying and properly embedding the pipe, preparing anchors, and backfilling will also require a sizable input of labor, time, and technical supervision.

As far as making provision for a second turbine in the future, Kitching of SHSE suggests the configuration shown in the sketch in Figure 6. The penstock which has been purchased can provide sufficient flow for two 30 kW turbines with negligible additional head loss.

Powerhouse. The powerhouse can be a simple structure built of mud-bricks plastered over with concrete, as is common practice in Liberia. The only component which is essential is a firm foundation of properly reinforced concrete. The powerhouse need be no larger than to provide sufficient room to house the turbogenerating machinery and associated control equipment with adequate access to all sides of this machinery to facilitate any repair and maintenance. It can, on the other hand, contain a workshop and office and be constructed of rigid pillars to support an I-beam from which the turbogenerating equipment could be supported during installation or major repairs. Given the equipment purchased for this project, this beam is really not necessary after installation of the equipment. Either the frame supporting all the equipment should be placed in the powerhouse before the walls have been put up or else a door of sufficient width should be incorporated in this structure. Because of the weight of the equipment, the floor of the powerhouse has to be sufficiently strong, with proper footings when built over a filled-in area as is envisioned. The spent water from the turbine is discharged from under the turbine and a water-tight tailrace must be constructed to prevent this water from eroding the powerhouse foundation.

It has been noted by the Peace Corps volunteers working on the project that the micro-hydro scheme is to be designed so that a second turbogenerating set might be included in the powerhouse at some future date. By proper design, additional costs, beyond those of the turbogenerating equipment itself, could be insignificant. However, if a second generating set is installed, it is envisioned that most power would continue to go to Yandohun, the larger of the two villages and the only one with road access. Therefore, some means of synchronizing the two turbogenerating sets will be necessary in order that the power generated by each set can be transmitted over the same lines. This would involve additional costs and complexity. Another option would be to use only the original turbogenerating set for the generation of electricity and the second turbine for direct mechanical drive of agro-processing equipment, saws, etc., in a powerhouse/village industries workshop if sufficient space is available at the powerhouse site. The actual layout of the powerhouse will depend on the final configuration which is decided upon.

Mechanical aspects

Because the turbogenerating equipment purchased for the Yandohun site has been assembled on a common frame, installation of the equipment is facilitated. The only task requiring some care is the final placement of the frame vis-a-vis the lower end of the penstock to insure alignment of the axis of the penstock with that of the intake to the turbine pipework. Generally, mounting holes are left in the foundation at the approximate

locations of the anchor bolts. The frame is then temporarily supported and carefully aligned, shimmed if necessary, and then grout is poured under the frame and around the anchor bolts in the mounting holes. Complete instructions will be furnished by SHSE.

When the installation has been completed, the proper procedure for commissioning the plant must be followed. The distribution system need not be completed to undertake this test. Though commissioning is usually undertaken by an experienced individual, this might be avoided depending upon the complexity of the system and the qualifications of those present. If everything with the electronics portion of the equipment is in working order, getting the plant on-line should not be difficult. Further details can be provided in due course.

It will be necessary to establish a maintenance schedule based on the operational experience of SHSE with their equipment. This will involve checking and replacing the belts and bearings and adding grease when necessary. Tools to undertake the necessary repair and maintenance work should be purchased and kept in order in the powerhouse. A supply of some items such as grease and belts should be kept on hand.

Though Pelton turbines can make efficient use of flows much smaller than their design flow, this is only the case with nozzles of adjustable area. This is usually performed through the use of a spear valve. With the equipment purchased for Yandohun, the nozzles are fixed. Since two nozzles of equal size are included with this unit, it is possible to make use of either both nozzles (using about 180 cfm) or one nozzle (using about 90 cfm). With the nozzles furnished, it is not possible to make use of flows less than 90 cfm (which may occur during 5-10% of the year). However, when a better idea is gained of the actual flows in the Yando Creek, the existing nozzles could be replaced during the dry season by nozzles of smaller jet area. According to SHSE, the nozzles are threaded and can simply be screwed into place.

