OPERATIONAL PLANNING OF MAHAWELI WATER RESOURCE SYSTEM

by

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Introduction

The Mahaweli Water Resource System (MWRS) consists of reservoirs, diversion structures, hydro-power plants and irrigation sub-systems which are linked through river reaches, canals and tunnels. Figure 1 shows the MWRS in schematic. Rainfall in catchment areas provides the reservoirs and diversion structures with water which then becomes the basic resource of the system. Reservoirs are used to regulate water so that time lags between availability and demand can be smoothened out while diversion canals and tunnels are used to convey water from the points of availability to points of demand.

Irrigation sub-systems, which are quite small in number but well scattered over the down-stream areas of the MWRS, also have regulating tanks, diversion structures and canals and therefore, are capable of satisfying the demands of their own irrigation schemes. Although these sub-systems can be operated independently, the MWRS is expected to supplement their deficiencies whenever necessary.

Hydro-power plants are expected to supplement the rest of the energy generation system in meeting the national energy demand and therefore need to be operated in combination with the operation of Kelani system hydro-power plants and thermal-power plants.

System Operating Policy

Having briefly described the system configuration and two basic demands on it, and water being the only resource available in meeting these demands, now we can examine how the system could be operated in order to meet the demands with a given reliability.

As described earlier, some man made components of the system (ex. sluices and spills of reservoirs, power plants, diversion structures) provide the capability of controlling available water within built-in ranges that are specific to each control facility. This is a fascinating aspect, that could be used to satisfy demands by utilizing uncontrolled and unforeseen flows that result from rainfalls in catchment areas. However, these control points are scattered over the system and hence cannot be operated from a central station or by an individual. Operation from a central station is further undermined due to lack of speedy communication at most of the control points. This can, in a way, be overcome by specifying operating instructions (or operating policies) covering a specified period for each control point. For instance, a diversion sluice could be instructed to divert a specified quantity of water over

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a planned period of time. If better control is required, the distribution pattern of the quantity of water over the period also could be given. As a further refinement, it could also be instructed to release a certain fraction of the flow reaching the control point subjected to a given maximum. Therefore, depending upon the need, an operating policy could be defined for a diversion point either independent of inflows or as a function it. Similarly, for a reservoir, a release policy could be described either independent of the reservoir capacity or as a function of it. This policy could also be made to vary over the time and hence time dependent throughout the planned period. Once such operating policies for each of the control points of the system are established to cover the planned period, the set of such policies could be referred to as the System Operating Policy (SOP).

System Simulation Program

The next question on line would be the reliability of SOP in meeting the demands both irrigation and energy. The easiest method is to try it on the real system. However, apart from the cost of risk in doing so, the results could not be used to judge the policy for adaptation in future planning, since it is almost unlikely that the same pattern of hydrology would repeat. This is the point where one would think of developing a computer program which could imitate the operations of the real system and is generally known as System Simulation Program (SS).

Like in the real system, given the demands both irrigation and energy, SOP and the hydrology of the season, the SSP imitates the operations of all control points according to SOP, over the season and produces the performances of various activities. But the problem, which still remains, is the difficulty of estimating the hydrology for the planning period. Without a good estimate of the hydrology, the testing of SOP for its reliability is not satisfactory.

This is the stage where observed hydrologies of past years (records are available for over 30 years) become important. It is not too difficult to use the SSP to imitate the system operations with the planned demands and SOP but on the hydrologies of those past years by taking each year separately and to produce sets of performances corresponding to each of those years. Having done this much, if one could justify that, those past hydrologies sufficiently represent the hydrologic variability that exists in the real system, then it is also true that system performances thus simulated, also sufficiently represent the probable variations. Figure 2 shows the process of simulation in brief.

In contrast to the energy demand, the rainfall plays a major role in determining the irrigation demand. Therefore, unlike factors such as crop type, cropping extent and dates of cultivation, the irrigation water requirement cannot be planned in advance. This creates the situation where water requirements of irrigation schemes could only be obtained by simulating the physical process by which the irrigation water releases are determined. This process which is included in the SSP, decides the irrigation water requirement by accounting for the prevailing hydrologic conditions.

System Operating Policy - Reliability

Having clarified the above fact, the same process can be used to evaluate the reliability of a given SOP. Firstly, it becomes necessary to define failure criteria against both energy and irrigation demands. That is, against each demand, the acceptable limits that shortfalls could occur in meeting the demand during the whole of the simulation period, are to be defined. Having defined failure criteria as described above, a given SOP can be tested using SSP with real demands and past hydrologies, for its reliability. If the given SOP is found to be unsatisfactory in the first trial, it is the usual practice to alter the SOP until it produces performances which comply with the already defined reliability criteria. There could also be instances, where the demands are too high that there may be no SOP which could satisfy the reliability criteria. In such cases, there is no alternative other than to reduce the demands until a satisfactory SOP is found or to relax the reliability criteria.

