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A PLAN FOR SELF SUFFICIENCY IN POWER FOR PAKISTAN

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ABSTRACT

The main source for cheap power for Pakistan is hydroelectric. Pakistan has about 8000 MW of this potential, the upper Indus contributing a major share, Skyok dam. Skardu dam have the best storage potential and the reach of Indus from Skardu to Bunji has the best hydel pontential. Skardu dam has a stroge of 20KM^3 against KM^3 for Bhasha for the same dam height of 200 metres. Even Skyok dam yeilds 9 KM^3 same as Bhasha with only 165 metres. The life of Skardu is 5 times the life of Bhasha. The Indus gorge from Bunji to Thakot in which reach Bhasha, Dasu Patan etc. are located are risky because of the high scismic activity in this reach, besides the storage have limited capacity and other disadvantages. Bhasha dam does not help in firming up the hydel stations in the most attractive reach of Indus Skardu to Bunji nor can it control Indus as carryover storage. For the long term, Skardu dam and the reach of Skardu to Bunji could be developed. For the short term there is no way except to go in for Kalabagh dam both for water and power immediately/ Schemes such as Bunji, Thakot, Kohala, Ghazi Ghariala, greater Thal storage hydel, Canal and barrage hydels are desirable schemes in the short term period up to AD 2000.

The present method of power generation based on imported oil is expensive. All cheaper available sources should be tried. Apart from Nuclear power, power from inferior coal with the latest ultra carbo fluid-54 technology should be studied to replace the present method. Power from even rice husk could add over 1000 MW as a cheap source. This could be developed at the rice mills and would help rural electrification. From rice husk ash cheap cement can be made. Power by wind turbines has great application in the coastal and hilly areas. Power from blue green algae for coastal area is another source. This algae is the fastest growing algae in he world. To over come the shortage of funds for power generation, joint ventures with China for hydel stations in the upper Indus such as

Skardu and Bunji should be taken up in exchange for supply of some power supply to China for the Sinkiang region where 200 million people are to be settled. China could supply the equipment and help in construction of these projects. They could cooperate with us in other fields such as tourism and mineral development. The power from Bunji which could be taken up immediately would not only supply power to China but also nothern areas, Azad Kashmir and Chitral. Cheap power in these areas would help the economic lot of these backward areas and also control the environmental degradation by stoppage of cutting trees for fuel.

Though shortage of funds has been the main bottleneck for implimentation of power projects the failure in preparing a large number of projects out of which we can pick and choose has been another reason for lapse in power wing of WAPDA. A research and development section for new sources of power and master planning and guiding the consultants in prepating projects is necessary.

Pakistan has been facing heavy load shedding in recent years as the present installed capacity of about 6000 MW cannot meet our demand. The resultant loss of industrial production has been estimated to be as much as U.S.$ 2.5 billion in recent years the load shedding of last year has reduced the GDP by 2 percent. A more desastrous consequence of the power shortage is the suppression of potential new investment in industry and agriculture leading to declining overall investment and GNP growth. Demand for power is growing at the rate of over 10 percent.WAPDA needs to add at least 1000 MW a year to its system. According to one estimate this will require Rs.28.28 billion for 1989-90 and Government is offering Rs.15.84 billion. This amount is not enough to carry out even ongoing projects. In 1988-89 WAPDA demanded Rs.33 billion and had been allowed Rs.13 billion. Financing of power projects is a serious problem. According to Dr. Akmal Hussain an eminent economist, both courage and economic diplomacy is required in persuading the I.M.F. to exclude the expenditure of WAPDA from the Government budget ceiling. At the moment WAPDA's investment even where it is justified by high rates of return is constrained by the I.M.F. stipulation which in effect requires new investment to be financed by an increase in taxation of power tariffs. Exclusion of WAPDA from the Government budget ceiling would enable it to finance ambitious investment schemes through commercial borrowing on grounds of economic viability of the projects concerned. We have plans to make Pakistani exports competitive. This can be achieved by building a heavy industrial base with projects in steel, engineering Nuclear energy plants, fibre optics, advanced electronics etc. The heavy industries in most cases would be joint projects where foreign and domestic enterprise can come together. Even for power projects joint ventures are possible. This is the main prerequisite for our economic independence. The strength of India lies in its heavy industrial base, foundation of which was laid soon after independence, whereas Pakistan had to be satisfied with light industries in its early years. As hydroelectric power is the cheapest source of power and Pakistan has over 18,000MW of hydro electric potential we whall first discuss hydro electric power.

1. Water and power potential of upper Indus

The upper Indus fed by glacial tributaries like shyok, shigar, Astor, Hunza and Gilgit is located in Baltistan and Gilgit areas known as northern areas of Pakistan. This is an important geostrategic area between China, India and the Soviet Russia. Some of the highest mountains and largest glaciers are located in this zone, out of the world's 50 high mountain peaks about 35, the famous K2 are situated in this area. The world's largest glacial range outside the polar region i.e. Siachin is located here which is 46 miles in length.

The Karakorum highway (KKH) connecting China and Pakistan was completed in 1978. It was opened to traffic in 1979. The road connecting Kashgar and Islamabad has an easy gradient of maximum 8% only which can carry heavy equipment and tanks. the road from Karakorum to Khaplu via Skardu is a 40 class road. Skardu is 150 k.m. from the main Karakorum highway. The first 50 km of road from Karakorum highway to Skardu, no doubt, passes through difficult terrain as it follows the loop of Indus. During discussions with the Fronitier works Organization a tunnel to cut short this road was suggested but at that time the importance of the road did not justify this. A tunnel of 4.5 miles would get rid of this 36 miles of difficult road. In fact Montreal Engineering co who have studied power generation from this loop of the river upstream of Bunji had suggested 3 tunnels of 14meters diametre. A tunnel for the road is fully justified when upper indus dams and hydro electric projects are undertaken. The general misunderstanding that the northern areas are not accessable is no longer true.

The great potential for water and power in the upper indus was known for a long time. the irrigation map of west Pakistan of 1960 indicates the Skardu dam site and the Bunj hydro electric site where a tunnel of 4.5 miles could give a drop of 800 ft on Indus. the first reconnaissance report on the upper Indus storages Skardu and Khapalu sites was prepared by Harza in July 1962. The sites were visited by Engineers of WAPDA and Harza who were preparing a master plan for water and power resources for Pakistan. Harza report of July 1962 states that:-

"The Skardu area from a physical stand point, is by far the largest open basin on the Indus above Tarbela dam site, with a capacity to store any quantity of water upto probably 40 million acre feet. the catchment areas is 44,000 square miles and the annual run off is estimated roughly at 45 million acre feet. the Skardu site possesses an important advantage over upstream alternative in that it would control all these major branches of Indus, the Shigar, the Shyok and the Indus itself. The Khaplu reservoirsite appears to have very favourable physical characteristices for development of a large scale storage. The only limiation appears to be the run off volumes of the Shyok river which is roughly estimated at 15,000,000 acre feet annually. Storage equal to the annual run off would equire a dam of about 600 ft height which appears physically practicable. Such a reservoir would intercept much less silt than would a similar reservoir at Skardu since the inflow is only one third as gross and would accordingly have a much longer life. Development and population in the Khaplu Valley is considerably less than in the Skardu Shigar Valleys"

The above report is based on first visit without any surveys and without any information but Harza have done a great service in bringing out the potential of these sites particularly the Khaplu or yugo site which was first identified by them. Montreal Engineering Company (MECO) prepared hydro electric inventory and ranking report in 1985. In addition to the two storages of Khaplu or yugo and Skardu they identified a new site at Bhasha in the Indus gorge just downstream of the border of Gilgit Agency. The Indus gorge downstream of Skardu was always considered as neither safe nor economical for high dams in the past.

	Description	Unit	Yugo Dam	Skardu Dam	Basha Dam
1.	Height of Dam	M	165	230	200
2.	Width of Dam	M	770	1050	950
3.	Storage	KM^3			
	Live		6.9	19.0	7.0
	Dead		2.1	6.0	2.0
4.	Reservoir Area	KM^2	155	300	112
5.	Full Supply	M	2590	2316	1160
6.	Normal tail water level	M	2440	2134	975
7.	Life of reservoir	Years	300	400	80

It would be seen from the above statement that Skardu dam has almost thrice the live storage capacity of Bhasha and even yugo dam has almost the same live storage as Bhasha with even a lesser height of dam. Skardu dam even with 200 M height, (same as Bhasha) yields a total storage of 20 KM^3 against 9 KM^3 for Bhasha. One of the greatest advantages of Skardu dam is that it is the only dam on Indus which can control the Indus flows to a considerable extent. This has excellent flood control benefits as Summer flows in Indus could be effectively controlled by Skardu dam and the water that is now causing severe damage shall be stored to meet the shortages in the critical months. The last line in the table indicates the life of the reservoir. It would be seen that Bhasha has a fraction of the life of Skardu and yogu dams. The life of even 80 years is liberal for this highly seismic reach of Indus gorge as the large land slides could considerably reduce the life of the dam. An important point about Indus storages is that these have to replace the supplies of the eastern rivers given away to India permanently and as no storage is permanent, the longer the life the better for us. Thereservoir level of Skardu of 2316 M is above the Airport level of 2225 M. The Airport is 14 km downstream of Skardu town and is situated close to the river bank. In any case the airport has to be shifted to a site upstream say near the confluence of Indus and Shyok where hard levelground is available. Besides this would have the further advantage of being nearer to the line of control with India and also nearer to Siachin glacier. Submergence of areas in the Indus and Shigar due to Skardu reservoir need to be studied and the dam height adjusted to avoid flooding of any large cultivated and developed areas as far as possible. In any dam project submergence of areas is inescapable and has to be tolerated. In the case of Bhasha 100KM of Karakurm highway would be submerged and the fertile vallies on either side of the river upto 100 KM. In the case of Mangla dam Murpur town had to be shifted.

MECO have overlooked some important factors in development of the hydro electric potential of the upper Indus, which are discussed below:-

1. River development for storage should normally start from the upstream as storage water would be available for all hydro electric sites downstream. Storage on the downstream cannot help the hydro electric sites upstream like storage at Skardu can make available.

2. The Indus is steeper in the upper reaches particularly downstream of Skardu. The enclosed long section Appendix-A shows that the river has the steepest slope from Skardu to a point downstream of Bunji i.e. between km 2250 to km 2350 from the river mouth.

3. One of the most attractive site for hydro electric power development on Indus is on the loop upstream of Bunji where a tunnel of only 4.5 miles develops a drop of 800 ft. This coupled with the increased releases from the Skarddu reservoir would make available one of the best hydro electric sites in Asia. MECO have recognised the great value of this site it and have ranked this as No.2 in their ranking study as can be seen from Appendix-II, but because their Bhasha storage is on the downstream this site looses its power potential to a considerable extent.

4. Another advantage of the upstream sites on the Indus is that the quantity of sediment would be much less and the life much longer.

5. An important feature of the dam sites in the upper reaches is that they require smaller size of diversion tunnels and smaller capacity of spillways.

II. Comments on Hydro electric ranking of Indus Projects by MECO.

Appendix-II indicates the ranking of various sites by MECO and Appendix-III Table 2-1 gives details of the first ranked site as Bhasha dam. As discussed in the previous sections Bhasha dam is very inferior to the other two sites viz. Skardu and yogu, as a storage Bhasha suffers from some other serious disadvantages the following are some:-

(1) There is no rock up to 55 meters in the foundation.

(2) The dam is located in the seismic zone. According to the "Atlas on seismicity and volcanism" (Swiss Reinsurance Co 1978) which classifies areas of the world into four seismic zones. The 1840-41 land slide dam at site A (Bhasha) are located in the second most severe zone, rated as having "heavy exposure to earth quakes" please see Appendix-IV. During the period 1927-1983 there were 146 recorded events of Richter Magnitude 4.0 or greater within 200 km of Bhasha Dam.

(3) The floods caused by bursting of a dam similar to the land slide dam of 1840-41 have been examined by MECO but they state that the dam would be overtopped by such floods only when it silts up after the first fifty years. They seem to depend on the rare frequency of the occurance. An important point to be kept in mind is that a dam of 200 meters with considerable see page through the fault zones could itself create movements in the dangerous Naga parbat slopes which were responsible for the disastrous land slide dam of 1840-41. This created a dam of 200 meters in the river i.e. of the same size as Bhasha. The dam then burst due to a flood wave from another land slide near Bunji upstream. This is why the

Indus gerge was avoided for dams in the past. There seems to be no justification whatsoever for taking risks for such a dam when we have better dams upstream and would further improve the excellent hydroelectric potential upstream of this dam. The first ranked site after Bhasha as per the consultants is Dasu dam which is located downstream of Bhasha. This dam is proposed to be 235 meters high and is 35 meters higher than even Bhasha. MECO seems to assume dams of 200 meters and above as normal in the Indus gorge. They do not seem to realise the severe problems of foundations on Indus, for much lesser height of dam like Tarbela we had encountered serious foundation problems. Unlike rivers in Europe and North America we have poor foundation under most of our dams, good foundation is an exception rather than a rule. This dam suffers from all the defects of Bhasha and some more as it is nearer to the seismic zones of Jaglot sycline and patan mantle thrust zone(please see Appenxix-IV).

The second ranked site Bunji of index capacity of 1290 MW has already been discussed and should be in fact the first even before Bhasha or any other dam. It has great potential even as a run of the river site. In fact it was recommended in the preliminary hydro electric and water plan. prepared by WAPDA under the revised action programme for irrigated agriculture in 1977-78. MECO have suggested a dam of 270 meters at Bunji site with no live storage as in the case of Dasu which is not at all justified. All that is required is to have a low dam and a tunnel to connect the neck of the Indus loop which can generate about 800 MW. This could be firmed up when storages such as Skardu upstream are completed. One objectioon raised against Bunji Hydel is that it is too far from the main grid An important point to be noted about this is that the distance from Bunji to the national grid via kunhar valley is the same as the distance from the proposed Bhasha to Tarbela dam along the Indus. Another vital point about Bunji is that it is centrally located in the Balistan and Gilgit agency and can supply much needed power to this area and Azad Kashmir aloong the Astor Valley and Neelum Valley to Muzaffarabad. We can even supply power to China via Khunjrab pass and Chitral via the shandur pass. All these three areas are within 250 KM distance from Bunji. The power lines radiating from Bunji in these directions could energise the areas on the way which are the most backward in Pakistan. The cutting of trees, even valuable fruit trees in severe winter would stop with availability of cheep hydroelectric power and thus the environmental protection would be ensured. This will have profound effect on the welfare of the hill people. the large majority of these people now suffer from shortages of food and of fuel for cooking and warmth. They are often victims of tuberculosis anemias and other deseases of poverty. An excerpt from the report by a panel of international experts which included Dr.Roger Revelle, President Kennedy's Science Advisor and others in 1978 known as Indus Basin Research Assessment Group is enclosed as Appendix-V.

