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REMODELLING APPROACH FOR KABUL RIVER CANAL SYSTEM IN VIEW OF CHANGING AGRO-HYDROLOGICAL CONDITIONS

BY

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ABSTRACT

Kabul River Canal (KRC), completed in 1872, is one of the oldest irrigation system in the North Western Frontier Province. The scheme was originally designed to improve and extend the irrigation of a small circuit canal known as Joe-Sheikh. The canal was mainly designed for the Kharif discharges of 350 cusecs. Its present culturable commanded area (CCA) is 48,700 acres. The irrigation intensity originally designed was 100 percent, which in practice has increased to 133.6 percent.

The Primary objective of the irrigation system is to achieve equitable distribution of irrigation supplies to the crops according to the designed requirements, with a reduced cost of maintenance. However, the KRC system is not fulfilling its primary functions due to various Socio-technical reasons. The main problems identified are inadequate capacity to pass designed discharges, silting and scouring of the channels and hydraulic structures. These problems have resulted in inequity in the availability of irrigation supplies between the upper and tail reaches of the canal system.

The deficiencies of existing irrigation system pertaining to the seepage losses, sedimentation of the canal and inadequacy to meet with the demands of crops could be removed by remodelling the existing system. An attempt is made here to broadly indicate the line on which the canals need to be remodelled in recognition of the changing agro-hydrological conditions.

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Historical Features of Kabul River Canal System

The Kabul River Canal System is one of the oldest irrigation system in the province (Fig.-1). It has played an important role in the agricultural production of the area. At one time it was known as the Michni-Nowshera Canal. It takes off from the right bank of the Kabul River where it debouches from the hills, a short distance above the Michni Fort at the village of Warsak about 24 km North-West of Peshawar. The canal after operation for a few years, fell into disuse due to siltation. It was restored at the instance of Mr. Tucker, Deputy Commissioner in 1885 and put into regular operation as a District Board work. The Deputy Commissioner anticipated that its restoration would have a quiententing effect on the hostile Afridi tribes in the same way that swat River canal had on the Mohmands (Handcock, 1905: 37).

The scheme was originally designed to extend the irrigation to a small district canal known as the Joe-Sheikh, but later an extended project was prepared to command much larger area of over 9,713 hectares with a discharge of 330 cusecs. The scheme was really the resuscitation of an old Mughal Canal which had flowed some 200 years before, (Punjab Government, 1901, Note No.XVI-A). The canal was opened for irrigation in July 1892. After necessary repair the canal was reopened for irrigation in February, 1893.

The first 1500 feet long reach acts as a feeder channel for both Kabul River Canal and Joe-Sheikh Canal, and has a capacity of 800 cfs. Beyond RD.1+500, 450 cfs flow into Kabul River Canal while 350 cfs are diverted to Joe-Sheikh Canal, which runs parallel to Kabul River Canal on the left side (Fig.1). The Kabul River canal system has 154 direct outlets and is unlined up to 72+000 which is the point of offtake of the first distributary i.e. Hazarkhani Branch. Kurvi Branch offtake from the left bank of the canal at R.D. 133+358. At RD.150+000 the Wazirgarhi Minor offtake from the left bank of the main canal (Fig.2).

Factors Governing Review of Design

Kabul River Canal System has been facing a number of problems for a long time. These problems are generally related with diversion arrangements, canal alignment, excessive silting in the canal resulting in deshaping of the canal and reduction in capacity, excessive seepage losses, inequitable distribution of supplies over the command area, entry of undesirable drains in Peshawar area and wastage of water through escape. These problems were analyzed technically in detail by NESPAK (1981). Before discussing the remodelling of the canal, it would be relevant to discuss the main factors viz seepage, sedimentation, cropping patterns and distribution of irrigation supplies which govern review of design capacity of the canal structures.

canal system are planned for a uniform irrigation intensity in the whole command area, the farmers in the upper reaches are able to draw supplies higher than their allocated share due to higher heads and sufficient quantity of water in the canal at their disposal.

In the tail reach, discharges reduce due to excessive withdrawals upstream, seepage being proportional to wetted area, assumes a larger percentage and the available head becomes smaller. All these factors combine into the resulting shortages in the lower reaches. In addition to these, the diversion to the canal are less than those required to meet the water requirements of the existing cropping pattern.

Basis for Remodelling of Irrigation-System Crop Water Requirement Criteria for Computation

In the estimation of irrigation water requirements of an area, estimation of consumptive use of individual crops is the first and the foremost step. The consumptive use of a crop is the water needed by a crop during its life cycle. Basically it is a function of climatic conditions, type of crop, its stage of growth etc. In Pakistan a number of studies have been carried out on the estimation of consumptive use, by Clymn (1973), Asghar (1962), Blaney-Criddel (1951) and Sadiq et la (1973). The most acceptable and widely used method of estimating consumptive use consists of crop use expressed as a product of a climatic index and a crop stage of growth coefficient or crop coefficient (Blaney-Criddle: 1950).