Electrical aspects

Specifications for the turbogenerating equipment issued by the General Services Administration in accordance with Federal procurement requirements were rather broad. They are as follows:

"1. Horizontal shaft 2-jet Pelton type turbine suitable for operation with 210 foot head and 150 cfm flow.
   * steel shaft suitable to drive 35 kVA generator
   * stainless steel buckets
   * gear operated butterfly valve at intake
   * butterfly valve for each jet
   * 8" flanged intake"

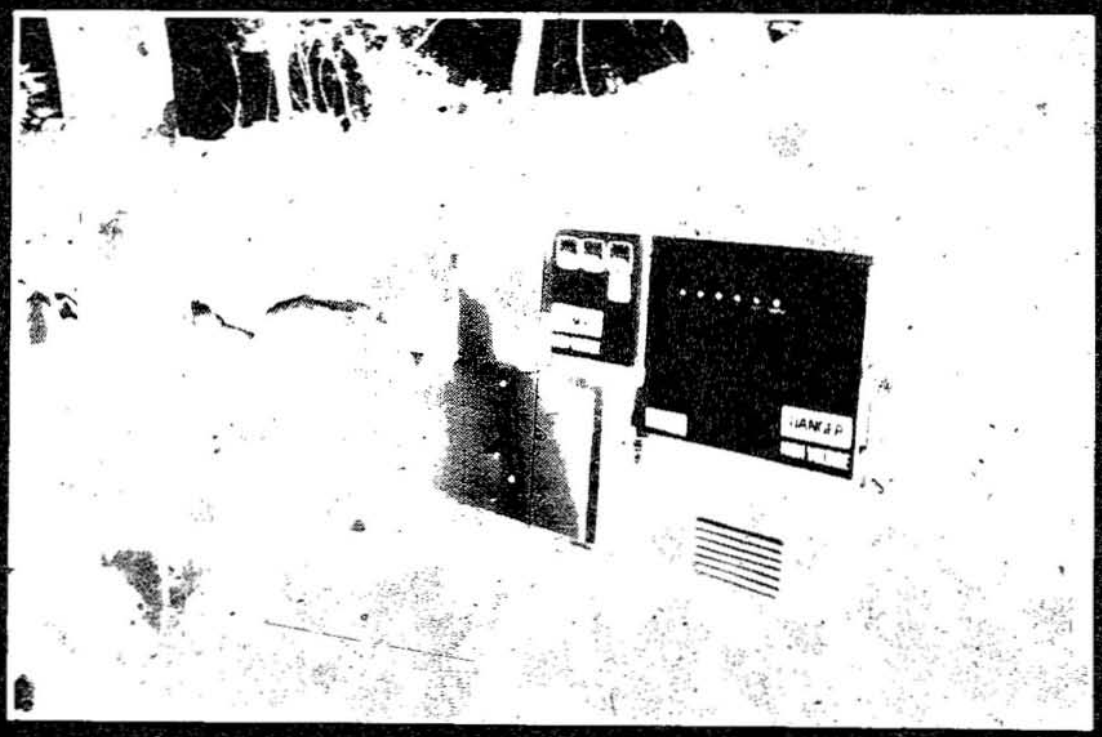
"2. Brushless synchronous generator, 35 kVA, 30 kW, 220 volts ac, 60 cycle
   * voltage regulator
   * ac instrument panel mounted and wired with voltage, current and Hertz meters with switches to read each phase"

"3. Three phase electronic load controller to include:
* overspeed protection
* ballast heaters capable of absorbing the full generator output with appropriate fittings for sealed installation in penstock or tailrace"

"The above three items are to be mounted on a steel skid suitable for installation on a 4" concrete slab. The items are to be pretested and packed and crated suitably for ocean shipping. Complete instruction manuals for installation, start-up and maintenance are to be provided."

The order also includes 620 feet of 12-inch, 200 psi PVC pipes with mechanical joints and two tees.

The turbogenerator assembly was placed in temporary storage at the Yandohun micro-hydro site in early February 1982. On 24 February, Messrs. Inversin and Lawrence of NRECA with Mike Smith and Gary Duncan, present and former Peace Corps volunteers respectively, inspected the turbogenerating equipment and load controller assembly and found it in apparent good condition. Photographs were taken and all the instruction manuals were removed and taken to Monrovia. Copies were made for NRECA use and extra copies plus originals were given to Mike Smith.



A view of the turbine housing and control panel.

