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Inland Navigation in West Pakistan—A Few Proposals

By

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Introduction

A look at the communication map of West Pakistan indicates that the most highly developed areas are between latitude 29°N to latitude 35°N, whereas West Pakistan extends from latitude 24°N to 37°N. The centre of gravity of the highly developed area is along latitude 32°N. The only modern seaport for the whole of West Pakistan is at Karachi which is on latitude 25°N. This shows that for trade and commerce, goods have to be transported over a distance of about 700 miles before their real destination or despatch begins. This long distance of the hinterland is straining the rail and road transport services. Goods have to wait sometimes for months at Karachi to be cleared. This not only raises the cost of transportation but is affecting the general price levels in the country. Karachi also serves as a port for Afghanistan and after Independence the load which was originally shared by Calcutta and Bombay also has to be carried by Karachi. From defence considerations, we have a very vulnerable transport system in West Pakistan. The road and railway both run close to each other right from Karachi to Peshawar.

In 1959, a directive was issued by the President of Pakistan that a study should be carried out to make river Indus navigable from Kalabagh to sea and also to study the feasibility of converting existing irrigation canals into navigation channels. The West Pakistan Irrigation Department carried out certain studies. The reach of the river Indus from Sukkur to sea presents serious difficulties, as there is little water in Indus below Sukkur in the non-flood season. A new alternative was proposed by the author for an independent navigation channel making use of Jamrao canal up to Jamrao Weir and a multi-purpose navigation-cum-irrigation channel from Jamrao Weir to Kotri. Alternatives were also examined for making use of Kalri Begar feeder and Kalri lake with a new link from Kalri lake to Karachi. As this link has to pass through difficult terrain from Kalri lake to Karachi, a new alternative was finally examined for a link from Kotri to Karachi along Indus. Though the link from Kalri lake to Karachi was supported by the Navigation directorate, the officers of the Irrigation Department who had a thorough knowledge of the southern areas,

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preferred an alternative alignment from Kotri to sea along Indus. This paper discusses a few proposals for inland navigation in West Pakistan.

History of Inland Navigation in West Pakistan

River Indus and tributaries were used for navigation since time immemorial. The earliest historical evidence of navigation on Indus is obtained from a seal and potsherd-graffito from Mohenjo-daro 2500 B. C. both of which show a boat with sharply upturned bow and stern of a kind parallelled in Crete, Egypt and Sumer. One of the representations shows a mast and yard, the other a central cabin and a man at the steering oar.

Alexander is supposed to have crossed West Pakistan from Jhelum to Kotri in about 330 B.C. He is known to have employed 200 river craft for this purpose. Ptolemy describes the mouths of Indus in his day which were altogether different from those of today. During the Muslim period after the conquest of Sind by Arabs, navigation must have played an important part, as Arabs were a great maritime nation.

As late as the 14th century A.D., navigation along rivers, canals and other water courses was a flourishing trade. The most authenticated description of the various canals and rivers in this era and the territories covered by them are given by Rennell in his book, "Map of Hondoostan of the Mogul Empire". For all these waterways, naturally the principal sources were the Indus and the Ganges and their larger tributaries.

"The Indus and its branches", writes Rennell, "admits of an uninterrupted navigation, from Thatta, the capital of Sind, to Multan and Lahore, for vessels of near 200 tons and a very extensive trade was carried on between those places respectively in the time of Aurangzeb; but at present very little of this trade remains, owing to a bad government in Sind and probably to the hostile or rapacious disposition of the Sikhs, the present possessors of the countries of Multan and Lahore."

An impressive observation of Rennell from the defence point of view is that "it opens a communication between the different posts and serves in the capacity of a military way through the country, and infinitely surpasses the celebrated inland navigation of North America, where the carrying places not only obstruct the progress of an army but enable the adversary to determine his place and mode of attack with certainty."

"Whether this grand design of Feroze's was completely executed, I have no means of knowing . . . . Had it been completed, it must have ranked with the greatest works of this kind; we should then have seen two capitals (the Ganges and the Indus) rivers, which traverse a large part of Southern Asia, which enter the sea at a distance of 1,500 British miles as under, and which stretch out their arms, as it were, to meet each other, united by art; and

those, by Nature, to a third; so as to form an uninterrupted inland navigation from the frontiers of China to those of Persia."

Rennell's map 1792 shows how richly the gigantic plain was served in the 14th century by a system of waterway known as "Nehr Behisht", canal of Feroze connecting Sutlej and Jumna via Saraswaty. Parts of these channels have fallen in the alignment of modern irrigation system of the Western Jumna canal.

Steam power propelled the first water craft in the Indo-Pakistan sub-continent in 1823. By 1834 steam had asserted its superiority. On Indus the British established two flotillas known as the Indus flotilla operating between Sukkur and Kotri and the Punjab flottilla between Sukkur and Kalabagh. The flotillas were used mostly for military and commercial purposes. This was not only effectively used for supplies to Afghanistan but was very handy to rush troops to suppress the uprising of 1857, also known as the first war of Independence of the sub-continent. But for this it would have been impossible to reach the northern areas, as there were no proper roads or railways.

After the first war of Independence, navigation on Indus received more attention and the river became a busy highway of commerce and trade. It is during this period that a statement says cotton and cotton goods, oilseeds, indigo, sugar, etc., worth about nine crore of rupees were exported from the Punjab area through Karachi; considering the prices of things at that time, it should have been a fair volume. Imports were only about one-tenth of this value and consisted of metals, metallic goods, piecegoods, etc. These figures are for cargo carried on steamers only. About an equal volume of traffic is said to have been handled by private sail boat owners as independent operators.

Transportation of goods from inland to Karachi was not, however, a very easy sailing affair, inland vessels of Indus Flotilla could not deliver their cargo directly to deep sea vessels at Karachi harbour due to shallow water at the mouth of the Indus; ocean vessels could not enter the sheltered inner waters of the river for picking up cargo. The lighter inland vessels, designed to navigate on weather-protected rivers could not cross the near eighty miles of heavy monsoon seas between the Indus mouth and the harbour of Karachi. Therefore, as a year round arrangement, the Indus Flotilla delivered their cargo at Kotri to a privately operated Sind Railway Company, which took it to Karachi by land.

Such large quantities of cargo were, however, moved without any through service being available to the public. The owner was supposed to be incharge of his goods at all points of transhipment and each unit, even the two government flotillas, had different freight rates. A piece of baggage destined from Peshawar to Karachi had to really rough it through. From Peshawar to Attock it came

by road, Attock to Kalabagh by country-boats. Kalabagh to Sukkur, Punjab Flotilla steamer carried it. At Sukkur it boarded on Indus Flotilla Steamer, which dropped it at Kotri whence it rode a train to Karachi. It should have required a fair amount of good luck for a thing to arrive in time and intact.

Operation of the two Government Flotillas was discontinued from 1871, when through railway service was established. Traffic of privately operated boats also petered out gradually as increasing withdrawals of dry season river flows added to navigation hazards on the water courses of the area. But the survival of this primitive form of water transport during such a long period of neglect in competition with more modern and efficient land transports, is proof enough for the economic feasibility of inland navigation in West Pakistan.