In large canal commands, it is understood that all the area under a particular crop cannot be planted in one ten-day period. It is important from practical as well as from water requirements point of view. Due consideration has been given to the number of ten-day periods in which planting of a particular crop shall be completed. Water requirements computed for the copping pattern, consumptive use and planting distribution data are modified by pre-planting water requirements, effective precipitation and the use of residual soil moisture (kincaid & Heerman: 1974). A pre-planting irrigation three or four inches is customary to facilitate seed bed preparation and provide an initial charge of soil moisture. This pre-planting water is generally assumed to be applied in the ten days preceding planting.

Pre-planting water allowances for rice crop are generally higher than those for other crops and large quantities of water are used both prior to planting and early in the growing season to fill the paddies necessary for rice cultivation or to raise the water table to the soil surface depending upon the type of cultivation practiced. The pre-planting water requirements are included in computing irrigation water requirements in addition to the consumptive use.

Soil moisture denotes water residual in the soil and available for crop consumptive use towards the end of the growing season. Therefore, it does not need to be restored by irrigation. The soil moisture not restored by irrigation is subtracted from the consumptive use requirements of the last few ten-day periods of growing season.

Irrigation water requirements calculated at field are computed at watercourse head considering the watercourse efficiency and at the canal head by considering the canal efficiency as well. Following efficiencies have been used in this study. (NESPAK:1981).

Field Efficiency	(e_a)	=	75%
Watercourse Efficiency	(e_d)	=	85%
Canal Efficiency	(e_c)	=	86%
Division Factor	$= (e_a * e_d * e_c)^{-1}$	=	182%

Designed Cropping Intensities and Pattern

The existing cropping pattern is derived from the records of Irrigation and Agriculture Department of Government of NWFP. The historical intensities for the Project Area are computed on the basis of records of the Irrigation Department from 1965-66 to 1979-80) (NESPAK:1980). It indicates that annual cropping intensity decreased from 150 percent in 1965-66 to 106 percent in 1979-80, because of decrease in irrigation supplies from canals. However, Kharif-Rabi ratio from 1965-66 to 1979-80 remained almost uniform at 1:1.

The important factor considered for establishing future cropping intensities and pattern is irrigation supplies and their pattern of distribution in relation to the cropping calendar. The cropping pattern adopted is considered optimum in view of proposed canal capacity and irrigation supplies. The ultimate achievable annual cropping intensities have been established as 150 percent-with Kharif 65 percent and Rabi 85 percent.

Presently maximum requirements of 527 cfs occur in the third ten-daily period of June vide Table-2. Generally they remain quite high from June to August. From the end of November to beginning of March very small discharge is required for irrigation supplies. These water requirements have been worked out on the basis of the average of actual cropping intensities in the project area and present the realistic picture of the required irrigation supplies.

Total requirements during Rabi amount to 44,349 AF (acre feet) while during kharif 124,068 AF of water are required, the total diversion requirement being 168,417 AF annually. Table -3 shows the maximum water requirement to be 521 cfs in the third

ten-daily period of June. The general trend of variation during the year is nearly the same as in case of the existing cropping pattern. The period of high water requirements occurs from the beginning of June to beginning of September and very low flows are required in the canal during December and January. The diversions required during Rabi and Kharif are 54,286 AF and 126,952 AF respectively, the total annual requirement being 181,238 cfs.

Selection of Cropping Pattern

The crop water requirements were actually calculated for two cropping patterns on the basis of Kharif and Rabi ratio. These cropping patterns are shown along with the existing cropping pattern in Table-4 and 5. for our climatic conditions maximum crop water requirements are in June and July which fall in Kharif period. Any increase in cropping intensity in the Kharif period raises the peaks falling in the months of June and July. The water requirement peaks for different alternatives as well as for the existing cropping pattern are shown in Table-6.

According to this table if the canal is designed on the basis of water requirements of alternative I for Kharif-Rabi ration as 1:1, the remodelling ratio is (570/450 = 1.27) as against proposed remodelling ratio of (500/450 = 1.11). The proposed remodelling ratio is also in proportion to the proposed increase in intensity from 133 percent to 150 percent.

Alternative I is not feasible because the discharge of 570 cusecs cannot pass through present system and secondly due to high flow peak in Kharif and low flow in Rabi create maintenance problems.

Irrigation Supplies and Equitable Distribution

According to the water requirements, the maximum supply required is 521 cfs in the last ten-daily period of June while the predominant requirements during high flow season remain below 500 cfs. The designed discharge for the canal has therefore been adopted as 500 cfs. The distribution of the discharges to various offtaking channels has been proposed to be in direct proportion to areas under their command after accounting for losses through the canal and are shown in Table-7. These discharges are based on a duty of 1 cusec per 110 acres. The canal as well as structures are designed for this discharge. However, it will be capable to take additional discharge of 21 cusecs which is only 4.2% of design discharge for the short duration of 10 days.

Also this is in line with the general practice of the Irrigation Departments where it is considered that the canal is safe for occasional running of additional discharge of

up to 10%. The head regulator is also capable of discharging the additional quantity of water required for the short duration. The river flows during the last ten daily period of June are quite high. Thus there will be no constraint in the running of the additional discharge in the canal.