On the basis of the purchase order, inspection of the assembly at the site and the photographs, the following features were noted:

The total order was awarded to Small Hydroelectric Systems and Equipment (SHSE) in Acme, Washington. SHSE designed and manufactured the PELTECH turbine and the frame and engineered the procurement and integration of the generator and load controller modules into the final assembly. The generator, furnished by Fidelity Electric, is a 12-terminal machine which can be connected for a range of voltages from 120 to 480 volts, three-phase or single-phase. Although it could not be confirmed at the time of the inspection at the site, it is presumed to be connected for three-phase, 220/230 volts line-to-line as specified on the purchase order.

Thomson and Howe of Kimberly, British Columbia, Canada, furnished the load control system which consists of three modules: (1) load controller; (2) load management; and (3) frequency guard. The load controller monitors the generator load changes in terms of frequency departures from the nominal 60 Hertz generated voltage and generates signals to solid state devices which switch variable increments of current into "passive" resistor loads as needed to account and correct for small frequency excursions caused by changes in the "active" (user) load. The load management module controls four large passive resistor loads (water-cooled) and gets signals from the load controller module to look at the load situation every four minutes and to switch in or out those resistors as necessary. Although the manufacturer's manuals do not make the theory of operation very clear, the load management module apparently keeps the load control module "centered" by switching on or off larger load increments so that the latter always has latitude to operate over its limited range to fine tune the frequency (and accordingly, the turbine speed). Finally, the frequency guard module is intended to detect frequency excursions above or below set limits and to actuate related alarms or controls to shut down the turbine. In this installation, a gravity-loaded jet deflector is held open by a solenoid which gets its current from the frequency guard module as long as conditions are normal. Should conditions depart from normal, the hold-in solenoid is deenergized and a weight-operated lever operates a deflector in front of each of the two nozzles through a simple mechanical linkage. The turbine then would slow to a halt although the water would continue to flow into the turbine casing.

SHSE interpreted the specifications regarding the automatic load control in such a way that the passive load resistors (which are ordinary water heater elements) are mounted in a water-tight steel compartment through which water, tapped off the penstock before the turbine inlet, is circulated and then dumped into the tailrace. This unit is an integral part of the total assembly with water piping and electrical connections to the water heater resistance units all made at the factory.

Protection and Control Equipment. There are two prime aspects of the installation and operation of the generation/distribution system to consider. First is control and protection of the turbogenerator and its electrical output.

Acting at the request of USAID/Monrovia, the Liberia Electricity Corporation (LEC) reviewed the turbogenerator specifications, made a brief visit to the site and the load centers of Yandohun and Dungalahun and provided certain recommendations in their letter dated 21 September 1981 (see Appendix). Concerning the turbogenerating set, LEC had little to judge from other than the brief purchase specifications. LEC's recommendations for control and protection of the turbogenerating set are appropriate for a central station-size installation but are overly elaborate and correspondingly costly for a very small machine.

Their recommendation for voltage, current, and speed indicators is met by the unit as built (see the letter, page 2, sub-paragraph (a)).

Sub-paragraph (b) calls for pushbuttons for start, stop, alarm cancellation, closing and opening of breaker and emergency stop. Pushbutton start and stop are neither feasible nor desirable. Start-up is simply by opening valves and activating the automatic load controller system. The automatic shut-down has been described and is adequate. No alarm is needed—when the lights go out, the machine needs attention. The lights going out in the village would indicate that the automatic shut-down should be checked to see if it has been activated. If desired, a simple, battery-operated relay-triggered alarm could be rigged up in each village. From our examination and photographs of the turbogenerating set at the site and the lack of any specification in the purchase order for a main breaker, it appears as if the breaker panel contains only branch breakers for the four passive resistors and auxiliary control circuits and therefore no generator breaker. When the shop wiring diagrams promised by SHSE are available, this will be confirmed. Assuming this to be the case, a generator breaker will be necessary, but this can be a simple thermal inverse time delay 3-pole breaker with an instantaneous attachment such as the new QO line made by Square D. Tripping would be indicated by the toggle which is used also to reclose the breaker. Switches for auto/manual and such, which are also called for, are not necessary since there is no auto-start.

Sub-paragraph (c)—automatic start and stop, initiated by pre-set conditions such as high or low water alarm or temperature—are not practical or necessary. High temperature alarms are not practical for small machines since there are no imbedded detectors in such generators. An ordinary thermometer could be taped to the generator frame and the operator instructed how to react to its readings.