From the fundamental considerations of friction losses, water transports are much better than either roads or railways. They are supported on a fluid medium and load concentrations are not as severe as on the axles of a land transport. The moving parts on a floating craft are much fewer and all its movements being gradual and rhythmic, it spends the propulsive power most economically. Land transports suffer from the unevenness of their tracks resulting in great loss of energy and the added mechanical wear increases maintenance problems. Longitudinal grades are missing or less frequent on a waterway. Vibration and jerky movements also cause more damage and losses to goods carried by land transport than in carriage by water craft. Horizontal and vertical clearances are usually more liberal on waterways than on railways and roadways. Movement of big and heavy machinery is, therefore, more easily done on water. It also saves the road pavements and railway tracks from damage by excessive loads and does not tax the load carrying capacity of culverts and bridges.

Need for an Inland Waterway in West Pakistan

Quick returns can be obtained by investing capital to improve the transportation system. This is the basic need for all other developments. This is one of the reasons why loan giving agencies give loans for the transportation sector even to underdeveloped countries.

Both in the interest of long-range development and the overall economy of the country water transport claims equal attention as a national responsibility. That each type of transport has a duty and a field clearly cut out for it is accepted by experts. It is conceded that waterways and railways are destined not to supplant but to supplement each other. Between the two there is a natural division of traffic. To the rail road goes the least burdensome traffic, which demands regularity and quick transit; to the waterways gravitate the

heavy freight of small value, which can only be transported when freights are low. Waterways, by increasing traffic, are rather the auxiliaries than the competitors of rail roads. In procuring for the manufacturers cheap transportation of raw materials they create freights which subsequently gives profits to the rail roads. Oil transport by water would reduce fire hazards.

Though slow, lack of speed by water is more than made up by the great bulks that can be handled at a time with suitable craft. Weight for weight fewer men are required to manage the cargo. The capital cost of equipment, maintenance of craft and construction of necessary works are generally cheaper than for railways. For comparable distances freight charges are about half to a third of the rates by rail. During the last few centuries political reasons outweighed economic considerations. The State helped the extension of railways by guaranteeing minimum profits and allowing other concessions for development. Inland navigation, on the other hand, was left severely alone. It is a moot point whether the story of inland water transport in Pakistan would not have been different, had the same enthusiasm, as for steam propulsion on land, been applied to water craft.

In certain quarters it is believed that water transport and railways are essentially competitive. But the developments made in Europe in the last quarter of the 19th century clearly indicate the fallacy of such an assumption. Between 1875 and 1900, when enthusiasm for railways was at least as great as in Pakistan, the German Government executed a programme of river improvement and construction of artificial waterways at a cost of about Rs. 66 crores. The Rhine, in which only small vessels of shallow draft could navigate up to Strausbourg, was converted into a deep channel for taking barges of as much as 9 feet draft up to Cologne, while vessels of 600 ton capacity and more could steam up as far as Strausbourg. In the same period the German inland fleet was trebled to cope with the increased traffic. Sixty million tons of coal were transported in 1900 against the 12.5 million in 1870. Following the German effort, France, Belgium and Holland also developed their waterways considerably. Please see figures I and II.

Some engineers consider navigation as something primitive and undesirable and even unsuitable for West Pakistan. As such, inland navigation and river transport was left almost literally high and dry. A few examples of navigation canals in the advanced countries are discussed to make a convincing case for inland navigation in West Pakistan.

Some examples of important European navigation canals

Holland now possesses some 4800 miles of navigable canals and rivers. This is about 48 times the average width of the country. Of these canals

about 1500 miles are suitable for ships up to 400 tons and about 930 miles for ships up to 1000 tons. About 340 miles are navigable for vessels about 2500 *i.e.*, almost 3½ times the average width of the country.

The extent to which Holland depends on water transport is evident, when we consider that in 1952 the transport of goods in Rotterdam alone was 43,409,000 metric tons. This means that working a full 24 hours day, 14 trains of 30 wagons each would be needed per hour. Water transport has no difficulty in coping with the Rotterdam trade, for a mere 75 barges of an average of 2000 tons burden would suffice per day. A single tug can easily tow 10,000 tons of goods, a performance equal to that of 20 to 25 heavy locomotives.

The development of inland navigation in the Netherlands is clearly reflected in the widening and deepening of the Amsterdam-Rhine canal since 1826.

		sq. ft.		metric tons.
In 1826 :	cross sectional area	310	largest ship	500
In 1890 :	,, ,, ,,	900	,, ,,	1350
In 1938 :	,, ,, ,,	2750	,, ,,	4300
Potential:	,, ,, ,,	3860		

When Henry Ford, the automobile king, saw all these canals his advice was to fill them in and to make roads on them. The Dutch have no intention of following his advice, for their fleet of inland vessels about 20,000 of them, transport their goods particularly mass products and heavy piecegoods, in a cheap and effective manner.

In fact, one of the best ways to build a road in a low marshy land is first to dig a canal; some soft layers of peat are removed in this way before a body of sand is provided to act as a foundation for the hard road. This sand base often penetrates 50 feet into the soft layers, so that enormous quantities of sand are needed before the road can be built. It is for this reason that the roads in the low lying parts of Holland are among the most expensive in the world.

In such soil the construction of canals is also extremely difficult. There is a case on record of an attempt to dredge a canal in Netherlands which refused to increase in depth, no matter how much dredging was done. This lasted for days until suddenly a depth of 50 feet was found behind the dredger. The peat layer had had a tendency to float and had been completely dredged away. It is apparent from the above how important it is to develop inland waterways for a low deltaic country. Roads are most uneconomical in such areas both in capital cost and maintenance. East Pakistan is similar to Holland in this respect.

Waterways are of immense value to land-locked countries with no outlets to sea. Moscow is a remarkable example of how this land-locked city has been connected by navigable waterways. Moscow is now well known as the port of five seas. The Volga Don Canal is called the route of the five seas. Prior to its construction, a system of canals linked the Volga with three seas of the European part of the USSR, the Baltic, White and Caspian. Thus Moscow, the capital of the Soviet Union, was then a port of the three seas. Now, with the establishment of a single water transport system in the European part of the USSR, two more seas are reached by water from Moscow—the Black and the Azov.

During the six years of navigation on the Volga Don Canal the amount of coal transported has grown 15 times. Timber transportation has grown approximately at the same rate. Now, timber is shipped not only to the Donbas but also to regions of the Black Sea coast, the North Caucasus, and even over the Danube to Rumania, Hungary and Bulgaria. Other goods also shipped in huge quantities on the Canal are foodstuffs, building materials, fertilizers, fish, salt, metal and machinery. As a passenger transport, the Moscow-Rostov-on-Don route is one of the most popular water lines for holiday travel. This line is plied by new diesel-electric ships supplied with all conveniences. During the past navigation season, over one million passengers were carried over the canal.

The American Parallel

It is indeed curious how the history of water transport in Pakistan has closely followed that of U.S.A. until the first World War. After the advent of steam, between 1820 and 1850, the tonnage of cargo carried by watercraft in America had risen eleven-fold, and the length of canals from 1,200 to 37,000 miles.

As in Pakistan, the development of railways in America put a stop to the growth of water transport. From 1880 onwards the transport on waterways declined rapidly. By 1889, half the length of canals originally built for navigation had been abandoned; and within a decade steam boats had become a rare sight on the waterways. After the first World War, the folly of neglecting these vital lines of transport appears to have been recognised. Since then the American water transport has staged a striking revival and now claims a public aid of more than 130 million dollars a year. The experience of all countries has shown that development of navigation channels brought in its train industrialization of regions, stepping up traffic along waterways. In the U.S.A. as a result of such a policy, designs of vessels have undergone revolutionary changes to accommodate increasingly large cargoes. Freights weighing as

much as 23,000 tons are being transported in one tow by steam vessels.