The next ranked site Tha kot also suffers from the same defects as Dasu as it has a dam of 205 meters. In the low Thakot a dam is of 60 meters makes available a net head of 114 meters due to the cutting of the loop in the river. Same arguments as for Dasu apply to patan one great advantage of Thakot site is that it is close to Tarbela but without a storage upstream they may not be economically justified particularly if high dams are to be constructed at these sites. The next site on Indus is Rakhiot which is located in the Indus Gorge close to the land slide of 1840-41. From the considerations of Index cost also with 0.097 $ per KWH which is high it is not a desirable project particularly as a dam of 140 meters is proposed with no storage. The last ranked site on Indus by MECO is yulbo which is about 89 KM upstream of Bunji. It is strange that Skardu dam has been ignored in the ranking though yublo which is 61 KM downstream of Skardu dam has been included. Even at this site a dam of 140 meters is proposed with a index cost of 0.135 $ per KWH and a index capacity of 710 MMW. As Bhasha is downstream of the site this site has no benefit of releases from storage. In conclusion it may be stated that none of the sites identified by MECO except Bunji are economically feasible and Bunji was already indentified by us. How come that an experienced and renowned firm like MECO has given no priority to the excellent storages of yugo and Skardu and the large hydro electric potential of the reach from Skardu to Bunji and selected a risky and uneconomical site like Bhasha and preferred the inferior hydroelectricsites mostly downstream of Bhasha. This shall be discussed in the next para as author of this paper had discussions in 1982 with MECO during formulation of studies as General Manager, planning Water WAPDA.

In the very first presentation made by MECO about the potential sites on Indus they had overlooked Shyok dam identified by Harza in 1962. The aauthor of this paper objected to this. On 24.10.1982 a meeting was held in the room of Member power, CIDA and MECO representatives discussed the status of the so called 'Disputed' area of Baltistan Gilgit agencies as India may object to the construction of works in this area as it is "disputed". The provisions of the Indus Basin Treaty were explained to them and it was made clear that India had no right to object to our construction of works on Western rivers, Indus, Jhelum and Chenab as these rivers' water were entirely allocated to Pakistan and it is India that has to take our permission for any work on these rivers in areas under their occupation. A copy of the Indus Basin Treaty was given to them and in one of the meetings the Pakistan Commissioner for Indus Waters was also present. It was made quite clear to them that Pakistan had sacrificed the three eastern rivers of Ravi, Bias and Sutlej for exclusive rights on the Western rivers. No country in the world had permanently surrendered the water rights as Pakistan did and this is why a clause exists in the treaty that Indus basin treaty should not be quoted as a precedent for any future, International water Treaty. After the meetings a Note was put to Member(power) by the author of this paper that the Consultants should not have any reservation about the disputed areas and should consider all sites on the Indus, Member (power) noted on the file "I do not know why they undertook rankng study in the first instance. Any way I agree that we must select the actual first ranked site and must ask MECO to make sure of it". A letter was issued by the author of this paper accordingly. Another serious lapse committed by the consultants was to suggest that Bhasha dam should be constructed instead of Kalabagh dam to ensure better power potential. WAPDA took strong exception to this as Kalabagh dam was in the final stages of investigation by International consultants whose investigations were being financed by UNDP and supervised by IBRD. A letter was issued to MECO not to open the issue of kalabagh dam at this stage and concentrate on their own ranking studies. Inspite of this the consultants in their final report 1985 gave alternatives with kalabagh dam and without the Kalabagh dam for the ranking study. It is strange that MECO had such dislike for Kalabagh dam whereas renowned dam consultants Chas T. Main for IBRD lieftink report of 1967 felt that Kalabagh dam is one of the best dams and is preferableeto Tarbela dam as Kalabagh is one of the few dams in the world where sluicing of sediments is possible. Tarbela dam had to be built because the investigations at that site were more advanced and due to the limited time available for the completion of Indus basin works. Kalabagh dam could not be taken up. Another attractive feature in the case of Tarbela dam was supposed to be the off channel storages from it which had not later proved feasible. We all know the problems faced at Tarbela and the heavy cost we had to pay for it. Due to the diversion of the three eastern riverrs to India, the need to augument supplies early was great before a major high dam on the Indus, the author of this paper suggested a low dam storage for about 3 MAF at Chashma in 1962 and the proposal for this was presented in a paper for the Engineering Congress. This dam also was not approved by the Federal Government as the Chashma Jhelum link had to be expedited. As this was an excellent site for a storage, the size of the project by providing the storage of 0.8 MAF in the Chashma barrage itself was approved with great difficulty as the IBRD saw the advantages of this project, but the West Pakistan Government had to pay for the extra cost of raised barrage. This storage served a very useful purpose before the completion of Tarbela dam. Though the barrage was not operated as suggested in the paper it has served a useful purpose and has not silted up in one year as predicted by some of our engineers. It still has about half million acre feet storage.

III. Comments on the ranking schemes in Jhelum, Kabut, Swat and Chitral basin.

Appendix-II, gives the ranking and Appendix-III Tabel 2-2 and 2-3 gives details of the schemes. As per Appendix II Kalangai is ranked as the eighth scheme. This dam on Swat river is 145 meters high with a storage of 1436 KM^3. The index cost is $ 0.143 per KWH index capacity 256 MW. An important point about this dam is that it submerges a large part of the intensively cultivated Swat Valley and the people will never allow this dam to be constructed, in fact the irrigation department initiated this dam in the fiftees and had to give it up. Another hydrological aspect of this dam is that it does not create new water by storing large surplus flood water as all the flood water is used up in down-stream canals.

The ninth ranking scheme is Kohala which is located on Jhelum river. This project has a net head of 134 meters and is one of the best projects. The cost is $ 0.144 KWH and index capacity of 85 MW which is quite reasonable. It may be stated that this scheme was considered as far back as sixtees by WAPDA, a paper was presented on this in the hydroelectric seminar of March 1975 by the author of this paper. The Minister of water and power chaired this seminar but unfortunately though all realised the great value of this scheme, things did not move as it involved construction of a tunnel of 6 miles long. If constructed in time it could have met the sereous shortage of power to the extent of 600 MW in the most critical period of April, May and June when both Tarbela and Mangla are at the lowest. MECO have given a low priority to this as they seem to be against run of the river projects though run of the river projects which supply power in the critical months should be given high priority and WAPDA is now doing it. Power at this site could be further increased by diversioon of supplies from Neelum which scheme also is being seriously pursud by WAPDA.

The tenth ranking scheme of MECO in Munda dam on Swat river which has a height of 205 meters and a storage of 1468 KM^3. the index cost is $ 0.161 per KWH and the index capacity is 492 MW which is not so economial. This dam site is downstream of Kalangai and the two are mutually exclusive, all the arguments against Kalangai apply to this also. If Kalangai is built first as the eighth ranking scheme and Munda built later it would submerge the power house and make it non functional. None of these schemes could come as high priority.

The eleventh ranked scheme in Karot on Jhelum river. This provides for a dam of 70 meters with no storage and a net head of only 51 meters. The index cost is $ 0.173 per KWH and index capacity 93 MW. There is nothing about this scheme which is worth consideration as the index cost is high. The consultants have not examined the Ghazi Ghariala Scheme from Indus. This is one of the high priority hydel schemes to generate 1000 MW which is being investigated by WAPDA. The greater Thal storage and hydro electric scheme has not been recommended by MECO as they felt there would not e enough water for this small storage of 1.6 MAF after Bhasha and/or Kalabagh. The point missed by MECO is that this storage is to act as an after regulation for fluctuations of Tarbela dam which would thus improve Tarbela dam operation. This project is supposed to be completed before any otgher dam on Indus and as such there is no problem. It is strange that a such an experienced firm has produced such a poor study. Canada has played a major role in the development of power projects in Pakistan and we were always satisfied with their consultants. In this connection we cannot absolve the Pakistani counter parts in WAPDA who hve failed to check the major deviatins in the approach to the ranking study against clear directive of Member (Power) in 1982. If checked in time we could have got a not only a better plan but saved the time and money wasted on Bhasha and other unfeasible schemes.

IV. Revised Proposals for the Development of Indus Water & Power Potential.

The 1967 IBRD Master Plan of Water and Powder identified certain projects on the Indus, the Revised Action Programme for irrigated agriculture prepared by WAPDA in 1979 reviewed the original plan of 1967 due to the changed conditions and identified Kalabagh dam as the next project on Indus. This was approved by the IBRD and UNDP In this Plan Kalabagh dam had been scheduled to begin in 1987 with probable completion by 1994. This was about five year deferral from the WAPDA Power Wing schedule of generation. The gap was expected to be filled up by other hydel and thermal projects mainly by Nuclear power projects which did not materalise thus creating serious shortages of power. The Kalabagh dam project was deferred in the revised Action Plan because of the heavy investment that was required which would affect other investments though the water from Kalabagh dam was required as soon as possible as a number of projects were pending for want of water from Kalabagh dam. The Kalabagh dam was fully justified purely from the water requirement point of view. It would be seen from this that Kalabagh dam has already been badly delayed. Any new dam on the Indus would take 10 to 15 years so there is no alternative but to go in for Kalabagh dam immediately.

An important study carried out in the Revised Action Programme was the shotage of water in the existing canal system which was affecting the yield of crops. Appendix-VI brings out that there is shortage of water in almost all months, the worst being in the months of May to July and in Rabi from December to March. The period May to July is most critical for both Tarbela and Mangla for power generation as by that time the reservoirs are at the lowest level. With Kalabagh the position may improve to some extent for Tarbela but the real solution to this can be met by a large carry over storge upstream upstream of Tarbela dam, such as Skardu the details of this dam have been discussed in the section of water and power potential of the upper Indus. Releases from the Skardu dam would meet irrigation shortages and help firm up the power generation of Tarbela, future Kalabagh and the hydel stations from Skardu downstream right upto the sea including barrge hydel schemes. There is another misconception about dams like Bhasha that it would help a great deal in increasing the life of Tarbela dam. The dead storage of Bhasha is only 2 KM^3 (1.8 MAF) which would silt up fast due to land slides apart from sediment brought by Indus water. In the original higher dam concept MECO had kept a dead storage of more than double this. An important point to be noted about dams like Tarela is that even if the dam silts, as long as the intake capacity is not affected it can generate the required power if enough supplies from an upstream carry over dam like Skardu are available which role cannot to be played by Bhasha which itself would use up its limited live storage of 7 KM^3 against Skardu's 19 KM^3 faster.

As discussed under the Para on 'comments on hydro electric ranking of Indus Projects by MECO' the Bunji hydel project should be taken up immeditely not only for Gilgit, Baltistan, Azad Kashmir and Chitral but also for China. As our hands shall be full when Kalabagh, Kohala Ghazi Ghariala, Greater Thal hydel are started and there would be shortage of funds also, it may worth while involving China in a joint venture for this. They can supply equipment and help us in construction in exchange for supply of some part of the power to China. China is short of power and would welcome this joint venture as China is our ideal friend. After the completion of Bunji hydro electric project China could help us in construction of Skardu dam. As already discussed completion of this dam would open up possibilities of large number of projects in the indus reach from Skardu to Bunji as this is the best reach of Indus for power generation. Besides it would firm up the run of the river Bunji hydel station. Another important point about Skardu hydel is that it can supply power to the south eastern part of Sinkiang via the Shigar river. Ashkole to Muztagh east pass. This is the route to the foot of K2 mountain and is used by the expeditions. Please see Appendix-VII. Another power line from Skardu to Khaplu upto Siachen Glacier could help our forward position for defence. There is no better means of transport in these hilly glaciated regions than overhead cable electric trolly line as ground movement in this area is very difficult and slow. In fact this power line could be completed after Bunji hydel.

V. Requirements of power for China particularly for the western region and joint ventures with Pakistan.

China has plans to settle 200 millin people in the Xinjiang Uighur (Sinking) region. At present it has a population of 14million mostly Muslim. For Industry and agriculture, power is a basic need if such embitious programme is to be carried out. Mr. Wang Qinqhua gives the following details about power development in China on the occasion of fortieth anniversary of the founding of the Peoples of Republic of China. Although China began to build power industry as early s 1882, the country more than half a century later, still had only several medium sized and small power plants worth a combined generating capacity of 1.85 million K.W. The country's power industrty began developing rapidly after new China was founded in 1949. Today China is the fourth largest power producer in the World, after United States, the Soviet Union and Japan. In 1988 the country had an aggregate generating capacity of 115 million K.W and generated 543 billion KWH of electricity. According to Chinese Ministry of Energy Industry Chaina's generating capacity and power production increased at an annual rate of 11.1 percent and 13:2 percent respectively in the past 40 years. The past in particular has seen a rapid growth of the power industry. Annual addition of power generting capacity reached 3.2 million KW in the early eightees and exceeded 10 million KW in 1987 and 1988. Another 12 million KW is expected to be added this year.

While thermal power plants suply most of the country's power needs 70,000 small hydropower stations provide electricity to 600 million rural residents. In many remote pastoral areas, mountain villages and islands, local people use electricity for grain and fodder processing and cooking, as well as lighting.

China has abundant coal and hydropower resources. Coal deposits reach an estimated 880 billion tons and hydropower resources if tapped have a generating capacity of 680 million KW currently thermal power plants provide 70 percent of the country's total power supply. Since the early seventies many power plants have been constructed in coal producing areas notably Shanxi and Hobei Provinces and inner Margolia in North China. As power needs shoot up in coastal areas following the implementatin of the open policy, big thermal power plants are being built in coastal port cities such as Dalian, Tianji Shanghai and Fuzhon.

Currently 119 large and medium thermal power plants are being constructed across the country. They have an aggregate generating capacity of 32 million KW.

In the meantime construction of hydroelectric stations has been speeded up. Along the yargtze river China's longest, are already a dozen large stations. After 14 years of continuous construction, the gezhouba hydropower station straddling the mainstream of yangtze was completed in 1988. The station hs 21 generators with a combined capacity of 2.7 million KW, the largest power facility in China. Many more are being constructed along the yangtze. Feasibility studies of the super large three gorge stations were completed in 1988, and its construction is expected to begin at the turn of the century, hydropower development also concentrates along the yellow river, the second longest in China and the Hongshui river in southern China. In the former, seven large stations have been built and another one is under construction on the latter are also built four big stations.

Compared with super abundance of hydropower resources, however such development is still too slow. Only eight percent of the country's total hydropowr resources has been utilized according to the energy industry ministry but the construction hs been accelerated. The ministry says hydropower stations will have a total generating capacity of 80 million KW at present. Stations now being built have an aggregate generating capacity of 24 million KW.

China is also going nuclear in power generation. Currently under construction are two Nuclear power projects the 300,000 KW Qinshan plant in the coastal province of Zhejiang and the 1.8 million KW Daya Bay plant in south China's Guandang province. they are scheduled for operation in 1990 and 1992 respectively.

'China's power industry, after 40 yers of development has grown into a vibrant sector of the national economy from an extremely weak basis' said Huang Yideng Minister of Energy Ministry. Huangs stated that the country's industry has entered a new stage which is characterised by the adoption of large capacity generators. The construction of large and super large stations and the erection of ultra high tension lines and extensive power grids.

Despite the fast developmnt of power industry in the past four decades, China is still suffering from serious power shortages. Many factories cannot operate at full capacity. The country needs an additional 80 billion KWH of electricity a year according to an estimate. An overheated economy and waste are two culprits of the shortages. The central government is now reducing capital construction and speeding up the construction of power projects to remedy the situation. Experts believe that this will take a long time to accomplish."

The China daily recently quoted Yue Luqur of the ministry of energy resources as saying each year Chhina was short of 30 million tonnes of coal, five million ton of oil and 50 million kilowatts of electricity. To alleviate the shortage China will spend 20 million Yuan (5.4 $ billion) starting this year 27 power projects including oil fields, coal mines and coal and hydropower stations.

The cost of elecricity from new plants wil be more than 0.2 yuan (0.05 cents) per KWH, more than doule the current level. An unpublished policy documents approved by plenary session of the communist party this month said prices of oil and coal would be gradually raised to help the energy sector Yue said one quarter of the 20 billion would come from abroad, but gave no details. Most foreign firms are not interested in energy investment because of long pay back period and the convertibility of Chinese currency which they would save if the power was sold domestically under the circumstances. China should be happy if it can get cheap power from Pakistan joint ventures for the Sinkiang region.

VI. Cooperation with China in other fields

The Northern areas have attracted considerable foreign tourists since the opening of Karakurm Highway. Two studies carried out in 1979 and 1981 indicatd an annual increase of 41 percent on this highway. Due to lack of facilities the tourists have not increased as expected. The main requirement which can help develop this area is electricity which can be made available from the projects already discussed. This area is ideal for adventure tourism as it has 35 out of world's 50 mountain peaks including the access to the second highest peak in the world-K-2. Recently studies have shown that trends in tourism are changing from four 'S' viz sun, sand, sea and sex to adventure because of pollution on beaches, change in tastes and fashions, strong ripple and substitution affects. In recent years adventure tourism has grown at an annual rate of about 40 percent throughout the world. The backward areas of both China and Pakistan would benefit from this increase. Though foreigners have great fascination for this area it is a pity that Pakistanis do not fully appreciate what a great country we live in. One reason for this is the lack of information, though it is ten years since Karakurm Highway was opened some people still feel it is a dangerous road. What is surprising is that some engineers feel that the road is subject to land slides etc. They fail to understand that maintenance has to be a regular feature of hilly roads. There is also a misunderstanding that the road cannot take heavy construction equipment. It is designed for 70 ton tanks and it can take all type of equipment. As our future for water and power lies in the northern areas we have to motivate the new generation of Pakistan to go and work there. The spirit is not lacking in our young men who have offered themselves for Jehad in Afghanistan and would also help with reconstruction of that war ravaged country. All that is required is the motivation for this economic Jehad for the development of Pakistan. It is well known that Harace Greely raised the slogan 'go west young man and grow with the country'. This slogan developed the western United States. Could we find a charismatic leader in Pakistan who can say, go north young man and grow with the country. The mineral wealth of this vast area has remained unexploited due to lack of communications and power now is the time for going in for this. When mineral tycoons look at these majestic mountain areas they exclaim 'what have you got inside perhaps those items you are looking for'. There are many things to investigate. Another of nature's marvel is the Deosai plain located at 14,000 ft. above sea level, 2500 sq. mile in area, one of the world's largest plain at this high attitude. Pakistan's highest lake, Sheosar is also located in this plain. The Deosai is locatd only 15 miles from Skardu. It has the finest pastures in summer and a veritable paradise for high attitude flowers. If scientifically managed this plain could be used for growing some of the finest flowers in summer. It may be stated here that during the formulation of sixth five year plain, export of flowers was considered an important source of foreign exchange for Pakistan. Doesai could supply large quantities of flowers with little effort as they grow naturally in this area. Another adventage of this vase plain is cattle breeding particularly yak and dzo (dzo is a cross between a yak and a cow and is used for ploughhing. China has offered to transfer its technology to Pakistan in this field and other fields. Deosai is subject to high winds in summer and this could be used for wind power untill we get hydroelectric power from Bunji hydel. There is a jeep road connecting Skardu to Deosai at present. With the availability of power from wind the main problems for agricultural and animal husbandry operations would be taken care of including tourism.

VII. Short term plan for energy generation

In preceeding section long term projects for the next 10-15years and beyond were discussed, in this section it is proposed to discuss the short term projects for the next 5-10 years. WAPDA is already implementing some of them and has plans to take up some more in the immediate future, these are mostly oil and gas fired thermal stations which are expensive. In the Revised Action programme prepared by the planning Division Water of WAPDA in 1979, considering costs of alternative energy uses, load growth rates, alternative use of natural gas, high import price of oil pricing effects and financing opportunities, it was concluded that Nuclear power would be the most suitable for filling the gap in the generation schedule caused by deferral of Kalabagh dam. Unfortunately we have not been luckly to get a Nuclear plant in the last decade, now that China has taken the initiative it is hoped they will start moving. This does not mean that kalabagh should be delayed any more. It is urgently required not only for power but for water for our old and new canals. Already our agricultural growth has been considerably affected by postponing this project apart from serious shortage of power. It is good that we have started using coal for power generation from Lakhra but in this connection some new developments in use of coal for power generation need to be considered as the methods now followed are costly. Large scale use of oil for power generation should be avoided as it increases the cost of generation beyond the capacity of the common man. It certainly does no credit that a new oil terminal at Karachi port for an annual import of a million tonnes of oil is being constructed.

(1) New Liquid coal formulation

A new liquid coal formulation hopes to compete in cost with fuel oil and natural gas. The product, called ultracarbo fluid 54 consists of 54 percent of coal 30 percent water 16 percent fuel oil. It is made in two steps in an ash removal step, coal is ground to 5 to 10 micrometer particles in water, oil is injected into the mixture to act as an aglomerant and the mixture is agitated. This causes hydro carbon particels in the coal to combine with fuel oil. Ash particles remain in suspension. Ash and water are separated from the coal/oil agglomerates by a vibrating seive, the coal/oil mixture is then partially dehydrated by centrifuge. Only pyritic sulphur is removed from the coal the ash content after treatment s 0.7-0.8 percent. In the second slurry formation step 0.5 percent weight of proprietary additives (mostly nonionic polyethoxylates) are mixed with water and added to the coal oil mixture. This quantity of additives is relatively low (about 50kg additive per metric ton of slurry) compared with other slurry processes. Technology transfer company cadet international (Lille) is now assembling patents on the work done by researcheers of the universite technologique be compared (UT.c campeiegne france) This process could be studied for future coal fired stations in Pakistan.

(2) Energy from rice husk

As we are in a very difficult position due to shortage of power, all possible resources of power have to be tapped until we complete major projects. One such source which has not been exploited in Pakistan is power from rice husk. Indonesia and Malaysia have used this source extensively. Every year approximately 80 million tonnes of rice husk are produced in the world. In Pakistan the volume available in quantities of 0.7 to 1.7 million tons per year and as it is not properly utilized it is causing serious enviromental problems such as water and air pollution. The use of rice husk for power generation has never been seriously considered though we are passing through the most severe power shortage. Although various analysis show that rice husk has a low calorific value (as comparted to fossil fuels) and rather high ash and silica contents,. nevertheless it is an important alternative source of energy. The energy value of rice husk (3000-36000 K coal per kg) is almost 40 percent of the value of the bitminous coal as per the statment of Engineer Mohammad Arif. The potential thermal energy per year that can be harvested from it comes out to 500 to 1200 MW which is not low considering our present shortage. Possible means of conversion of rice husk energy are:

(a) Extraction of electrical energy by steam turbine.

(b) Pyrolytic cracking rice husk.

(c) Rice husk gasifier system.

The extraction of electrical energy by steam turbine seems more feasible and as such it is being used in other countries of south east Asia. A continuous flow of rice husk is delivered to the furnace of a specially designed boiler where husk ignites and burns without fuel after initial heating by oil burner. The hot combustion gasses pass from the furnace through the heat recovery boiler and produce high pressure steam which drives electricity generating turbines. Excess steam is used through heat exchanger for drying wet paddy. This allows the rice mills to do away with the present heating system using light fuel oil which will result in substantial saving in operation cost. As an initial attempt small plants with capacity to generate 350 -500 KW with husk consumption of 1 to 1.5 tons could be developed in Pakistan. These plants may be attached with the existing rice Mills complexes to operate the machinery. In this connection it is also of interest to know that an advanced country like USA is using pea nut shells which had become an environmental hazard in the southern states of Georgia (the state of former president Carter). They used the simple technique of mixing the pea nut shells with coal in coal fired stations and thus got rid of the problem of disposing off the vast quantities of this material. It is a pity that we have not done research in use of local materials and biomass for power generation. The excess electricity from the rice mills may be supplied to the nearby villages through the national grid. This would be the cheapest and quickest way to electrify the villages. The transmission losses in the grid would also be reduced as power would be available close to the villages. The major rice growing areas are located in north eastern Punjab, Sind right bank of Indus and Kotri barrage areas. Most of these areas are comparatively backward and this proposal would help them in improving their economic standards. Some incentives could be given to the rice mills to undertake these generators in the first instance. In due course when they see the advantages they would go in for it in a big way.

Another possible area of cost recovery will be utilization of rice husk ash removed from the boiler for making cement. The cement may not be first class but is good enough for construction. With the high cost of cement ad shortages this cement shall help the rural area where very large structures are not required. The cost would be within the capacity of the rural population. An article by Ray Smith of the United Kingdom's Building Research Establishment (BRE) is enclosed as an Appendix-VIII.

It would be seen from the above that the use of rice husk would help in the village electrification and making available cheap cement by getting rid of the large mountains of rice husk which are polluting the environment through this method.

An ingenous method is followed by Greece for power generation in its coastal areas. This consists of growing green blue algae in the sea coast of greece in specially created compartments. Green blue algae is the fastest growing algae in the world and can produce enough biomass for gas generation and through it power generation. Why cannot we try this in the coastal areas of Sind and Baluchistan which are most backward? We have left the coastal people only with fishing which also is becoming difficult due to poaching by foreign vessels on our terrtonal waters which use modern methods and thus leave the poor local fishermen with nothing. A scheme for gas and power generation by Blue green Algae and finding imployment for the local coastal people could be examined.

(3) Power Generation from small Hydels

Power Generation from canal falls was started soon after independence due to the serious shortage of power, a number of power stations were constructed. But when power from Warsak, Mangla and Tarbela was available ad also from the very large gas and oil fired thermal stations these small hydel stations lost their importance particularly as the cost of civil works had gone up considerably. However in the early eightees the Planning Division Water initiated some proposal for power generation at barrages in addition to canals. The idea was to use the large perennial supplies at barrages for power generation. These stations could be larger than canal fall stations as they involve river flows but would also have greater generation capacity also. In the preliminary proposal the following capacities at abrrages were suggested:-

		Potential (KW)
1.	Kalabagh (Jinnah) Barrage	40,000
2.	Chashma barrage	70,000
3.	Taunsa barrage	55,000
4.	Guddu barrage	30,000
	Total:	195,000 Say 200 MW

These capacities were considerably enlarged later by GTZ consultants who were advising WAPDA. They raised the capacity of Chashma project from 70 MW to 270 without considering the serious affects on the operation of Chashma barrage. Though some model studies were carried out these were not enough to ensure the safe operation of the barrage. Mr.Nisar Ahmad former General Manager WAPDA advised WAPDA that Chashma barrage would be seriously affected by the prroposals of GTZ, The irrigation and power department also took serious objection to diversion of practically the whole discharge in most of the months leaving the barrage high and dry resulting in silting of the pond creating serious problems in operation and safety of the barrage. The problem was studied in some depth with fresh hydraulic model studies. The author of this paper was also one of Consultants to the irrigation and power department. The studies really proved the diversion of such large discharge of (106000 cusecs) definitely caused silting of the pond area. It was then decided by WAPDA that the plant capacity should be reduced to half. Proposal can be examined to have the power house in the middle of the Barrage downstream.

The Chashma hydel economics is very poor even for a full capacity of 270 MW, the reduction to half the size caannot be economically justified. The original project of 270 MW with 12 units cost $ 309.2 million with 61.43 percent foreign exchange. The cost per unit works to Rs.1.13 for a return of 15.5 percent. The financial return drops to 10.6 percent with the sale price of Rs. 0.7 per unit. The cost per KW is Rs.27,387 (one of the highest cost per KW) which the consultants state is high because of the high cost of civil works. The thermal generation alternative worked out based on steam plant using furnace oil gives a cost of power per unit of Rs.0.992 other thermal equivalents have not been worked out. A very important factor not considered by the consultants is the standard of economic analysis followed by WAPDA for its power projects. WAPDA recons project benefits to the extent of 40 percent only, consultants have assumed 100 percent benefits. Inspite of this the economic financial feasibility is poor. With the reduction to half its capacity and applying WAPDA rules on benefits the project becomes completely unfeasible economically. there seems to be little justification for this project particularly as even with half the capacity it could interfere with the operation of the barrage some what. The economics of the other barrages like Kalabagh, Taunsa and Guddu would be worse as the head availablle at these barrages is much less. When the planning division WAPDA originally conceived power generation at the barrages it was never imagined that the projects would be distorted to this extent and none in WAPDA seem to have pointed out this vast variation. In any case these projects are not worth taking up. It is high time WAPDA examines the economics of all these projects. It is certainly not worth taking the risk with the barrages which command millions of acres of land just for the sake of generation at the most 200 to 300 MW. There are better hydro electric projects elsewhere with no such risks.

(4) Energy from wind Turbines

The coastal areas of Sind and Baluchistan have enough velocities of wind which could be used for generation of power. Even an advanced country like USA is using wind for power generation as this is economical. In places with average wind speeds of 12 miles per hour or greater wind machines will soon compete with conventional sources of electricity and may eventually meet 20 to 30 percent of power needs. Commercial wind power development began in California in 1981 relying mostly on medium sized wind turbines with an average capacity of 30 to 100 KW. California's wind farm developers installed 1100 wind machines at 20 separate wind farms in 1982. Plans for a huge 126 MW wind farm using 300 foot high wind machine built by aerospace companies are on the anvil. Poineering wind farms have recently been started in Hawai, New England and the rocky mountains. A half dozen additional states are poised to follow. Europe where wind mills helped power in the early industrial revolution also have ambitious plans. The Netherlands is currently building a wind farm close behind are Denmark and West Germany. The above information is based on an article of 1983. The position must have changed much more, it is time Pakistan seriously examines this source for the remote coastal and the hilly areas. The present method of running long transmission lines should give way to mini grids powered by different sources of energy available locally.

VIII. Conclusion

Though shortage of funds is one of the factors for our slow progess in completion of power generation this is not the only factor. In 1975 David Hopper, Vice President of IBRD had toldd the then Chairman WAPDA that Pakistan is going to face a serious power crisis in the comming years as they have no projects for power generation. He told the Chairman that a small poor country like Bangla Desh had put up a port-folio of 30 power projects to the IBRD. He stated that funds shallnot be a constraint if proper projects are put up. No wonder Bangla Desh has very little load shedding whereas in Pakistan it is shattering our econmy. So we have failed in project preparation. To help Pakistan the IBRD had suggested that we should undertake a revision of the master plan for power as the one prepared in 1967 by the IBRD known as Leiftink plan had undergone major changes. They made the same proposal to the Water wing which is a smaller wing of WAPDA who immediately created a master planning division and completed the Revised Action Programme in 1979 under the supervision of IBRD. In fact some preliminary ideas on power planning were also studied by them but as power wing showed no interest, the idea of a master plan was given up. The only attempt made by the power wing on master planning was the MECO study for hydel ranking study which has been already discussed. Even this study was completed in 1985. No attempt was made to study other sources of power as it was assumed that natural gas and expensive imported oil would meet all out requirements in the absence of Nuclear power. Too much dependence was placed on Kalabagh dam and none of the other hydel stations suggested could be taken up.WAPDA alone may not be responsible for this as sanctions have to come from the Federal Government which delays them.

A valuable lesson that we can learn from past experience is that WAPDA should strengthen its in house planning Organization to act as a think tank for projects and to initiate new ideas. Complete dependence on consultants would not serve the purpose as we have to have a strong Organization which can guide and control them. Besides we have to create a Research and development wing to study new technologies on power generation It is only recently that power wing has upgraded the post of Chief Engineer planning to general Manager, whereas water wing created this post in 1975 and it has a large multi disciplinary organization which can tackle any situation. It is true that in the power wing Engineers are not willing to work in the planning division but incentives could be created for them.

IX. Summary and Recommendations

(1) The economy is suffering a heavy loss due to load shedding, WAPDA needs to add at least 1000 MW per year to the system. Financing would be difficult by foreign loans under IMF stipulations which require investment to be financed by an increase in taxation. Exclusion of WAPDA from the Government Budget ceiling would enable it to finance large new projects through commercial borrowing on grounds of economic viability of the projects concerned.

(2) The best way to meet power shortage is through hydroelectric power generation. The upper Indus has the best water and power potential in Pakistan. Skardu dam and the reach of the river Indus from Skardu to Bunji offer the best sites for water and power projects. Skardu dam has about thrice the capacity of Bhasha dam (suggested by MECO) with a life five times that of Bhasha. Even yugo dam on Shyok river has as much capacity as Bhasha with a life of about four times that of Bhasha.

(3) Bhasha is located in the most dangerous Indus gorge subject to seismic action and heavy mountain slides. There is no rock in the foundation upto 55 meters. It susbmerges 100 KM of the karakurm Hoghway and settled valleys on either side of the river upto 100KM. It cannot firm up the excellent hydroelectric sites in the reach Skardu to Bunji. As considerable work has been done at Bhasha site it may however be kept in the list of schemes for ranking for the present to study if we can make use of the information for a modified smaller scheme.

(4) The Bunji site develops a drop of 800 ft by having a tunnel of 4-1/2 miles only. This is the most economical site on the Indus for immediate power generation. The distance from Bunji to the national grid via Kunhar is the same as the distance of Bhasha to grid via Indus. The site is located in the centre of gilgit and Baltistan agency and its

distance from Muzaffarabad, the khunjrab pass and sandhur pass of chitral is about 250 KM. It could thus supply power to China, Azad Kashmir and Chitral at very economic cost.

(5) The other dam sites recommended by MECO downstream of Bhasha such as Dasu and high Thakot are all in 200 meters range and some even higher than Bhasha with no useful storage and suffer from the same defects and are even nearer to the zones of seismic activity, low Thakot is the best as it is nearest to Tarbela and away from the zones of destructive seismic activity. This scheme could be considered even in the short term plan emmediately along with Bunji.

(6) The sits upstream of Bhasha identified by MECO are also un-economical without an upstream storage.

(7) Preference of Bhasha over excellent carryover storage like Skardu seems to be a deliberate attempt to have a dam outside Gilgit and Baltistan under the misunderstanding that this is 'disputed' area between India and Pakistan. MECO have been unfair to Skardu by not even considering power generation at the site which shows their lack of interest in this excellent site. Skardu is only 150 KM upstream Bunji by road and for power lines it could be considerably reduced. Though Bunji is recommended as No.2 priority scheme there is little sense in ignoring Skardu with such a great potential.

(8) Appraisal of projects by MECO on Jhelum, Swat, Kabul and Chitral is sketchy. The only new site proposed by them on Jhelum at karote is not attractive either. They have not commented on Ghazi Ghariala which is a good project nor they have recommended greater Thal storage hydel project.

(9) The (RAP) Revised Action Programme for irrigated agriculture prepared by WAPDA in 1979 worked out the shortage of water supplies to the existing canals, it suggested that there is shortage of supplies for the optimum yeilds in all the months but severe shortages exist from May to July and in Rabi from December to March. May to July is the time of critical power shortage also as both Tarbela and Mangla are at their lowest level thus also restricting tubewell pumping. The RAP recommended immediate implementation of Kalabagh dam to meet these shortages by 1994 at the latest.

(10) As a long term project Skardu could be taken up with Bunji to precede Skardu. These two projects could be under taken as a joint venture with China as we can supply some of the power to Sinkiang. This would reduce our share of the costs and would be within our means by avoiding western country loans and the IMF conditionalities. This

shall help develop gilgit Baltistan, Azad Kashmir and Chitral. China is short of power and should be happy to have a joint venture with Pakistan. There could be cooperation with China in other fields like tourism and mineral development also.

(11) For the short term plan apart from oil and gas fired thermal stations coal fired stations based on new liquid coal formulation known as ultracarbo fluid -54 may be examined for the future coal stations.

(12) As we have large quantities of rice husk polluting the country side power generation from rice husk at the rice husking mills could be taken up. The ash from this could be used for making cement. Possibilities of growing blue green algae in the coastal regions of Sind and Baluchistan for gas and power generation could be examined. This is the simplest way of rural electrification and save us the transmission losses.

(13) Power generation from wind turbines is ideal for coastal and hilly areas as this is the cheapest. Even advanced countries like USA Europe are using this now.

(14) The low head hydroelectric projects at barrages need to be reviewed as they seriously affect the operation of the barrages unless the capacity is cut down to very uneconmical size. Other hydel stations such as Kohala, Ghazi Gharialia, greater thal should be expedited instead.

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LIST OF APPENDICES

Appendix IA- Plan and profile Indus river (Km 2080 to Km 2480) Shyok and Gilgit rivers MECO-1985.

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1D- Indus river inventory schemes Bunji dam and hydroelectric scheme MECO 1985.

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Appendix-II- Diagram of annual energy potentials-Rank after Bhasha by MECO - 1985.

III- Inventory of Schemes - Indus river basin, Jhelum river basin, Kkabul, Swat and Chitral rivers basin (3 sheets) by MECO-1985.

IV- Diagram from paper Engineering implications of impoundment of the Indus river by an earth quake induced land slide by James A Code and Sadiq Serhindi ASCE Seattle 1986.

V- Excerpts from the Indus basin research assessment group report 1978.

VI- Statement of crop water requirement and water supply at water course head from the Revised Action Programme WAPDA planning Division 1979.

VII- A map of upper Indus showing road to SinKiang from Skardu via East Mustagh pass and to Siachin glacier.

VIII- An article by Ray Smith of the U.K. building Research Establishment (BRE) 1989.

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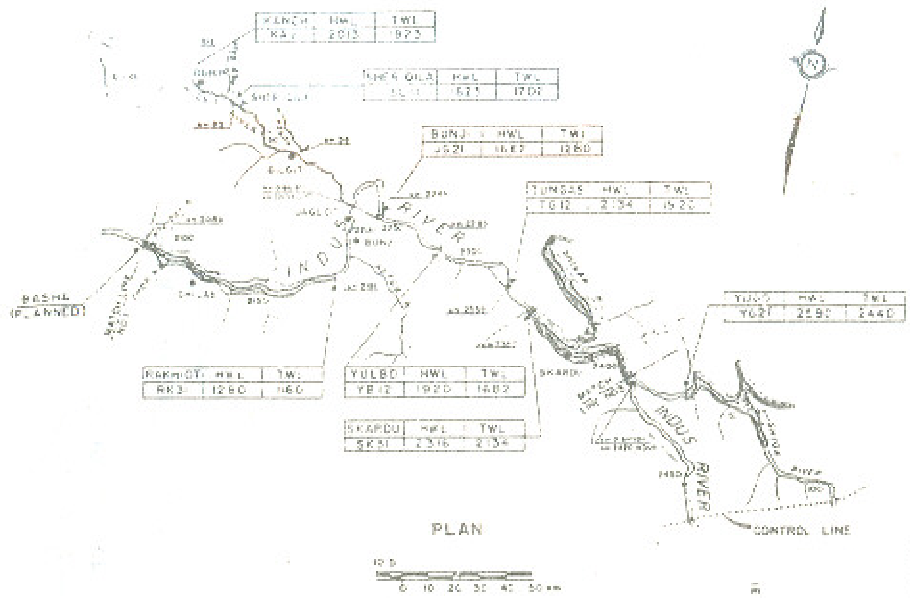
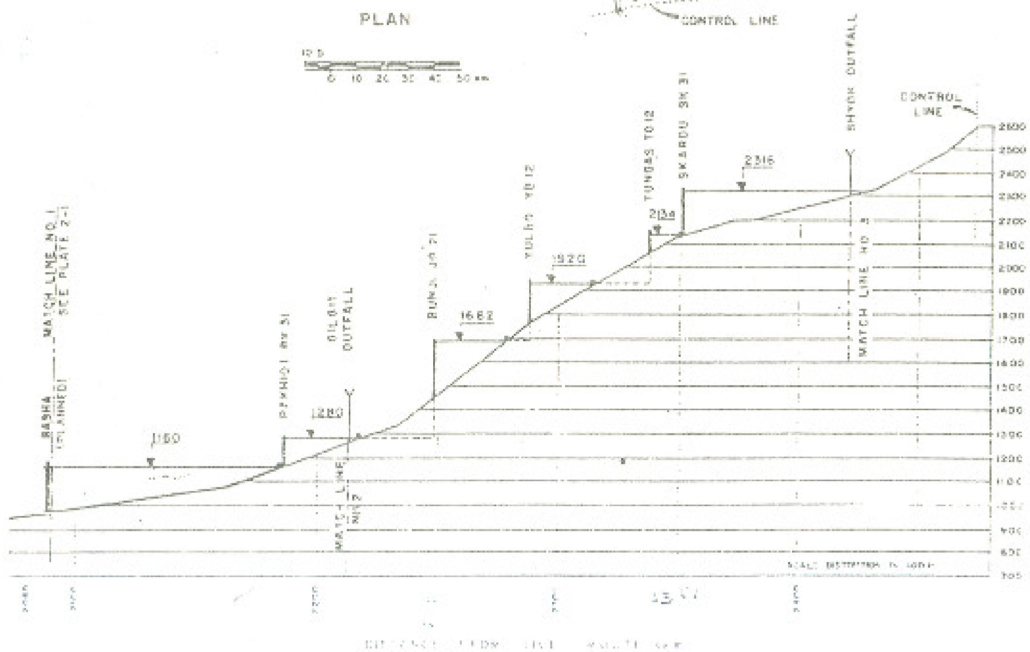
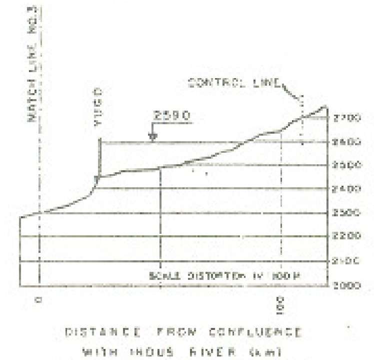
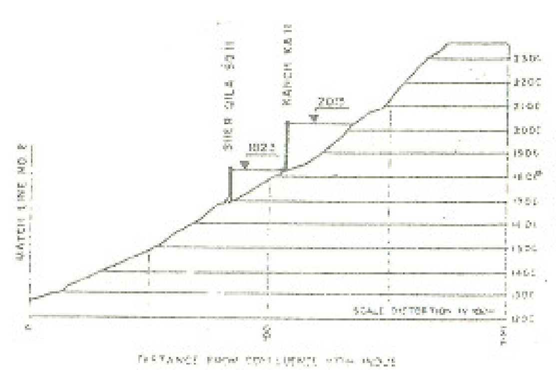






PROFILE OF SHYOK RIVER



PROFILE OF GILGIT RIVER

LEGEND

POWER TITLE

SCHEMES

SKARDU	HWL	TWL
SK31	2316	2134

DISTANCE FROM RIVER MOUTH

HYDROELECTRIC INVENTORY AND RANKING PAKISTAN

PLAN AND PROFILE

INDUS RIVER (km 2080 To km 2480)

SHYOK AND GILGIT RIVERS

PLATE 2-2

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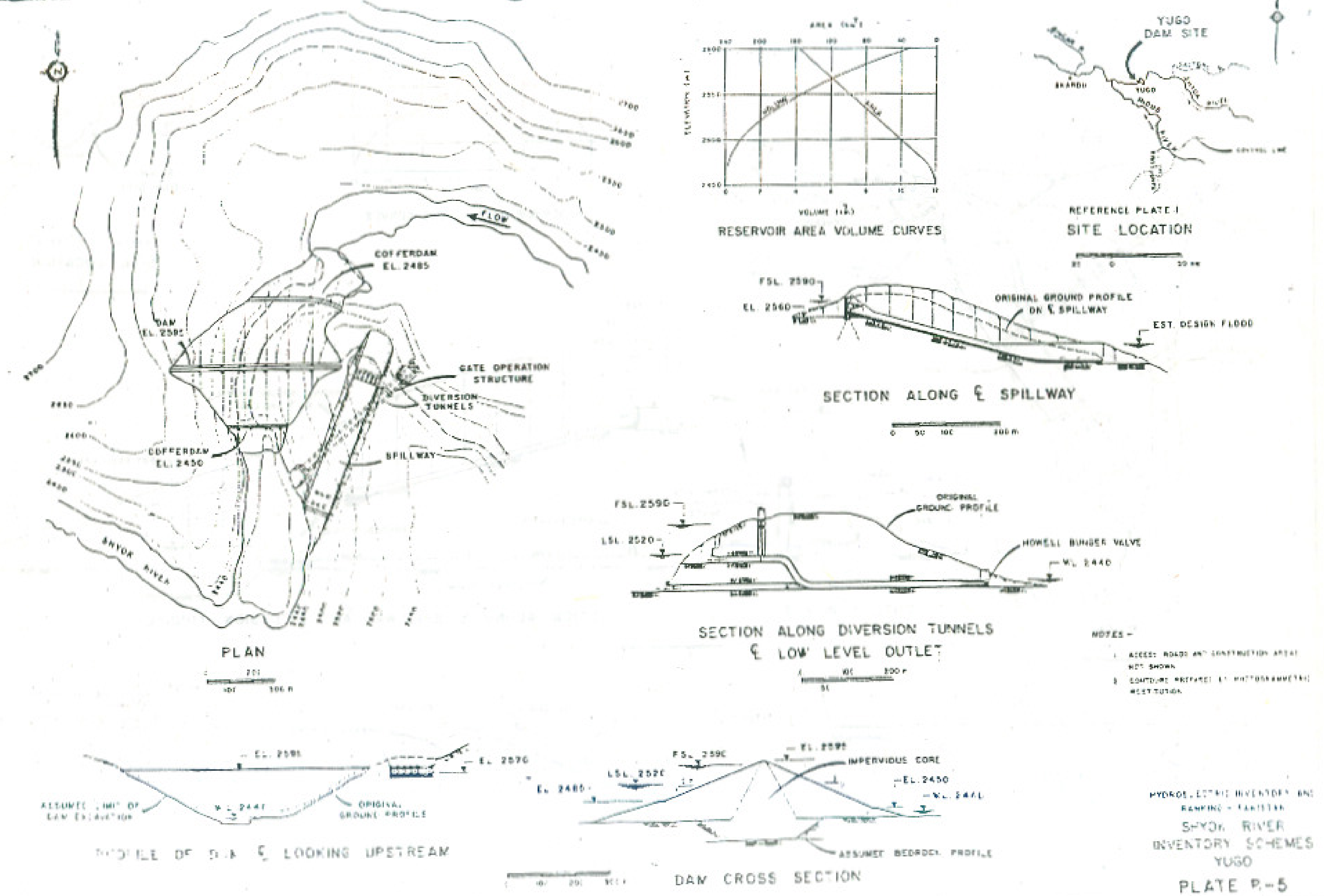

NOTES –

1. ACCESS ROADS AND CONSTRUCTION AREAS NOT SHOWN.
2. CONTOURS PREPARED BY PHOTOGRAMMETRIC RESTITUTION.

HYDROELECTRIC INVENTORY AND RANKING – PAKISTAN

SHYOK RIVER INVENTORY SCHEMES YUGO

PLATE P.-5

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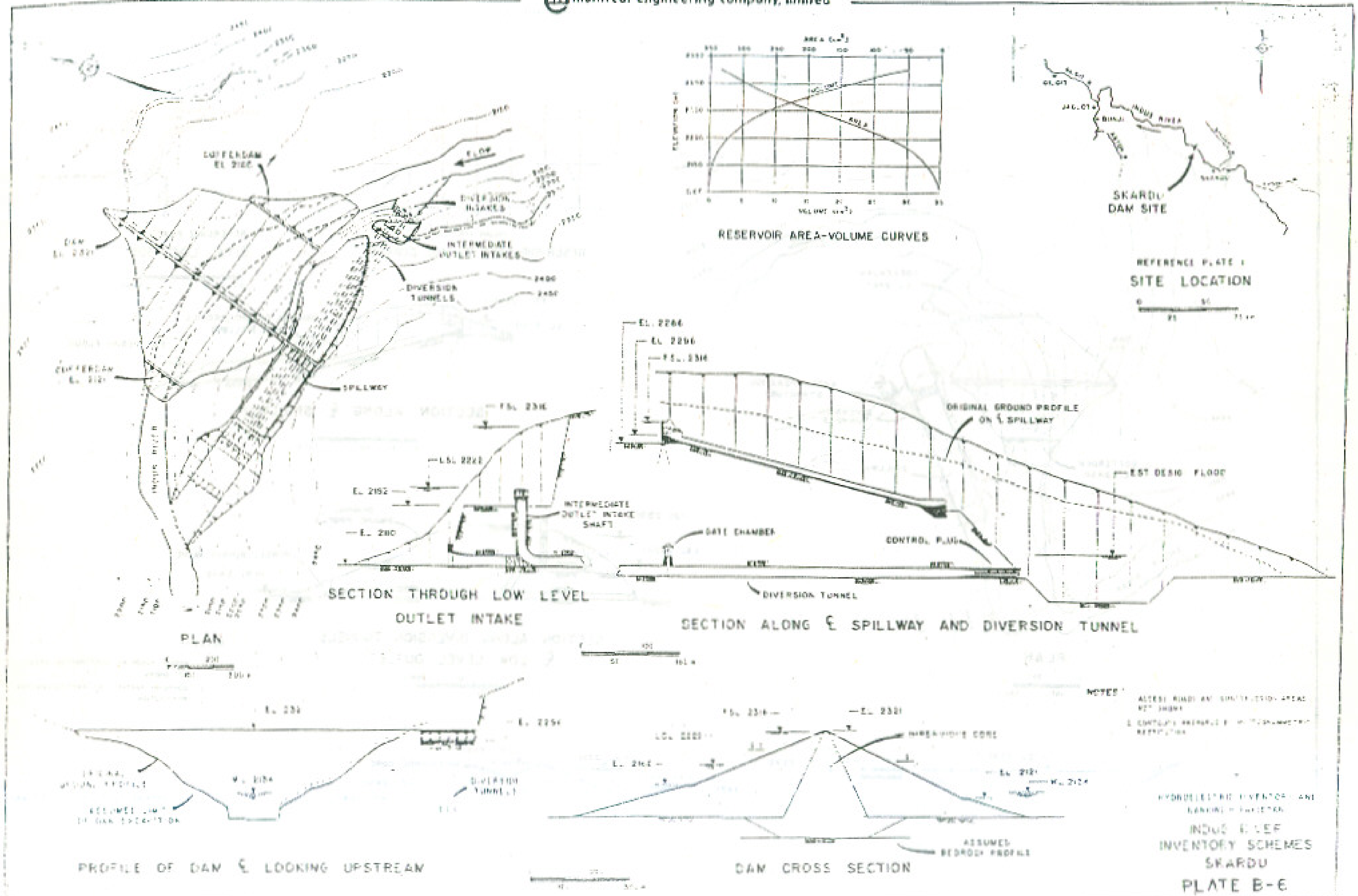
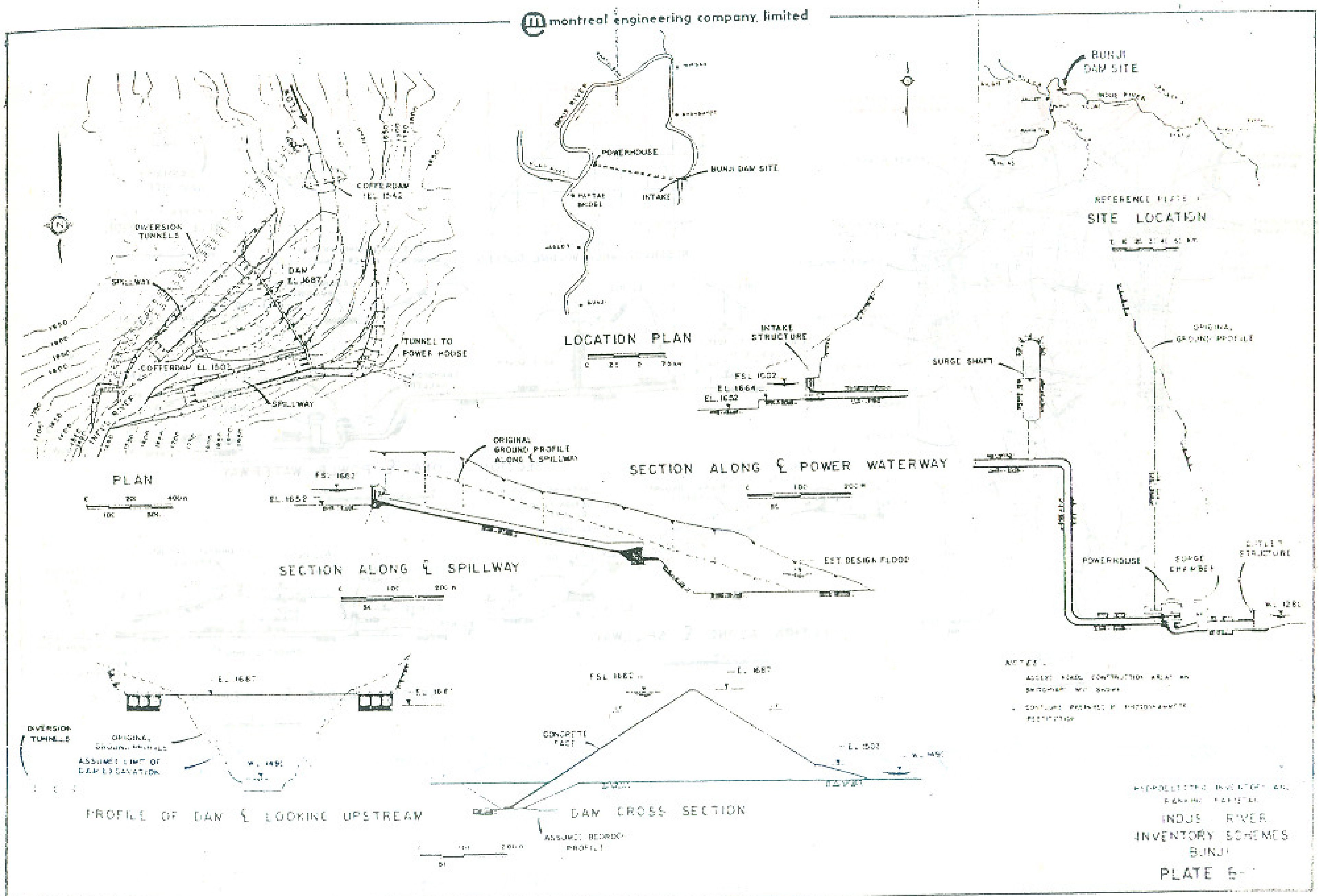
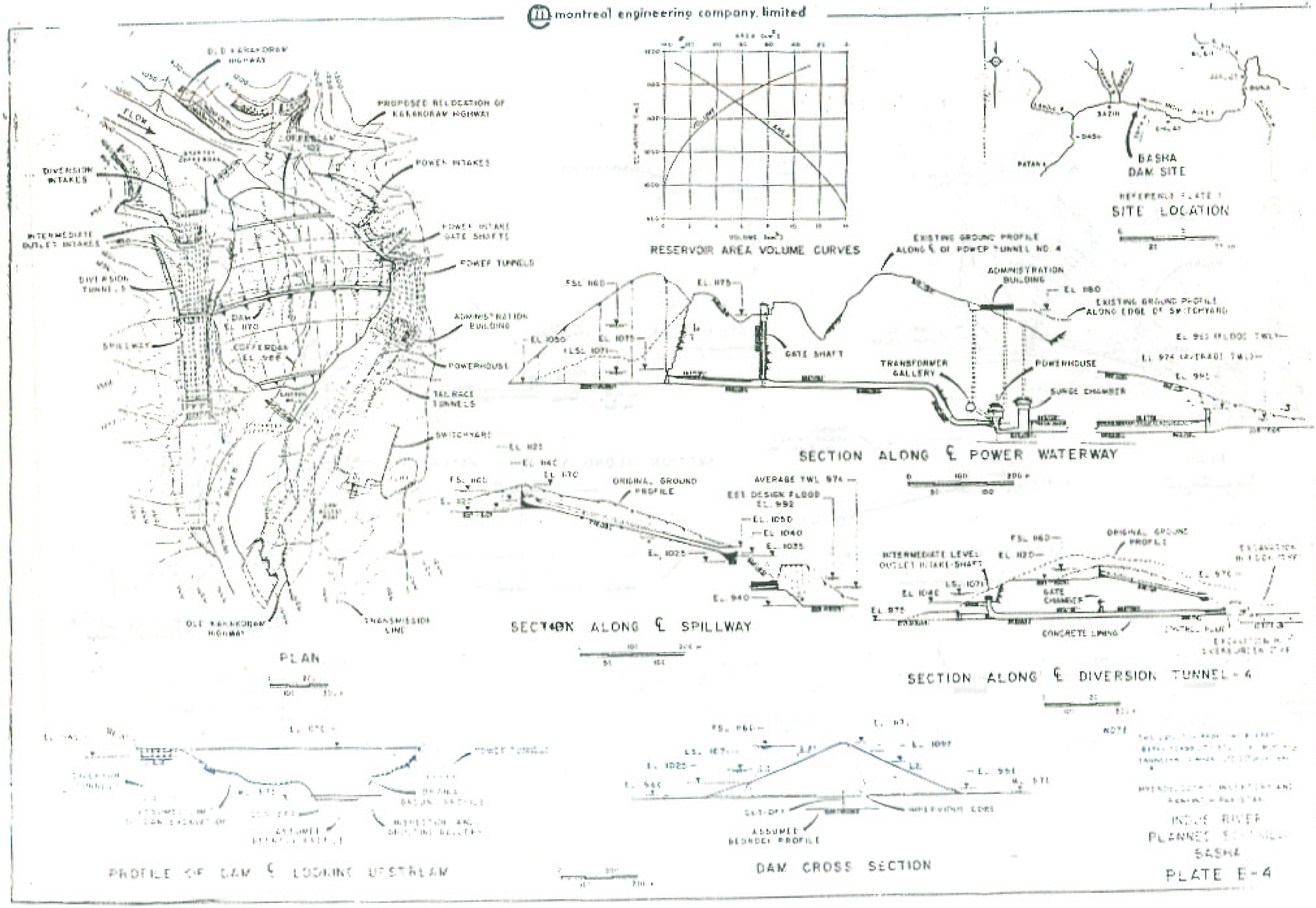


HYDROELECTRIC INVENTORY AND RANKING - PAKISTAN

INDUS RIVER
INVENTORY SCHEMES
SKARDU

PLATE B-6


montreal engineering company, limited
PLAN
COFFERDAM EL. 1542
DIVERSION TUNNELS
SPILLWAY
DAM EL. 1687
TUNNEL TO POWER HOUSE
COFFERDAM EL. 1507
LOCATION PLAN
POWERHOUSE
BUNJI DAM SITE
INTAKE
INTAKE STRUCTURE
FSL 1682
EL. 1664
EL. 1652
SURGE SHAFT
BUNJI DAM SITE
SITE LOCATION
ORIGINAL GROUND PROFILE
ORIGINAL GROUND PROFILE ALONG ℄ SPILLWAY
SECTION ALONG ℄ POWER WATERWAY
SECTION ALONG ℄ SPILLWAY
EST. DESIGN FLOOD
POWERHOUSE
SURGE CHAMBER
OUTLET STRUCTURE
W.L. 1281
NOTES
EL. 1687
DIVERSION TUNNELS
ORIGINAL GROUND PROFILE
ASSUMED LIMIT OF DAM EXCAVATION
W.L. 1481
PROFILE OF DAM ℄ LOOKING UPSTREAM
FSL 1682
EL. 1687
CONCRETE FACE
EL. 1507
DAM CROSS SECTION
ASSUMED BEDROCK PROFILE
INDUS RIVER
INVENTORY SCHEMES
BUNJI
PLATE 6-1



montreal engineering company, limited
OLD KARAKORAM HIGHWAY
PROPOSED RELOCATION OF KARAKORAM HIGHWAY
FLOW
COFFERDAM
POWER INTAKES
DIVERSION INTAKES
INTERMEDIATE OUTLET INTAKES
POWER INTAKE GATE SHAFTS
POWER TUNNELS
DIVERSION TUNNEL 5
DAM EL 1170
ADMINISTRATION BUILDING
SPILLWAY
COFFERDAM EL 986
POWERHOUSE
TAILRACE TUNNELS
SWITCHYARD
RIVER
OLD KARAKORAM HIGHWAY
TRANSMISSION LINE
PLAN
RESERVOIR AREA VOLUME CURVES
BASHA DAM SITE
SATIN
PATAN
SITE LOCATION
EXISTING GROUND PROFILE ALONG ℄ OF POWER TUNNEL NO. 4
FSL 1160
EL 1175
EL 1050
EL 1075
FLSL 1071
GATE SHAFT
TRANSFORMER GALLERY
ADMINISTRATION BUILDING
EL 1180
EXISTING GROUND PROFILE ALONG EDGE OF SWITCHYARD
POWERHOUSE
SURGE CHAMBER
EL 974 (AVERAGE TWL)
SECTION ALONG ℄ POWER WATERWAY
FSL 1160
EL 1170
ORIGINAL GROUND PROFILE
AVERAGE TWL 974
EST DESIGN FLOOD EL 992
EL 1050
EL 1040
EL 1035
EL 1025
EL 940
SECTION ALONG ℄ SPILLWAY
FSL 1160
ORIGINAL GROUND PROFILE
INTERMEDIATE LEVEL OUTLET INTAKE-SHAFT
EL 1120
LSL 1071
EL 1048
GATE CHAMBER
EL 975
EL 976
CONCRETE LINING
SECTION ALONG ℄ DIVERSION TUNNEL - 4
PROFILE OF DAM ℄ LOOKING UPSTREAM
FSL 1160
EL 1025
EL 1097
EL 961
CUT-OFF
ASSUMED BEDROCK PROFILE
IMPERVIOUS CORE
DAM CROSS SECTION
NOTE
INDUS RIVER
BASHA
PLATE E-4

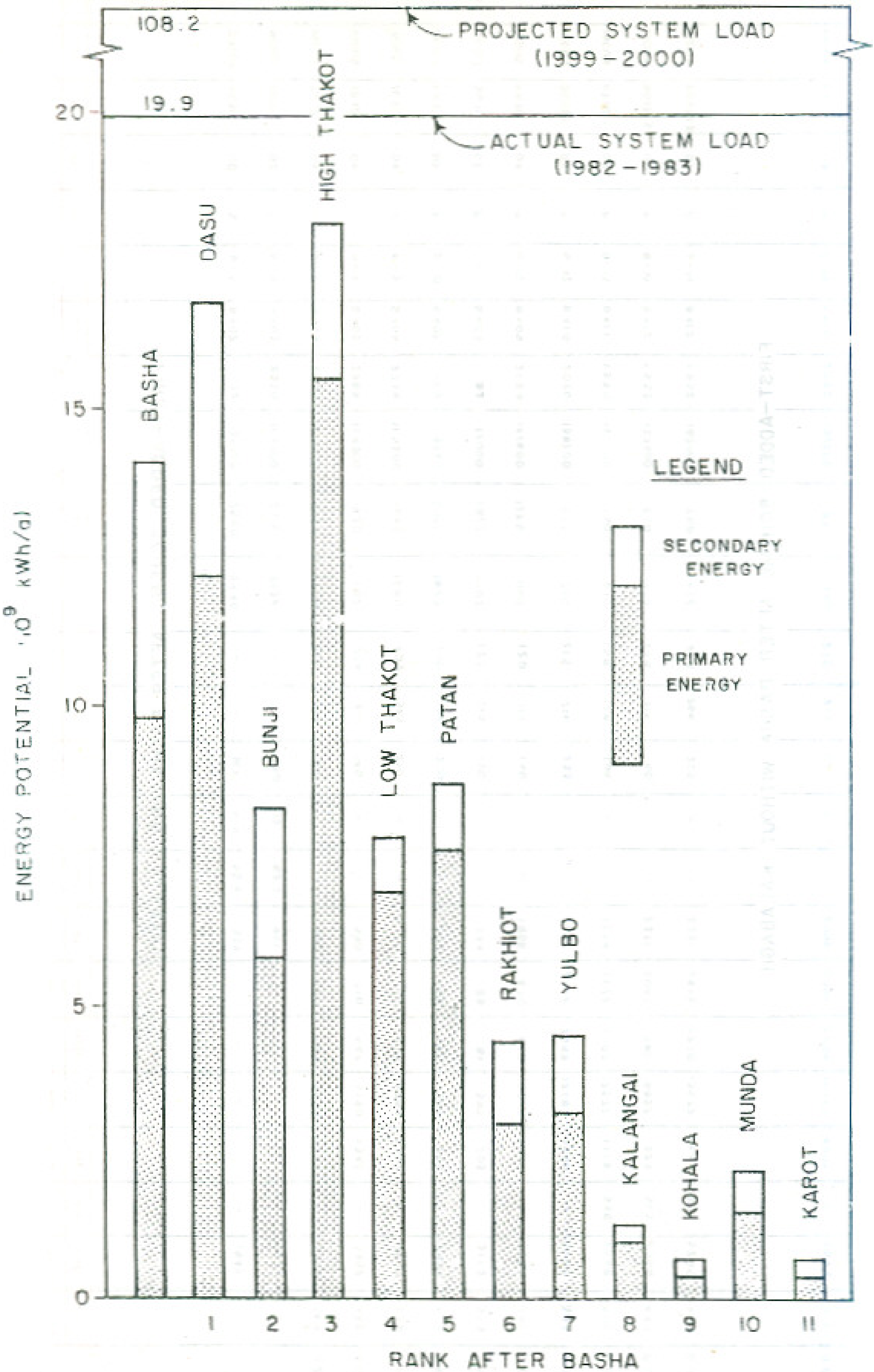


FIGURE I
AVERAGE ANNUAL ENERGY POTENTIALS

TABLE 2-1
INVENTORY OF SCHEMES-INDUS RIVER BASIN

REFERENCE DATA							PHYSICAL CHARACTERISTICS										POWER AND COST DATA										REMARKS
SCHEME	RIVER	ALTERNATIVE	REVISION	PURPOSE POWER-P STORAGE-S	DRAWING REFERENCE	TEXT REFERENCE	APPROX DIST FROM MOUTH km	DRAINAGE AREA km²	ELEVATION ABOVE MEAN SEA LEVEL: NORM MAX HEADWATER LEVEL m	ELEVATION ABOVE MEAN SEA LEVEL: NORMAL TAILWATER LEVEL m	GROSS HEAD m	NET HEAD m	HEIGHT OF DAM m	LIVE STORAGE VOLUME: VOLUME km³	LIVE STORAGE VOLUME: % OF ANNUAL FLOW	AVERAGE FLOW m³/s	INDEX CAPACITY AT PLANT MW	MINIMUM CAPACITY DELIVERED MW	PRIMARY ENERGY DELIVERED GWh/a	SECONDARY ENERGY DELIVERED GWh/a	ADDITIONAL COMB TURB CAPACITY	TOTAL INVESTMENT COST (EXCL IDC) 10⁶ US $	NET ANNUAL COST (INCL IDC) 10⁶ US $	INDEX COST (INCL IDC) US $/kWh	INCREMENTAL CAPACITY INDEX (INCL TRANS) US $/kW	TRANSMISSION INDEX COST (EXCL IDC) US $/kW	
(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	[illegible]
							FIRST-ADDED SCHEME AFTER BASHA AND KALABAGH																				FOR STORAGE [illegible] SCHEMES [illegible] STORAGE INDEX (10^6 US $/km³)
UGO	SHYOK	YG 31	00	S	B-5	B 402	22	33700	2590	2440	–	–	165	5.9	55.4	338	–	–	–	–	–	1943	–	–	–	–	[illegible]
KARDU	INDUS	SK 31	02	S	B-6	B 403	2550	112700	2316	2134	–	–	230	19	63.3	951	–	–	–	–	–	3829	–	–	–	–	202
UNGAS	INDUS	TG 112	04	P	B-7	B 404	2339	113000	2134	1920	214	187	127	–	–	962	625	588	2809	1147	–	3472	568	0.202	2069	595	
ULBO	INDUS	YB 122	04	P	B-8	B 405	2289	114200	1920	1682	238	211	140	–	–	990	710	667	3190	1342	–	2852	432	0.135	1740	509	
UNJI	INDUS	JG 212	04	P	B-9	B 406	2249	115600	1682	1280	402	379	210	–	–	1025	1290	1213	5793	2492	–	2689	335	0.058	964	291	
ANCH	GILGIT	KA 11	03	P	B-10	B 407	102	9740	2013	1823	190	186	200	–	–	207	122	115	549	283	–	2759	478	0.871	3610	2814	
HER QILA	GILGIT	SO 11	02	P	–	B 408	83	11000	1823	1702	121	119	130	–	–	234	88	83	395	203	–	3112	599	1.517	4620	3120	
AKHIOT	INDUS	RK 112	04	P	B-11	B 409	2188	147600	1280	1160	120	118	140	–	–	1858	670	630	3010	1347	–	2216	291	0.097	952	450	
ASU	INDUS	DS113K	04	P	B-12	B 410	2020	158700	975	760	215	211	235	–	–	2099	2712	2549	12181	4600	–	3107	332	0.027	391	132	
ATAN	INDUS	PT 112 S	08	P	B-13	B 411	1990	160700	760	610	150	128	104	–	–	2254	1172	1102	7577	1119	590	2968	501	0.071	1647	135	
HAKOT	INDUS	BG 132 S	04	P	B-15	B 412	1952	162400	610	472	138	114	60	–	–	2337	1043	980	6897	923	565	2566	443	0.069	1879	114	
HAKOT	INDUS	BQ 232 S	01	P	B-14	B 412	1952	162400	760	472	288	264	205	–	–	2337	2415	2270	15972	2137	1308	5200	947	0.064	921	92	
							FIRST-ADDED SCHEME AFTER BASHA WITHOUT KALABAGH																				
ASU	INDUS	DS113	04	P	B-12	B410	2020	158700	975	760	215	211	235	–	–	2099	2398	2254	10767	4807	–	3044	312	0.029	416	143	
ATAN	INDUS	PT 111 S	02	P	B-13	B 411	1990	160700	760	610	150	128	104	–	–	2254	1172	1102	7027	1496	449	2968	484	0.073	1647	135	
HAKOT	INDUS	BQ131S	06	P	B-15	B 412	1952	162400	610	472	138	114	60	–	–	2337	1043	980	6619	1192	494	2566	431	0.070	1879	114	
HAKOT	INDUS	BQ231S	01	P	B-14	B 412	1952	162400	760	472	288	264	205	–	–	2337	2415	2270	15328	2760	1144	5200	918	0.065	921	92	

TABLE 2-2

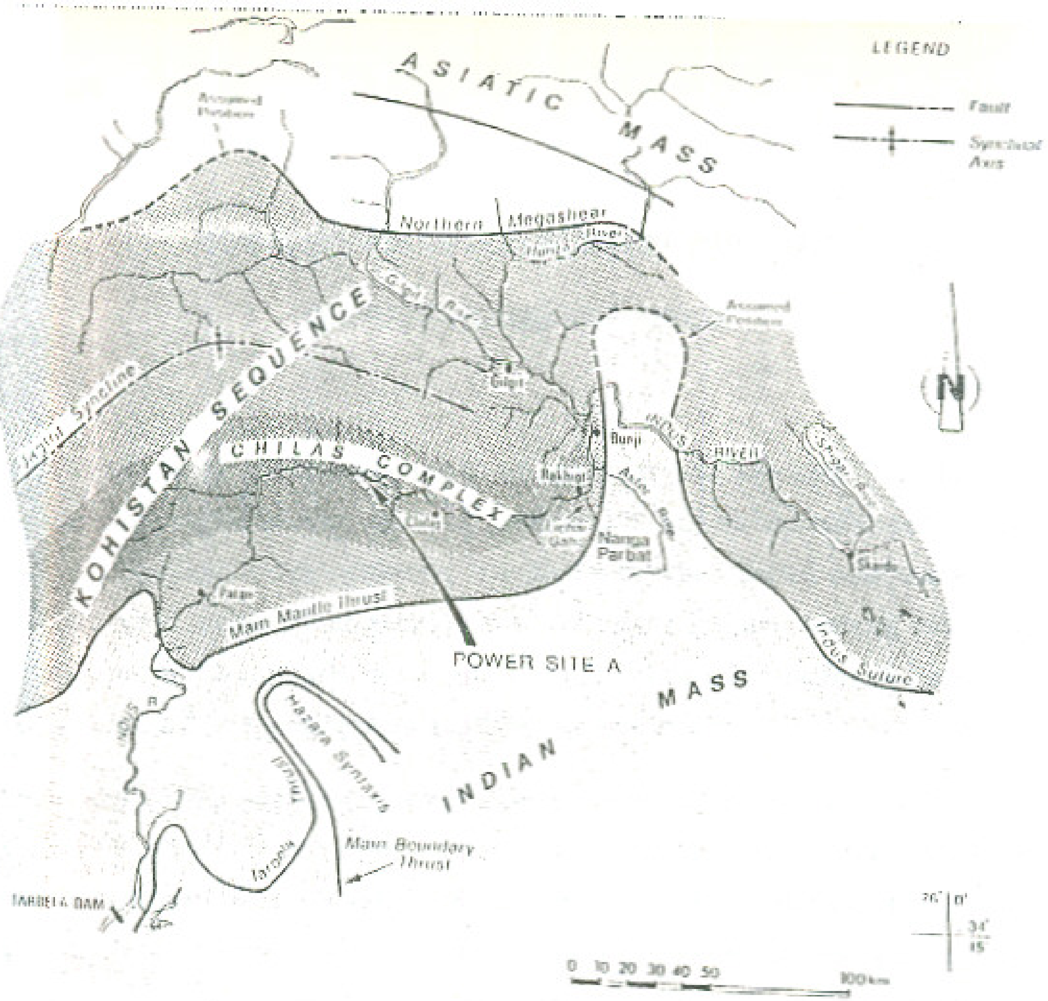
INVENTORY OF SCHEMES - JHELUM RIVER BASIN

REFERENCE DATA						PHYSICAL CHARACTERISTICS										POWER AND COST DATA												REMARKS
RIVER	ALTERNATIVE	REVISION	PURPOSE POWER-P STORAGE-S DIVERSION-D	DRAWING REFERENCE	TEXT REFERENCE	APPROX DIST. FROM MOUTH km	DRAINAGE AREA km²	ELEVATION ABOVE MEAN SEA LEVEL: NORM. MAX. HEADWATER LEVEL m	ELEVATION ABOVE MEAN SEA LEVEL: NORMAL TAILWATER LEVEL m	GROSS HEAD m	NET HEAD m	HEIGHT OF DAM m	LIVE STORAGE VOLUME: VOLUME km³	LIVE STORAGE VOLUME: % OF ANNUAL FLOW	AVERAGE FLOW m³/s	INDEX CAPACITY AT PLANT MW	MINIMUM CAPACITY DELIVERED MW	PRIMARY ENERGY DELIVERED GWh/a	SECONDARY ENERGY DELIVERED GWh/a	ADDITIONAL CONSTRUCTION CAPACITY MW	TOTAL INVESTMENT COST (EXCL. IDC) 10⁶ US$	NET ANNUAL COST (INCL. IDC) 10⁶ US$	INDEX COST (INCL. IDC) US $/kWh	INCREMENTAL CAPACITY INDEX (INCL. TR.) US $/kW	TRANSMISSION INDEX COST (EXCL. IDC) US $/kW	
(1)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)
										FIRST - ADDED SCHEMES																
NEELUM	NJ II	01	P&D	C-6	C405	44	6680	998	842	156	125	30	—	—	316	76	71	341	239	—	568	97	0.284	5705	79	
JHELUM	KH II	01	P	C-7	C406	476	14200	777	610	167	134	36	—	—	349	85	80	382	290	—	404	55	0.144	3368	71	
KUNHAR	NR II	03	P&S	C-3	C402	112	1040	2560	2208	352	289	195	0.306	19.8	49	177	166	513	214	—	710	98	0.192	1296	67	
KUNHAR	SU II	03	P&S	C-4	C403	93	1350	2208	1268	940	800	160	0.149	6.9	64	332	312	1303	582	—	1678	255	0.196	1526	61	
KUNHAR	PO II	02	P&S	C-5	C404	12	2440	838	733	105	103	130	0.320	9.6	106	133	125	307	238	—	515	66	0.215	665	36	
JHELUM	AB II	02	P	C-8	C407	421	25100	610	557	53	52	80	—	—	809	90	85	406	295	—	946	135	0.333	1092	121	
JHELUM	ML II	02	P	C-9	C408	400	26100	557	504	53	52	75	—	—	825	93	87	419	307	—	895	122	0.292	986	99	
JHELUM	AP II	02	P	C-10	C409	375	26600	481	433	48	47	70	—	—	833	86	81	385	285	—	733	96	0.250	991	88	
JHELUM	KR II	02	P	C-11	C410	355	26700	433	381	52	51	70	—	—	834	93	87	419	308	—	589	73	0.173	1091	98	
										COMBINATION SCHEMES																
NEELUM JHELUM	NJ II KH II D XXH IID	01 01 01	P&D P —	C-6 C-7 —	C405 C406 —	44 476 —	14200	998 777	842 610	156 167	125 134	30 36	— — —	— — —	67 349 416	76 187 263	71 176 247	341 839 1180	239 616 855	—	568 510 1078	166	0.140	—	—	
KUNHAR KUNHAR	NR II SU IIS XSU IIS	03 03 03	P&S P&S —	C-3 C-4 —	C402 C403 —	112 93 —	1350	2560 2208	2208 1268	352 940	289 800	195 160*	0.306 0.149 0.455	22.5	— 64 64	177 609 786	166 573 739	513 2391 2904	214 587 801	—	710 1915 2625	407	0.140	—	—	
KUNHAR KUNHAR	— PO IIS XPO IIS	— 03 03	P&S P&S —	— C-5 —	— C404 —	— 12 —	2440	838	733	105	103	130	0.455 0.320 0.775	23.2	— 106 106	786 199 985	739 187 926	2904 461 3365	801 187 988	—	2625 528 3153	488	0.145	—	—	
KUNHAR JHELUM	— AB IIS XAB IIS	— 02 03	P&S P —	— C-8 —	— C407 —	— 421 —	25100	610	557	53	52	80	0.775 — 0.775	3.0	— 809 809	985 167 1152	926 157 1083	3365 749 4114	988 401 1389	—	3153 988 4141	636	0.155	—	—	
KUNHAR JHELUM	— ML IIS XML IIS	— 02 03	P&S P —	— C-9 —	— C408 —	— 400 —	26100	557	504	53	52	75	0.775 — 0.775	3.0	— 825 825	985 169 1154	926 159 1085	3365 758 4123	988 415 1403	—	3153 930 4091	627	0.152	—	—	
KUNHAR JHELUM	— AP IIS XAP IIS	— 02 02	P&S P —	— C-10 —	— C409 —	— 375 —	26600	481	433	48	47	70	0.775 — 0.775	3.0	— 833 833	985 156 1141	926 147 1073	3365 700 4065	988 383 1371	—	3153 810 3963	608	0.149	—	—	
KUNHAR JHELUM	— KR IIS XKR IIS	— 02 03	P&S P —	— C-11 —	— C410 —	— 355 —	26700	433	381	52	51	70	0.775 — 0.775	2.9	— 834 834	985 169 1154	926 159 1085	3365 758 4123	988 415 1405	—	3153 646 3799	578	0.140	—	—	

TABLE 2-3

INVENTORY OF SCHEMES-KABUL, SWAT, CHITRAL BASIN

REFERENCE DATA							PHYSICAL CHARACTERISTICS										POWER AND COST DATA										REM…
SCHEME	RIVER	ALTER-NATIVE	REVISION	PURPOSE POWER-P STORAGE-S DIVERSION-D	DRAWING REFERENCE	TEXT REFERENCE	APPROX DIST FROM MOUTH KM	DRAINAGE AREA KM^2	ELEVATION ABOVE MEAN SEA LEVEL: NORM MAX HEADWATER LEVEL M	ELEVATION ABOVE MEAN SEA LEVEL: NORMAL TAILWATER LEVEL M	GROSS HEAD M	NET HEAD M	HEIGHT OF DAM M	LIVE STORAGE VOLUME: VOLUME KM^3	LIVE STORAGE VOLUME: % OF ANNUAL FLOW	AVERAGE FLOW M^3/S	INDEX CAPACITY AT PLANT MW	MINIMUM CAPACITY DELIVERED MW	PRIMARY ENERGY DELIVERED GWH/A	SECONDARY ENERGY DELIVERED GWH/A	ADDITIONAL COMB. TURBINE CAPACITY MW	TOTAL INVESTMENT COST (EXCL IDC) 10^6 US $	NET ANNUAL COST (INCL IDC) 10^6 US $	INDEX COST (INCL IDC) US $/KWH	INCREMENTAL CAPACITY INDEX (INCL TRANS) US $/KWH	TRANSMISSION INDEX COST (EXCL IDC) US $/KWH	
	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	
FIRST-ADDED SCHEMES																											
[illegible]	SWAT	KL II	01	P&S	D-5	D44	239	2020	2073	1934	139	136	160	0.316	11.4	88.1	116	109	269	224	—	982	141	0.524	846	90	
MIRKHANI	CHITRAL	MK II DI	01	D	D-3	D42	20	13400	1243	1146	—	—	125	—	—	307	—	—	—	—	—	1399	—	—	—	—	DISTAN… AFGHA…
KH?ZANA	PANJKORA	KZ II	01	P	D-4	D43	15	5890	762	651	111	109	115	0.682	29.3	73.9	110	103	413	74	—	610	86	0.208	801	120	
KALANGAI	SWAT	KG 21	01	P&S	D-6	D45	92	11700	695	564	131	128	145	1.436	17.9	254	256	241	998	285	—	1057	143	0.143	548	50	
…DA	SWAT	MD II	02	P&S	D-7	D46	32	14100	564	366 *	198	194	205	1.468	16.3	285	492	462	1507	700	—	1567	242	0.161	402	30	
COMBINATION SCHEMES																											
…KHANI/ …HAZANA …OMBINED	CHITRAL PANJKORA	MK II DI KZ II D XKZ II D	01 02 02	D P&S —	D-3 D-4 —	D42 D43 —	20 15 —	5890	762	651	111	109	120	1.272 1.272	35.4	40 74 114	— 221 221	— 208 208	— 634 634	— 126 126	—	1399 632 2031	515	0.812	—	—	
…RKHANI/ …ALANGAI …OMBINED	CHITRAL SWAT	MK II DI KG 21 D XKG 21 D	01 01 01	D P&S —	D-3 D-6 —	D42 D45 —	20 92 —	11700	695	564	131	128	145	1.950 1.950	21.0	40 254 294	— 350 350	— 329 329	— 1296 1296	— 368 368	—	1399 1085 2484	621	0.479	—	—	
…RKHANI/ …NDA …OMBINED	CHITRAL SWAT	MK II DI MD II D XMD II D	01 03 02	D P&S —	D-3 D-7 —	D42 D46 —	20 32 —	14100	564	366	198	194	205	1.855 1.855	18.1	40 285 325	— 728 728	— 684 684	— 1834 1834	— 994 994	—	1399 1606 3005	726	0.396	—	—	



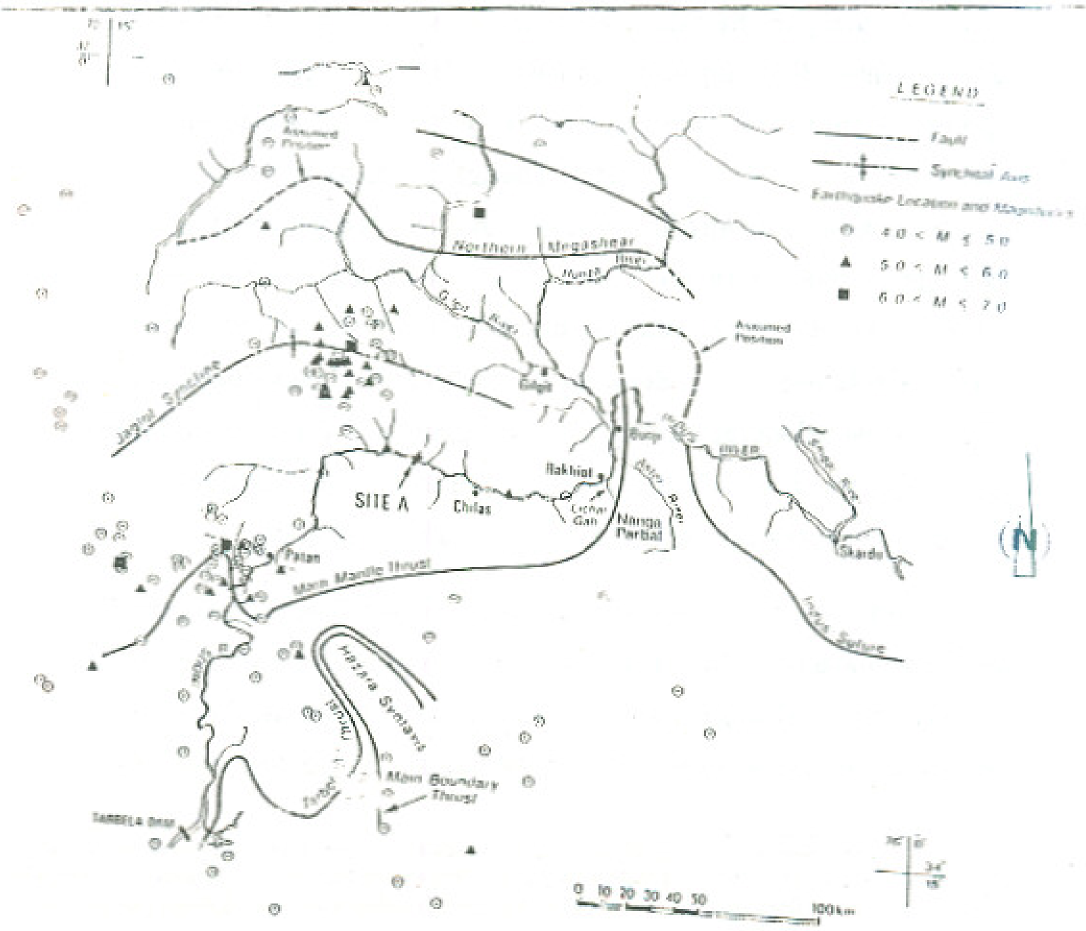


Figure 3. Seismicity of northern Pakistan*

Appendix - V

EXCERPT FROM INDUS BASIN RESERCH ADVISORY GROUP REPORT

Figure 7 sets out the problem for the upland areas in an aggregate causal sequence. Some alternatives for intervening in this process of empoverishment and degradation are also listed, many of which are presently being tried on a limited scale. Although this process has been observed for decades in Pakistan, very little effective interventioon has taken place and that which has been attempted has not had sufficient financial and institutional support for the results to be anything but discouraging.

In Pakistan as a whole, where overall rapid population growth has necessitated that short term growth-generating investments be given the highest priority, the lion's share of public resources has been directed to the Indus Plain, where there continues to be the greatest potential for the rapid development of agriculture and raw materials and hence the highest rates of return. If it could be shown, however, that the environmental degradation occuring in the hill areas incurs measurable and significant costs in the Plain, through increased flooding and reduced surface storage, the investments in upland development of public resources generated on the plain would be justified by even the most stringent rate of return criteria. Though progress in quantifying these effects has been spotty to date,[1] it is already apparent that the component due to human activities is not yet large in relation to the effect of silt loads from natural erosion. More evidence must be gathered and more study conducted to evaluate the rate of soil loss from upland areas and its relationship to defoliation and livestock movements. The relationship of natural over seasonal storage in the upland regions to soil loss should then be examined so that the likely impact of continued and accelerated upland erosion on the distribution of downstream river flows throughout the year can be estimated.

Whether or not this research turns up significant upstream-downstream interactions, the welfare of an important twenty percent of Pakistan's population is at stake if upland environmental degradation is permitted to continue. In addition, valuable soils, suitable for slope forestation and cultivation, are being lost and are recoverable only

1. Good work has been done estimating sediment yields from different parts of the catchments on the Indus and the Jhelum upstream of the Tarbela and Mangla Dams. See: "Watershed Management Summary," WAPDA Master Planning and Review Division and works from the Mangla Watershed Management Project of WAPDA.

through thousands of years of further natural weathering. In a time when the costs of energy and raw materials are high, the forests and other vegetation supported on these soil and threatened by continued population growth, represent valuable energy and material resources. The value of these resources can be measured either in terms of direct energy and raw material content or in terms of the costs of meeting the basic needs of upland dwellers in their absence. Considering all these factors, steps must be taken to slow the degradation process and to provide opportunities to upland dwellers to increase their standard of living.

A difficulty in formulating strategies to deal with upland degradation is the diversity of types and causes. This requires that a different mix of remedial actions should be carried out in different regions. Climate and forest types vary from sub-alpine, with forests of pine and fir trees, through temperate dry and moist climates with mixtures of cedars, pines, junipers, firs and oaks, to subtropical moist climates with pine trees and subtropical dry climates with scrub vegetation. At higher altitudes and moister climates, accelerated erosion is occurring through indiscriminate logging of steep slopes. Elsewhere erosion is being accelerated by over-grazing of fragile soil. At lower altitudes there is rapid erosion of sloping agricultural terraces cutting into the hillsides, with sheet erosion and gullying of range lands. There are differences in human population densities, in proportions of cultivated land and in stream volume and rainfall in different upstream regions. Winter temperatures vary widely and consequently the need of fuel for space heating also varies. The potential cost-effectiveness of measures to control erosion and deterioration of forests and pastures is probably widely variable in different regions.

Among the actions that might help to maintain the environment and to improve the living conditions of the peoople are : forest plantations of fast-growing trees for fuel, timber and livestock forage; development of more efficient ways to use energy for cooking, heating, and hay-drying; increasing food supplies and diversifying diets by encouraging farmers to grow potatoes and vegetbles; raising farm incomes by establishing orchards of fruit and nut trees and by introducing small-volume, high-value agricultural products such as honey bees, silk culture, medicinal plants, spices and fragrances; improving livestock productivity by controlled breeding and by maintain livestock in confinement rather than under free-grazing conditions; construction of roads or other means of transportation such as ropeways; encouragement of tourism; village electrification from central power stations; development of villages and small town industries, for example, dairying and production of cheese and butter; public health and nutrition sevices that will lower infant and child mortality and reduce adult sickness; provision of domestic water supplies and of water for irrigation; education and training to provide the people with economically usable skills; encouragement of out-migration, both to the towns of the Indus Plains and to the Middle Eastern countries where skilled laboor is in short supply; and lowering of population pressure by reducing human fertility.

Many of these actions are interdependent or complementary in the sense that they will reinforce each other. Education and training are essential if out-migrants from the hills are to be able to compete successfully for employment with present inhabitants of the plains and if migrants to the Middle Eastern countries are to find satisfactory jobs. Development of local industries will require skilled, disciplined workers, as well as electrification from cental power stations of village and town hydroelectric plants, and improed means of transportation of raw materials and finished products. Expansion of tourism will be facilitated by better transportation, increased skills and development of local arts and crafts. Maintaining livestock in confinement will require availability of hay, crop residues, or forage from fast-growing trees. This change in the mode of livestock management could triple the quantity of fertilizer nitrogen from animal sources, because it would conserve the nitrogen excreted in the urine. At the same time it would eliminate the erosion resulting from animal trails criss-crossing the steep hillsides. Public health and nutrition services which will lower infant and child mortality, together with provision of primary education and employment outside the home for women, may be the most important means of reducing human fertility. Forest plantations of fast-growing trees should ultimately lower the cost of fuel. The price of fire-wood is now sixteen rupees per maund, which means that rural families who must purchase fuel spend about as much for fuel as for food. It is no wonder that the present forests are being depleted by cutting slow-growing tees for fuel, as well as by clearing to expand the areas of cultivated land. Although way to lower fuel costs could include the development of inexpensive, efficient stoves for cooking and heating or use of electric hot-plates for cooking. In existing cooking stoves, probably more than ninety percent of the heat energy is wasted.

Electrification either from central power plants or local hydroplants could provide power for pumping domestic water supplies to hill villages and for pumping irrigation water from numerous perennial streams to the less erodible lower terraces which have been cultivated for many years. If double cropping could be carried out on these lower terraces, the pressure to expand agricultural lands further up hill slopes to meet the needs of growing local population should be diminished.

from these suggested remedial activities can be formulated strategies for slowing environmental degradation and improving the standard of living of upland dwellers. Some of the activities are already under way or in the planning stages. Balanced strategies must be formulated for each localities and as much support as possible should be provided to subsequent monitoring, researach and development activities.

* * * * *

Rapid population growth	Low standard of living	Low commercial skill levels	Reduced incentives to out migrate	Further population grwoth
	Dependence on Livestock products		Destruction of existing cultivable land	
Limited cultivable land, water and indigenous energy resources		Soil erosion		
	Defoliation for feed and fuel			
			Permanent loss of slope soils suitable for reforestation	
			Reduced bank water storage	Reduced reservoir life
			Downstream siltation	Reduced dry season flow
				Increased flooding on the plains due to river bed accumulation and greater wet stream flow

Intervention

1. Incentives to out migrate
2. Agricultural technology to increase land and water productivity
3. Commercial energy supplies

1. Improved animal husbandry, penning livestock
2. Education programs
3. Investments in skill development
4. Reforestation

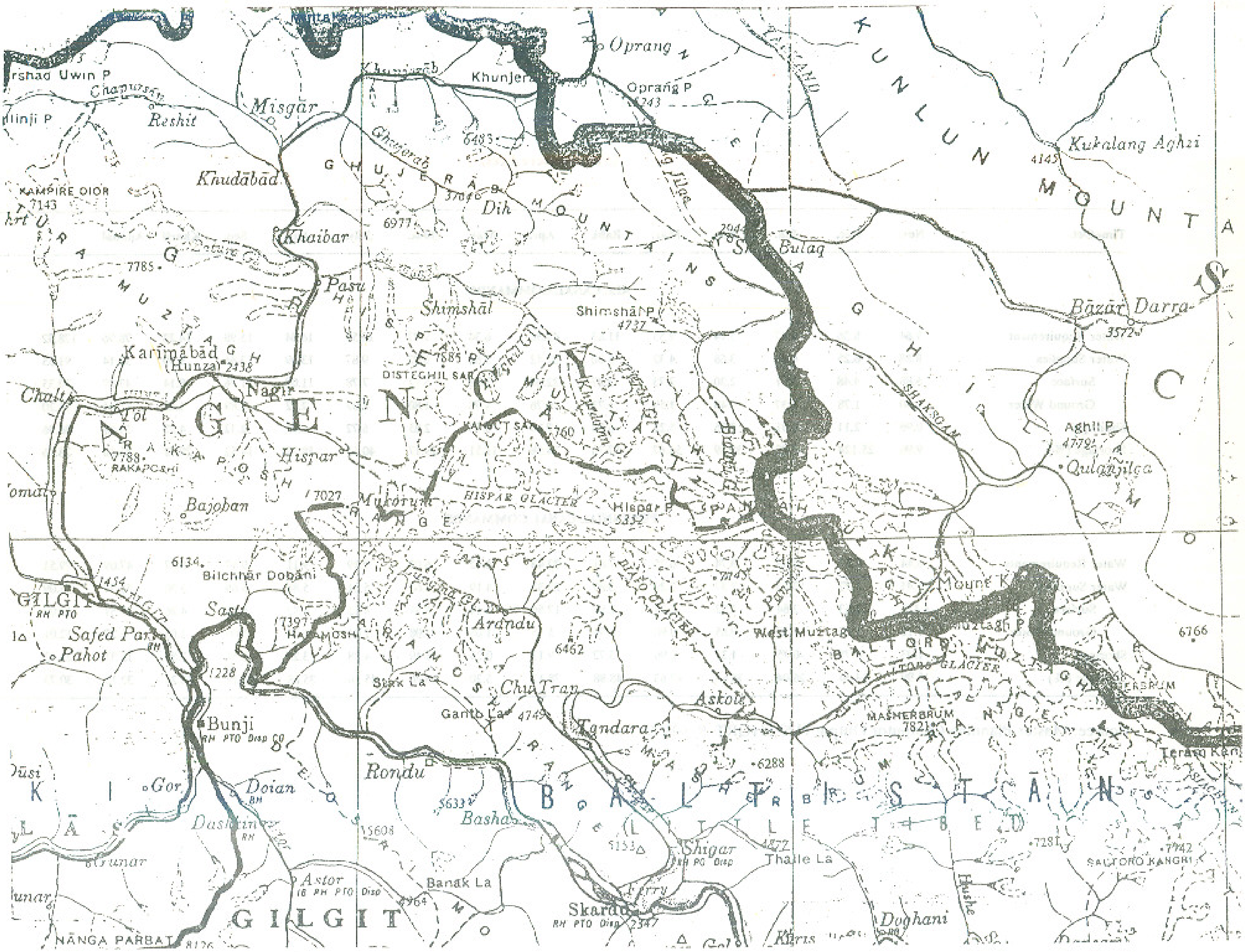
Figure 7. The Problem of the Uplands

Appendix III (b) - 2
Table - V-17

Crop watr requirements and water supply at Watercourse Head
(Million Acre Feet)

Time Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Rabi.	Apr.	May.	June.	July.	Aug.	Sep.	Kharif	Annual	
ALL CANAL COMMANDS															
Water Requirement	9.64	8.36	4.47	5.74	9.53	11.83	49.56	6.34	9.77	10.59	16.34	15.98	14.23	78.96	128.52
Water Supplies	8.68	6.25	4.48	3.68	4.32	5.00	32.42	5.61	6.92	9.87	13.09	13.66	9.99	59.14	91.55
Surface	6.88	4.48	3.11	2.20	2.73	3.27	22.26	3.83	5.12	7.78	11.07	11.76	8.14	47.69	70.35
Ground Water	1.80	1.78	1.37	1.48	1.59	1.73	9.76	1.78	1.80	2.09	2.02	1.89	1.85	11.44	21.20
Shortage	0.96	2.11	-0.01	2.06	5.21	6.83	17.14	0.73	2.85	6.72	2.95	2.32	4.23	19.82	36.96
Shortage (%)	9.96	25.124	-0.22	35.89	54.67	57.73	34.58	11.51	29.17	40.51	18.39	14.52	29.72	25.10	28.76
PERENNIAL CANAL COMMANDS															
Water Requirements	6.44	5.51	2.88	3.74	6.25	7.61	32.43	4.42	6.02	9.49	9.11	9.17	8.87	47.09	79.51
Water Supplies	5.41	4.72	3.63	2.37	3.29	3.89	23.31	4.19	4.62	5.21	5.86	6.69	5.30	31.77	55.09
Surface	4.125	3.63	2.84	1.52	2.39	2.93	17.56	3.14	3.54	4.15	4.82	5.59	4.26	25.51	43.07
Ground Water	1.16	1.09	0.78	0.85	0.90	0.96	5.75	1.05	1.08	1.06	1.04	1.00	1.05	6.27	12.01
Shortage	1.03	0.79	-0.75	1.37	2.96	3.72	9.12	0.23	1.40	4.28	3.25	2.58	3.57	15.31	24.43
Shortage (%)	15.99	14.34	26.04	36.63	47.63	48.88	28.12	5.20	23.26	45.10	35.68	28.14	40.25	32.15	30.73

Source: Master Planning Computor Output H20 SHORT 9-4-1979.


Misgar
Reshit
Khudābād
Khaibar
Pasu
Shimshāl
Shimshāl P 4737
Dih
Khunjerāb
Oprang
Oprang P
KUNLUN MOUNTA
Kukalang Aghzi
Bāzār Darra
Aghil P
Qulānjilga
Karimābād
(Hunza)
Nagir
Chalt
Hispar
RAKAPOSHI
Bajoban
Mukorum
HISPAR GLACIER
Hispar P
DISTEGHIL SAR
GHUJERĀB
Bilchhar Dobāni
GILGIT
Safed Pari
Pahot
Sasli
Bunji
Doian
Gor
Rondu
Basha
Arandu
Chu Tran
Stak La
Ganto La
Tandara
Askole
West Muztagh
BALTORO GLACIER
Mount K
MASHERBRUM
Shigar
Thalle La
Skardu
Astor
Banak La
NANGA PARBAT
BALTISTĀN
LITTLE TIBET
SALTORO KANGRI
Doghani
Hushe
GILGIT
SHAKSGAM
Shor Bulaq

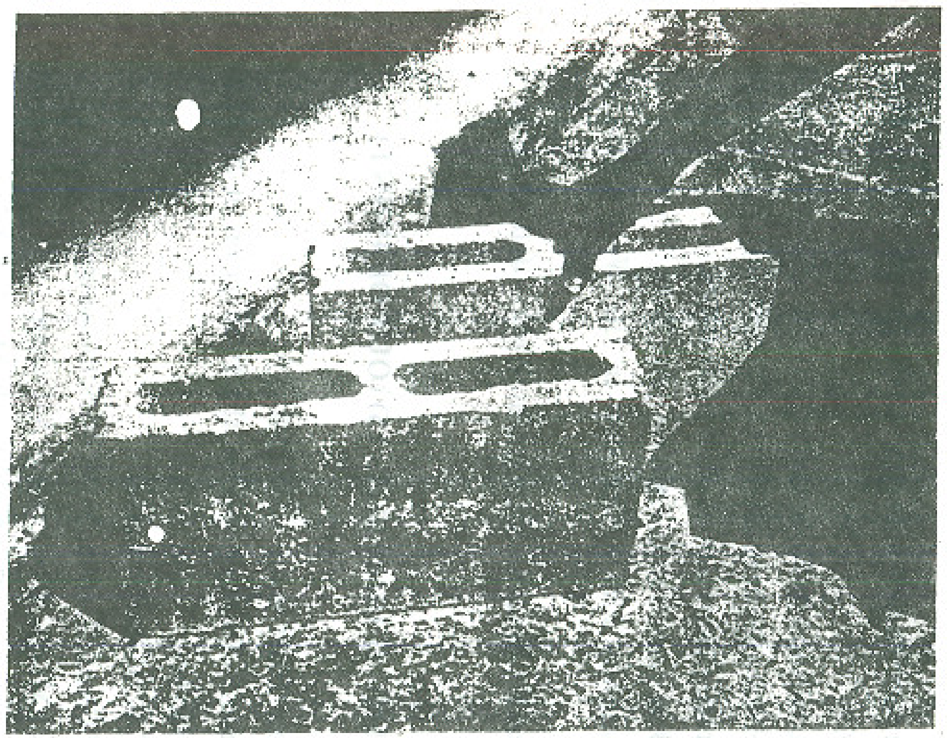
Cement from rice husk

By Ray Smith

LONDON—A low cost building material for use in the construction of housing is available to any developing country where rice is grown. The material is rice husk ash cement (RHAC), a mixture of the ash from burned rice husk which has a high silica content, hydrated lime and water. It sets like any other cement. Alternatively, ash can be mixed with ordinary Portland cement (OPC) to make it go further.

Every year approximately 80 million tonnes of husk are produced by the rice mills of the world and although some of it is used as fuel, most is wasted. Indeed, the disposal of rice husk is a considerable problem. Fortunately, however, rice is grown mainly in the developing countries, many of which suffer an acute shortage of building materials.

The solution to both the disposal problem and the building materials shortage is available in RHAC. Development work has been carried out by the overseas division of the United Kingdom's Building Research Establishment (BRE) in cooperation with colleagues in Malawi, Sierra Leone, Thailand, India and Guyana. The results of this joint research work are of general use for all developing countries where rice is grown.



Although there is little difference in the appearance of these two concrete blocks, the front one was made with rice husk ash cement and the rear one with ordinary Portland cement.

To make RHAC, the rice husk is first burned in an incinerator to produce a good quality reactive ash. Then the ash is ground in a ball mill to make a fine powder. Lime is added to produce the cement.

In Malawi, BRE has been working with the University of Malawi at Blantyre Polytechnic. Using a simple steel wire mesh incinerator to burn the husk and a ball mill for grinding, a good quality ash was produced.

Experiments with quantities of ash and lime showed that the best general purpose RHAC was achieved with a mix of one part by weight of lime with two parts of ash. One part of this RHAC mixed with three parts of sand made a mortar of adequate strength for general brick and block laying, such as that used in low income housing.

The high cost of steel in Malawi meant that the pilot-scale incinerator had to be built from an alternative material. BRE designed a cheaper and easily built incinerator made from the fired clay bricks produced locally. Incinerator temperatures were studied to find the best heat for producing the reactive ash. The BRE incinerator allowed for a continuous production process, with husk being added to the top as ash was withdrawn from the bottom.

Alternatives to the ball mill for grinding the ash were also tried out, but local maize mills and the pestle and mortar were less successful.

A test wall was built at Blantyre, using fired clay bricks laid in RHAC mortar. Part of the wall was rendered with the same mortar. Now, several years later, there are no signs of deterioration and a demonstration building is now planned using the same methods.

The work in Malawi is being used to demonstrate the RHAC techniques to other countries in Africa. BRE's overseas division has already helped spread the knowledge to Sierra Leone where there is a particular shortage of cement-based materials, yet much rice is grown.

Husk has been gathered from several mills and the technique of burning demonstrated. The ash produced there shows good promise.

Following an inspection by BRE of the extensive rice production industry in Thailand for the National Housing Association there, it was recommended that production of RHAC should proceed. The National Housing Association will be able to control the manufacture of RHAC and its use in mortars and blocks and will also be well placed to monitor the performance of the finished products over a long period of time.

In India, work on RHAC has been carried out in several research institutes. The process is technically feasible, but there is insufficient demand for the material. Ordinary Portland cement is manufactured locally and is generally available at a reasonable price. Consequently RHAC will only be economically viable during the occasional shortages of OPC.

BRE has been cooperating with the Institute of Applied Science and Technology in Guyana where the work has concentrated on mixing rice husk ash Technology in Guyana where the work has concentrated on mixing rice husk ash with OPC. Various proportions have been investigated and a mixture of equal weights of the two materials has produced an RHAC of equal strength to that of OPC alone — representing a considerable cost saving. Good quality concrete blocks have been made.

In Guyana the brick-built incinerator has tried and now a slightly larger version has been constructed. A ball mill is to be installed at one of the largest rice mills in the country.

This technology is particularly important in Guyana where there are no deposits of limestone from which either lime or OPC can be made. All OPC is imported, so th use of rice husk ash as part of th mix can offer considerable savings in foreign exchange.

Laboratory tests carried out in the developing countries and at BRE have concentrated on finding the optimum temperature for burning rice husk to produce the best quality ash. Ash burned in the temperature range 600° to 750°C has the best composition for reaction with lime or OPC to form good RHAC.

At the present time, RHAC is not recommended for reinforced concrete nor in civil engineering works, but it is suitable for mortars, rendering and plain concrete work in low technology use.—LPS.

PAKISTAN ENGINEERING CONGRESS

List of papers in Annual Proceedings

"M" indicates that the paper was awarded the Congress Medal
"KM" indicates that the paper was awarded the Kennedy Medal

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