Regarding sub-paragraph (d)—speed monitoring equipment—a frequency indicator is provided and the frequency guard module already described will shut the unit down in case of frequency disturbances. This will alert the users (and the operator) to correct the trouble and to manually restart the machine or to close the main water valve.

Sub-paragraph (e)—annunciation (meaning target or lamp indication) of over or undervoltage, overcurrent and earth fault is neither practical nor justified on such a small machine. The generator has permanently lubricated ball bearings and the turbine has visual-level grease reservoirs which do require watching but with no alarm provisions. A kWh meter on the output to the village loads (not including the passive load) as well as

another reading total generation might be useful especially for evaluating the system. Whether or not additional instrument transformers are necessary can be determined when SHSE provides the complete wiring diagrams. Low-voltage switch gear need be nothing more than the QO Square D breaker discussed previously. "Apparatus cubicle" with potential transformers and such is not necessary since generation is at 220 volts. Station service (local lighting and a trickle-charged battery emergency light) could be picked off a 120 volt connection on the generator. However, it might be simpler to operate station lighting on 220 volts which is available within the control panel. Other auxiliaries such as battery-operated emergency lights could also operate on 220 volts. "Sundry equipment"—battery charger, water level measuring device, ac and dc alarm bells, dc fuse board—are found in large plants. In the case of the plant at Yandohun, direct current control is not used.

Finally, though the Thomson and Howe electronic load controller, load management, and frequency guard modules are regarded by the supplier to be very reliable, there is little experience in their use under loads actually experienced in remote, rural areas in tropical countries. As designed, certain failures among these components could render the system ineffective. Although the Thomson and Howe instruction manuals indicate a one-year warranty on parts and labor necessary to repair manufacturing defects, it obviously is impractical to implement such a warranty in the remote project area of Liberia. Depending upon the nature of the load, it might be possible to temporarily circumvent the electronics after failure of any of the components so that the system is not rendered completely useless during the time that repairs are undertaken. However, before this can be done, access to more complete wiring diagrams for the equipment

A view from Yandohun village illustrating the style of construction used in the typical home

provided must be gained. Such information has been requested from SHSE and Thomson and Howe.

Summarizing the above, this small plant must be as simple as possible to keep costs down and to be of minimum complexity so that non-skilled people can operate it. The cost of overcontrol and overprotection could exceed the cost of the controller and protected equipment—mostly the generator—and including more than is already provided with the turbogenerating package is not essential.

Distribution. The second main component of this project is the distribution of the generated energy to the villages of Yandohun and Dungalahun. On the basis of the relative number of houses in the two, about 3/4 of the plant output (whatever it may initially be) would go to Yandohun and about 1/4 to Dungalahun. Using a generated power of 32 kW (for round numbers), 24 kVA would be the maximum to Yandohun and 8 kVA to Dungalahun.

The only map relating the plant site to the villages is one drawn by Mike Smith (Figure 7). From the powerplant, up the penstock line to the road, and along the road to Yandohun village is a total distance of about 9,000 feet. This is the route appropriate for a buried cable. Overhead lines could cut across some of the curves in the road and reduce this distance by perhaps 500 feet.