Navigation is one of the main components of T.V.A. Multi-purpose project. The Suez Canal was considered an engineering wonder in the last century but bigger and more interesting navigation canals followed. The Panama Canal connects the Atlantic and the Pacific Oceans with a series of locks negotiating a difference in level of about 150 feet. St. Lawrence Seaway, recently completed, is a gigantic multi-purpose project connecting the Atlantic ocean with the Great Lakes between U.S.A. and Canada. This seaway has brought even Chicago (which is in the middle of U.S.A.) within the reach of ocean-going vessels. Cost of such gigantic projects have been justified because of the high returns, possible from an inland navigation canal.

A Plan for a Navigable Waterway from Peshawar to Sea

In West Pakistan inland navigation can be developed on the major rivers which have water throughout the year and seasonal navigation on others. Storage reservoirs upstream of Warsak and future Mangla and Tarbela dams make av ilable lo g navigable reaches. The biggest scope is offered by river Indus on which navigation still exists in some reaches. Very few canals are suitable for navigation as they run with low supplies in winter and even those which run with steady supplies require heavy remodelling for navigation. There are, however, some big canals in West Pakistan which can be usefully employed for navigation economically. This shall be discussed subsequently.

Very little information is available about the volume of traffic on the waterways in West Pakistan. It is, however, known that some country sail boats transport rock salts, alkaline clays and coal between Kalabagh and Sukkur on Indus. These two points are separated by about 500 miles. There is no navigation lock at Sukkur barrage though locks exist at Kalabagh, Taunsa and Gudu which were constructed after Sukkur. Sukkur is a great obstruction to through navigation on Indus. The Kotri Barrage (G. M. Barrage) has a modern navigation lock.

A census of boat traffic on Indus at Kotri carried out in 1946, indicated that the total number of boats throughout the year was 680 downstream to Kotri and 638 from Kotri upstream. This works to less than four boats passing Kotri per day. The total maundage of the boats going downstream was 1,80,035 maunds (6,547 tons) and those going upstream only 638 maunds. This shows that goods travelled mostly from upstream to downstream. Statistics of the dimension of the country boats plying in this reach of the river show that they had a maximum length of 72.5 feet, maximum width of 20.25 feet, maximum height above water level 12.75 feet, maximum draft of 6 feet. The maximum carrying capacity of a boat was 1250 maunds (44 tons) only.

This shows how badly this historical waterway was neglected.

"All modern industries require large quantities of water supply for their processings and cooling. If water supply is so combined with water transport facilities and some flood protection, most industries would prefer to be located on a river. Some of our large cement, fertilizer, sugar and textile mills as well as the salt, iron ore and coal mines are already located within a short distance of the Indus channel. Inland navigation could benefit all these units and as our control on floods in the valley increase, we may expect many more industries established along the way closer to the river".

The Government of West Pakistan has already started studies in this connection and as a first phase, the navigation of river Indus from Kalabagh to Sukkur is being studied. The reach of river Indus from Kalabagh to Attock has narrow gorges and steep slopes. Navigation in this reach would be difficult unless dams are constructed on this river to create a suitable depth for a navigation channel. Potential dam sites on Indus exist at Kalabagh, Khushalgarh and Attock. The lower reaches of river Kabul from Attock to Peshawar could be made navigable by a future low dam at Attock. In the upper reaches, river Swat joins Kabul river and could contribute supplies in winter months through releases from its future storages, such as Kolangi dam on Swat and Gurudope dam on Panjkora, which would further help making available greater depth in Kabul river for future navigation.

It is possible to provide a lock in the Sukkur barrage by converting one of its bays into a rafting bay. A more serious obstacle to navigation downstream of Sukkur is the limited depth available in the Indus in winter months, when no water passes downstream Sukkur. Kotri barrage depends mostly on regeneration supplies downstream of Sukkur.

The real difficulty, in developing a navigable waterway, is presented from Sukkur to Kotri and Kotri to sea. Canalization of the river between Sukkur and Kotri in winter months could be very expensive, as the river has a tortuous course many times its length in floods. The operation and maintenance costs of a navigation channel would also be exhorbitant.

An ideal solution would be to have an independent navigable waterway from Sukkur to Kotri and Kotri to sea. This paper discusses the possibilities of a multi-purpose project for a navigation-cum-irrigation channel from Sukkur to Kotri and Kotri to sea. The proposal makes use of some parts of the major irrigation canals in the southern areas such as Nara Canal and Pinyari feeder.

Details of the Proposal for a Navigable Waterway from Sukkur to Kotri

River Indus between Sukkur and Kotri is becoming more and more difficult for navigation due to bigger diversion of supplies of river Indus in

the upper reaches. The Indus Basin Plan with its future storages and link canals shall further reduce the flow period between Sukkur and Kotri. The regeneration of supplies shall also reduce due to the smaller period of high flows. Whatever small supply is released from Sukkur downstream for Kotri shall be wasted in the wide meandering river. An important point about river Indus is that it runs on a ridge built by its own sediment deposits which encourages heavy losses. The future programme of tubewell pumping along the river also shall have its effect. It would be ideal if we can find a natural water course which runs at the lowest levels as a drain and has a well defined regular course. Nara canal from Sukkur to Jamrao weir is one such channel as it runs in the bed of eastern Nara river. The curves in its head reach have been straightened and there are proposals to deepen this canal by dredging and also to straighten the curves in the lower reaches also.

There is already boat traffic in Nara perennial canal with a designed discharge of about 13,000 cusecs at head but running to about 10,000 cusecs. A new connecting link of about 70 miles between Jamrao weir and Indus upstream of Kotri barrage would not only serve as a navigation channel but would also work as a feeder for Kotri barrage in crucial months, when only very small discharges are released downstream of Sukkur for Kotri. (Please see figure III). A channel of 50 feet bed width and 8 feet depth is proposed in the first phase from Jamrao weir to Kotri. This shall pass a discharge of 1050 cusecs and cuts the least number of channels, roads and railways. The following are some of the advantages of this alignment :

1. The length along Nara Canal and the new proposed link reduces the distance between Sukkur and Hyderabad considerably as this is the chord of the loop formed by the Indus. The low weather channel of Indus would be many times longer than this new alignment.
2. The shifting of landing grounds and the marking of navigable river channels can be obviated by using this artificial channel for navigation-cum-irrigation.
3. As old Naracut offtakes upstream of Sukkur barrage, the necessity of providing any lock gate in the barrage at Sukkur is obviated in the first instance and the dangerous reach of Sukkur gorge also is avoided.
4. As Nara canal itself is the bed of old Nara river which had been abandoned, this forms a natural channel for navigation and drainage. The area between Jamrao and Sukkur has no communications along Nara and is extremely backward. With this canal made navigable, this area would develop fast.

It can be seen from the alignment plan that the link channel from Jamrao to Kotri passes near Nawabshah and is mostly in cutting so that it may facilitate provision of suitable free board at the bridges without undue raising. The only important canal, which crosses this channel, is the Rohri canal which can be syphoned under it. The loss of head is so small that it can be easily adjusted by regrading Rohri canal between the control points upstream and downstream. There are one or two small channels whose offtakes could be shifted suitably to provide pumping from the navigation channel.

The navigation-cum-irrigation feeder channel joins Indus8 miles upstream of Kotri. Due to heading up at the Kotri barrage the reach between its tail and Kotri of Indus is navigable. If need be, this channel could be extended right up to Kotri. During flood months, an alternative navigable route along Indus from Kotri to Sukkur and Kotri to sea is also available to serve important places along the river.