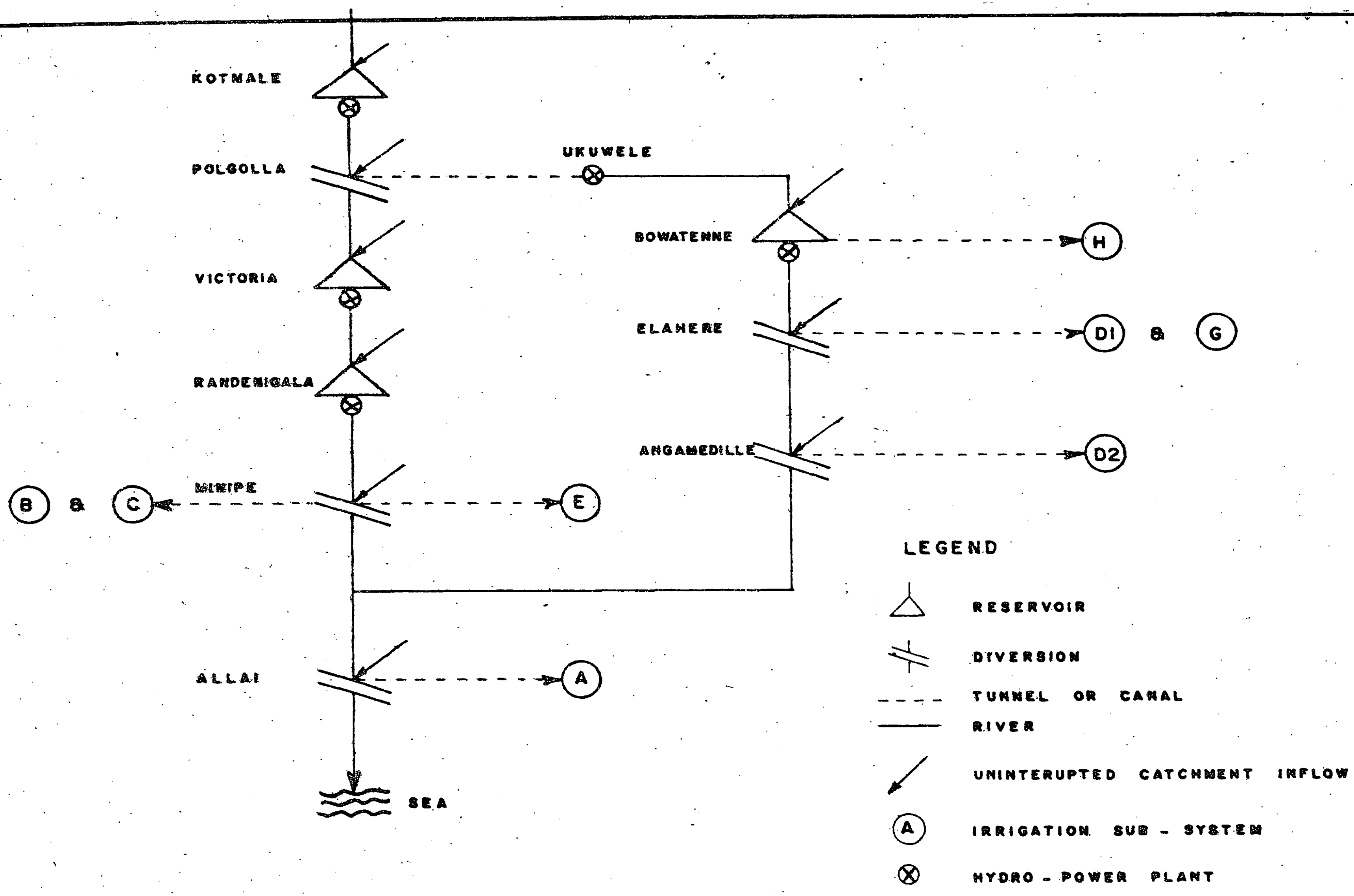
System Operaing Policy - Implementation

After going through the described process of analysis, the final decision of whether to accept the proposed SOP for implementation in real system operation or not, must be taken by the agencies who are most concerned about their individual requirements. However, once a particular SOP is agreed upon for implementation, there still are problems which need the authority of a central organization to overcome. For instance, a particular hydro-power plant may be in a position to generate energy according to its own operating policy although the total demand and generation at other plants do not require it. A similar case could be an irrigation demand which can be supplied by either of two upstream reservoirs while both reservoirs are in positions to meet that demand according to their own operating policies. In other words, when a single demand can be met through more than one control point or when two or more demands are to be met through a single control point, such control points cannot be operated using their own operating policies alone. In such instances, the use of SSP is again required as an operating tool. By using a projected hydrology for the next operating time-step (usually one week) and with the system status (reservoir storages) as observed at the end of the preceeding time-step, the operations of the system over the next time-step can be simulated by SSP using the agreed SOP. The simulated operational activities thus obtained, such as diversions, reservoir releases and energy generation at different plants can then be used directly as real operational parameters for those control points over the next time-step. The repetition of this process at the end of each time-step, is an interpretation of the planned SOP into operational information for each individual control point where it's own operating policy alone is not sufficient to operate it usefully.

Conclusions

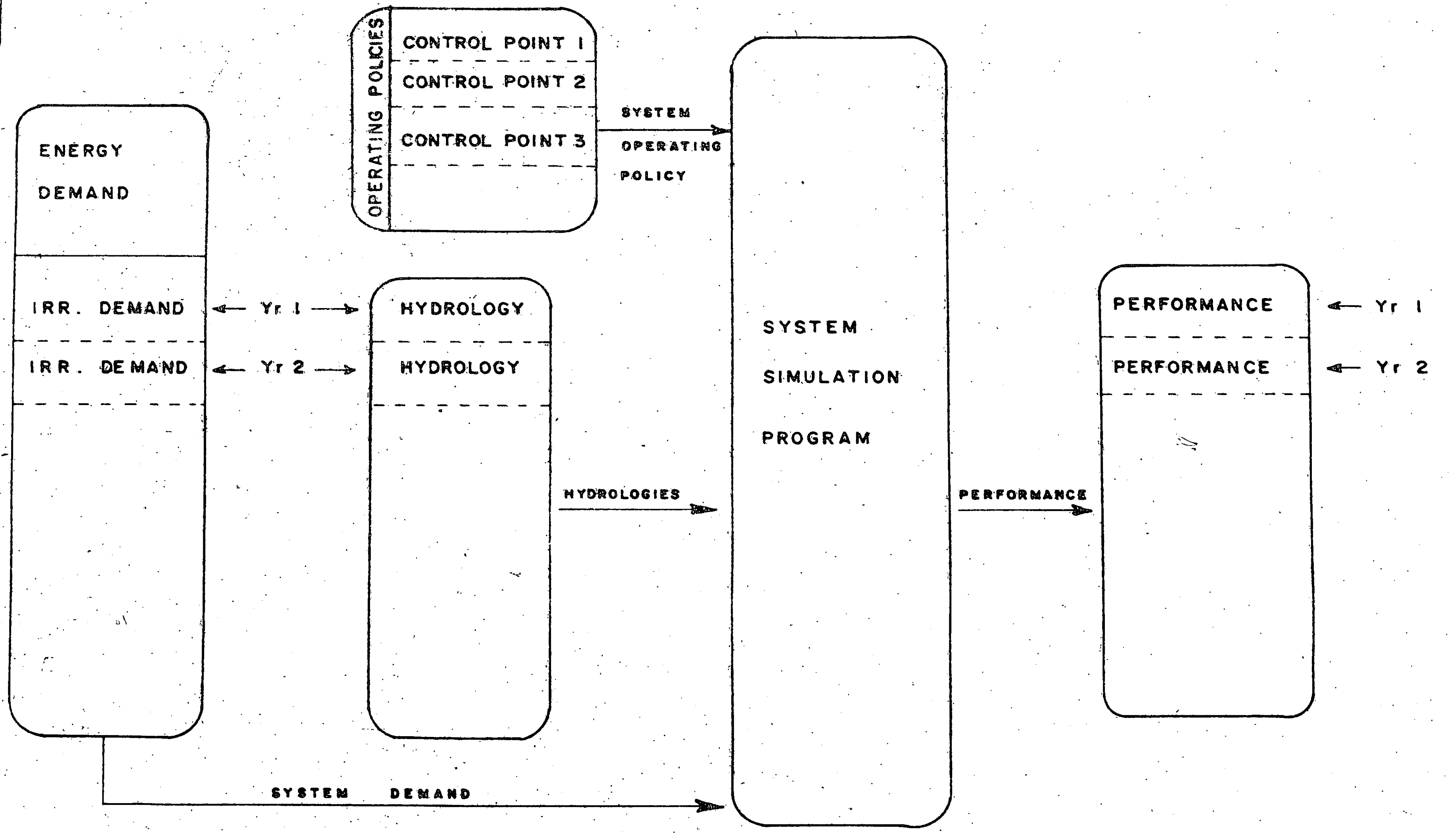
At present, almost all originally planned main storage reservoirs and hydro-power plants in the Mahaweli system are in operation. However, the development of irrigation projects which are to be benefitted by Mahaweli diversions has been slow, while the growth of energy demand also was slower than originally anticipated. This has created a situation where demands (irrigation and energy) are relatively at a lower level than the system capability and hence there is a greater flexibility for planning and execution of system operations.

However, with the continuation of irrigation development and growth in energy demand, this flexibility in operation will reduce requiring greater emphasis on operational planning. Moreover, when the demands reach the system capability level and continue to rise above it, a criterion will have to be defined for reducing demands (ie. curtailing of hydro-power generation by switching on to thermal generation and/or reduction of cropping areas) appropriately, in order to develop SOPs in the future.



MAHAWELI WATER RESOURCE SYSTEM

FIGURE . I



SYSTEM SIMULATION PROCESS

FIGURE. 2