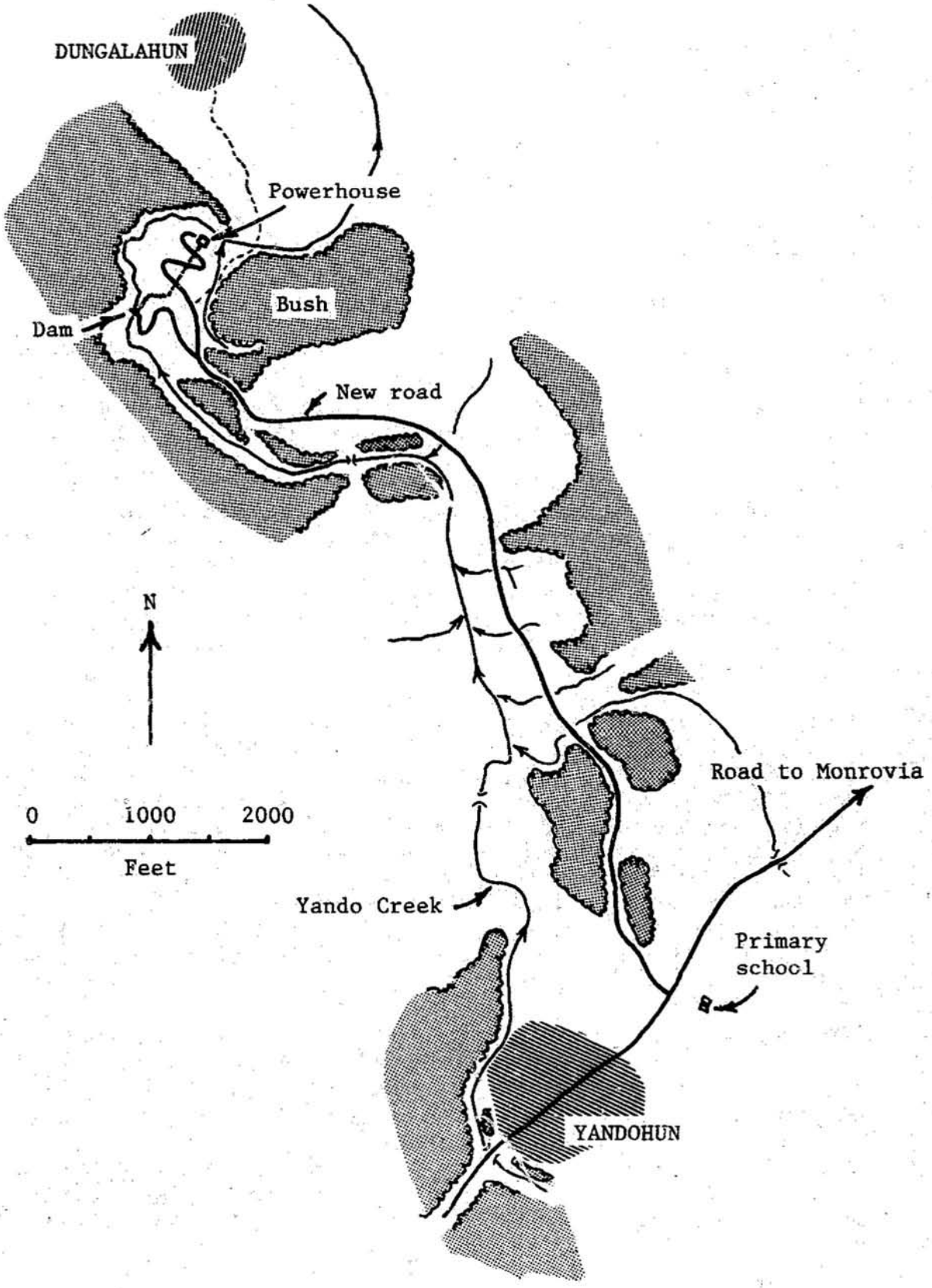
Alternative designs for the distribution system include the following:

Alternative A
Step-up at the plant to 7.2/12.5 kV, run three-phase service to Yandohun and single phase to Dungalahun by 15 kV buried cable, and step-down to 120/240 volts in the villages for secondary distribution.

Alternative B:
Step-up to 7.2/12.5 kV at the plant, run three-phase overhead lines of #6 aluminum cable on treated poles to Yandohun and Dungalahun, and step-down to 120/240 volts in the villages for secondary distribution. This is the scheme probably considered by LEC in arriving at their cost estimate of $164,484 for distribution presented on page 3 of their 21 September 1981 letter (see Appendix). LEC advocates use of concrete poles for this project but wood poles (with treatment of some sort) were seen along the road enroute to the site. If concrete poles could actually be delivered to the site and set at a lower cost than wood poles, concrete poles would be the better choice.

Alternative C:
A slightly lower cost variation of this scheme could be the same except for a single-phase feed to Dungalahun which would be adequate for lighting such a small village. Motor loads would be limited to five horsepower by single-phase service, but it does not seem likely that motor loads would exceed such a value.

Figure 7
Map of the Yandohun-Dungalahun area (drawn after an original prepared by Mike Smith, Peace Corps volunteer)



Alternative D:
Step-up to 2.4 kV at the powerhouse with buried three-phase #6 cable to Yandohun and single-phase to Dungalahun plus secondary distribution at 120/240 volts as before.

Alternative E:
Step-up to 480 volts and run a bundle of triplex secondary buried cables to both villages plus secondary distribution at 120/240 volts.