Remodelled Design of Main Canal

Kabul River Canal, as it exists now, consists of an earthen channel in its first 72,000 feet length, a lined reach in the next 34,000 feet followed by 94,000 feet long unlined portion up to its tail. The hydraulic design of two portions is as follows:

Unlined Portion

For remodelling a canal in alluvial material, it is necessary to determine the cross-section and slope which will convey the design discharge and sediment load. For preparing the remodelling design of Kabul River canal, cross sections of the existing canal were observed and plotted (NESPAK: 1981). From the longitudinal section average slopes of various reaches were determined. The conformity of these slopes to Lacey,s (1939) regime was tested and these were found to be in general conformity with Lacey,s slope. The corresponding Lacey,s sections were found to approximate the existing section quite closely and involved minimum earth work. The cross-sections have been designed for non-silting & non-scouring velocities for the development of the proper regime. If proper regime is not achieved, than the geometry will suffer gradual change and performance will deteriorate. Inadequate slope leads to siltation and loss of discharge capacity, excessive slope causes scour, endangering structures. Inadequate width leads to bank scour and excessive width to meandering. (Lacey:1939, Inglis:1949). As the canal system was suffering from lack of supplies in the tail reaches and inequitable distribution, it was deemed necessary to raise the water levels through out. Slight flattening of the slopes due to adoption of Lacey,s approach has helped achievement of this goal. The portions of the canal from start to RD.72+000 and RD.106+000 to tail have been designed as an earthen channel on the basis of Lacey,s regime approach which relates the discharge to bed slope, wetted perimeter, flow area and silt factor. The sediment studies have indicated that the median diameter (D_{50}) of the bed material is 0.323 mm which gives the silt factor as unity.

Lined Portion

The lined portion from RD. 72+000 to RD. 106+000 has been designed on the basis of Manning,s formula. The velocities in the lined reach have been kept between 2.6 fps and 3.5 fps, so that the maximum incoming silt load can be washed away.

Seepage Problem

The area under the culturable command of Kabul River Canal has been affected by waterlogging for a long time. Records of depth of water table prior to the construction of the Canal are not available but the earliest measurements during the first quarter of the twentieth century have indicated that water table was about 10 feet below the ground surface at that time. With the advent of regulated canal system later on, a rise was registered in ground water levels ranging between 0 to 5 feet. For a long time now, no marked tendency of rise or fall in the water level had been observed. As such the sources of recharge and discharge appear to have attained a dynamic equilibrium. The general movement of the ground water reservoir is in the north-easterly direction and the main cause of high water table are the seepage from canal system, along with infiltration from farm irrigation and inadequate drainage in the area. Due to high water table conditions, the zone of saturation has risen to the root zone of the plants and the plants with long roots like cotton find survival impossible. The farmers therefore have switched over to cropping patterns much different from those envisaged originally for the area (NESPAK: 1981). Excessive seepage from the canals also results in irrigation water shortages especially in tail reaches where idle lands with shallow water table are subjected to excess evapotranspiration which in turn causes accumulation of salts at the surface of the lands.

Seepage Analysis

It is a well established fact that the groundwater table in a major portion of the Project area lies quite close to the natural ground surface. This condition is not the result of only a local phenomenon; it is actually the creation of the groundwater regime in the whole region which depend mainly on the groundwater geology, the sources of groundwater recharge and the direction of movement of groundwater (NESPAK 1981). The principal sources of recharge to groundwater reservoir in the region can be identified as follows:

Seepage from Canal System

Seepage from the regulated canal systems is considered to be the most important source of recharge to the groundwater reservoir. Two major canal systems offtake from Kabul River on its right side namely, Warsak High Level Canal system and Kabul River canal system as shown on Fig.-1. The warsak canal system comprises two canals, warsak lift canal and warsak gravity canal. Kabul River canal system bifurcates into Kabul River canal and Joe-Sheikh canal. A major distributary Hazar Khani branch, offtake from its right bank at RD. 72+000 and flows parallel to it for 23 miles.

There is thus a four tier channel system flowing parallel to Kabul River canal at different levels which act as obstructions to the natural sub-surface drainage in addition to being major sources of recharge to the groundwater reservoir. During the long years of the operation of the regulated canal irrigation systems, the groundwater reservoir has formed a regular gradient in the north easterly direction. The command area of Kabul River canal lies in the plains at the toe of the general slope and is just adjacent to the junction of the groundwater reservoir with the surface flows of Kabul river. As such a major portion of the seepage emanating from the canals at higher elevations on its right side finally accumulates in this area to accrete the groundwater table.

Total seepage from Kabul River canal comes out to 30 cfs. It is 7 percent of the discharge at the head of Kabul River canal. The total losses from the canal, distributaries and minors have been estimated at 10 percent of the design discharge at the head of Kabul River canal. Also accounting for evaporation losses, total losses will be about 14% of design discharge.

Deep Percolation from Farm Irrigation

Another important source of groundwater recharge is through deep percolation from farm irrigation. Experimental work is available e.g. Trout et al (1984), Akram et al (1981) and Clyma (1984) within the country for establishing the farm irrigation efficiencies which are generally dependent upon physical properties of soil, level of farming and management practices, especially land levelling of fields, plant population and salinity and waterlogging status of the area. In view of the physical properties of soils in the project area and prevalent cropping pattern, a farmer efficiency of 75 percent has been assumed, the rest 25 percent being farm losses. A major portion of this loss percolates down to ground water table.

Infiltration due to Rain

The annual precipitation in the project area averages about 16.4 inches. Out of this 40 percent falls during July and August while March receives a mean monthly precipitation of 2.6 inches, which is the highest for any month. From 1975-76 to 1979-80, the precipitation has been higher, its average being 20.8 inches. Some of this rainfall is used for meeting the evapotranspiration needs of crops and the rest infiltrates into the groundwater table.

Sediment Analysis

Sediment transported by flowing water either as suspended matter or as bed load

present problems of vital importance in many projects of irrigation. The design and sizing of many hydraulic structures requires a predetermined knowledge of the quality and quantity of suspended particles carried by water. The success of a canal irrigation system is highly dependent on the accuracy of judgement exercised in the evaluation of sediment carrying capacity of the water diverted to the distribution system in relation to the sediment concentration in the parent river. Quershi (1972) described the nature and extent of the silt problem in Nara & Jamro Canal. The settlement of sediment diverted into the canal along with water may decrease its capacity and eventually lead to failure. It can happen if the sediment carrying capacity of water in the canal is less than the amount of sediments actually entering the canal. On the other hand if sediment carrying capacity of canal water is more than that entering at head, the water will tend to scour the bed and banks of the canal which is again undesirable because it may lead to weakening of the banks. Both these phenomena put an extra burden on the operation and maintenance costs of the system.

Consideration of the above facts has led to the development of famous Lacey,s (1939) regime theory which aims at designing canals which should neither scour nor si' with the passage of time. The amount and type of sediments play basic ro designing canals by this approach. Most of the canals in Pakistan are designed or basis of this approach and therefore the importance of sediment studies cannc overemphasized.

Computation o sediment yields

The sediment data of Kabul river published by Surface Water Hydrology Proje during different months in the period of record (1961-70) has been used to devel sediment rating curves (Fig.-3). The regression line fitting the data may b mathematically expressed by the following equation:

$$O_w = 1000\ Q_s^{0.3326}$$

Where Q_w = mean daily discharge in cusecs and
Q_s = suspended sediments in tons/day

Obviously the discharge of sediments in the river varies with the water discharge. The principal runoff in Kabul River occurs in monsoon months from April to September. Because of proportionately large volume of runoff combined with high sediment concentration in these months, about 97% of annual sediment transport has been found to take place in monsoon months in the period of record. Average suspended load in Kabul River Canal is approximately 57.55 acre ft/year i.e. 73,947 Tons/year or 202.59 Ton/day (NESPAK: 1981).

Gradation of Bed Material

Gradation of bed material is the most important factor for determining the silt factor to be used in the design of a canal. Size of bed material load in flow over a sand bed is smaller than the size of bed material and is most important parameter used in evaluating in sediment transport. Thus, if an alluvial channel forms its bed by transporting material from upstream, the bed material size will reduce with distance in downstream direction Mahmood:1973). This type of reduction has been documented for natural rivers and canal by Rafay (1964) and Rana (1971). In case of Kabul river canal, the excessive amount of silt entering the system has reduced the water carrying capacity of the canal and upset its regime. The median bed material is found 0.323 millimeters. This value is to be used for determination of silt factor in Lacey (1939) for the design of canal.

Distribution of Irrigation Supplies

The water distribution, evidently is the crucial activity in an irrigation scheme. The aim is an adequate, timely and reliable supply of the required water at each farm outlet. Where the water is scarce in relation to farmers demand for it, the most important of all the functions of irrigation project management is to ensure that it is effectively and fairly distributed. (Bottrall:1981). Inequitable distribution of irrigation water supplies has always been a problem in Kabul River canal system. The tail reaches of the system have been experiencing chronic irrigation supply-shortages. It is reported that during the second quarter of the current century, large chunks of culturable areas had to be excluded from the command in view of shortages of water. An attempt was made by the irrigation department for meeting shortages by installing 11 tubewells in the same area in 1969. Later on, Peshawar salinity control and Reclamation pilot project was commissioned by WAPDA for ameliorating the water-logging and salinity problems which is also helping to some extent, in compensating for lack of supply from the canal system.

There are a number of causes for shortages occurring at the tails of the main canal and its distributaries. The most important of these is that the design capacities of various distributaries and minors are not in direct proportion to the area under their command as shown in Table-1. The table clearly shows the initial inequitability of design discharges to the disadvantage of the distributaries offtaking from the lower reaches. The area under the commands of Wazir Garhi and Pubbi Minors have therefore originally been given a set back in respect of irrigation supplies. It is noteworthy that the combined CCA of these distributaries is 5434 acres which is 11.1 percent of the total area while the supply allocated to them is 26.87 cfs, which is only 7.2 percent of the total discharge. Pabbi minor is the worst hit as it cannot draw even 50% of the required discharge. It is generally seen that even if the supplies from

Manning,s roughness coefficient has been selected as 0.016 in view of the local conditions and the side slopes have been retained as 1:1. The lining is proposed to be 4 inches thick 1:2:4 concrete with a 3/4 inches thick base layer of 1:6 cement-sand mortar. A freeboard of 1.5 feet has been provided above the full supply level. The proposed parameters of the whole canal including the lined and unlined portions are given in Table-8.

Conclusions

The performance of a canal based irrigation system depends on a complex set of interaction between the two distinct set of parameters: the effect of physical design of conveyance system and its associated control and regulation structures and the management inputs of operation of structures and maintenance of conveyance system.

Kabul River canal system facing environmental problems of waterlogging and sedimentation on one hand and technical deficiencies on the other hand leads to inefficient water distribution. The primary design principle of Kabul River canal system was that each unity of service area (CCA) will receive an equal share of scarce water. However total share received is expected to irrigate only a limited proportion of land through adjustable proportional module whose dimensions are directly linked to the area commanded. This reflects the concept of "protective Irrigation".

Kabul River canal system is remodeled on the modern approaches keeping in view the cropping patterns and crop water requirements. The discharges at all points in the system are adjusted to deliver on basis of actual demand. Physical infrastructures are consequently redesigned and remodeled; adjustable control structures are kept minimum and only head regulator in the main canal, blow the regulator water, is distributed through the fixed structures.

Waterlogging conditions are prevailing in the whole region. It is not possible to eliminate taking localized ameliorative measures. Thorough water balance studies in the region be carried out separately for annihilating the waterlogging and salinity menace totally.

The average annual suspended sediment load transported in the Kubal River canal system amount to 74,000 tons (57.5 acre feet) This silt load is being distributed into the canal system impairing its efficiency.

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TABLE-1

DISTRIBUTION SYSTEM IN KABUL RIVER CANAL COMMAND

Name of Branch Distributary or Minor	Culturable Command		Designed Capcity at Head of Offtake	
	Area in Acre	Percentage of total CCA	Discharge in cfs	Percentage of total discharge
1. Hazar Khani Branch	11,728	24.1	106.00	28.2
2. Kurvi Branch	7,485	15.4	74.30	19.7
3. Wazir Garhi Branch	2,688	5.5	17.00	4.5
4. Pabbi Branch	2,746	5.6	9.87	2.6
5. KRC Direct Outlets	23,347	48.00	164.52	43.7
6. Tehkal Lift Scheme	706	1.4	5.00	1.3
Total	48,700	-	376.69	-

TABLE-2

Diversion requirements for existing cropping pattern

Period (Rabbi)		Irrigation Requirements (cfs)	Periods (Kharif)		Irrigation requirments (cfs)
October	1	323	April	1	269
	2	258		2	308
	3	244		3	324
November	1	230	May	1	306
	2	223		2	310
	3	102		3	362
December	1	085	June	1	450
	2	076		2	486
	3	073		3	527
January	1	028	July	1	502
	2	053		2	488
	3	042		3	457
February	1	113	August	1	476
	2	079		2	419
	3	187		3	397
March	1	105	September	1	398
	2	150		2	355
	3	203		3	331
Total		44,349 AF	Total		124,068 AF

TABLE-3

Diversion requirements for proposed cropping pattern

Period (Rabbi)		Irrigation Requirements (cfs)	Periods (Kharif)		Irrigation requirments (cfs)
October	1	330	April	1	340
	2	269		2	374
		285		3	366
November	1	305	May	1	326
	2	303		2	320
	3	124		3	369
December	1	101	June	1	455
	2	092		2	486
	3	091		3	521
January	1	035	July	1	494
	2	065		2	478
	3	056		3	447
February	1	138	August	1	465
	2	109		2	409
	3	231		3	392
March	1	147	September	1	398
	2	206		2	358
	3	266		3	337
Total		54,286 AF	Total		126,952 AF
					Total Annual = 181,238 AF

TABLE-4

DESIGNED CROPPING RATTERN FOR KHARIF

CROPS	BASE YEAR		FUTURE	
	INTENSITY	AREA	INTENSITY	AREA
Rice	0.8	414	1.0	487
Maize	21.8	10596	20.0	9740
Fodder	3.8	1863	4.0	1948
Vegitables	4.9	2388	5.0	2435
Orchards	12.3	6001	12.0	5844
Sugarcane	21.4	10416	22.0	10714
Others (Pulses)	2.5	1198	1.0	487
Kharif Total	67.5	32876	65.0	31655

TABLE-5

DESIGNED CROPPING RATTERN FOR RABI

CROPS	BASE YEAR		FUTURE	
	INTENSITY	AREA	INTENSITY	AREA
Wheat	17.00	8302	33.00	16071
Barley	0.6	303	-	-
Oilseed	0.1	36	2.0	974
Fodder	10.4	5061	10.00	4870
Vegetables	2.8	1386	5.00	2435
Orchards	12.3	6001	12.00	5844
Sugarcane	21.4	10416	22.00	10714
Other (Tobacco)	1.4	703	1.00	487
Rabi Total	66.1	32208	85.00	41395
Annual	133.6	65084	150.00	73050

TABLE-6

CROPPING PATTERN ALTERNATIVES

Alternatives	Cropping Intensity		Cropping Ratio		Maximum Water Requirement (cfs)
	Kharif	Rabi	Kharif	Rabi	
Alterna - I	0.75	0.75	1	1	570
Aterna II	0.65	0.85	1	1.31	500
Existing	0.67	0.66	1	1	450

TABLE-7

A DESIGN DISCHARGES FOR KABUL RIVER CANAL (KCR) SYSTEM

Main Canal-RD	Offtaking Channel	CCA (acres)	Water Requirment (cfs)	Seepage loss (cfs)	Total Water Requirment (cfs)	Accu:Requirment (cfs)
200+000		2,949	31.76	5.09	36.85	36.85
167+379	Pabbi Branch	2,746 2,291	25.12 24,68	1.36 4.51	26.48 29.19	63.33 92.52
150+000	Wazir Ghari	2,688 2,550	25.28 27.46	1.46 5.59	26.74 33.05	119.26 152.31
133+358	Kurvi Branch	7,485 2,826	68.48 30.43	6.36 12.17	74.84 42.60	227.15 269.75
106+000		1,732	18.65	0.69	19.34	289.09
71+878	Hazar Khani Branch	11,728 5,850	107.29 63.01	10.98 4.20	118.27 67.21	407.36 474.57
66+932	Tehkal Lift Scheme	706	7.60	-	7.60	482.17
20+200		1,373	14.74	0.29	15.03	497.20
14+000		260	2.80	-	2.80	500
1+500		-	-	-	-	500
00+000		-	-	-	-	500
Total				51.24		

TABLE-8

: PROPOSED PARAMETERS OF KABUL RIVER CANAL

Reach RD to RD	Design cfs	Bed Slope	Bed Width (ft)	F.S.D. (ft)	Side Slope	Type of Section
00+000 to 1+500	850	1:5596	66.58	5.10	0.5:1	Earthen
1+500 to 18+000	500	1:5122	50.14	4.28	0.5:1	Earthen
18+000 to 41+650	490	1:5090	49.14	4.26	0.5:1	Earthen
41+650 to 70+000	444	1:5000	46.80	4.17	0.5:1	Earthen
70+000 to 72+030	444	1:4972	46.80	4.17	0.5:1	Earthen
72+030 to 80+870	277.68	1:3012	16.00	4.00	0.5:1	Lined
80+870 to 106+000	277.68	1:5000	17.00 15.69	4.25 4.50	1:1	Lined
106+750 to 133+350	260.48	1:4594	35.13	3.52	0.5:1	Earthen
133+350 to 150+000	144.03	1:4162	25.40	2.93	0.5:1	Earthen
150+000 to 167+379	87.25	1:3829	19.25	2.54	0.5:1	Earthen
167+379 to 178+179	35.10	1:3290	11.41	1.97	0.5:1	Earthen
178+179 to 189+363	23.40	1:3000	8.50	1.77	0.5:1	Earthen
189+363 to 193+258	11.70	1:2770	6.05	1.46	0.5:1	Earthen
193+258 to 196+000	6.80	1:2500	4.1	1.35	0.5:1	Earthen
196+00 to TAIL	3.50	1:2000	4.1	1.30	0.5:1	Earthen

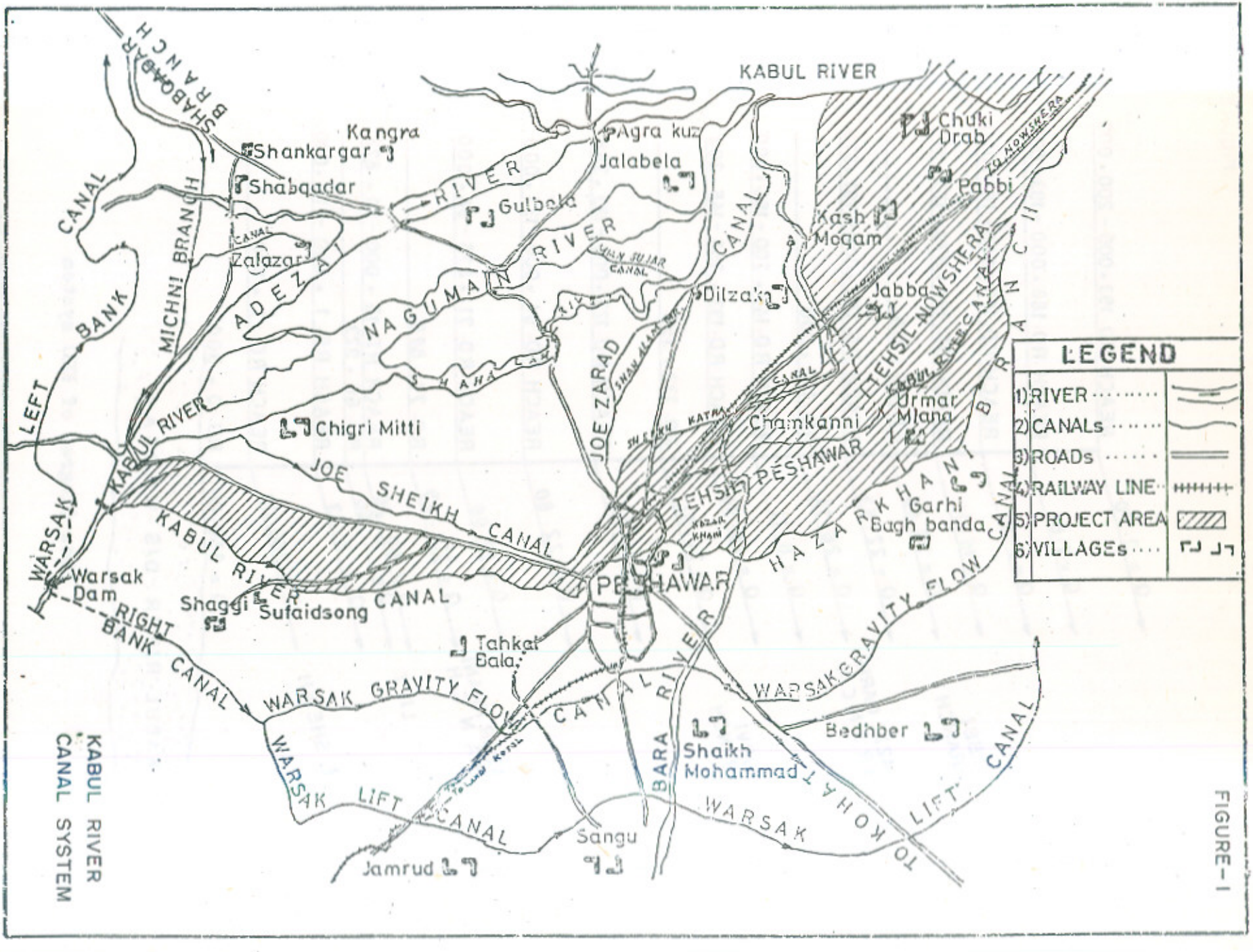
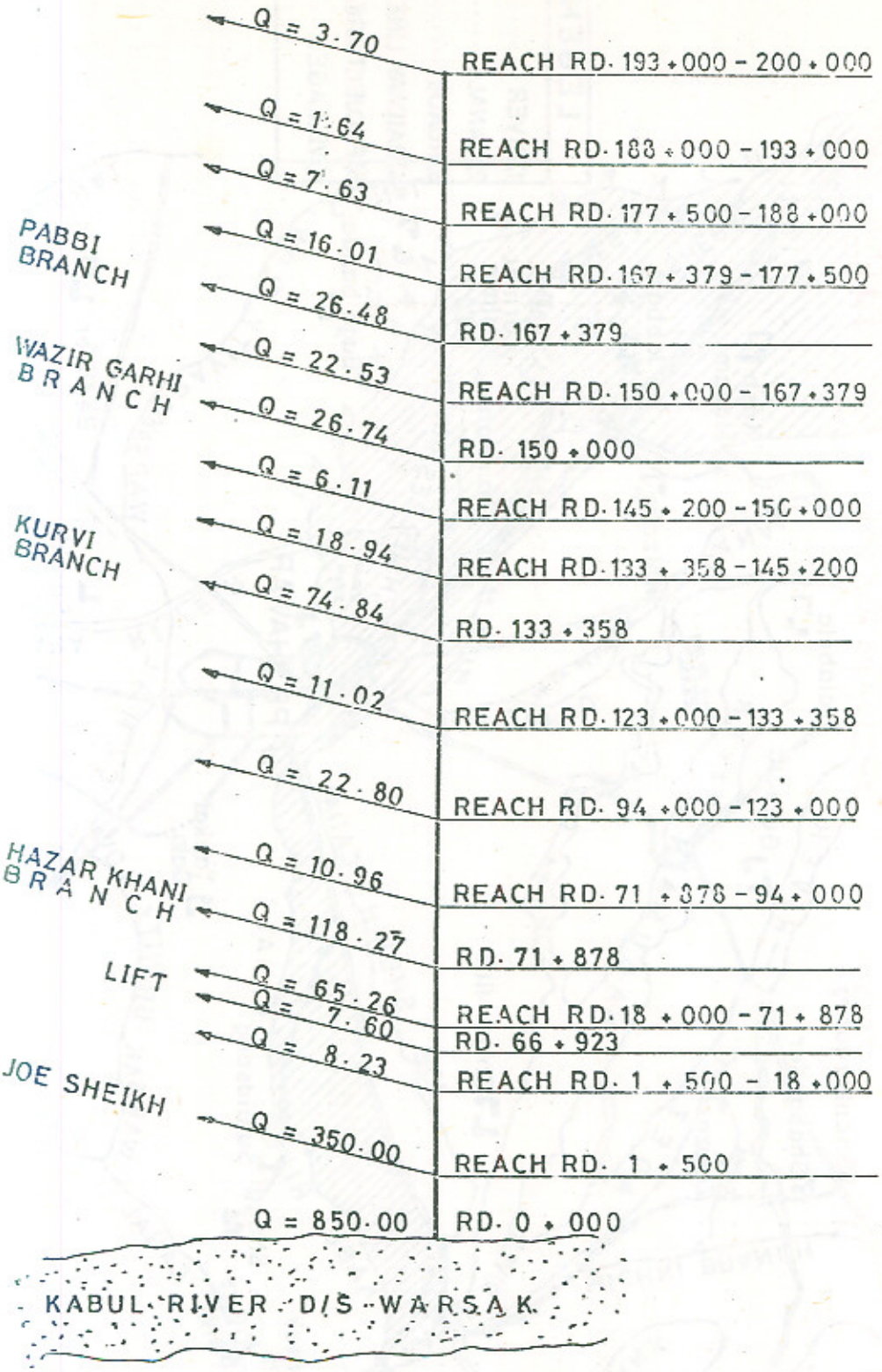


FIGURE-1

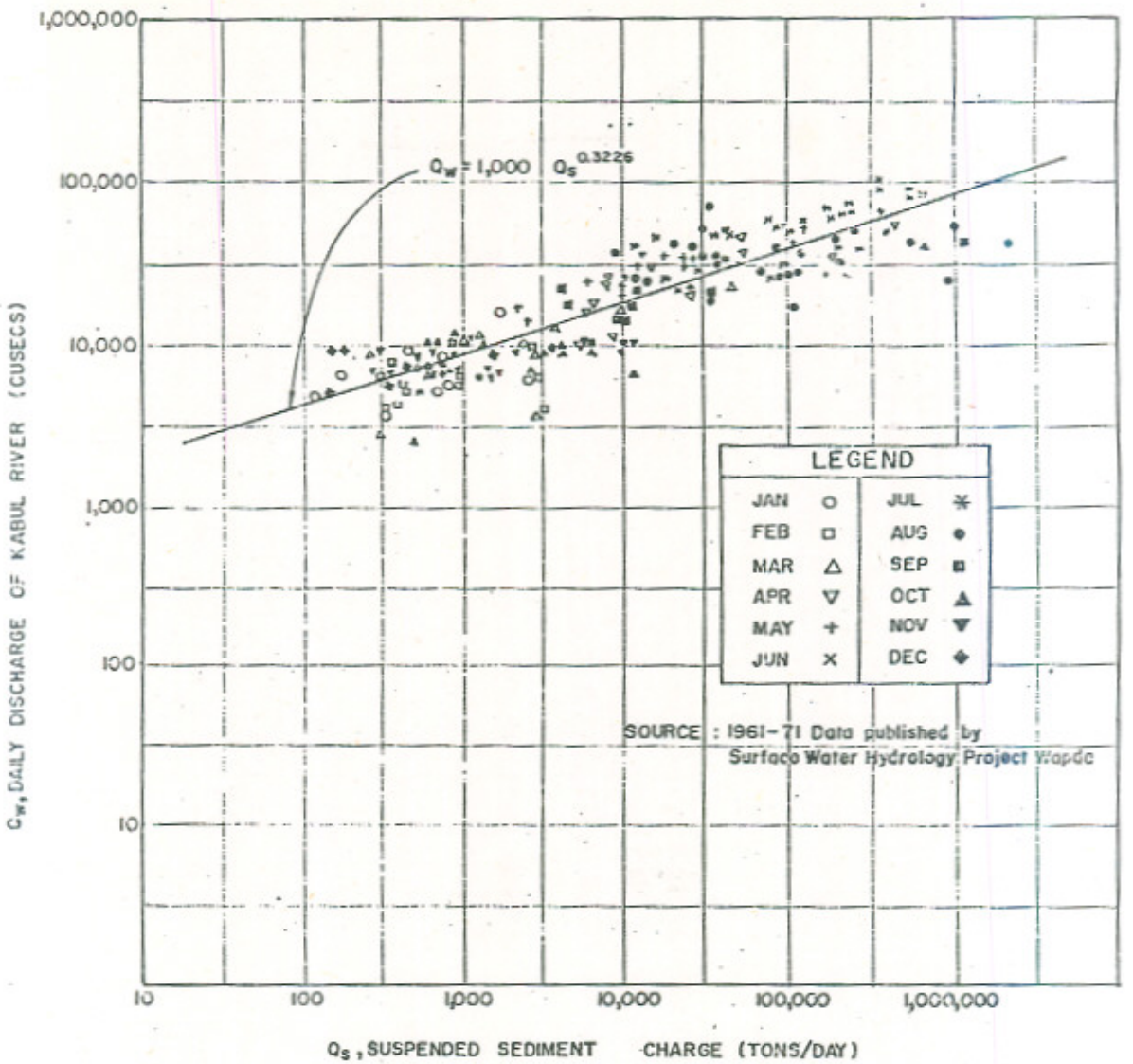
KABUL RIVER CANAL SYSTEM

FIGURE – 2



Flow diagram of KRC system

FIGURE – 3



Sediment Rating Curve of Kabul River
(NESPAK : 1981)