Some salient features of a navigable canal from Kotri to Sea

An alternative was examined for a navigable canal from Kotri to sea via Kalri Beghar feeder, Kalri lake and a new link from Kalri lake to Karachi as a multi-purpose project for irrigation and navigation. After the study of economics of this proposal, it was decided not to recommend an alternative from Kalri to sea, as the cost of the link from Kotri to Karachi was high. The new proposal consists of making use of Pinyari canal off-taking from Kotri barrage, which runs close to river Indus. A link shall be provided from Pinyari feeder to the river Indus downstream Thatta up to which back water of the sea is available. Pinyari feeder is a big canal with deep section and there are reaches in which navigation is already being practised. This could be further improved to take care of the additional traffic of barges in a length of 75 miles to join river Indus downstream of Thatta. An important factor in this connection is that Pinyari is a non-perennial canal and as such water has to be passed through this during the dry months. As the river downstream of Kotri shall be practically dry, it may be necessary to keep some supply escaping through Pinyari feeder into the river not only for fresh drinking water for the people living along the river, but also to see that the salinity of the Arabian Sea does not encroach into the mouth of river Indus, due to the stoppage of fresh water. The reach of river Indus from downstream of Thatta to the mouth of river could be easily made navigable due to the backwater effect. Keti Bundar is a port at the mouth of river Indus which is already being used by smaller crafts. This port is being developed as a subsidiary port, as the Government is keen to have alternative ports for Karachi.

Feasibility of navigation in some of the bigger canals in West Pakistan

In accordance with the directive of the President of Pakistan, the former

Chief Engineer (Water), WAPDA who is now Secretary to Government, West Pakistan, Irrigation and Power Department, had made certain proposals for navigation of some of the proposed inter-river links. The West Pakistan Water and Power Development Authority examined proposals for providing enough flexibility in the designs of the following links under the Indus Basin Treaty :—

(*a*) Rasul-Qadirabad-Balloki Link.
(*b*) Chashma Jhelum Link.
(*c*) Balloki-Suleimanki Link.

Rasul-Qadirabad-Balloki Link runs in deep cutting and is mostly below the sub-soil water level and as such can be easily made navigable even with low supplies in the link in winter. The Chashma Jhelum Link in the head reach is below sub-soil water level and in the tail reach is in comparatively less cutting. It may be more difficult to make this Link navigable than Rasul-Qadirabad-Balloki Link. An important point even about Rasul-Qadirabad-Balloki Link is that it does not connect any commercial places and as such may not be of any great use for transport of commodities. The following additions may be required, if this link is to be made attractive :

(1) The reach of river Ravi from Lahore to Balloki should be made fit for navigation so that an important town is connected to Rasul-Qadirabad-Balloki Link.
(2) Sheikhupura could also be connected to the link, as Sheikhupura main drain outfalls into the link, if this drain is deepened for navigation, we would get another important outlet. Similarly more important points along the link could be connected.
(3) The reach of river Jhelum from Rasul to Jhelum town should also be made navigable as enough water would be available due to releases from Mangla dam even in winter months.

The Balloki-Suleimanki Link in the head reach could be made navigable as the link runs in very deep cutting and there is enough free board in all the masonry works. Below RD 1,06,000 a second link is proposed which shall also be in cutting and could easily be made a navigable link right up to Suleimanki. Important places like Chunian and Pattoki could also be connected to the link by subsidiary navigation links.

Cost of the Proposals

WAPDA has given figures of cost for keeping flexibility in various link canals (Appendix I). The cost of the link from Jamrao to Kotri and Kotri to sea would be a few crores of rupees, as the capacity proposed for the link is small to make it fit only for barges of a draft of 3 to 4 feet. The

total length of the new channels is about 150 miles and as they have a capacity of a major distributary, cost is no great problem. As this is a multi-purpose project, the cost to be charged to navigation would be such that it could be paid up in a few years by the heavy traffic which shall pass through the waterway.

It would be of interest to mention here that a country like Netherlands has excavated 800 million cubic yards of earth for drains and smaller canals and 200 million cubic yards of earth for shipping canals in the first half of this century alone. The total excavation for the Suez Canal up to 1955 is of the order of 300 million cubic yards. This shows how productive inland navigation can be. Holland became a great marine power a few centuries back and it is said by Swedes that they could not see anything Russian in the Russian fleet of Czar, Peter the Great, except the flags and that if this fleet had to fight against the Dutch, "it had to be done under Dutch admirals commanding Dutch sailors with Dutch gunpowder shot from Dutch cannons".

This paper is not a detailed study of possibilities of inland navigation in West Pakistan, but is meant to give certain lines of thinking which have occurred to the author from time to time. As such firm costs cannot be stated. Considerable survey, investigation and research would be required to prepare a feasible navigation scheme for inland waterways in West Pakistan. As the subject has not received the importance it deserves, I have attempted to give my personal thinking on the subject, without any pretence to expert knowledge.

Need for further research and study

The traffic envisaged along this waterway is that of steel barges or wooden and country boats for carriage of materials in bulk. There are possibilities of mechanical towing of these craft. As traffic develops, the channels could be widened and deepened to accommodate bigger vessels. It may be some time before we resort to the modern aluminium alloy tugs towing a string of shallow barges and fast motor boats. To start with we can make use of the country boats fitted with motors and strengthening them suitably. Considerable research is needed for manufacturing cheap barges for carriage of materials in bulk. China has recently manufactured concrete barges which opens out a new chapter in cheap and economical means of transport. As Pakistan is short of steel, these concrete barges would be worth a trial. It could be further improved with modern techniques of prestressed concrete. As navigation craft would be entirely financed by private enterprise, this will save the Government considerable investment. Considerable savings in foreign exchange are possible as the heavy investment on imported railway and road vehicles could be kept under check. Investigation and research is also

required for finding most economical materials for river and sea defences, training works, landing facilities etc. We could learn a lot from the experience of countries which have faced difficulties in obtaining suitable materials for construction. In this connection, example of the loss of all timber defences in Netherlands is of interest.

"The first trouble was the appearance of a sea worm. Presumably it had arrived with a ship from some far off shore. It had a hideous form. The Dutch coast consists of loose or soft material and the weak spots of the coast had been protected against the scouring action of the sea by means f massive wooden shore defences. Once they had made them, people felt safe behind these strong and expensive works.

In the year 1730 the worm appeared and ate up the wood of the sea defences. This sent a wave of fear through the whole population. It was a national disaster. The land had become defenceless against its worst foe. It was useless to make new wooden protections. The Churches ordained public prayers for the removal of this 'terrible scourge of God'. Even a class of poetry was born which has become known as the 'worm poetry'. Holland seemed lost because of the mere loathsome worm.

However, in due time, two clever men, Pieter Straat and Pieter Van der Deure, invented the stone defence. Their names should not be forgotten for their simple but good invention proved to be the solution; we still make these stone defences. The worn Limnoria is still with us and is eager enough to eat any wood standing in the sea except tropical hardwood, but we use stones now. However much we should like to use some home produced material to replace these stones, which have to be brought from remote lands, we have not succeeded in finding a good substitute, though concrete and baked clay go a long way. Asphalt may be a tribute.

Great use was likewise made of the inspiration of one of the contractors —or was it one of the Zuiderzee fishermen? to use the heavy boulder clay, abundantly available at the bottom of the Zuiderzee. This tough alluvial clay has played a predominant role in the fight against the currents in the gaps and has helped greatly to keep expenses within reasonable limits."

The President of the British Institute of Civil Engineers, Sir George Humphreys, points out that the greatest possible use has been made of the materials available *in situ*; boulder clay, sand and brushwood. Such clever and economical work deserves, he says, special mention. We appreciate this praise. Vierligh would hardly have wished to accept us as his descendants, if we had ignored his rule to work "at little cost". He said, "It is not enough to make dikes and dams, but they must be made cheaply for the general profit". And again: "by His grace, God has given us these materials to make dams;

brushwood, turfs, stones, clay, straw, reeds, etc., and you need not seek others, but use the materials you have artfully".

In Egypt we worked with papyrus, in England with blackthorn and in China with millet stalks. The Chinese also planted out willow and today it is a commodity sold universally in China for hydraulic works.

As for the Chinese, we have great admiration for their ancient hydraulic methods, for the way their dikes are constructed and for the manner in which they close gaps, though their methods differ from ours.

East Pakistan has many lessons to learn from Netherland particularly, as it is faced with a serious shortage of material for all types of construction. It should not be difficult for them to find places of tough alluvial clay which could be developed as a material in the defence works against the currents of sea and river.

Hazards of locks and other obstructions across waterways to fisheries

It would also be relevant to mention here that artificial obstructions across rivers upset the biological balance along the waterway. For instance, the Kotri Barrage has completely obstructed the passage of Pallah fish, as the fish ladder at this site is not working properly. Whenever we examine detailed proposals for a link with locks to the Arabian Sea, all aspects have to be considered. We have a valuable lesson to learn from the closing of Zuiderzee in this connection. The following interesting example is quoted :

It is interesting to relate how badly the fishermen fared initially and how their fears passed. At the outset it was just as if Nature wanted to bear out their gloomy foreboding: for hardly any fish could be caught any more. Instead of fish Nature sent a plague of mosquitoes, a plague so terrible that every house, every tree, every field and every human being, who ventured out of doors, became covered with a grey layer of sluggish mosquitoes, like a covering of dirty snow. These pests did not bite; they rendered it impossible to look out of the windows or to drive a car, for they obscured the view. If the windscreen wipers were set in motion, they only crushed the bodies of the mosquitoes, spreading a thick blubber over the windscreen, which no eye could penetrate. In some parts mischievous boys collected handfuls of mosquitoes, like snowballs, from the streets and window sills and threw them at passers by. Many of the old fishermen saw in this plague the proof of their belief that God does not permit interference with His plans. Egypt, too, had had its plagues.

We had violated the ways of Nature, but again Science provided an answer. The Fishery experts put forward a solution, remarkable for its simplicity. Their advice was to use the locks in the Zuiderzee dike at night time, preferably about midnight. The elvers, having come all the way from the

depths off the coast of Florida, and being avid for freshwater food, now passed the locks of the sealed off Zuiderzee by millions, there to devour the mosquito larvae, for the eel is a nocturnal hunter and sleeps in the day time. They scented the food they desired as it were, and at night had waited in squirming multitudes to gain admittance through the locks. But in the daytime they all lay in the mud with their hands just sticking out, asleep and unaware when the way to their quarry was open.

This simple use of natural means saved millions of guilders. The fishermen got their eels, fattened on mosquito larvae. The Egyptian plague which had assumed such frightening proportions, disappeared. The biological equilibrium, disturbed so roughly, readjusted itself.

Summary and recommendations.

1. West Pakistan has a vulnerable transport system as the entire province depends on a single modern port at Karachi at the southern tip of the country. The road and railway both run close to each other in the entire length of the Indus Valley.

2. River Indus has served as a great waterway since time immemorial. Due to the severe strain on the road and railway system, a waterway to relieve this pressure is essential. This would supplement but not supplant the other transport system, as there is a natural division of traffic between them.

3. After a temporary lapse due to the introduction of the railways all modern countries attach great importance to inland navigation. West Pakistan would do well to make every effort to create a waterway from Peshawar to sea.

4. River Indus is one of the largest in the world and has a perennial discharge in most of its length. It could be developed for navigation. Some of the bigger irrigation canals also could be used for navigation, if remodelled. The upper reaches of Indus from Kalabagh to Attock are steep and narrow and are not suitable for navigation unless a series of dams are constructed in this reach to create the necessary depth. Kabul river from Attock to Peshawar could also be made navigable by future dams. The reach of river Indus between Kalabagh to Sukkur is most suitable for navigation. Downstream of Sukkur there is practically no water in winter months and navigation can be developed at only heavy cost.

5. Nara canal on the east of Indus from Sukkur to Jamrao weir with a new link canal 70 miles long from Jamrao to Kotri could easily replace the river Indus from Sukkur to Kotri. This would also serve as a feeder canal for Kotri in critical months. As the length along this route is shorter, it would not only reduce the length to be traversed in this reach but would also save losses in the river. A channel of 50 feet bed width and 8 feet depth in the first phase it proposed.

6. An essential feature of any inland waterway in West Pakistan is that it should connect it to sea. From Kotri the Pinyari feeder could serve as the first part of the navigation canal to the sea. This link would also make available fresh drinking water for areas along the river and keep back the encroachment of saline water of the sea in the estuaries of river Indus. The reach of river Indus downstream of Thatta is subject to tidal action and could be easily made fit for navigation up to Keti Bandar which is being developed as a port.

7. To start with, the existing country boats could be fitted with motors after suitable strengthening. In due course, steel barges with modern aluminium tugs would be introduced. As the waterway would take away most of the bulk loads from the road and railway, it would save the Government heavy investment and foreign exchange for imported road and railway vehicles and fuel. A new industry would develop in the country with considerable advantages.

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I am indebted to the officers and staff of the former Central Design Office for the drawings.

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APPENDIX I

TABLE 1.—ALTERNATIVE APPROXIMATE COSTS FOR PROVIDING NAVIGATION FACILITIES.

Link	*Single Barge System*		*Multi Barge System*	
	Lift Gates	Sector Gates	Lift Gates	Sector Gates
	(Million Rs.)		(Million Rs.)	
Rasul-Qadirabad ...	1.515	2.500	2.015	3.000
Qadirabad-Ball ki ...	9.305	11.080	9.805	11.850
Bailoki-Sulemanki ...	3.455	5.780	3.955	6.270
Chasma-Jhelum ...	2.125	3.500	2.645	4.020
Total ...	16.400	22.869	18.420	24.870
Per cent increase in cost of 4 Link Canals ...	2.0%	2.8%	2.2%	3.0%

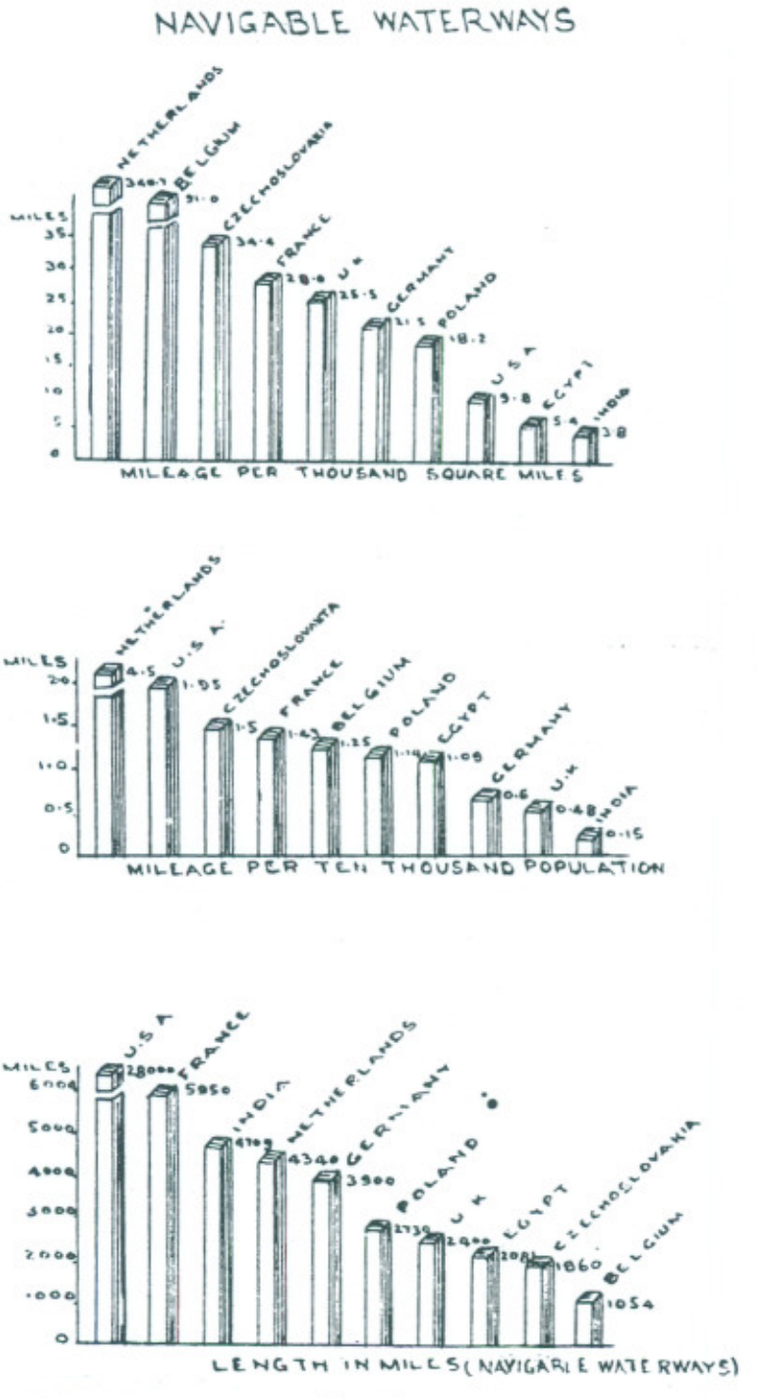

NAVIGABLE WATERWAYS
MILES
NETHERLANDS
BELGIUM
CZECHOSLOVAKIA
FRANCE
U K
GERMANY
POLAND
U S A
EGYPT
INDIA
MILEAGE PER THOUSAND SQUARE MILES
MILES
NETHERLANDS
U.S.A.
CZECHOSLOVAKIA
FRANCE
BELGIUM
POLAND
EGYPT
GERMANY
U.K
INDIA
MILLAGE PER TEN THOUSAND POPULATION
MILES
U.S.A
FRANCE
INDIA
NETHERLANDS
GERMANY
POLAND
U K
EGYPT
CZECHOSLOVAKIA
BELGIUM
LENGTH IN MILES (NAVIGABLE WATERWAYS)

FIG. I

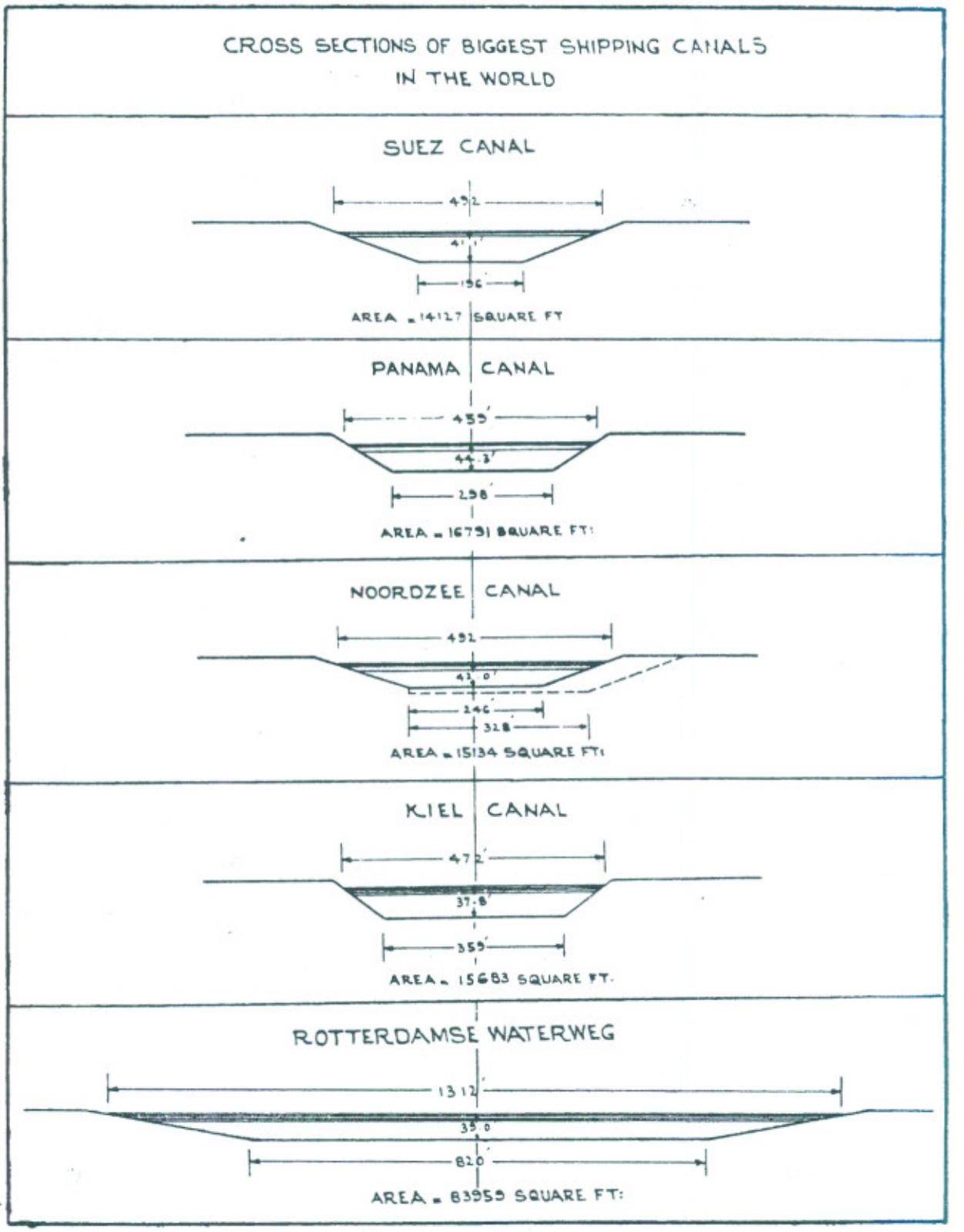

CROSS SECTIONS OF BIGGEST SHIPPING CANALS IN THE WORLD
SUEZ CANAL
492'
41'
196'
AREA = 14127 SQUARE FT
PANAMA CANAL
459'
44.3'
298'
AREA = 16791 SQUARE FT:
NOORDZEE CANAL
492'
42.0'
246'
328'
AREA = 15134 SQUARE FT:
KIEL CANAL
472'
37.8'
359'
AREA = 15683 SQUARE FT.
ROTTERDAMSE WATERWEG
1312'
35.0'
820'
AREA = 83955 SQUARE FT:

FIG. II

FIGURE. III

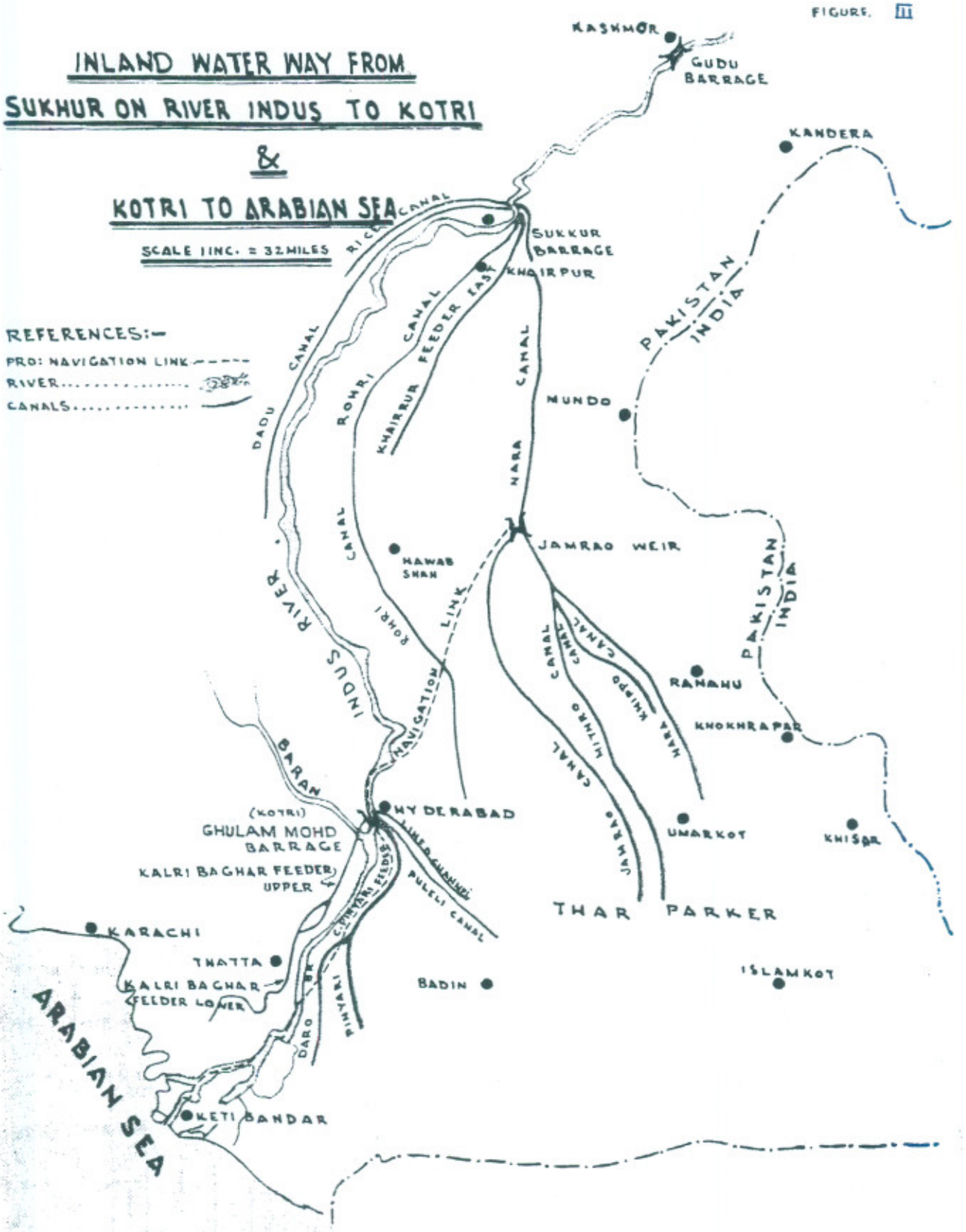

INLAND WATER WAY FROM
SUKHUR ON RIVER INDUS TO KOTRI
&
KOTRI TO ARABIAN SEA
SCALE 1 INC. = 32 MILES
REFERENCES:-
PRO: NAVIGATION LINK
RIVER
CANALS
KASHMOR
GUDU BARRAGE
KANDERA
SUKKUR BARRAGE
KHAIRPUR
RICE CANAL
DADU CANAL
ROHRI CANAL
KHAIRUR FEEDER EAST
NARA CANAL
PAKISTAN
INDIA
MUNDO
JAMRAO WEIR
NAWAB SHAH
ROHRI CANAL
RIVER INDUS
NAVIGATION LINK
RANAHU
KHOKHRAPAR
KHIPRO CANAL
HAKRA CANAL
MITHRO CANAL
JAM RAO CANAL
UMARKOT
KHISAR
THAR PARKER
BARAN
(KOTRI)
GHULAM MOHD BARRAGE
HYDERABAD
KALRI BAGHAR FEEDER UPPER
PULELI CANAL
KARACHI
THATTA
KALRI BAGHAR FEEDER LOWER
BADIN
ISLAMKOT
DARO
PINYARI
KETI BANDAR
ARABIAN SEA

FIGURE IV

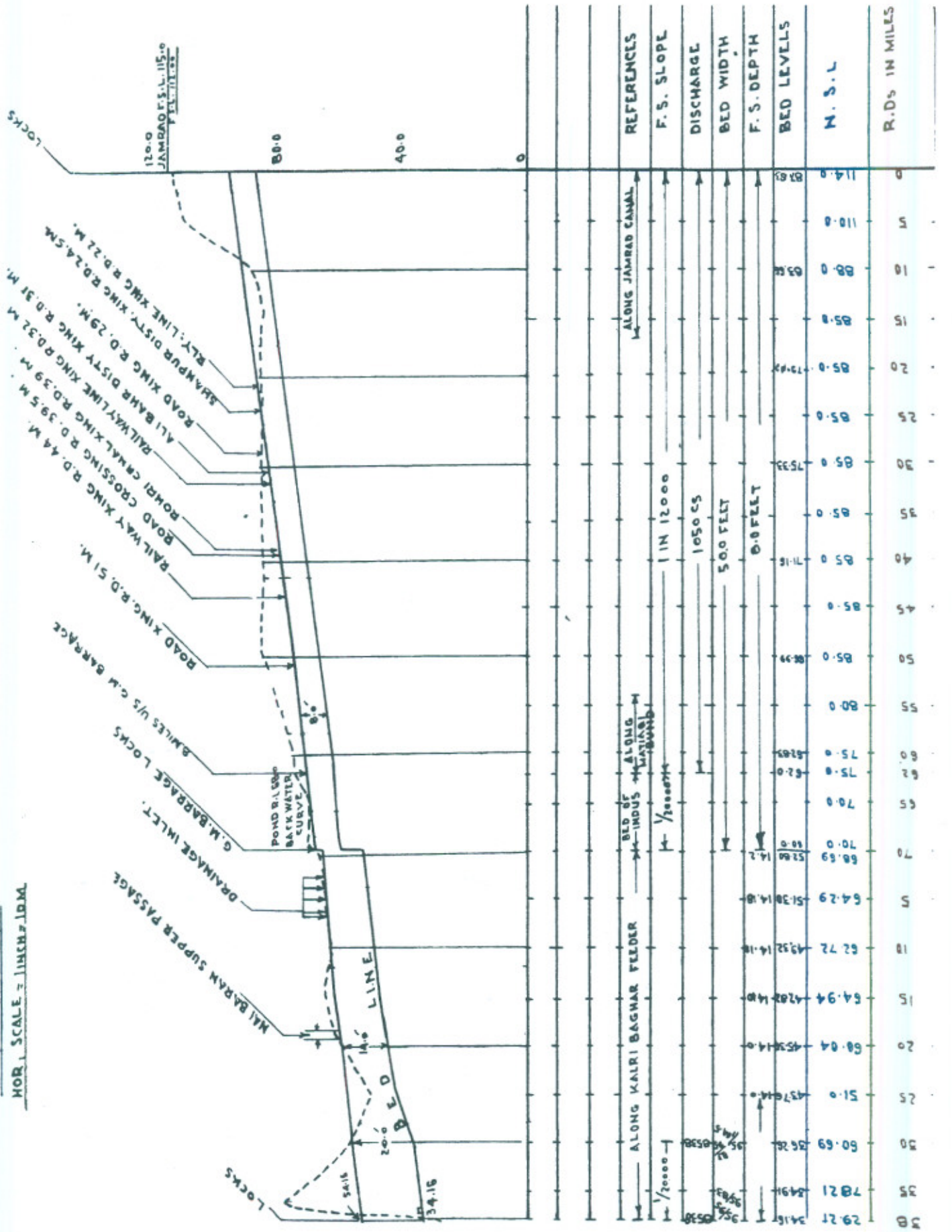
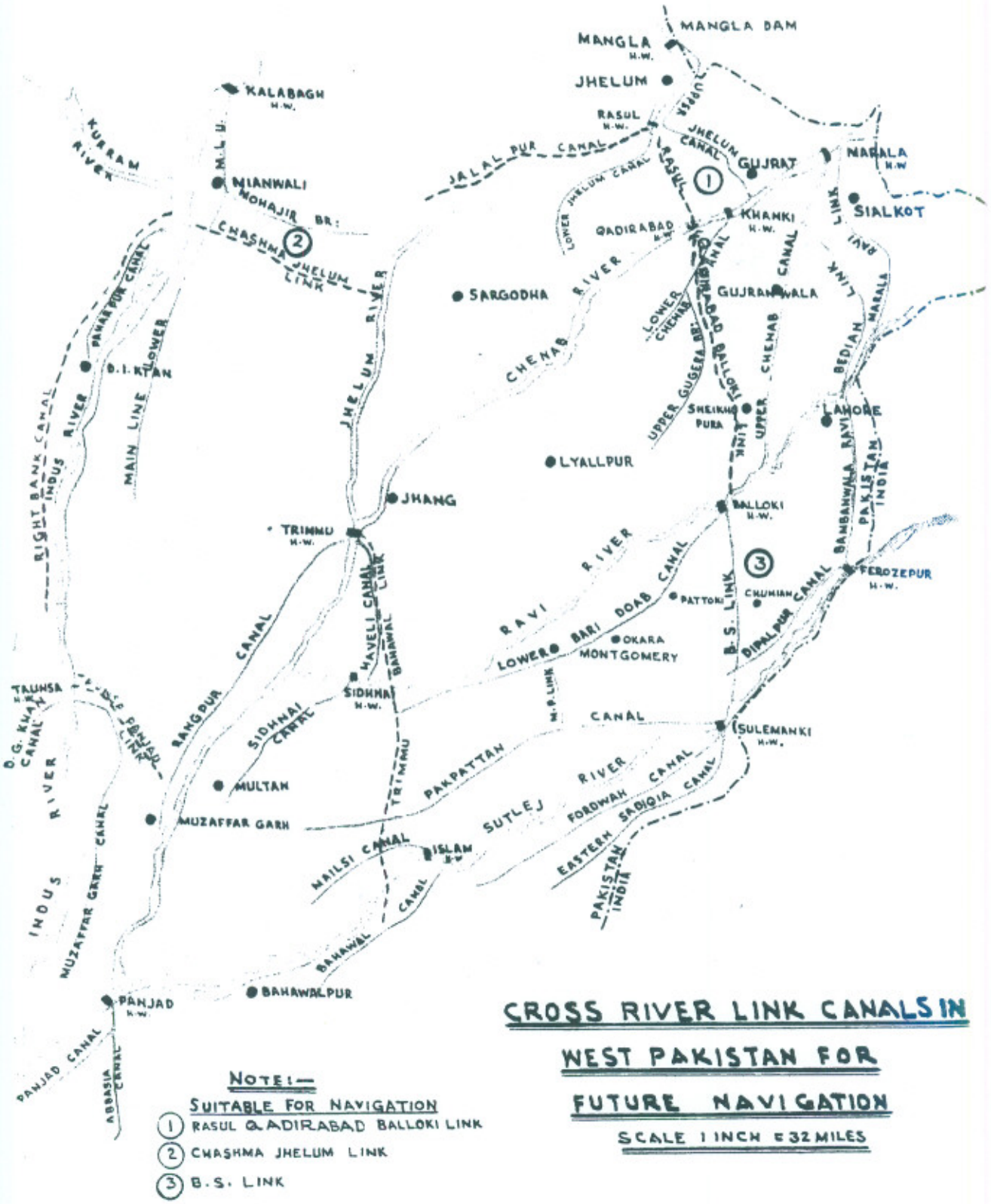

LONGITUDINAL SECTION
JAMRAO - KARACHI NAVIGATION CHANNEL
VERT. SCALE = 1 IN 400
HOR. SCALE = 1 INCH = 1 M.
LOCKS
JAMRAO F.S.L. 115.0
120.0
80.0
40.0
0
REFERENCES
ALONG JAMRAO CANAL
F.S. SLOPE
DISCHARGE
BED WIDTH
F.S. DEPTH
BED LEVELS
N.S.L
R.Ds IN MILES
SHAHPUR DISTY. XING R.D. 22 M.
RLY. LINE XING R.D. 24.5 M.
ROAD XING R.D. 29 M.
ALI BAHR DISTY XING R.D. 31 M.
RAILWAY LINE XING R.D. 32 M.
ROHRI CANAL XING R.D. 39.5 M.
ROAD CROSSING R.D. 44 M.
RAILWAY XING R.D. 51 M.
ROAD XING. R.D. 51 M.
BRIDGES U/S C.M. BARRAGE
G.M. BARRAGE LOCKS
DRAINAGE INLET
POND B.L. 100
BACK WATER CURVE
8.0
MAL BARAN SUPPER PASSAGE
BED LINE
14.0
20.0
54.15
34.15
LOCKS
ALONG KAIRI BAGHAR FEEDER
BED OF INDUS
ALONG KAIRI BAGHAR CANAL
1 IN 12000
1/20000
1050 CS
50.0 FEET
0.0 FEET

FIGURE V



NOTE:—
SUITABLE FOR NAVIGATION
(1) RASUL & QADIRABAD BALLOKI LINK
(2) CHASHMA JHELUM LINK
(3) B.S. LINK

CROSS RIVER LINK CANALS IN WEST PAKISTAN FOR FUTURE NAVIGATION

SCALE 1 INCH = 32 MILES