In all these alternatives, step-up transformers at the plant and step-down transformers at the villages would be necessary. LEC proposed 7.2/12.5 kV primary to the villages since that is their more widely used standard, based on U.S. REA practice. Availability of transformers, insulators, switching, and such at 7.2/12.5 kV is a factor in their recommendation. However, during our trip to Yandohun, what appeared to be 2.4/4.1 kV line was seen frequently along the road near villages. The open wire size of #6 is dictated primarily by mechanical strength considerations and is more than adequate for current-carrying capacity. Termination, splicing and burying of either 2.4 kV or 15 kV cable requires special skills which would have to be supplied by LEC in some fashion. Once properly installed, buried cables should cause no trouble and they would be relatively immune to lighting.

Installation of the bundled secondary (Alternative E) would be relatively simple and within the capability of a qualified electrician. It would have the additional advantage of dealing with relatively low voltages (480 volts) rather than 2,400 or 12,500 volts. Alternative E would require larger conductor cross-sectional area and would incur larger power losses than the high voltage cables. Also the dry-type transformers for this application cost more than the oil-filled high primary voltage transformers for the other alternatives.

Voltage drop from the generator to the loads is a significant factor in Alternative E since the line currents would be much higher, where the 2.4 kV or 7.2 kV alternatives would have negligible voltage drops. The steady-state (24 kVA load) voltage drop was interpolated from REA Bulletin 1607, page 69, using three 4/0 aluminium triplex feeders to Yandohun at about 3.6 percent for the assumed 24 kVA load stated earlier. This is acceptable for a rural village. Voltage drops from motor-starting inrush currents (such as village water supply pump or coffee huller) would have to be considered. Such motors should not be enough for inrush kVA to exceed the 24 kVA which might mean that such loads would have to be started during daylight (non-lighting) periods.

Very rough cost comparisons were made of these alternatives including step-up transformers at the plant, a circuit recloser (breaker) for line protection (except for Alternative E), primary line as indicated, transformers on poles in the villages, duplex or triplex service drops from distribution poles to the houses and special connections to the school and a water pump in Yandohun, plus about 15 % contingencies, with totals rounded off. A large measure of volunteer local labor for clearing, pole and anchor hole digging, pole setting, and backfilling was assumed in the cost estimates.

Table 2
Comparison of costs of alternative distribution plans

Alternative	Description	Total Cost	Step-up, cable or wire termination, and lines to villages	Village distribution and house wiring
A	15 kV cable	$70,000	$ 55,000	$ 15,000
B	7.2/12.5 kV line on poles	48,000	33,000	15,000
C	as B except single-phase to Dungalahun	47,000	32,000	15,000
D	2.4 kV cable	51,000	36,000	15,000
E	480 volt bundled secondary	45,000	29,000	16,000

Table 2 indicates that the difference between Alternatives C and E is relatively little in terms of costs. Considering the voltage drop and losses aspects, plus little or no allowance in Alternative E for adding generation capacity at a future date, it appears that Alternatives B and C are the better choices, with possibly a slight cost advantage for Alternative C.

All alternatives except Alternative E would have sufficient capacity for accepting twice the initial power potential of the site. By proper selection of the original station transformers, they could be used at the village ends of the lines, with larger units replacing the original station transformers when and if the capacity of the plant is increased.

There is a vast potential for hydropower of all sizes on the African continent, especially in the central belt from west to east, though clearly some nations are more endowed with this resource than others. The potential for micro-hydropower projects is also immense though the purpose of such projects would more likely be tied to rural development than to oil import substitution.

The micro-hydro project implemented by the local community at Yandohun is the first such project in West Africa and, it is probably safe to say, in all of Africa. Because of the existence of this vast potential on the one hand, and because it has yet been virtually untapped to date on the other, it is important that, as with any prototype projects of this nature, adequate planning by those knowledgeable in the technology and aware of the pitfalls and promises associated with this technology is essential. Because of the impact, either favorable or unfavorable, a prototype project can have, this planning should not be taken lightly. It should not be undertaken by enthusiasts who may be aware of some of the potentials of the technology but not well versed in all its ramifications, technical and otherwise. The apparent simplicity of hydropower technology is beguiling.

To date, there has been much more interest in the technical aspects of this project. But even assuming that all the technical problems regarding the installation are resolved within the given constraints, this will not assure the success of the project. There are several areas that still need to be addressed before this project can be viable. Among these are (1) the designation and training of local personnel to ensure satisfactory operation and maintenance of the plant and (2) the setting up of a management structure to determine and implement policy (policies regarding, for example, allocations and priority use of available power, establishment of a tariff structure and mechanism for adjustments, establishment and maintenance of revenue and operations accounts, and use of local labor to maintain civil works in working order).

And even if the organizational and operational questions have been answered, there is still no guarantee that such an undertaking can be viable and have a beneficial impact on the community. Determining its viability and impact is, of course, one of the stated reasons for undertaking the project.

Since the LEC has responsibility for the generation, transmission, and distribution of electrical power in Liberia, it might be advisable and probably necessary to include the LEC actively in any further developments. Although during a meeting with Lionel Keller, LEC proposed to undertake the installation of the distribution systems at Yandohun and Dungalahun, to train local individuals to run it, and to manage the system, their actual involvement should not be a foregone conclusion. Meetings of interested parties must be called to address these questions as well as the question of finding additional sources of funding.

Several lessons might already have been learned from this activity. This project involved the application of a renewable energy technology (with all the pluses that that brings to mind in this day and age), a suitable rural site, and staff committed to spending several years in the field working with the project. Therefore, in spite of the fact that it was a technology which was untried in a rural setting in Africa, there seems to have been a big push from Monrovia in 1979 to get approval for funding of this activity. Although a number of reservations were raised by the project review committee in Washington, approval was eventually granted. Addressing these reservations rather than repackaging the proposal may well have led to a more effective prototype project. However, had the project not been pushed through, there may not have been sufficient interest or momentum to give more thought to the project before its approval. Now that the project is off the ground, there is more reason to give it some thought. But giving this thought beforehand would have been advisable.

But, of course, delaying approval of the activity without providing the expertise to appropriately address these arguments would have been of little use. As it now stands, it would clearly have been advisable to have had access to the required expertise and experience at the project formulation stage so that the final system could have been designed around the needs of the community, the realities of the site, and the skills which are available locally. One might then, for example, have specified a turbine with a manually adjustable nozzle to make use of the low flows during the dry season. One might have located the coffee processing equipment, which was envisioned from the outset, at the powerhouse itself with a mechanical drive so that any failure of the electrical system would not imply complete shutdown of the plant. One might have located the load controller, if that indeed would have been the choice made for governing the turbogenerating equipment, in the village so that a beneficial use could be made of all the excess power rather than dumping heat into the tailrace. These and other possible design changes might well have led to a more appropriate configuration. And it is only by giving the system the attention it deserves at the planning stage that a system which might be reproducible elsewhere can be developed. This, after all, is the purpose of this activity.

As far as the Yandohun project is concerned, the die has been cast and if one is to continue work, one must try to do the best under the circumstances. Though a more appropriate system might well have been designed, this is not to say that the present design is not a typical micro-hydro design. However, with any possible future projects dealing with micro-hydropower or other forms of renewable energies in a rural setting, the lessons learned should be kept in mind and adequate expertise applied from the outset.

And finally, as a prototype project, it is unfortunate that though funds have been set aside, no baseline study has been undertaken to date. One is reminded in cables from Monrovia, and elsewhere, that "...this pilot activity will provide an opportunity to assess the economic, social and general development impact of mini-hydro units in rural areas" and that "...included in the project is a close examination of the changes to

determine what, if any, social costs results...". Yet one gets the impression that this was included more to obtain approval than because it was felt useful to the overall objective of the activity.

This impression is reinforced elsewhere. It can be seen, for example, in a comparison of the activity paper finally approved by the project review committee with the original paper. Though no major changes were made, the changes that were made can be summarized as follows:

1. expanding the section on "Cultural Impact Considerations" and including a new section on "Baseline Study and Evaluation Plan" (though nothing in this area has been done to date);
2. revising downward the USAID contribution from $89,400 to $50,000 (which, in fact, was increased later to $70,000);
3. increasing the number of beneficiary villages within a 5-mile radius and updating benefit figures to reflect the increased cost of diesel fuel in general use in Liberia for the generation of electricity;
4. removing the provision for additional advisory assistance by the IRT contractor and rather noting that technical assistance would be volunteered by a number of specific individuals and groups (who apparently have volunteered little, if anything, to date); and,
5. including a cost/benefit ratio of .95 and omitting the cost of the project per beneficiary (regarded high by a number of critics and, even then, only one-third the cost per beneficiary more correctly noted by the Minister of Planning and Economic Affairs in his letter to the Minister of Local Government).

These changes all seem to reinforce the impression that the writers of the paper were more interested in form than in substance, whether or not that was the case. If one is honestly interested in assessing new technologies in new situations in the developing world, it is imperative that the issues at hand be addressed and not skirted nor blurred beyond recognition.

If this is indeed to be a prototype project, then a study of the method of implementation and the impacts of these activities is essential. This study must be undertaken by qualified, unbiased individuals. It would serve little purpose if undertaken as a theoretical study in a vacuum. It should not be undertaken simply to comply with a previous commitment.

LIBERIA ELECTRICITY CORPORATION

P. O. BOX 165. MONROVIA, LIBERIA

OFFICE OF THE MANAGING DIRECTOR

CABLE: LECORP
TELEX: 4288 LEC LIB.
Tel. No. 222883/222388

LEC-MD/TDM/111/'81 September 21, 1981

Mr. Charles L. Strickland
Rural Development
United States Aid Mission to Liberia
P.O. Box 1445
Monrovia

Dear Mr. Strickland:

Further to your request for assistance on the Yandohun/Dungalahun Mini Hydro Project our Engineer, Messrs. Joseph Mayah, Ian Yhap and Silvo Secchi, visited the site and have reported as follows:

Firstly, that there was some concern about the manner in which the civil work was being conducted, in that the dam's foundation was not being anchored properly and is feared that this might not be able to contain a flood situation.

Secondly, as no one could tell them anything about the electrical specifications for the power house their recommendations for that are as follows:

I. 1. Generator
2. Transformer
3. Controls and protection
4. Low voltage switchgear
5. Sundry equipment

- presently, we understand that the Generator has been ordered and shipped. A review of the specifications indicate inadequate protection.

- a standard distribution transformer (3Ø or 3x1Ø) should be selected. Voltage rating should be 12.47 kv/208v for the three phase configuration and 7.2 kv/120v for single configuration. The rated power in KVA of the transformer should be the same as the maximum continuous generator output in KW divided by the full load power factor of the generator.

LIBERIA'S DEVELOPMENT DEPENDS ON ELECTRICITY

- cubicles for controls and protection should be selected to contain

  a. Instrument unit with
     voltmeter
     ammeter
     speed indicator

  b. operation unit with

     - pushbuttons for start, stop, alarm cancellation, closing of breaker, opening of breaker and emergency stop

     - switches for manual - auto and alarm on-off.

     - position indicator for the main breaker

     - symbolic diagram

  c. automatic control unit for start, stop initiated by present conditions i.e. high or low water level, temperature high or low, pressure etc.

  d. speed monitoring equipment

  e. annunciation

     - Relay protection
       standard protection are as follows:
       - over current
       - over voltage
       - undervoltage
       - earth-fault (neutral pt. voltage).

  There should be an operation indicator (flags) for each protection as well as various monitors such as overtemperature, runaway, low oil level etc.

- A KWH meter should be mounted in the station

  Low voltage switchgear

  Apparatus cubicle is to be selected to contain:

- voltage transformers
- station service transformers
- outgoing fuses for station ckts. etc.

  Cable cubicle

  Attachments and anchoring for cables coming from below

Circuit breaker cubicle contains

- circuit breaker
- current transformer for relay protections
- current transformer for relay measuring

Sundry equipment:

- Battery
- battery charger
- water level measuring device
- alarm bells for AC and DC.
- D.C. fuse board
  etc.

Thirdly, the distribution system was looked at and the cost indicated are as follows:

Survey Costs	-	$ 384.00
Construction Cost	-	10,770.00
Material Costs	-	119,122.89
Handling Charges 15%	-	19,541.53
Contingency 13%	-	16,935.99
Engineering/Supervision 10%	-	13,027.69
TOTAL		$164,484.10

Enclosed herewith is a sketch of the proposed distribution system for the area. We will be happy if you would call at our offices so that this matter could be discussed fully.

Kindest regards,

Very truly yours,

Harry T. Yuan, Sr.
MANAGING DIRECTOR

encl: