Table of Contents

FEASIBILITY: Revival of Natural Waterways to Drain out Storm Water

1 Introduction

1.1 Study Background

In the study area on left bank of Indus SCARP projects like Ghotki FGW Project, SCARP Khairpur, North Rohri FGW Project, South Rohri FGW Project and LBOD Project were constructed. Basically these projects were introduced to check the rising water table and reclaim water logged and salinity affected agricultural lands in the relevant areas. Except LBOD other projects had not been designed for storm water drainage. Fresh water tube wells were pumping ground water directly into field water courses, whereas the saline water from tube wells in Scarp Khairpur was being pumped out through surface drains into Rohri Canal to mix and dilute it with river water in order to make it usable for crops. This was done due to absence of any drainage outlet for saline water in project area.

Originally the alignment of LBOD Spinal Drain was planned to start from Khairpur area to terminate in the Runn of Kutch after running for about four hundred and thirty five kilometers. Its capacity was designed to take the drainable surplus from nearly six million acres of land as well as the storm water runoff from the areas south of Shaheed Benazirabad district. The ultimate discharge to the Runn of Kutch was estimated to be about 18,000 cfs. Unfortunately, this plan could not be fully implemented after the completion of Stage-I of LBOD up to Shaheed Benazirabad district. As such the areas outside the LBOD Stage-1 catchment have been left out without any drainage network until now.

During the unprecedented rains in 2011 ranging from 600 to 1100 mm, following seven districts of lower Sindh on left bank of Indus suffered tremendous losses due to inadequate storm water drainage systems of LBOD and Badin area and non availability of any drainage outlet in Khipro, Umerkot, Dighri, Tando Adam, Tando Muhammad Khan, Tando Allahyar and Tando Ghulam Ali areas. The Table-1.1 indicates that crops like cotton, sugarcane, chillies, rice, tomatoes, fodder etc on 1,518,285 acres of land were damaged, 64,541 cattle heads perished, 1,068,955 houses were damaged. In addition to it, out of 5,196,882 affected persons 249 died and 459 got injured in these districts.

Among the seven rainhit districts of southern Sindh Badin district suffered the maximum loss of life and property, whereas the districts of Sanghar and Benazirabad were at second and third number. These losses occurred in LBOD catchment area as well as outside its catchment. However, the stormwater from LBOD catchment was evacuated within three months due to availability of an inadequate drainage network. But the stormwater from non LBOD areas (Left over Areas) where no drainage system was available took six months because the storm water was evacuated by pumping it out into canal network. Pumping of storm water into canals further caused flooding in tail reaches of canals due to no demand of water by farmers as their lands were already saturated by heavy rainfall.

Table-1.1: summary of losses/ damages due to rain in sindh - 2011

As on 28 november 2011

S. No.	District	Persons Died	Persons Injured	Persons Affected	Houses Damaged	Cattle Head Perished	Area Affected (Acres)	Crop Area Damaged (Acres)
		Total	Total	Total	Total			
1	**Badin ***	73	10	1,021,301	382,562	10,060	984,805	375,718
2	**Mirpurkhas ***	60	230	705,151	118,110	12,280	819,833	171,522
3	**Sanghar***	39	93	1,237,432	213,928	19,040	927,201	356,473
4	**Sh.Benazirabad***	39	82	900,000	200,000	22,646	U.S	290,000
5	**T.Allahyar***	3	5	569,829	70,163	197	369,685	81,645
6	**T.M.Khan ***	17	24	585,411	72,935	187	390,997	78,038
7	**Thatta ***	18	15	177,758	11,257	131	198,111	164,889
	Grand Total	**249**	**459**	**5,196,882**	**1,068,955**	**64,541**	**3,690,632**	**1,518,285**

Source: National Disaster Management Authority (NDMA) Pakistan.

Similarly in 2012, unprecedented rainfall to the extent of 150 to 300 mm in a single day occurred in Ghotki, Sukhar and Khairpur districts on left bank of Indus. Losses and damages as reported by Provincial Disaster Management Authority (PDMA) are presented in Table-1.2.

Table-1.2: Summary of losses/ damages due to rain in sindh - 2012
As on 02 November 2012

S. No.	District	Deaths	Injured	Persons Affected	Houses Damaged		Villages Affected	Crops Affected (Acres)	Cattle Head Perished
					Partially	Fully			
1	**Ghotki**	34	143	342,300	38,955	11245	3,268	174,408	445
2	**Khairpur**	9	8	499,000	15,130	4,070	1,448	107,435	183
3	**Sukkur**	NR	NR	NR	11,908	325	NR	42,780	27
	Totals	**43**	**151**	**841,300**	**54,085**	**15,640**	**4,716**	**324,623**	**655**

Source: Provincial Disaster Management Authority (PDMA) Sindh

The Table-1.2 reflects that about 324,623 acres of standing crops were damaged, 655 cattle heads perished and 69,725 houses were damaged in three districts of upper Sindh on left bank of Indus. Out of 841,300 affected persons 43 lost their lives and 151 suffered injuries.

The extreme rainfall events in the year 2003, 2006 and 2011 in lower Sindh and 2012 in upper (northern) Sindh caused unparalleled loss to the human lives, marooning of settlements, standing crops, livestock, damage to the physical and productive infrastructure, means of communications, displacement of flood affected population and their livelihoods. According to a report of PDMA the estimated value of damages from the 2011 flood was about Rs.454 billion and the losses of 2012 flood are being evaluated.

1.2 Project Objectives

The main objectives of this intervention are to:

- Facilitate early evacuation of storm water flows from crops and settlements;
- Reduce the flood pressure on the existing drainage networks of LBOD and Badin by offloading storm water from LBOD Spinal at three locations before reaching in Badin area;
- Increase agricultural production by way of improving crop yields and cropping intensities.
- Reduce losses to infrastructure like roads, canals and drains by diverting major quantity of storm water to natural routes i.e. dhoras.
- Improve environmental conditions in the area.
- Minimize loss to properties, human lives, crops, livestock, poultry and fish farms;
- Avoid submergence of structures and back flow in sub drains and branch drains;
- Intercept the rising water table by round the year flow in dhoras;
- Provide drainage to five leftover areas on the left bank of Indus;
- Protect the settlements with bypasses where critical;
- And Harvest flood water by storage in the natural depressions where ever possible.

Activation of the waterways will be the part of the regional master plan for the left bank of Indus, Delta and Coastal zone. However, in accordance with the directive of Honorable President of Pakistan, to provide on priority storm water drainage facility to the worst flood affected districts of southern Sindh

during the monsoon 2011, activation of the natural waterways in lower Sindh shall be considered on top priority.

1.3 Context and Justification (Issues and Options)

These calamities challenged the ability to cope with such catastrophe, and warranted corrective and mitigation measures to avert similar miseries, in the event of reoccurrence of rains of alike magnitude in future. This experience also provided an opportunity to evaluate the performance of the drainage network, need for its strengthening, and to explore ways to offload pressure on the drainage system. This also flagged the need for exploring ways to evacuate storm water from Left Over Areas (LOAs) like Khipro-Umerkot, Dighri, Tando Adam, Tando Muhammad Khan, Tando Allahyar, Tando Ghulam Ali, Khairpur and Ghotki areas presently not served by and connected to any drainage network. Moreover, the existing fresh ground water tube wells installed in Ghoki, Khairpur, North Rohri and South Rohri areas are not meant for draining out storm water.

The natural flow of storm water was blocked by inadequate sized culverts and bridges on roads; therefore, relief cuts were given to roads like MirpurKhas–Naukot road, Badin-Naukot road, Tando Adam – Hyderabad road, Chamber –TandoAllahyar road, Badin – Sujawal road, Shahdadpur-Tando Adam road, Hala- Shahdadpur road, Badin-Sirani road etc at several places where flow of water was blocked.

Breaches and illegal cuts made by farmers to the canal distribution network and drainage network for quick evacuation of storm water from cotton, chillies, tomatoes and sugarcane fields also increased the flow in the drainage network. The irrigation escapes continued to flow during the monsoon rains.

Damages were reported to cash crops, orchards, houses and road network due to flooding caused by the encroachments on the alignment of dhoras and blockage of storm water in the towns of Jhudo, Digri, Naukot, Tando Ghulam Ali, Mirpur Khas, Pangrio, Khoski and Badin. The irrigation water of escapes and breaches of the canal network combined with the storm water played havoc with the neighboring Towns and Villages and damaged infra structure in the area.

The existing drainage networks of LBOD and Badin designed for lower runoff (five year return period) according to the rainfall conditions at the planning stage are unable to drain out the catchment areas under present climatic conditions. The rain-fall pattern in Sindh has been modified due to climate change with the result that extreme events of rain fall have been recorded causing wide spread flooding in the areas and it is expected to continue in future also.

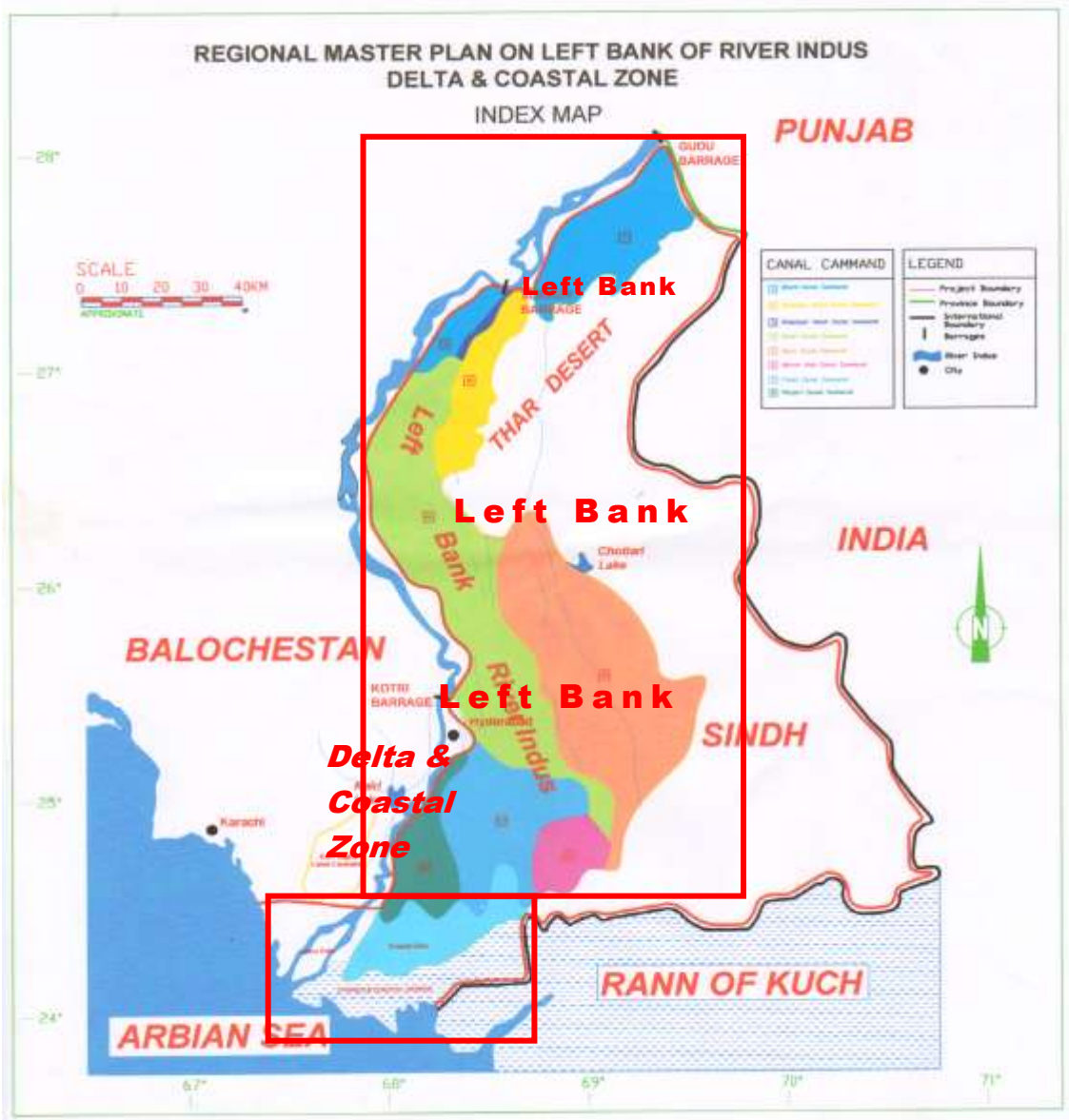
Submergence of main drains like MirpurKhas Main Drain, LBOD Branch drain and other direct drains out falling at their point of confluence with the Spinal drain occurred due to less working head.

To address these issues, the Consultants evaluated the possibility of employing the dormant dhoras to ensure safe disposal of flood waters. To mitigate the situation, revival of the natural water ways is critical. The reactivation of these dhoras would not only dispose off the storm water but will also serve as interceptor drains to check the rising water table. Moreover, the storm water in the dhoras can be utilized by the farmers at the tails of deficit irrigation channels after lifting through pumps.

2 Project Area Description

2.1 Location

The project is based on the command areas of Ghotki, Sukkur, and Kotri Barrages on left side of Indus River, including the areas that are presently not connected to any drainage network. (Map-1) The project area will also include the coastal belt and parts of the Thar Desert where most potential depressions are located. It covers about 9.757 M. Acres of cultivable commanded area (CCA) in the districts of Ghotki, Khairpur, Naushehro Feroze, Shaheed Benazirabad, Sanghar, Matiari, Hyderabad, Tando Muhammad Khan, Tando Allahyar, Badin and parts of Thatta, Sukhar, Umarkot and Tharparkar districts.



Map-1 Showing the Study Area: Left Bank of Indus River, Delta and Coastal Zone

The Gross Commanded Area (GCA) and the Cultivable Commanded Area (CCA) of the Barrages and Canals in the study area on left bank of Indus are presented in Table-3. The total GCA of the three barrages on left bank of Indus is 8.589 M. Acres which includes 1.017 M.Acres of Guddu Barrage, 6.163 M. Acres of Sukhar Barrage and 2.577 M. Acres of Kotri Barrage. Out of the eight main canals on left bank of Indus, Ghotki Feeder, Nara Canal, Akram Wah and

Phuleli Canal fall under the administrative control of Sindh Irrgation and Drainage Authority (SIDA) and the remaining four canals are under the administrative control of Irrigation Department, Government of Sindh.

Table-2.1: CCA/ GCA of Barrages & Main Canals in the Study Area

Barrage	Canal	Canal Classification	Maximum Authorized Discharge (Cusecs)	CCA (M.Acres)	GCA (M.Acres)
Guddu	**Ghotki Feeder**	Non-Perennial	**11,670**	**0.855**	**0.985**
Sukkur	**Nara**	Perennial	2,550	0.369	2.431
	Rohri	Perennial	2,150	0.322	2.928
	Khairpur F.East	Perennial	16,936	2.601	0.506
	Khairpur F.West	Perennial	13,861	2.24	0.300
		Total	**35,497**	**5.532**	**6.165**
Kotri	**Pinyari**	Perennial	3,770	0.487	0.981
	Fuleli	Non- Perennial	14,330	0.929	1.046
	2.2 Akram Wah	Non- Perennial	10,490	0.786	0.532
		Total	**28,590**	**2.202**	**2.559**
		G.Total	**75,757**	**8.589**	**9.709**

2.3 Topography and Physiography

2.3.1 Topography of the Study Area

The general slope of study area is flat and is considered as level to nearly level with an average gradient 0.75 ft per mile. The contours are almost at right angles to the river from Guddu Barrage to Nawabshah, and this has been the zone of the most persistent movement of the river course in the past. In Guddu barrage left command there are number of drainage lines, especially in the desert fringe, running south-west wards, towards the head reaches of Nara Canal. South of Nawabshah the valley broadens and general slope is to the south-east, towards Nara and eastern flanking trough of the valley. Likewise the old river courses fan out in this direction with several drainage lines between them, the most important drainage line is the Dhoro Puran, which runs south-east from Mirpur Khas to the old Nara bed (Hakro Dhoro), and eventually falls into Rann of Kutch. However, the Nara itself does not run along the lowest line for its entire length, as the ground level continues to fall eastwards, towards the Thar Desert, resulting in several lakes between the sand hills. On the left bank the old bed of Hakro River was utilized as Nara canal as early as 1859 and was connected to Sukkur barrage in 1932. Further south the alignment of the Fuleli canal runs on the ridge caused by the change of slope of the ground from south east to south.

2.3.2 Physiography of the Study Area

The study area is divided into three ecosystems viz. agricultural tract irrigated by three barrages Guddu, Sukkur and Kotri, desert ecosystem parallel to agricultural tract and coastal/ deltaic ecosystem. The great Thar Desert forms an equally well defined shape; the sand hills in the south are strongly aligned along a north east to south west axis and reach an elevation of about 200 feet. The greatest aggradations occur near the river, which consequently flows along a slight ridge of its own making. In Past River has flowed across most parts of the region and the meander plain represent the strips of slightly elevated alluvium with comparatively rough surface

topographically features lying along these early courses. Between these lie the cover flood plains, shallow basins of very smooth topography, where floods used to accumulate.

The cover flood plain extends in the lower reaches of the study area towards the lateral margins of the valley and delta. (Map-P3-M-P-023) The delta flood plain is distinguished principally by its extensive cover flood plain and narrow meander flood plain, the former deltaic distributaries. The Nara canal is aligned along the bed of old Hakro River that formerly had no direct connection to Indus system. South of Sukkur it cuts off a portion of Thar Desert, and then flows along the eastern margin of the region into the Rann of Kutch.

Within the boundary limits of study area, the Indus enters from the north at an elevation of 240 feet (amsl) above mean sea level, and the level of flood plain falls south wards at an average rate of seven inches per mile. The overall slope is somewhat less than as compared to the northern region (Punjab). The modern course of Indus River is at a comparatively recent delta. It began to flow through the gap in the Rohri hills at Sukkur only about fifteen hundred years ago and adopted its present course west of the Ganjo Takkar out crop at Hyderabad as late as 1758 AD. Elsewhere the slight projections in the contours indicate the various courses; the river has followed across the region.

2.4 Climate

2.4.1 Climatic regions of Sindh

Sindh is divided into three climatic regions: Siro (the upper region, centered on Jacobabad), Wicholo (the middle region, centered on Hyderabad), and Lar (the lower region, centered on Karachi). The thermal equator passes through upper Sindh, where the air is generally very dry. Central Sindh's temperatures are generally lower than those of upper Sindh but higher than those of lower Sindh. Dry hot days and cool nights are typical during the summer. Central Sindh's maximum temperature typically reaches 43–44 °C (109–111°F). Lower Sindh has a damper and humid maritime climate affected by the southwestern winds in summer and northeastern winds in winter, with lower rainfall than Central Sindh. Lower Sindh's maximum temperature reaches about 35–38 °C (95–100 F). In the Khirthar range at 1,800 m (5,900 ft) and higher at Gorakh Hill and other peaks in Dadu District temperatures near freezing have been recorded and brief snowfall is received in the winters.

2.4.2 Delta and Coastal Zone in Sindh

The Sindh coastal region is located in the south-eastern part of the country between the Indian border along the Sir Creek on the east, and the Hub River along the Balochistan coast on the west. The Sindh coast can be subdivided into the Indus Delta / creek system and the Karachi coast. The Indus Delta (2,560 sq. km) is the most prominent ecological feature of the coast and covers 85 percent of the coastal belt. The coastal morphology is characterized by a network of tidal creeks and several small islands with scattered mangrove vegetation.

Situated between the Indus Delta on the southeast and Hub River on the west, the Karachi coastal belt is about 100 km in length. Most of which, with the exception of scattered patches of mangroves, is devoid of any kind of vegetation and consists of shallow lagoons, sea cliffs, stacks and terraces, wave cut platforms, sea caves and notches.

The coastal waters have high salinity (Hein Van Gils, 2006) due to high evaporation rates, combined with negligible rainfall. Oxygen-poor water layers sometimes rise to the surface along the coast, leading to fish mortality. The wildlife along the coast consists of both marine and terrestrial species.

Cyclones on the Sindh coast are not common but do occur periodically causing considerable damage to coastal settlements. After 1947 (post partition), major cyclones occurred in June 1948, November 1993, and in May 1999.

2.4.3 Agro Climatic Zones

General Nature of Area:

The study area is cultivated mainly by canal commands of three barrages of Lower Indus region with some additional supplies through fresh ground water tubewells. The canal command spread over 9.757 M.Acres of land on left bank of Lower Indus basin. The quality of cultivated land is by and large moderate to good to very good and is capable to produce good quality to high quality of agricultural produce by adopting modern management techniques.

Due to the favorable temperatures for plant growth, the crop production is possible throughout year. Sugarcane, cotton and rice are the main Kharif, where as wheat and oil seed are the main Rabi cash crops. Mostly all these crops and some type of orchards are grown on good and very good lands as classified in the agricultural development potential. The lands in use vary considerably from place to place, in most of parts, the variations occur within such a short distance and patterns are so complex that it is not possible to draw boundaries between the different crops. Moreover, each type of land under different crops cannot be mapped separately on a broad scale of mapping used in this on reconnaissance investigations. Therefore, a combination of two or more crops is possible as shown in Map-P3-M-P-008 & 009 of Atlus Volume-II.

Overall, out of total command area about 6,767,289 acres (69.7%) of land is being cultivated to different type of crops as shown in Agro map. These are mostly cultivated through canal command system; however within the fresh ground water zone additional supplies are also being supplemented through tubewells installed by the public and private sector.

2.4.3.1 Agro climatic zone under Guddu Barrage

Ghotki Feeder basically a nonperennial canal (converted to perennial) off taking from left bank of Guddu Barrage mainly irrigates the lands of Ghotki Area Water Board (AWB) with some additional supplies of fresh ground water tubewells.

The fresh ground water zone is naturally benefited to have additional supplies through public and private tubewells, hence all type of crops are grown throughout the year. The major cash crops are wheat, oil seed, vegetables, in Rabi and in Kharif cotton is a cash crop, where as sugarcane is perennial and is becoming dominant crop day by day due to flourishing of sugar industry within the study area.

However, cropping pattern is somewhat different in saline ground water zone as it is handicapped due to non availability of full canal supplies during the winter (Rabi) season. Therefore, major cash crop is cotton and rice in kharif and wheat, oil seed & pulses are grown on soil moisture conservation left in rice fields with some extra one to two irrigations supplies to Rabi crops allowed during their maturity period.

2.4.3.2 Agro climatic zone under Sukkur Barrage System

Overall, the left bank area under the command of Sukkur Barrage is perennially irrigated by four main canals viz Rohri, Nara, Khairpur East and Khairpur Feeder west. Nara Area Water Board (AWB) is one of the major part of this area.

Within the commands of above canals general cropping is practiced and mainly wheat, cotton, sugarcane, oil seed are the winter (Rabi) and summer (Kharif) crops. The fruits grown in this zone include dates, mangoes, banana, guava, etc; Under present conditions due to rapid increase in sugarcane industry on left & right bank of Indus, has created attraction to growers for growing the sugarcane throughout the study area. Especially the large areas of fresh ground water zones are thickly covered by sugarcane which is one of the major cash crop and next is the cotton. Whereas within the saline ground water zone of area the rice is mostly cultivated on slightly salt affected soils and cotton in grown on the lands which have got high potential and suitability for growing and producing high yields.

2.4.3.3 Agro Climatic Zone under Kotri Barrage

Kotri Barrage command on left bank has three canals, out of which Phuleli and Pinyari are nonperennial, whereas, Akram Wah (Lined channel) is a perennial canal. Within the command of

non perennial canals mostly rice covers the major area and next to this is cotton grown in kharif season. Sugarcane as a perennial crop is a major cash crop grown within the perennial command of Akram wah. Due to favourable climatic condition sugarcane yield in this area (Lower Sindh) is higher as compared to the northern parts of Sindh. In Rabi wheat, oil seed, pulses are mostly grown on residual moisture left in the fields after harvesting of paddy crop. During the maturity period of these crops one to two extra irrigations are allowed through the canals. However, in command of the Akram wah, wheat, oil seed, pulses, banana, and vegetables are the common crops of winter (Rabi) season.

2.5 Soils of Study Area

The soils of the Left Bank area are mainly formed by alluvial sediments deposited by Indus River. Only the old dissected desert on eastern border of Left bank contains an admixture of aeolian sand transported from Rann of Kutch, later on dissected by river Indus. The extreme lower Southern part of Badin area is a mixture of river alluvial and sea deposits.

2.4.1 Soil Textural classification

Soil survey in past has been conducted by different Govt/ Semi Govt agencies. The latest survey conducted by soil and Reclamation Directorate SCARP Monitoring organization WAPDA during 2005 by following the criteria used for appraisal was the same as given in Soil Survey Manual Agriculture Hand Book 18. The Textural groups and their corresponding five soil series recognized and mapped by WAPDA and updated by consultants selecting the sample representative sites within the study area are listed as under Table 2.2.

Table- 2.2: Soil Textural Groups

S.No	Textural Group	Soil Series	Textural Classes	Characteristic
1.	Coarse	Jhang	Sand and Loamy sand	Soils are excessively drained and have very low nutrient and Water holding capacity.
2.	Moderately Coarse	Farida	Sandy loam and Fine sandy loam	Fairly retentive of moisture for plant nutrients. Potentially productive and capable of producing normal yields of crops under good management. Not advised for raising high delta crops.
3.	Medium	Buchiana	Loam, Silt loam and Silt	Soils are moderately permeable and well retentive of moisture for plant nutrients, these have a high productivity potential and can grow wide variety of crops.
4.	Moderately Fine	Chuharkana	Sandy clay loam, Clay loam and Silty clay loam	Soils are moderately permeable and retain good quantity of moisture for plant nutrients. These are suited to grow high delta crops.
5.	Fine	Nokhar	Sandy clay, Silty clay and Clay	These soils have low permeability and develop cracks on alternative drying and wetting and pose difficulty in workability. These are mostly used for high delta crops.

The investigations carried out throughout the Left Bank of Indus depend upon approximately one to two sites per square mile. These locations or sites were augured up to 180cm depth for textural classification. For mapping purpose, the data of previous survey by LIP & MP&RD WAPDA has

been utilized and updated by consultants, selecting the representative sites for verification and maps showing soil textural groups have been prepared by using GIS technology.

Overall and command wise acreage and the percentages of five (5) textural groups are given in Table 2.3

Table 2.3 Command wise & total area of Left Bank under different Textural Groups

S. No	Main Canal	Area in Acres	Percent of each Textural Group					Miscellaneous	Total	Remarks
			Coarse Texture	Moderately coarse texture	Medium Texture	Moderately Fine texture	Fine			
1.	**Ghotki Feeder**	984,795	8.0	11.0	26.0	46.0	-	9.0	100	The miscellaneous Land type mostly covers the urban areas, grave yards, canal, drains and other Linear features.
2.	**Nara Canal**	2,431,394	3.0	20.0	43.0	29.0	-	5.0	100	
3.	**Rohri Canal**	2,927,713	5	11.0	46.0	32.5	-	5.5	100	
4.	**Khairpur Feeder East**	506,000	18	11.0	49.0	18.0	-	4.0	100	
5.	**Khairpur Feeder West**	300,000	1.0	44.0	25.0	18.0	5.0	7.0	100	
6.	**Pinyari**	981,207	3.0	23.0	31.0	29.0	-	14.0	100	
7.	**Fuleli**	1,045,651	1.0	14.0	38.0	42.0	-	5	100	
8.	**Lined (Akram Wah)**	531,965	0.5	11.5	36.0	39	-	13	100	
Total Left Bank Command Area		**9,708,725**	**5.0**	**18.0**	**37.0**	**32.0**	**-**	**8**	**100**	

It is obvious from the table that as a whole the dominant textures within the study area are medium (37.0% Buchiana Series) and moderately fine textured (32.0% chuarkana) soils, where as minor part of area is covered by moderately coarse (18% Farida) and coarse textured (5.0% Jhang) soils.

2.5 Land Resources

Land resource is defined as availability of land within the region and its utilization mainly for agriculture and other purposes depending on classification and categories of the soil. The development and utilization of land resources mainly depends upon the provision of water supplies, drainage and the associated control of salinity. In areas under lain by fresh ground water the land has limited hazards because of sufficient availability of irrigation water for growing variety of crops, for reclamation of saline soils with provision of drainage facilities. There is therefore no doubt that fertile lands with fresh ground water provide the best investment opportunities.

Bulk of cultivated land in CCA has very high potential for agriculture and soils are generally stable and there exists little to moderate hazard of their salinisation by canal irrigation water or by high water table, although their progressive sodication by low quality tubewell waters is of great concern.

At present, most of farm lands are being utilized for below their potential and with a high level of inputs and modern management, the present production of most of crops could be increased to a high profitable level. Therefore, emphasis should be given on soil, water and crop management.

Comprehensive studies of the soils done by the soil survey of Pakistan have no such affliction. In fact the low crop yields are not only the consequences of any single deficiency or constraint, but many factors like low fertility, water shortage, over irrigation, inadequate farm power, improper soil management, insects, plant diseases, primitive method of cultivation, soil salinity and water logging, all retain the productivity of our land.

Canal irrigated land in our study area is the back bone of agriculture; The quality of the cultivated land is by and large good to very good and they have got no inherent soil problem, but due to inadequate drainage, due to high watertable due to collection of runoff and because of uneven surface the agriculture potential of these lands have been deterioted and classification of affected soils is changed (refer agriculture development potential). The soils free of any hazard are well suited for wide range of crops.

Hence, it is commonly believed that most of our prime agricultural land, though inherently problem free and fertile is still under impending danger of deterioration due to the hazards as stated above. Under such situation the land resources should carefully be utilized by eradicating salinity and water logging and addoping the technical measures to save the fertile lands from further deterioration. Moreover, the lands classified under land development potential categories of “land with moderate economic potential with irrigation”; could further be developed and fully reclaimed by adopping reclamation procedures in the affected saline patches within the cultivated fields.

2.5.1 Land Development Potential

The left bank study area comprises about 9,786,231 acres of land, which is irrigated mainly by three barrages canal system, however some additional supplies of irrigation water are being supplemented through fresh ground water (FGW) tube wells installed in the area. During the field investigations it is observed that the lands within the head & middle reaches of irrigation system are getting more water than the required supplies, where as the tail end area having high economical potential under irrigation is not fully cultivated due to shortage of water. This has created two way problem i.e. the lands which are getting more water than their crop water requirement, slowly have become water-logged & the lands which are left as such at tail ends of the irrigation system are becoming saline due to capillary action of salts coming up through the profile horizon to the surface of soil.

Therefore, over irrigations at the head, middle and under irrigation at the tail ends of system have created high watertable and salinity problems, are mainly responsible for the limited agricultural production in the areas of potential lands. According to development possibilities these lands have been classified into five different potential categories (Map-P3-M-P-002) and are presented in tabular form (Table-1).

2.5.2 Land with very high economic potential under irrigation

The soils of this category have got very high potential and are mapped separately (Fig-I). This type of land in study area covers about 1,947,475 acres (20%) of the total area, and is suitable for cultivating wide variety of cash crops. However, it has been observed during the field investigations that the yield/ production is remarkable below its potential, because of low standard farming and insufficient or over supplies of irrigation then the crop water requirements. Very high crop yields could be obtained by using the good quality and variety of seed, proper

management and by selecting & cultivating the crops according to the agro-climatic zones of the area.

2.5.3 Land with high economic potential under irrigation

The second category recognized comprises about 4,839,885 acres (50%) of the study area. The soils of this category have got textural limitations, for example some are heavy textured (clayey) soils with problem of low permeability and poses difficulties in seed bed preparation combined with lack of irrigation water in nonperennial or due to over supplies in the perennial areas of the left bank. Such type of areas requires the proper precession land leveling, improved crop varieties, special care in seed bed preparation, use of required fertilizers, high yields of most of the crops could be obtained. Somewhere saline-alkaline problems appear in a form of patches within the cultivated fields because of non percolation of salts in the unleveled land surface which could be solved by leveling and applying gypsum ($CaSo_4$) to the affected areas.

2.5.4 Land with moderate economic potential under irrigation

The area covered by this category is about 1,961,425 acres (20.2%) of the total area. This category mostly includes the saline or saline-alkali soils and mostly found in undulating (low lying) areas. The reclamation of these soils is economically feasible by extra applications of water and by providing drainage facilities to the affected areas. If necessary gypsum ($CaSo_4$) should be applied and followed by rice for couple of years. After reclamation of soil, most of crops could be grown and can produce good agriculture products. Somewhere, parts of this category are lying uncultivated in a shape of vast patches because of relatively higher topographical position; such type of land could be brought under cultivation by leveling the surface of soil. Also some where a small part of this unit have shallow horizon of silty soils over sand within the profile; such type of land requires frequent light irrigations and split application of fertilizers with emphasis on cultivation of shallow rooted crops.

2.5.5 Land with poor grazing potential

This type of category covers an area of about 721,069 acres (7.4%) of the total study area. The major parts of the area have sandy soils and are not suitable for cultivation, and are mostly covered with natural vegetation, which provides poor grazing for animals. Further small parts (not mappable) within this unit comprises saline-alkali, dense, clayey soils which are not economical to reclaim, however some patches are under cultivation producing poor crop yields. Over all entire unit is capable to provide (natural plants, herbs, shrubs) poor to moderate grazing for Livestock.

2.5.6 Agriculturally unproductive land

This category covers about 238,871 acres (2.4%) of the total area. It includes very fine sandy soils, gravelly land, and dune land, rock out crop, marsh land and urban areas. This type of land is un-suitable for agricultural development and no improvements are possible, and are declared as agriculturally unproductive lands.

Table-2.4: Summary of Land Development Potential

Land Class	Land Potential Category	Area in (000) acres	% of Total Area	Remarks
1	Land with very high economic potential	1,947,475	20	Capable to grow all type of high yielding crops
2	Land with high economic potential	4,839,885	50	Requires proper precession land leveling,

				capable to grow most of crops.
3	Land with moderate economic potential	1,961,425	20.2	Need reclamation of salinity patches within cultivated fields, capable to produce reasonable yields of some particular crops. Rice is recommended for reclamation of soil.
4	Land with poor grazing potential	721,069	7.4	Provide only poor grazing for animals.
5	Agriculturally unproductive land	238,871	2.4	Dune land, gravelly land, rock out crop, classified as unproductive land.
6	Total area of left bank	9,708,725	100	Land falling under canal command system of study area.

2.6 Land Capability Classification of Leftover Areas

The left over areas from drainage point of view have not been attended previously by WAPDA and irrigation departments. Now these have been included in left bank regional plan and taken up for planning.

- Ghotki left over area
- Khairpur South left over area
- Tando Adam and Tando Mohammad Khan left over area
- Farash, Khipro, Umerkot left over areas
- Digri left over area

From Land capability classification point of view, maps of all above left over areas have been prepared separately, keeping under consideration the method and soil classification criteria suitable to the agricultural conditions of the particular area under study. (Map-P3-M-L-003 to 007) It is similar in basic structure to the U.S. soil conservation classification. Generally for all the leftover areas the soils placed in highest class (I) have got the least limitations for agricultural use and relatively little efforts are required to produce high crop yields. Where as in other classes (II-IV) in some components there are limitations for agricultural use and special managements are required to produce high crop yields. Soils in the lowest (V) class are mostly unfit for economic arable use.

The major limitations to agriculture in all left over areas are the arid and semi arid climate, combined with some drainage and Irrigation problems. Hence outline for classification recognized for each leftover area, have been bifurcated into two levels i.e. main Land capability class & its associated subclass.

The first is broadest group identified by Roman numerical (I-V), where as second limitation factor such as “r” irregular relief is used as prefix with the class numerals. Kinds of limitation may vary within each class and are designated with small letters. On the basis of limitations the following sub classes are recognized.

e - Soils restricted in use due to erosion hazard.

r- Irregular local relief hindering irrigation or tillage.

w- Soils restricted in use due to excess water because of poor drainage, high water table or overflow.
s- Soils restricted due to shallow soils depth, stoniness or slowly permeable.
a – Soils restricted in use due to salinity or alkali problem

2.6.1 Class I: Very good agricultural Land

In general, this Land capability class occupies only the irrigated or irrigable Land of the left over areas. No subclass is recognized in this class, since there are no or only slight limitations for crop production. Overall status of this class in left over area is presented in ((Map-P3-M-L-003 to 007)). Further it is pertinent to note that this class according to land resource has more or less the similar characteristics as of the agricultural Land development potential class-1 soils. Hence these soils are capable to produce wide range of different crops. Topographically these are level to nearly level, usually deep, well drained and have good water holding capacity.

From tilth & tillage point of view, such types of soils are easily worked to good physical conditions, favorable for germination and growth of plants. The surface texture is usually loamy or silty, but may be somewhere clayey in nature. Under traditional management, these soils could be used for general cropping. Under modern management and with sufficient irrigation water supplies, cash crops are recommended for Rabi are wheat and oil seed, where as in kharif cotton can produce a very good product and sugarcane as a perennial crop gives the good response. However, rice in such type of soils should be restricted.

2.6.2 Class II: Good agricultural Land

In each left over project area, this class occupies only as irrigated or irrigable land of the area. Soils in this class have minor limitations, for example, maybe due to low water holding capacity or undulating topography or any other hazard. Therefore, during traditional management, this class may possess one of the limitations like IrIIr (relief problem), IrIIw (water logging), IrIIs (shallow depth or stoniness)

Hence, for such type of minor limitations, modern management techniques are required to eliminate the prevailing hazards so that land could be cultivated to general cropping, and capable to grow cash crops same as recommended for class-I soils for Rabi & Kharif season, further rice cultivation for such type land is also restricted.

2.6.3 Class III: Moderate agriculture Land

This class occurs mostly in all leftover areas ((Map-P3-M-L-003 to 007)) and has got severe limitations like IrIIIw, IrIIIa, and dIIIw. It means that this type of soil contains one or more than one severe type of limitations; like soils somewhere are imperfectly drained, saline-alkaline and mostly loamy very fine sands with medium to fine textured surface. Traditionally most of these soils generally produce moderate yields, for such type of soils under modern management wheat & oil seed in Rabi & rice in Kharif are recommended and can produce moderate yields. However, rice can give good results from production point of view by applying fertilizer, insecticides & pesticides at proper time to save the crop from stem borer, subject to condition that rice is possible under sufficient irrigation water available during the cropping season. Further it is recommended that the low lying areas occupied by this class may be cultivated to paddy as it is high delta crop and resistant to water logging conditions.

2.6.4 Class IV: Poor (Marginal) agricultural Land

Soils in this class have severe limitations for crop production and have very narrow range of agriculture use. Improvement to a reasonable level of productivity may or may not be technically feasible, but would go to high expenditure for development or maintenance.

The irrigated soils in this class have either a severe hazard of water saturation below two or three feet due to the regional high water-table throughout the year associated with strong salinity at the surface or moderate salinity-alkalinity problem throughout the soil profile. Mostly soils in such type of class have poor structure, coarse textured, or of burial by shifting eroded sand dunes sand

from the surroundings, therefore, the sub classes associated with this class are ir IVw, ir IVs and ir IVa (Fig-1-4). Traditionally these lands are used for poor grazing and capable to grow some type of saline resistant crops/ fodder.

2.6.5 Class V: Unproductive Land

The land in this class does not have a potential for economic agriculture, grazing or forestry. It is best to left in its natural state ((Map-P3-M-L-003 to 007)), some parts may need a forestation or other measures to protect adjoining agriculture lands from its effect like blown sand.

Because of sandy nature, this type of land does not support any vegetation, due to low rainfall, high temperatures and very low water holding capacity. It has no potential for agriculture but its sandy material could be used for construction of buildings and other purposes. Other parts of the same class type of land are waterlogged and are mapped as perennially wet and partly saline marsh land with a poor stand of water reed grass and other grasses used for poor grazing. Therefore, on over all bases this class could be associated with Ve, Vw. Vs and Va sub classes. Keeping under consideration the maximum limitation factors, protection of such type of soils does not appear economic at present and irrigation water could better be used on better lands.

2.7 Water logging and Salinity

Command wise surface salinity status was observed during the S&R studies conducted by WAPDA Water wing (SMO) South in 2005. These are the latest studies conducted by this organization, later on such type of studies have not been conducted by any organization. Hence data is collected, processed and presented by consultants after rechecking and updating the study area on reconnaissance level for each canal command and on over all basis the statistical status of Left Bank area is presented in table 2.5and Map-P3-M-P-020.

Total four categories namely Non-saline, slightly saline, moderately saline and strongly saline have been recognized and mapped. The categories criteria for classification are according to the soil survey manual Agricultural Hand Book 18. These classes are briefly described as under.

Table 2.5: Left Bank Command Wise Salinity Status of the Area

S. No	Main Canal	Area in Acres	Salinity Class- ECe dS/m at 25° C (% of area)				Miscellaneous area	Total
			Non Saline 0-4	Slightly saline 4-8	Moderately saline 8-15	Strongly Saline more than 15		
1.	**Ghotki Feeder**	984,795	73	6.0	3.0	9.0	9.0	100
2.	**Nara Canal**	2,431,394	29	23	10	33	5.0	100
3.	**Rohri Canal**	2,927,713	57	22	6.0	9.5	5.5	100
4.	**Khairpur Feeder West**	506,000	72	13	4.0	4.0	7.0	100
5.	**Khairpur Feeder East**	300,000	61	17	7.0	6.0	9.0	100
6.	**Pinyari**	981,207	22	19	5.0	40	14	100
7.	**Fuleli**	1,045,651	44	21	10	20	5.0	100
8.	**Lined Channel Akram Wah**	531,965	27	23	15	22	13	100
9.	**Total area of Left Bank Command**	**9,708,725**	**48**	**18**	**7.5**	**18**	**8.5**	**100**

Non Saline

There are no visible salts on the soil surface and plant growth is not affected by salinity, this type of area covers about 48 percent of the total area in Left Bank.

Slightly Saline

Plant growth is uneven patchy, salts are mostly present in patches and cover about 18 percent of the total area.

Moderately Saline

Salts are fairly visible on the soil surface and growth of plants is affected and covers 7.5 percent of the total area.

Strongly Saline

There is no cultivation except some salt loving natural vegetation. Mostly this area is lying abandoned and covers about 18 percent of the total area.

Miscellaneous Land type

This is most important unit and includes built up area like cities, town, road, railway, canal drains and Industrial areas. It covers about 8.5 percent of the area.

2.8 Water Resources

The Lower Indus Left-bank region stretches along the River-Indus for 600 km like a curved v-shape, which expands from a 200 km wide desert range to 500 km wide coast along the Arabian sea. The natural river path use to meander over a wide range and split into many creaks and shallow channels as it reaches to the sea. Historically, the whole region was extended flood plains of the river Indus, which could be inundated during the flood season and simultaneously drained by the Indus and a supportive system of deeper drainage ravines dispersing into the coastal water bodies. All major tributaries of Indus join it before it enters into Sindh, however, contribution of hill torrents from the Khirthar range could be occasionally substantial.

The river-Indus is the main source of water for the region complemented by highly skewed and erratic summer rainfalls. The groundwater aquifer is predominantly saline. About 20% of the area has fresh groundwater aquifer. In some areas, intensive canal irrigation provides a shallow layer of useable percolated water, which, is recharged during summer. The pumpage of this water through shallow tubewells has consistently increased supplementing surface irrigation, industrial and domestic water uses. About 80% of the river flows in the Indus basin have been allocated to the provinces and then to the main canals off-taking from the barrages. The accountable water resources of the left-bank include rainfall, allocated canal supplies, renewable groundwater in canal command areas and direct uses from the water bodies by the local livelihood and vegetation.

2.8.1 Rainfall

The rainfall in study-area is erratic and confined to the monsoon period of July to September. The dominant pattern of the monsoon is two to three medium downpours during July or August. Heavy rainstorms normally occur in August and September. The winter months or Rabi season receives less than 10% of the total rainfall. The rainfall-normal's for six meteorological stations are shown in Table 3.3. The maximum average annual rainfall (228 mm) occurs at Chhor, which is located in the lower-half of the region, closely followed by Badin, representing the coastal region. Towards the North, average rainfall decreases to 117 mm per annum (Rohri). The station-average rainfall is not the weighted average of the Left-bank. These normal-values better represent rainfall in gross canal-command areas of the left-bank.

The last column of the table 2.6 shows average rainfall measured from 1977 to 2011 at Badin, Chorr and Nawabshah stations. The average annual rainfall of the period 1977-2011 (35 years) is

the same as long-term normal values for Badin. An increasing trend can be noticed for Chorr and Nawabshah, Figure 3.1. Thirty-five year rainfall shows two specific changes in average trends:

i. The annual average rains of 35 years at Chorr and Nawabshah are higher than the normal rains. The reason is increased frequency of high rainfalls and a decrease in incidences of nominal rainfall.

ii. Rainfall at the Chorr station has an increasing tendency because of more frequent above-average rains (Figure 3.1). The average rains of thirty-five years indicate 18.5 mm more rains at Chhor than the Badin.

Table 2.6: Climatic Normals of Rainfall at Left-bank Meteorological Stations in mm– updated 2010

Sindh	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Avg. 1977-2011
Badin	1.8	6.4	0.7	1.9	6.2	9.9	67.6	92.5	27.1	5.5	2.9	1.0	223.5	223.67
Chhor	1	3.5	0.8	1.6	7.2	18.4	79.3	69.3	37.3	6.2	3.6	0.2	228.4	242.12
Hyderabad	2	4.3	2.4	5	4.6	6.2	45.5	63	12.6	2.9	2.3	1.3	152.1	
Nawabshah	2.4	3.3	2.4	2.6	1.5	2.8	50.9	46.3	16.2	4.9	1.5	1.8	136.6	148.64
Padidan	2.8	4.6	4.1	2.7	1.4	2.7	40.5	40.5	12.6	2.2	1.7	2.1	117.9	
Rohri	4.8	5.9	5.3	2.7	5.2	5.6	45.5	25.1	11.8	3.4	0.7	1.1	117.1	
Stations Average	**2.47**	**4.67**	**2.62**	**2.75**	**4.35**	**7.60**	**54.88**	**56.12**	**19.60**	**4.18**	**2.12**	**1.25**	**162.6**	

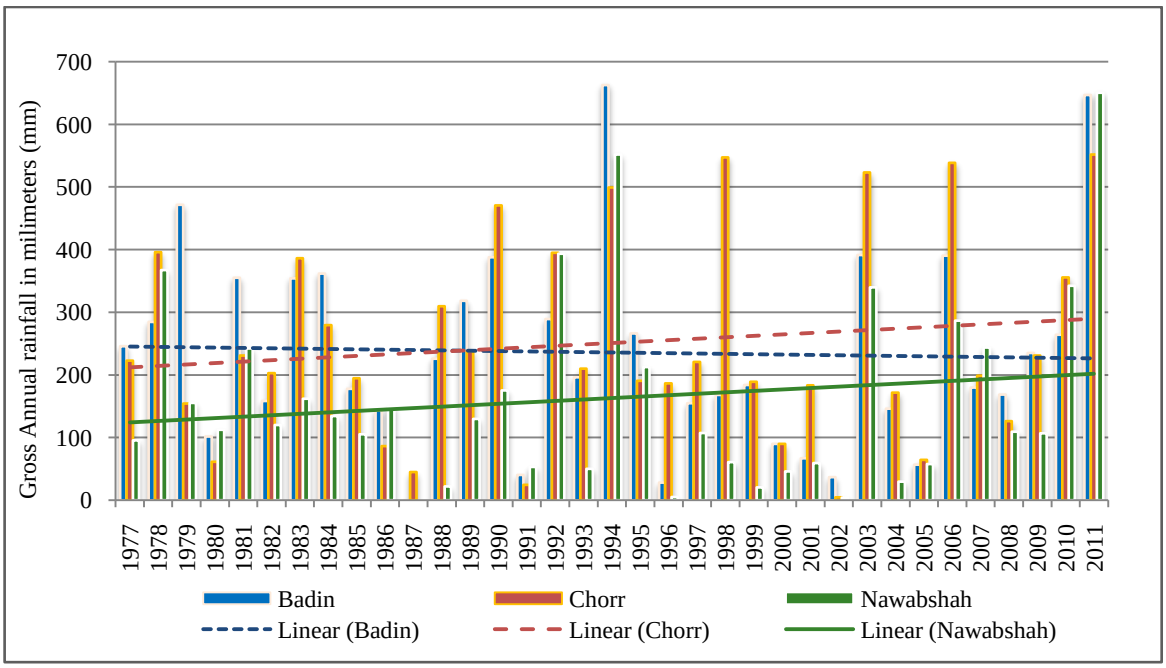


Figure 3.1: Total Annual Rainfall of 34 years at three MET Stations in LBOD catchment

The contribution of rainfall as a water-resource is limited in the region. The precipitation makes 25% of the reference evapotranspiration during July and August and only 13% in September. Because of unreliability of rains and maximum crop demands during summer, irrigation planning

relies on high canal diversions. While, the rainstorm can generate more than fifteen billion cubic meters (15 bcm) during heavy monsoon years and more than ten cubic meters (10 bcm) during fifty percent of the years. The local topography and aquifer conditions could not safe rain-runoff from heavy showers and it needs to be evacuated through an effective drainage system. The rain-runoff and drainage issues are further analysed in the report on drainage assessment scenarios.

2.8.2 Surface Water

The diversion of river flows through long conveyance and distribution channels is the main source of water in the project area. The provincial-shares of river flows are accounted at the head of main canals off-taking from river barrages. Under normal conditions, river structures, reservoirs and canal systems are regulated on 10-daily bases, to satisfy provincial shares and demands for water releases. The provincial water shares agreed in 1991, accounted as a sum of canal-diversions, provide seasonal and annual global targets for river water distribution. However, provincial requests could be different from the allocated shares for shorter periods. In the beginning of a season, the Indus River System Authority (IRSA) prepares a seasonal water distribution plan by keeping in view provincial allocations and expected availability of water in the network. The adjustments are made during operations, responding to the actual water availability, changes in demand and emergencies like floods.

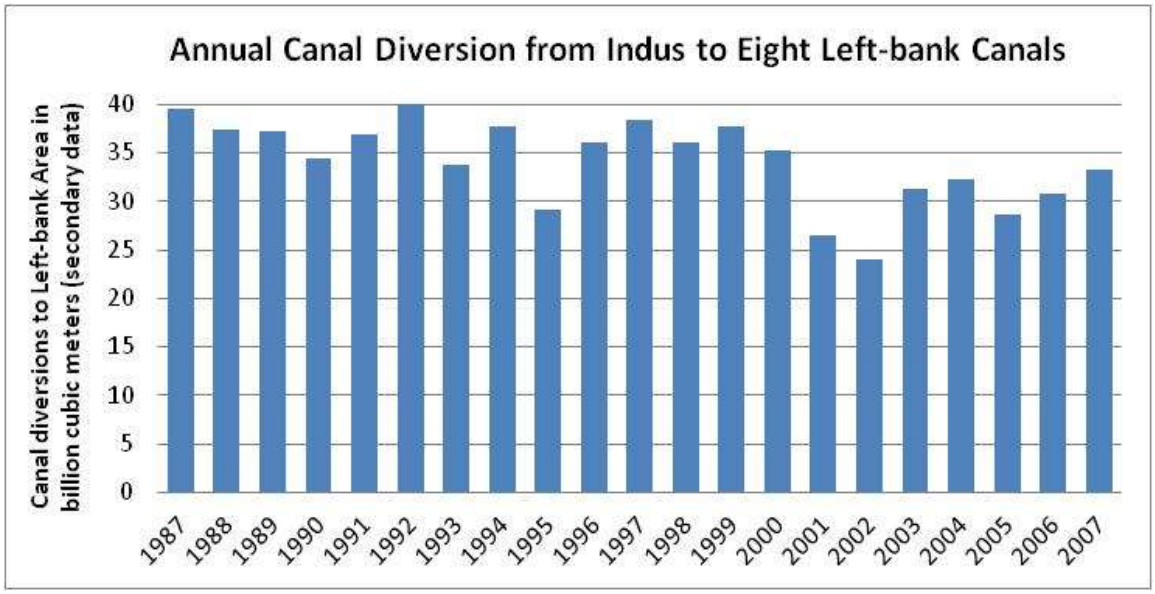


Figure 3.2: Annual Canal Diversions to Eight Left-Bank canals

The diversion-data of twenty years from 1987 to 2007 shows a decrease in maximum irrigation diversions to eight left-bank canals. Apparently, there is no reason for a systematic decrease in river supplies, however, it indicates that the formal irrigation diversions are currently constrained at the level of 1987. Some of the low-supply trends can be explained:

- From 2000 to 2002 were two years of severe drought in the basin. The river water availability was 30% less than the average annual flows.
- There were four years of heavy floods, 1992, 1995, 2003, and 2006. The canal closures and a decrease in water demands could be expected.

The irrigation diversions to individual canals against the seasonal allocations (WAA 1991) indicate higher water stress during Rabi than Kharif (Table 3.2). The natural Indus river flows in winter are only 25% of the summer flows. The snow-melt and monsoon rains are the major contributors of river flows during Kharif. Because of limited surface storages in the system, Rabi water availability is not sufficient to achieve the allocated flows in the system.

The water-balance analysis shows the quantitative contribution of different water resources and predominant role of river flows in meeting different water demands.

Table 2.7: Surface Water Allocations (1991) and Actual Supply (2007-08) to the Left-bank Canals

	Water Allocation 1991			Actual 2007-08			Diverted/Allocated	
	Kharif	**Rabi**	**Annual**	**Kharif**	**Rabi**	**Annual**	**Kharif**	**Rabi**
	Million Acre Feet			Million Acre Feet			Ratio	
Ghotki	2.30	0.95	3.25	2.237	0.913	3.150	0.97	0.96
North West	1.90	1.01	2.91	1.413	0.982	2.395	0.74	0.97
Khairpur West	0.65	0.53	1.18	0.526	0.333	0.859	0.81	0.63
Khairpur East	0.92	0.70	1.62	0.757	0.386	1.142	0.82	0.55
Rohri	4.84	3.95	8.79	4.172	2.365	6.537	0.86	0.60
Nara	4.16	3.25	7.41	4.913	2.662	7.575	1.18	0.82
Lined Channel	0.95	0.52	1.47	0.738	0.442	1.179	0.78	0.85
Fuleli	2.72	0.68	3.40	3.266	0.528	3.795	1.20	0.77
Pinyari	2.06	0.43	2.49	2.363	0.290	2.653	1.15	0.67

2.8.3 Groundwater

The use of groundwater remains limited in Sindh before the drought years of 2000-02. About 25% of the left-bank crop-zone has non-saline groundwater aquifer. The estimated number of tubewells in Sindh from 1970 onwards is shown in Figure- 3.3.3 (Water Statistics Project, reference Sindh Development Statistics 2006). The agriculture development, water shortages in winter and substantial increase in area with perennial cash crops, are the major factors behind the growth of shallow tubewells at a faster pace. Another factor behind this increase in well density is population pressure and increasing economic-value of the commercial agriculture.

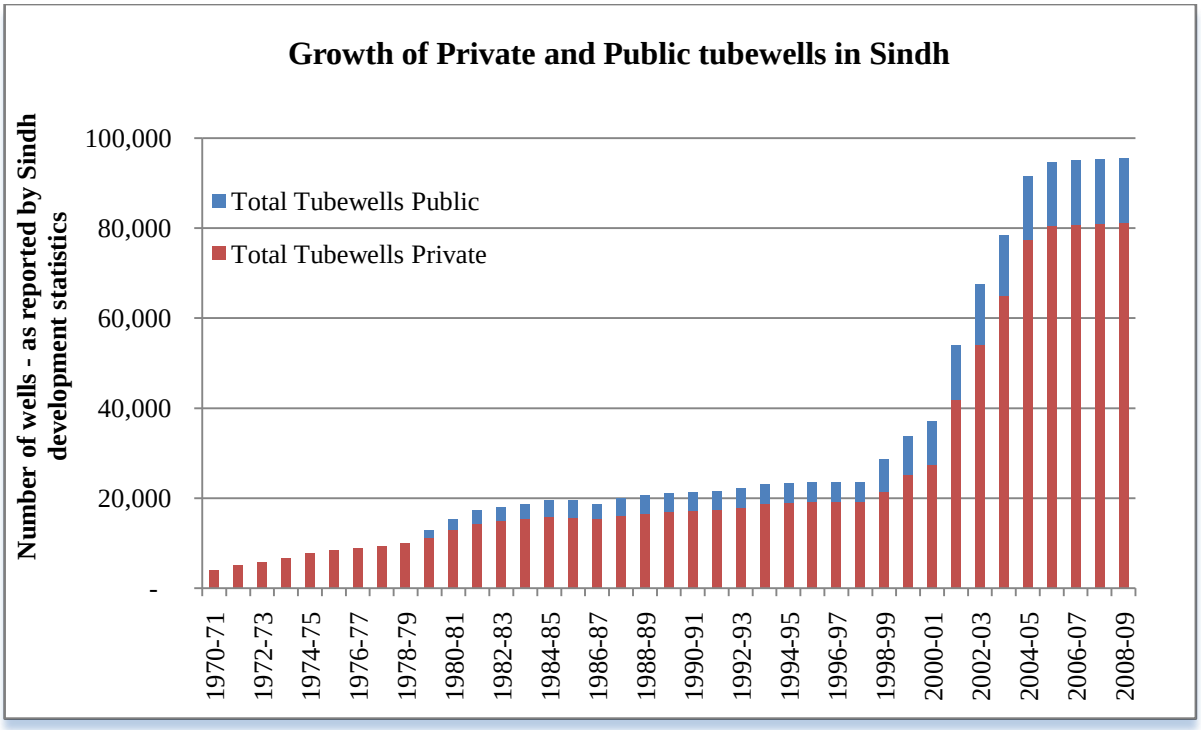


Figure 3.3: Growth of Tube-wells in Sindh from 1970 to 2010

The reported patterns of increase in private tube-wells could not be fully explained from the gross provincial data. As the monitoring surveys are not carried out on a regular interval, the reported data may contain a bias.

Table 2.8: Actual and estimated number of Public and Private Tubewells Installed in Sindh

Years	Electric Tubewells		Diesel Tubewells		Total Tubewells		Total Sindh
	Public	Private	Public	Private	Public	Private	
1970-71	0	2,082	0	1,989	0	4,071	4,071
1980-81	2,429	9,297	0	3,695	2,429	12,992	15,421
1990-91	4,164	12,431	42	4,739	4,206	17,170	21,376
2000-01	9,171	14,930	518	12,572	9,689	27,502	37,191
2008-09	13,099	18,637	1,116	62,541	14,215	81,178	95,393

Source: Agricultural Statistics of Pakistan

The quantitative contribution of groundwater in different sectors is estimated and discussed in the sections on water-balance analysis.

2.9 Agriculture

Agriculture sector is an important engine of growth in the study area. It directly and indirectly provides livelihood to about three fourth of the Sindh population residing in the left bank. The left bank receives almost 60% to 65% of the canal withdrawals, while its share in the total cropped area is about three fourth. Apart from wheat, the main staple, most of the main cash

crops and high value crops, such as cotton, sugarcane, vegetables, condiments, and fruits (mango and banana) are grown.

2.9.1 Farm Area, Ownership and Tenure

2.9.1.1 Farm structure and tenure

According to the last agricultural census of 2000[1], the farm structure in the left bank, despite dominance of small farms (in numbers), is in favor of large farms (in terms of total land area). Most farms are fragmented and are in joint ownership of extended family. This skewed structure is a constraint to access and distribution of factors of production, particularly to smaller farms. This also is a factor responsible for income disparity in the rural areas. Following is a description of farm structure vis-à-vis farm ownership, and tenurial pattern.

2.9.2 Farm ownership pattern

There are about 600 thousand farm owners in the Study area, managing about 3.4 million ha. The average farm size is about 5.7 ha. Three fourth of the total farm owners are subsistence farmers. They own about one fourth of the total farm area. The number of farmer owners, in very small farm size category[2], is about 21.4 percent (131 thousand), but they own only 2.4% of the farm area, with an average farm size of 0.6 ha. Similarly, 52.1% (312 thousand) small farmers own about 22.9% of the farm area, with an average farm size of 2.5 ha. The 77.4 thousand (12.9%) owners are medium size farmers, owning about 15.9% of the farm, with an average farm size of 7.0 ha. This farm size is optimal farm size for sustenance of an average family. About 69.2 thousand farmers (11.5%) are in the large farm size category and they own about 34% of the farm area, with an average farm size of 16.7 ha. The very large farmers are about 1.5% (9.1 thousand) and they own one fourth of the farm area, with an average farm size of 92.8 ha.

Based on the past trends in the ownership pattern, as evident from previous census, the number of farmers and the area owned in the higher farm size group is shrinking, consequently increasing share of smaller farms over the years. The main reasons are: i) land mutation; ii) land transfers; and iii) out migration by selling land and investment in urban areas.

2.9.3 Operational holdings and tenurial arrangement

There are 727.5 thousand operational farms cultivating about 2.8 million ha. About 441.4 thousand farms (60.7%) are operated by owners farmers (self/direct cultivation), managing 81.7% of the operated farms. The tenants or sharecroppers account for 35.2% and operate 21.2% of the area. The remaining farms are owner-cum-tenants accounting for about 4.1% of the total operators, cultivating 9.2% of the area. The average farm area operated is 3.9 ha. The average area operated by tenants is about 2.3 ha, while owner cultivators manage about 5.2 ha, and the owner-cum-tenants operate on an average about 8.6 ha.

2.9.4 Crop Area yields and Production

Cropping pattern

Sindh has two main cropping seasons, namely kharif – summer season (mid-April through mid-October), and Rabi – winter season (mid-October through mid-April). The main Rabi crops are wheat, rape and mustard, vegetables, and fodder. The main crops grown in kharif are cotton, sugarcane, paddy,[3] millets, and cluster-bean, kharif vegetables, pulses, nontraditional oilseeds,[4] etc. In addition to this, the left bank produces different fruits such as mango, banana, dates, papaya, guava, etc.

[1] Agriculture Census 2000: Province of Sindh. Statistics Division, Government of Pakistan
[2] Very small farm size group = less than 1 ha; Small farm size =1ha to <5 ha; Medium size farm = 5 to 10 ha; Large size farm = 10 to 40 ha; and Very large size farm = above 40 ha.
[3] Mostly in non-perennial areas of Guddu and Kotri barrages
[4] Mainly sunflower and safflower,

There is significant increase in wheat area and its share in the cropped area. The area under wheat reported as 764 thousand ha in 2007/08, accounting for 26% in the cropped area, has increased to about 821 thousand ha in 2009/10, sharing about 30% in the cropped area. It appears that wheat has replaced Rabi oilseeds whose area has reduced drastically. Similarly, area under cotton has increased from about 579 thousand ha in 2007/08 to about 600 thousand ha in 2009/10 accounting for about one fifth of the cropped area. The area under paddy has also increased from about 181 thousand ha in 2007/08 to about 261 thousand ha in 2008/09, and declined to about 238 thousand ha in 2009/10. The share of paddy in total cropped area oscillated between 6% and about 9% in the same period. The share of Sugarcane area in the total cropped area has declined from about 10.4% to 8.3% in the reported years. The area under sugarcane declined from about 304 thousand ha in 2007/08 to about 230 thousand ha in 2009/10. The area under fruit increased from about 142 thousand ha to about 145.5 thousand ha in the same period, while area under vegetables has also increased from 54.6 thousand ha to about 64.7 thousand ha in the same period indicating a shift to high value crops.

The existing cropping pattern and intensities of canal commands in the left bank was also estimated from the records of Sindh Irrigation Department, Sindh Irrigation Development Authority (SIDA), and Agricultural Department and published data by the Bureau of Statistics of Sindh and Pakistan. Where the availability of water is limited, the farmer prefers mixed cropping pattern with low delta crops such as pulses, oil seeds, orchard and fodder. In the upper reaches of the canal commands, the annual cropping intensity is higher than the lower reaches of the canal, because availability of water at tail ends is low. In Sukkur Barrage and Kotri Barrages, the upper reaches have higher cropping intensities compared to lower reaches.

The above cropping pattern is for the overall left bank and includes cropped area in the nonbarrage areas. In the following section cropping pattern and cropping intensities has been revisited using the command wise information on cropped area under various crops.

2.9.5 Cropping intensity

Based on computations from the land utilization data,[5] the overall cropping intensity in the Study area is estimated as 65%. It is highest in the Guddu sub-region (110%), followed by Kotri sub-region (63%), and 60% in the Sukkur region. One reason that explains high farming intensity in Guddu sub-region is rapid growth in private tubewells. Moreover, major portion of the culturable waste and area uncommandable lies in the Sukkur sub-region.

The cropping intensity mentioned above should not be seen same as command area specific cropping intensities. The estimated cropping intensity reflects cropping intensity of the Study area as a whole, which include barrage and non-barrage areas.

Based on further analysis of data[6] mentioned earlier, in 2009/10, the annual cropping intensity of Ghotki Feeder of Guddu sub-region is 35%. The annual cropping intensities of Khairpur West Canal, Khairpur East Canal Nara Canal, and Rohri Canal falling in the Sukkur sub-region is in the order of 89.7%, 82.7%, 40.4% and 63.7% respectively. Likewise annual cropping intensity of Akram Wah in Kotri sub-region is 30.1%, while cropping intensities of only Kharif season for Pinyari Canal and Fuleli Canal, both no perennial canals, is in the order of 19.3%, and 18.5% respectively. It is evident from the figure of cropping intensities that in Nara Canal command the annual cropping is very low which is the clear indicator that there is either acute shortage of water or the available water potential is not used intelligently. Similarly, there are alarming figures of cropping intensities in the command of canals falling in Kotri sub-region, which explicitly manifests that there is a huge shortage of water in this sub-region. This whole scenario needs a special attention to address the problem in a productive manner in order the alleviate the poverty prevailing in problematic sub-regions.

[5] Volume-II Table 4.6.14
[6] Volume-II Table 4.6.27 through 4.6.34

A recent survey conducted by WAPDA in 2006/07 shows that the cropping intensities has decreased from 127.7% in 1982/83 to 114.9% in 2006/07 in the LBOD system.[7] The results are encouraging about increase in cropped area, reduction in current fallow, and production.

2.9.6 Production

In the left bank of Indus the production of wheat during 2007/08 through 2009/10 oscillated around three million mt. The Sukkur sub-region accounts for about two thirds of the total production, followed by about 20 % produced in Guddu sub-region, while Kotri sub-region contributes 6% to the total left bank production.

The total production of cotton (seed cotton) in the left bank during the same period was about 2.5 million mt in the first two years, which increased to about 4 mt in 2009/10. This phenomenal increase is due to wide adoption of Bt varieties. About two third of the cotton is produced in Sukkur sub-region, followed by Guddu sub-region which contributes about one fifth in total cotton production, while about 5% is produced in the Kotri sub-region. Recently it has been reported that the performance of Bt cotton in Kotri sub-region has demonstrated exceptionally high yields and cotton may be an important crop in the coming years.

In the left bank paddy is also an important crop, and its production increased from half a million mt in 2007/08 to about 700 thousand mt, of which about 70% to 80% is produced in the Kotri sub-region, while the balance is produced in the Guddu sub-region and Sukkur sub-regions.

The total production of sugarcane in the three sub-regions was about 18.5 million mt, in 2007/08, which significantly declined to about 13 mt in the last two years. The total production of vegetables, a high value enterprise, in the left bank was 686 thousand mt in 2007/08, which increased to about 800 thousand mt in 2008/09, while it shows a drastic decline in 2009/10 reducing to about 200 thousand mt. The Sukkur sub-region which contributed about two third of the total vegetable production in 2007/08, its share declined to about 45% by 2009/10. The share of Kotri sub-region in total vegetable production in 2007/08 was about 15%, which has increased to about 50% by the year 2009/10. Sukkur sub-region produces about 85% of the fruits, followed by about 10% in the Kotri sub-region.

2.9.7 Crop yields

The average yield of wheat during the last three years i.e. 2007/08 through 2009/10 is stagnant at about 3.6 mt/ha, which is higher than the wheat average for Sindh, and higher than national average. The yield of seed cotton has shown significant increase in the last three years. The yield of cotton in 2007/08 was 4.2 mt/ha, which increased to 4.6 mt/ha in 2008/09, and in 2009/10 it recorded a phenomenal increase of 6.8 mt/ha. The yield of sugarcane has been erratic. In 2007/08 the estimated average yield was observed as 61 mt/ha, which declined to about 50.5 mt/ha in 2008/09, and increased to about 58 mt/ha in 2009/10

2.9.8 Shift in Cropping Pattern

Within the study area, Badin and Thatta are the districts where significant shift in cropping pattern have been noticed. The parameters analyzed to assess the cropping pattern are the area and crop-wise index of area in Badin and Thatta districts. The data collected from secondary sources for last 20 years indicate that about 32,000 ha in Badin district and about 460,000 ha in Thatta districtwere lost to sea intrusion. Analysis of cropped area trends in the Thatta and Badin area based on crop acreage data for 1991/92 through 2009/10 for all the crops, save sunflower, shows that the total cropped area declined after the cyclone and sea intrusion. Nonetheless, the cropped area in two districts has increased significantly in the post cyclone period, if the area under sunflower is also taken into account in the total cropped area. As the two districts are served by the eastern drain system i.e. LBOD and the western drain system for the Kotri barrage command area, hence this aspect is also one of the factor significantly affecting the cropping

[7] Final progress Report: Continuation of Monitoring of LBOD System. August 2006 to July 2008. SCARP Monitoring Organization (SMO) WAPDA, Hyderabad. June 2009

pattern. The 2010 river floods and 2011 storm water are also the main factors making shift in the cropping pattern of the lower Sindh districts. Unfortunately, despite concerted efforts this data for 2010 and 2011 could not be obtained from the Agriculture Extension Department or the Sindh Bureau of Statistics, but it has been observed during the consultative meetings, field visits surveys and face to face interactions with the farming communities that there is significant shift in the cropping pattern in the area.

In Badin district the total cropped area (excluding sunflower) in 1991/92 was reported as about 230 thousands ha which declined to about 199 thousand ha by the year 1997/98, during which the LBOD was being constructed. After the collapse of the tidal link and associated structures, the cropped area continued to decline till 2004/05 (about 49 thousand ha), but increased thereafter to about 207 thousand ha, which is about 10% lower than the base year. Similarly in Thatta district, the total cropped area (excluding sunflower) in 1991/92 was reported as about 101 thousands ha which increased to about 120 thousand ha by the year 1997/98. After the collapse of the tidal link and associated structures, the cropped area initially declined, but recovered and has increased to about 145 thousand ha by the year 2009/10; an increase of 43% over the base year. Refer Table 2.9 and 2.10 and Figures 3.4 and 3.5.

The abovementioned tables also show that with the acreage under sunflower included, the total cropped area has increased significantly over the last 19 years. In the Badin district the area registered an increase of more than 40% over the base year, while in the Thatta district the area has almost doubled in the same period. It may be mentioned here that the decline in the cropped area in the two districts may have been offset by the western drainage system.

The data on crop shares (excluding sunflower) shows that in Badin district, the share of Cotton area has increased from 2% in 1991/92 to 9% by the year 2009/10. In the Thatta district the share of paddy has declined from 58% to 50%, while wheat has increased from 6% to 11% in the same period. With the area under sunflower included, the share of sunflower has increased from 1%, in both the districts, to about 37% and 27% in Badin and Thatta districts. The year wise detail is presented in Table 2.11. The phenomenal increase in area under sunflower is that the recently introduced hybrid varieties have lower delta and two crops can be grown in the Rabi season.

Table 2.9: Crop Wise Details of Area Sown In Badin & Thatta Districts during Last 20 Years from The Year 1991 To 2010

Name of crop	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
	BADIN																		
Rice	96,535	54,142	78,359	60,396	71,640	79,439	75,449	74,197	64,190	70,459	60,958	64,783	58,751	58,934	61,199	62,324	59,132	80,544	82,687
Cotton	4,141	2,369	3,470	942	2,321	2,824	2,732	3,015	2,956	1,788	3,237	6,210	2,438	4,706	5,671	9,376	14,857	13,628	18,890
Kharif Fruits	2,646	2,649	2,648	2,593	2,788	2,982	3,066	3,149	3,210	3,441	3,325	3,208	3,626	3,192	3,178	4,688	4,327	4,803	5,278
Rabi Fruits	90	92	90	89	91	92	93	94	103	117	117	117	123	125	393	433	462	476	458
Sugarcane	56,942	52,491	61,157	54,256	58,474	57,037	59,989	62,613	30,898	43,792	47,872	52,139	43,260	36,248	38,453	39,667	59,847	53,640	46,117
Kharif Veg.	1,052	1,150	1,220	1,257	931	932	937	960	973	960	1,992	1,498	1,326	1,176	1,210	1,850	1,210	1,852	2,302
Rabi Veg.	1,377	1,625	1,619	1,628	1,969	1,994	2,005	2,014	1,942	2,017	4,152	4,396	4,094	3,865	6,470	4,639	4,918	4,976	4,888
Wheat	41,638	42,651	42,893	32,189	33,385	33,762	32,431	34,892	35,079	21,326	21,763	18,047	22,178	28,146	30,947	28,346	29,730	33,350	36,142
Kharif Fodder	16,780	14,391	14,489	14,523	14,155	12,858	13,125	13,484	10,859	8,455	8,697	5,236	7,518	4,992	5,802	6,479	4,152	4,071	2,302
Rabi Fodder	8,819	8,895	8,944	1,978	9,551	9,365	9,486	9,529	8,787	8,127	7,536	8,028	8,359	7,735	7,804	7,952	7,952	8,333	8,022
Subtotal	**230,020**	**180,455**	**214,889**	**169,851**	**195,304**	**201,285**	**199,313**	**203,947**	**158,997**	**160,482**	**159,649**	**163,662**	**151,673**	**149,119**	**161,127**	**165,754**	**186,587**	**205,673**	**207,086**
Sunflower	2,146	1,734	2,375	4,047	7,919	7,875	7,924	16,187	19,424	13,597	14,019	34,510	91,369	118,936	138,000	123,773	127,136	132,221	121,049
Total Area	**232,166**	**182,189**	**217,264**	**173,898**	**203,223**	**209,160**	**207,237**	**220,134**	**178,421**	**174,079**	**173,668**	**198,172**	**243,042**	**268,055**	**299,127**	**289,527**	**313,723**	**337,894**	**328,135**
	THATTA																		
Rice	58,291	42,961	60,118	51,448	61,418	68,394	65,321	66,249	58,140	61,496	45,792	56,422	54,778	54,169	54,178	68,192	77,646	78,486	72,100
Cotton	229	45	108	17	59	56	41	48	50	48	864	528	515	522	692	506	812	836	2,056
Kharif Fruits	1,810	1,817	1,810	3,013	3,216	3,419	3,479	3,538	4,573	4,963	5,381	5,798	7,925	8,765	16,219	15,866	12,488	11,047	9,606
Rabi Fruits	120	121	117	118	122	126	127	128	130	156	145	133	136	138	75	65	64	35	46
Sugarcane	22,438	21,727	25,308	23,470	24,361	23,676	25,851	28,319	25,009	23,697	26,742	28,226	30,695	22,648	20,851	27,356	40,969	33,179	31,229
Kharif Veg.	706	1,111	1,132	1,166	1,053	1,068	1,075	1,097	1,096	1,035	1,786	1,495	1,574	1,503	1,496	1,624	1,066	725	296
Rabi Veg.	2,724	2,405	2,396	2,383	2,711	2,717	2,810	2,820	2,734	2,846	1,892	1,980	2,122	2,092	2,555	2,824	4,097	5,060	4,764
Wheat	5,827	8,972	9,536	9,716	10,353	11,879	11,024	12,673	13,126	8,709	10,116	8,196	9,974	9,562	12,846	11,889	13,104	13,636	15,271
Kharif Fodder	1,330	2,268	2,363	2,382	2,372	2,000	2,051	2,111	1,838	1,532	1,561	1,806	3,921	2,510	2,156	4,101	3,607	3,516	3,145
Rabi Fodder	7,433	7,477	7,445	7,617	8,003	7,778	7,928	7,974	7,284	6,501	8,479	8,892	9,387	8,749	8,501	8,571	8,519	5,976	5,946
Subtotal	**100,908**	**88,904**	**110,333**	**101,330**	**113,668**	**121,113**	**119,707**	**124,957**	**113,980**	**110,983**	**102,757**	**113,476**	**121,027**	**110,658**	**119,569**	**140,994**	**162,372**	**152,496**	**144,459**
Sunflower	1,216	503	971	1,821	1,528	3,732	3,772	4,452	5,666	3,966	4,089	4,801	37,196	45,610	52,579	43,974	52,612	54,716	53,454
Total Area	**102,124**	**89,407**	**111,304**	**103,151**	**115,196**	**124,845**	**123,479**	**129,409**	**119,646**	**114,949**	**106,846**	**118,277**	**158,223**	**156,268**	**172,148**	**184,968**	**214,984**	**207,212**	**197,913**

Source: Unpublished Data from Department of Agriculture Extension 2011

Table 2.10: Crop Wise Index of Area in Badin & Thatta Districts during Last 20 Years

District	Name of crop	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10
Badin	Rice	100	56	81	63	74	82	78	77	66	73	63	67	61	61	63	65	61	83	86
	Cotton	100	57	84	23	56	68	66	73	71	43	78	150	59	114	137	226	359	329	456
	Kharif Fruits	100	100	100	98	105	113	116	119	121	130	126	121	137	121	120	177	164	182	199
	Rabi Fruits	100	102	100	99	101	102	103	104	114	130	130	130	137	139	437	481	513	529	509
	Sugarcane	100	92	107	95	103	100	105	110	54	77	84	92	76	64	68	70	105	94	81
	Kharif Vegetable	100	109	116	119	88	89	89	91	92	91	189	142	126	112	115	176	115	176	219
	Rabi Vegetables	100	118	118	118	143	145	146	146	141	146	302	319	297	281	470	337	357	361	355
	Wheat	100	102	103	77	80	81	78	84	84	51	52	43	53	68	74	68	71	80	87
	Kharif Fodder	100	86	86	87	84	77	78	80	65	50	52	31	45	30	35	39	25	24	14
	Rabi Fodder	100	101	101	22	108	106	108	108	100	92	85	91	95	88	88	90	90	94	91
	Subtotal	**100**	**78**	**93**	**74**	**85**	**88**	**87**	**89**	**69**	**70**	**69**	**71**	**66**	**65**	**70**	**72**	**81**	**89**	**90**
	Sunflower	100	81	111	189	369	367	369	754	905	634	653	1,608	4,258	5,542	6,431	5,768	5,924	6,161	5,641
	Total Area	**100**	**78**	**94**	**75**	**88**	**90**	**89**	**95**	**77**	**75**	**75**	**85**	**105**	**115**	**129**	**125**	**135**	**146**	**141**
Thatta	Rice	100	74	103	88	105	117	112	114	100	105	79	97	94	93	93	117	133	135	124
	Cotton	100	20	47	7	26	24	18	21	22	21	377	231	225	228	302	221	355	365	898
	Kharif Fruits	100	100	100	166	178	189	192	195	253	274	297	320	438	484	896	877	690	610	531
	Rabi Fruits	100	101	98	98	102	105	106	107	108	130	120	111	113	115	63	54	53	29	38
	Sugarcane	100	97	113	105	109	106	115	126	111	106	119	126	137	101	93	122	183	148	139
	Kharif Vegetable	100	157	160	165	149	151	152	155	155	147	253	212	223	213	212	230	151	103	42
	Rabi Vegetables	100	88	88	87	100	100	103	104	100	104	69	73	78	77	94	104	150	186	175
	Wheat	100	154	164	167	178	204	189	217	225	149	174	141	171	164	220	204	225	234	262
	Kharif Fodder	100	171	178	179	178	150	154	159	138	115	117	136	295	189	162	308	271	264	236
	Rabi Fodder	100	101	100	102	108	105	107	107	98	87	114	120	126	118	114	115	115	80	80
	Subtotal	100	88	109	100	113	120	119	124	113	110	102	112	120	110	118	140	161	151	143
	Sunflower	100	41	80	150	126	307	310	366	466	326	336	395	3,059	3,751	4,324	3,616	4,327	4,500	4,396
	Total Area	**100**	**88**	**109**	**101**	**113**	**122**	**121**	**127**	**117**	**113**	**105**	**116**	**155**	**153**	**169**	**181**	**211**	**203**	**194**

Source: Unpublished Data from Department of Agriculture Extension 2011

Figure 3. 4: Trend of Crop Cultivation Badin Area

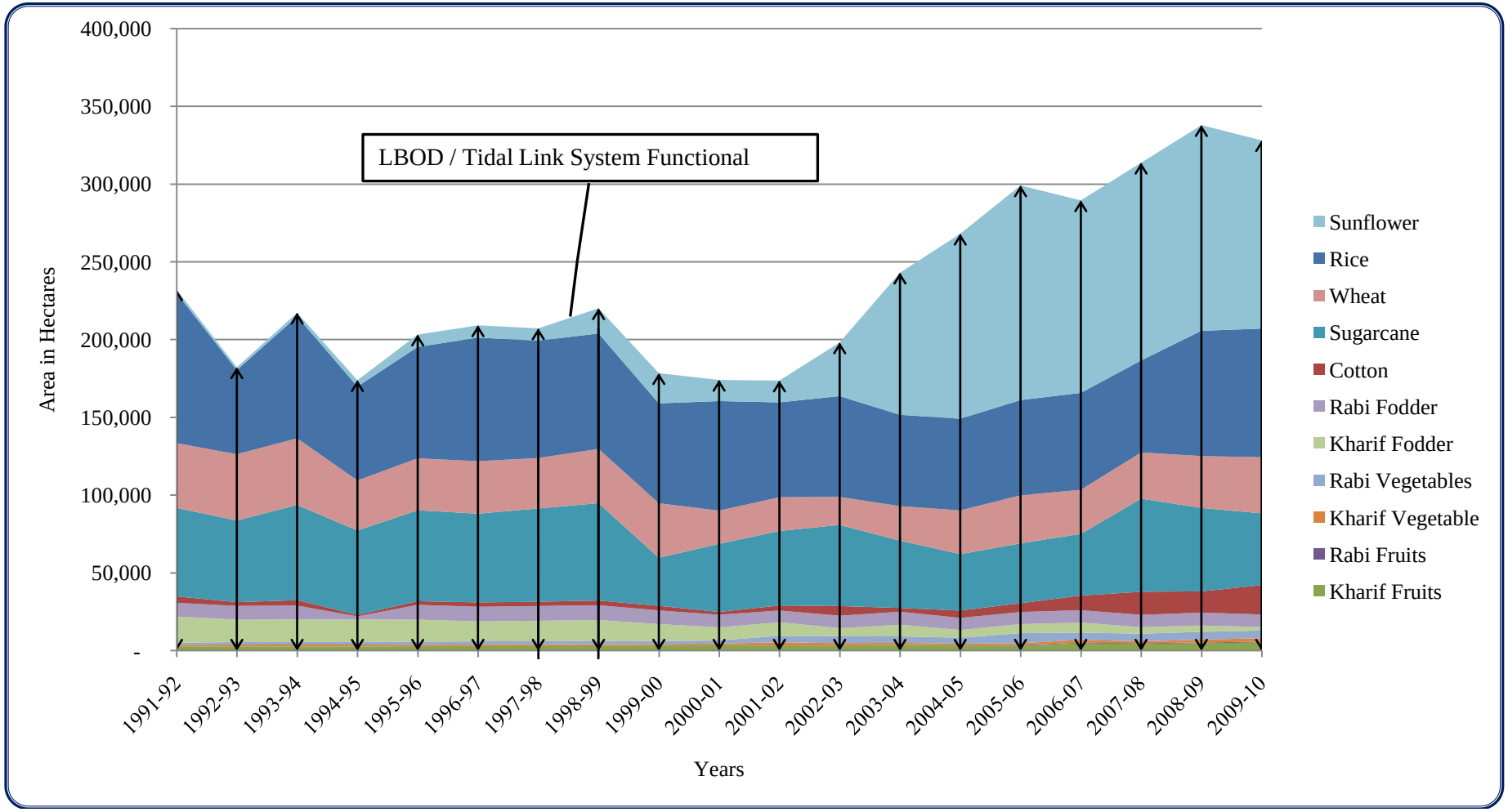


Figure 3. 5: Trend of Crop Cultivation Thatta Area

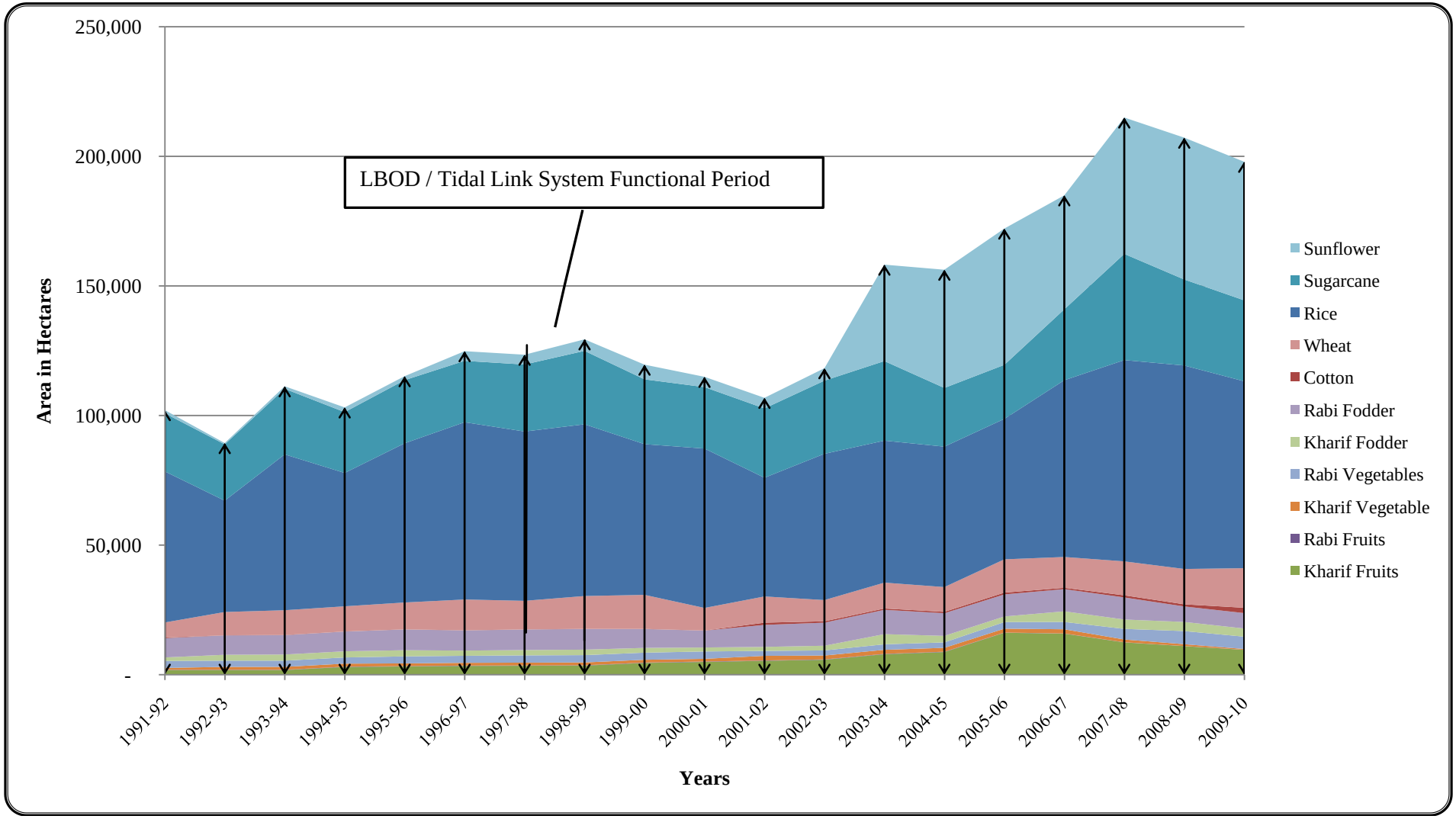


Table 2.11: Share of Different crops in total cropped Area (Excluding Sunflower) In Badin & Thatta Districts during Last 20 Years

District	Name of crop	1991/92	1992/93	1993/94	1194/95	1995/96	1996/97	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10
Badin	Rice	42%	30%	36%	36%	37%	39%	38%	36%	40%	44%	38%	40%	39%	40%	38%	38%	32%	39%	40%
	Cotton	2%	1%	2%	1%	1%	1%	1%	1%	2%	1%	2%	4%	2%	3%	4%	6%	8%	7%	9%
	Kharif Fruits	1%	1%	1%	2%	1%	1%	2%	2%	2%	2%	2%	2%	2%	2%	2%	3%	2%	2%	3%
	Rabi Fruits	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Sugarcane	25%	29%	28%	32%	30%	28%	30%	31%	19%	27%	30%	32%	29%	24%	24%	24%	32%	26%	22%
	Kharif Vegetables	0%	1%	1%	1%	0%	0%	0%	0%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
	Rabi Vegetables	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	3%	3%	3%	3%	4%	3%	3%	2%	2%
	Wheat	18%	24%	20%	19%	17%	17%	16%	17%	22%	13%	14%	11%	15%	19%	19%	17%	16%	16%	17%
	Kharif Fodder	7%	8%	7%	9%	7%	6%	7%	7%	7%	5%	5%	3%	5%	3%	4%	4%	2%	2%	1%
	Rabi Fodder	4%	5%	4%	1%	5%	5%	5%	5%	6%	5%	5%	5%	6%	5%	5%	5%	4%	4%	4%
	Subtotal	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
	Sunflower	1%	1%	1%	2%	4%	4%	4%	7%	11%	8%	8%	17%	38%	44%	46%	43%	41%	39%	37%
	Total Area	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Thatta	Rice	58%	48%	54%	51%	54%	56%	55%	53%	51%	55%	45%	50%	45%	49%	45%	48%	48%	51%	50%
	Cotton	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	1%	0%	1%	1%	1%
	Kharif Fruits	2%	2%	2%	3%	3%	3%	3%	3%	4%	4%	5%	5%	7%	8%	14%	11%	8%	7%	7%
	Rabi Fruits	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Sugarcane	22%	24%	23%	23%	21%	20%	22%	23%	22%	21%	26%	25%	25%	20%	17%	19%	25%	22%	22%
	Kharif Vegetable	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	2%	1%	1%	1%	1%	1%	1%	0%	0%
	Rabi Vegetables	3%	3%	2%	2%	2%	2%	2%	2%	2%	3%	2%	2%	2%	2%	2%	2%	3%	3%	3%
	Wheat	6%	10%	9%	10%	9%	10%	9%	10%	12%	8%	10%	7%	8%	9%	11%	8%	8%	9%	11%
	Kharif Fodder	1%	3%	2%	2%	2%	2%	2%	2%	2%	1%	2%	2%	3%	2%	2%	3%	2%	2%	2%
	Rabi Fodder	7%	8%	7%	8%	7%	6%	7%	6%	6%	6%	8%	8%	8%	8%	7%	6%	5%	4%	4%
	Subtotal	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
	Sunflower	1%	1%	1%	2%	1%	3%	3%	3%	5%	3%	4%	4%	24%	29%	31%	24%	24%	26%	27%
	Total Area	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Source: Unpublished Data from Department of Agriculture Extension 2011

2.10 Livestock

Brief overview of livestock subsector in the left bank: Nationally, it is estimated that the livestock sector accounts for about 50% in the total agriculture Gross Domestic Product (GDP)[8]. As the demand for the dairy products is significantly higher in the province of Sindh, it is estimated that the share of livestock in total provincial GDP is higher than national estimate. In the left bank there are about 8.5 million large ruminants, followed by 11.5 million small ruminants. Amongst the 936 thousand pack animals in the left bank, 73% are horses, mules, and assess. Camel population is about 218 thousand, and is concentrated in the Tharparkar district of the Sukkur sub-region.

Status: Livestock plays an important role in the economy of the Sindh province. Livestock represents an important component of agricultural sector in Sindh. Indeed, crop and livestock activities are to a great extent, interdependent upon each other for their functioning in the farm sector.

Broadly there three systems classified as mixed farming system, extensive system and intensive system. In the mixed farming system, crop farming and livestock raising are supplementary and complementary to each other. In extensive system livestock is raised mainly depending upon the grazing of pastures and crop residues. In intensive system, livestock especially buffaloes are produced in urban and peri-urban areas for milk purposes. In this system all the inputs including feed, water and medicines are made available at farm shed and there is no grazing of animals.

Table 2.12: Number of Livestock in Sindh, 1986, 1990, 1996, 2000 and 2006 Census (in '000')

Type	1986	1990	1996	2000	2006
Cattle	3,874	2,792	5,464	3,946	5,968
Buffaloes	3,220	2,566	5,615	4,222	1,928
Sheep	2,616	1,194	3,710	2,220	3,363
Goats	6,755	4,618	9,734	8,913	9,599
Camels	218	140	225	261	64
Horses	76	30	63	49	76
Mules	5	4	12	10	67
Asses	500	302	694	533	560

Source: i) Livestock Census, 2006

Table 2.13: Number of Livestock by district in Left Bank of Indus (1996 Census) (in '000')

District	Cattle	Buffaloes	Sheep	Goats	Camels	Horses	Asses	Mules
Hyderabad	436	772	173	854	8	3	30	0.4
Badin	289	368	164	302	7	1	9	0.3
Thatta	339	314	170	241	11	1	24	0.2
M. Khas	364	300	201	1,000	6	4	24	0.4
Tharparkar	485	40	899	1,971	103	8	151	0.5
Sanghar	353	253	197	702	8	4	31	0.6
Sh. Benazirabad	328	355	136	500	4	2	19	0.7
Naushahro Feroze	309	395	111	527	7	1	28	0.5
Khairpur	436	493	124	694	10	3	32	0.6
Sukkur	209	171	56	272	7	4	15	0.7
Ghotki	173	193	63	372	2	2	17	--
Total	**3721**	**3654**	**2294**	**7,435**	**173**	**33**	**380**	**4.9**

Source: Pakistan Census of Livestock, 1996

Cattle population during the decade (1996-2006) increased 26.74%, buffaloes by 30.71%, sheep by 60.69% and goats by 29.15%. In draught animals camels increased by 23.93%, mules by 69.32%,

[8] Economic Survey of Pakistan 2009/10, Economic Advisers Wing, Ministry of Finance, Government of Pakistan

asses by 44.87% and horses decreased by 28.19%. The animal population (2006 census) in Badin and Thatta districts is tabulated hereunder:

Table 2.14: Number of Livestock in Badin and Thatta District

Name of Animal	Badin District (number)	Thatta District (number)
Cattle	315,369	410,614
Buffaloes	498,253	367,117
Sheep	223,072	162,131
Goats	878,299	351,366
Camel	8,672	10,702
Horses	1,714	3,036
Mules	184	566
Asses	18,947	19,137
Poultry	611,560	973,268

Source: Livestock Census Report, 2006

Livestock plays a vital role in agriculture-based economy by providing motive power for agriculture operations and supply of beef, meat, milk, hair, skin, manure and number of other products. Livestock is treated as part of agriculture. This is natural and logical. Agriculture provides food in form of grains, fruits, vegetables, oilseeds, sugarcane etc. Livestock give milk and meat directly as food. Livestock directly helps in production of food grain and supplying dung as organic manure. Similarly, muscle power of draught animals for land preparation and other agricultural operations is a great contribution towards agriculture. Therefore, there is an organic relationship between agriculture and livestock.

Livestock live on pasture, straw and crop residues, not edible for man. This way, livestock convert waste into useful products.

2.11 Fisheries

Brief overview of fisheries subsector in the left bank: During the past years the fish catch increased from 57 thousand mt in 2003/04 to 62.8 thousand mt and declined to 60.3 thousand mt in the year 2006/07. During the past few years the share of fish catch in Kotri subregion declined from 62.4 percent to 55 percent, while the share of the Sukkur subregion increased from 12.7 percent to 24.4 percent in the same period. Similarly the catch increased from 29.7 percent to 31.5 percent in the Sukkur subregion, while in the Ghotki subregion it increased from about 13 to 24 percent. This is mainly due to the salinization of freshwater bodies in the Kotri subregion, particularly in the delta and coastal zone.

In the Study area, the fisheries subsector provides livelihoods to about 32,000 household. It is reported that in 2006/07 fisher folk population distribution, there were 23 thousand full time fisher folks, while there were about 8.8 thousand part time fisher folks. The table also shows that there are 3,560 boats, out of which 1,810 are sailboats and 1,750 are rowboats.

Status: Sindh province holds the premier position in the fisheries sector of the country. It commands almost 100 percent of the brackish, 65 percent of the fresh water and 71 percent of the marine water resources of the total fisheries area of the Pakistan. These resources comprise 400 commercially important species of the marine fish, 200 species of fresh water fish and 13 species of shrimp. The coastal areas of Thatta and Badin districts are considered major fishing areas.

Fisheries are an important activity in Badin. About 10 percent of the overall marine fish exports originate from Badin. The district is also considered to be among the most productive in Sindh for

fresh water fisheries. Badin is considered to have some of the most productive fresh water fisheries in Sindh. Inland fisheries statistics for Sindh in 2002 revealed that out of the total fish production of 80,659 tons, some 14,152 tons or 17.5 percent were produced in Badin which was second only to Thatta district in inland fish production.

As a coastal district, Badin relies on fisheries as an important component of economy. The current situation suggests that habitat protection has not been addressed, enrichment is not a priority and general indifference to the fisheries sector is pervasive. As such, it is no surprised that little has been done to check the discharge of dangerous effluents and untreated waste into water sources, which not only seriously undermines water quality but also threatens the existence of fish species. Similarly, the absence of land use planning, accelerated urbanization and population growth have transformed some streams into virtual municipal drains.

About 10 percent of the overall marine fish exports originate from Badin. Promoting fish production will not only raise the income of fish farmers, but will also benefit other businesses including processors and exporters.

During 2000-2001, total fish production in Pakistan was recorded at 665,000 tons; the contribution from marine fisheries along Sindh and Balochistan coast lines was 480,000 tons, while the contribution of inland fisheries was 185,000 tons. Of all the coastal fisheries the contribution from the Sindh coast and Indus delta is higher than Balochistan despite Sindh's coast line being smaller (only 350 km). During 1999, out of a total of 474,665 tons of marine fish catches in Pakistan, the Sindh coast contributed 333,047 tons; the exclusive economic zone (EEZ) under the control of the federal government produced an additional 184,545 tons. Badin, being part of the Sindh coastal area, contributes significantly to marine fish production, especially shrimp. It is estimated that out of the marine fish exports worth US $100 million, about 10 percent comes from the Badin coast.

In Badin taluka, there are 100 fish farms covering 1,619 hectares. In Tando Bago taluka, there are 150 fish farms encompassing 3,540 hectares. Fish farms are also found in Golarchi, Matli and Talhar.

The vast majority of these fish ponds have been established in former lakes and natural depressions. Only a dozen or so fish farms are reported to be managed on scientific lines and profitable in financial terms. Most of the farms are facing problems related to technology, maintenance of proper soil and water balance and feeding practices. There is a need for appropriate training as well as the establishment of hatcheries to supply fry from successful species.

Badin has many other fresh water fisheries including natural depressions and water bodies such as the Dhoro Puran, surface drains, inland lakes, tidal lakes and canals and distributaries. The development of fresh water fisheries at selected locations in these vast areas could yield significant gains in terms of fish production as well as income generation for the local communities.

2.12 Forestry

After agriculture, forestry is the second largest land use in Sindh. Forests are a natural endowment and valuable resource for the province with a distinctive feature of being renewable. Sindh is blessed with variety of forest types such as Riverine forests located along both sides of Indus, irrigated plantations located in the command area of irrigation systems of Sukkur, Guddu and Kotri barrages and Coastal forests located in deltaic region of Indus.

Forests have vital social, economic and environmental importance for the people of Sindh province. They provide productive and protective functions, diversified types of functions such as production of timber for constructions and raw material for industries, fuel wood for energy, non-wood products for domestic and industrial uses, protection and preservation of environment including erosion and water logging and salinity control and, employment generation for rural people. Role of forests and farmland trees in the maintenance of environment, absorption of solar energy and sequestration of Carbon dioxide, protection of river banks from erosion, conservation of biodiversity and wildlife and prevention of desertification is also equally important. Due to these functions, forestry is considered as an important resource for social and environmental development.

2.12.1 Forest Resource in Sindh

Out of Sindh's total land area of 14.091 million ha, an area of 1.126 million ha, is under the control of Sindh Forest Department (SFD) for different types of forests. Although total area controlled by SFD is 8% of the province, but only an area of 2.3% is covered by productive forests. Functionally, forests in Sindh are categorized as productive and protective forests. Table -8 provides the forest types and details of area under each category.

Table 2.15: Categories and types of Forests and area in Sindh

Category	Type	Area (M.ha)	% of total land area of Sindh	% of area under forests
Productive Forests	Riverine	0.241	1.72	21.5
	Irrigated Plantations	0.082	0.58	7.3
	Sub-Total	0.323	2.30	28.8
Protective Forests	Mangroves	0.344	2.45	30.6
	Rangelands	0.457	3.25	40.6
	Sub-Total	0.801	5.70	71.2
Total		**1.124**	**8.00**	**100**

Source: Sindh Forest Department's Records

2.12.2 Forest resource base in study area

There are three major types of forests in the study areas viz irrigated plantations in the command area of Sukkur, Guddu and Kotri barrages and coastal forests along the coast. Rangelands located in Kohistan and Registan areas are also declared as protected forests. All these forests are managed by the Forest Department Government of Sindh.

2.12.3 Irrigated Plantations

Irrigated plantations of Sindh, also known as inland forests, were once riverine forests but isolated from Indus waters by earthen embankments constructed in the 1930s. Presently, these plantations are irrigated from Sukkur, Kotri, and Guddu barrage irrigation systems. The concept of irrigated forestry was introduced by British with the objective to provide fuel wood to railways and cantonments in the country. Due to these reasons almost all the irrigated plantations are located along or close to railway line in Sindh and Punjab provinces. The principal species used to be *Dalbergia sisoo* (Shisham) in Upper Sindh plantations, while *Acacia nilotica* (Babul) in the lower Sindh. Due to the fact that *Shisham* is water demanding species it was replaced by Babul and *Eucalyptus camaldulensis. Eucalyptus* was increasingly planted in all the plantations as it was a fast growing tree used for industrial purposes.

2.12.4 Area located in left bank of Indus/study area

Of the total area of 82,000 ha under irrigated plantations in Sindh, an area of 65,175 ha is located left bank of Indus in Thatta and Badin districts. District-wise area of irrigated plantations is shown in Table 3.13.

Table 2.16: District-wise Area of Irrigated Plantations on Left Bank of Indus in Sindh

District	Area (Ha)
Ghotki	11,431
Khairpur	5,013

Naushahro Feroze	634
Shaheed Benazirabad2	1,933
Sanghar	9,121
Umerkot	500
Hyderabad	3,282
Tando Muhammad Khan	7,918
Thatta	15,833
Badin	9,510
Total	**65,175**

2.12.5 Management Objectives of forests

The following are the main management objectives of Forestry.

1. To increase vegetative cover over state forest lands in the province through conversation and improvement in the existing Riverine and irrigated for maximizing sustained production and preservation of ecosystem.
2. To meet the fuel wood and timber requirements of the province on sustained basis.
3. To promote environmental stability and preserve bio-diversity and natural heritage.
4. To intensify management and adopt post care and strict measures against deforestation as so to enhance productivity in line with potential of the site.

2.12.6 Sources of irrigation of Forests

The only source of irrigation to these plantation areas is through network of canal irrigation system of three barrages. Like agriculture, water has been allocated at the rate of 1.0 cusec for 40.0 ha plantation from different distributaries throughout the province. Internally, the Forest Department has constructed water courses for proper distribution to all irrigated plantations.

2.12.7 Coastal / Mangrove Forests

The area of the deltaic plain from the shoreline to the alluvial valley covers about 29,500 sq. km in the shape of fan. It represents a typical dry (arid) subtropical delta with high evaporation rate and negligible precipitation.

The Indus delta, built up by the discharge of large quantities of silt washes down in Indus River from Karakoram and Himalayan mountain ranges. The delta is spread over in about 600,000 hectares and is characterized by 17 major creeks, mud flats – satellite imagery in the year 1999 indicates about 260,000 hectares of delta are covered with mangroves.

The mangroves are biologically a highly productive environment, as today, the only species growing and forming forests is *Avicennia marina* locally known as *"Timer"*. The mangroves are very important ecosystem both economically and ecologically. Although the mangroves play productive roles but their protective role is more effective than productive.

Some of the roles/functions of mangroves are as under:

- As a pool of biodiversity they support diverse forms of plant and animal life.
- Provide food, shelter and breeding ground to prawns, several fin-fish, crabs and other marine life.

- Reduce wave action and help stabilize coastlines.
- Assimilate sewage water wastes and heavy metals from industrial plants.
- Protect seaports from siltation.
- Reduce the intensity of Cyclones
- Provide livelihood to a population of more than 100,000 people living along the coastline.
- Source of wood for heating and cooking and fodder for livestock.
- Provide shelter to migratory birds during winter.

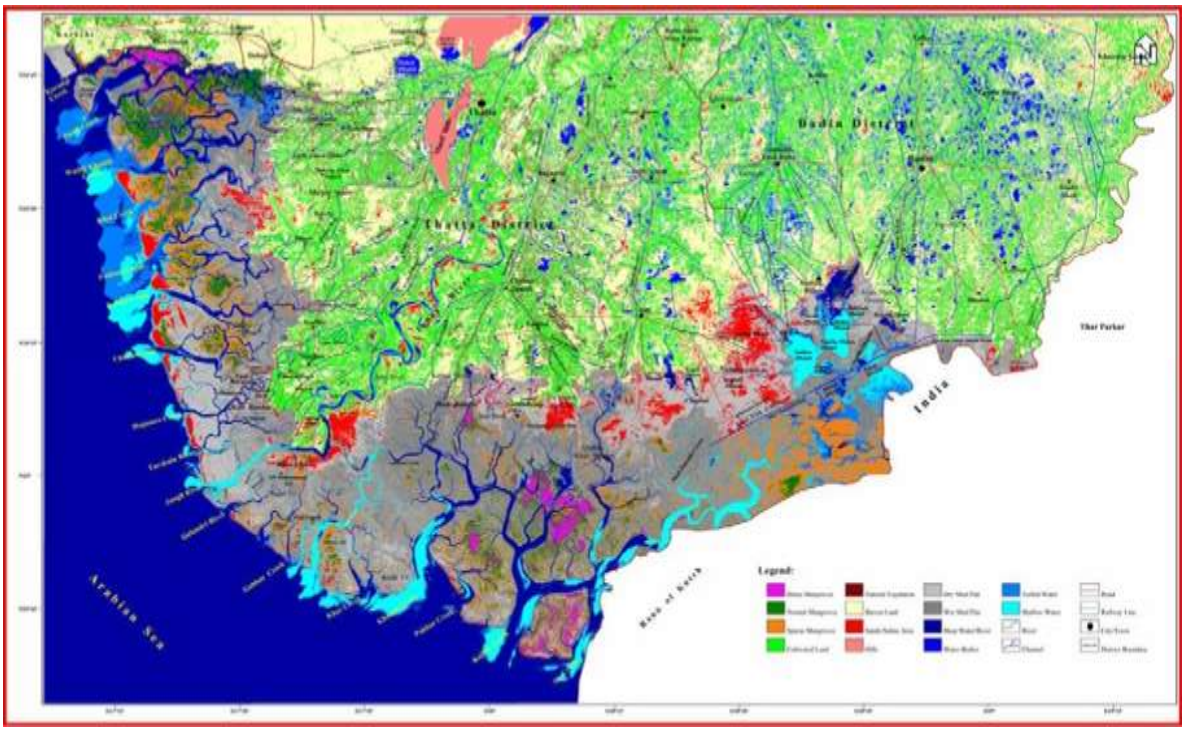


Figure 3.6: The Indus Delta

Nutrient flows: The major sources of nutrient supply to the Indus Delta are:

- Freshwater and the riverine sediments as suspended load through Indus River discharge.
- Regeneration of nutrients within the deltaic areas through microbial activities.
- Supply through the physic-chemical processes operative on the coast and in the offshore delta**.**

Mangroves are dependent upon fresh water discharges from River Indus. The mangroves are dominated by a single species, *Avicennia marina* which is over 95% of the trees, though a few stands of *Ceriopsis tagal*, *Brugiuiriera conjugate*, *Aegiceras corniculatum* and *Rhizophora mucronata* also occur.

Mangroves are uniquely adapted to water-logged and oxygen-deficient tidal mud flats, where no other plant survives. These forests, besides having environmental value, also protect the sea ports from siltation and erosion, act as perfect breeding ground for shrimps, besides providing low grade timber for house construction, poles for boats, fuel wood for curing shrimp, and fodder for livestock. Mangroves are used as firewood and fodder for domestic animals. *Avicennia* wood does not make good fuel wood as other mangrove species e.g. *Rhizophora*, it is still used extensively by local people for their own uses. On the other hand *Avicenia* are excellent fodder for domestic animals. It is

estimated that in past about 16,000 camels were fed upon mangroves. This practice has reduced the quality of growth and quantity of resource. Besides mangroves protect coast from wind and ocean currents

Commercial exploitation of mangrove forests for extraction of wood was not permissible except dead, dying and uprooted trees were allowed to be removed to meet the fuel wood requirements of local population and their removal was carried out legally under permits. Grazing, browsing and lopping however, is regular feature for livestock especially camel grazing and local use.

2.13

3 POLLUTION CAUSED BY EFFLUENT OF SUGAR MILLS

Out of 33 sugar mills in Sindh, 30 are located on left bank of Indus. Three out of 33 sugar mills use the molasses to produce industrial alcohol (ethyl alcohol) a significant quantity of which is exported. Mills in Sindh have crushing capacity ranging from 4,000 to 9,000 metric tons per day. It is estimated that these mills discharge untreated effluent of about 25 million cubic meters per year in the irrigation and drainage systems (SDPI 2006). This untreated effluent has high BOD, COD and TDS levels which pollute the water and are hazardous for humans and other biotic life. The sugar mills in Sindh mostly dispose off their untreated effluent into the LBOD drainage system that kills the fish and induces toxic chemicals in the drainage system. (Image-3.1)

Image-3.1: Polluted Water of Sugar Mills entering into Spinal Drain from MMD

The sample image taken from Google Earth clearly shows the polluted water entering the LBOD Spinal Drain from Mirpur Khas Main Drain. The difference in colour of polluted water before entering drainage system is prominent.

The consultants have analyzed water samples collected from the effluent of various sugar industries to estimate the physio-chemical parameters and to assess the quality of the effluent. (Table-4) Research has indicated that the parameters such as pH, EC, TDS, DO, BOD, COD significantly exceeded the permissible limits, indicating the need of proper treatment of waste water at source before discharge into water bodies.

The water quality test results indicate that all the parameters tested exceed the permissible limits and SIDA and EPA of Government of Sindh should not allow untreated effluent to any existing or future drainage network. The provincial Environmental Protection Agency (EPA) should implement the environment protection rules in letter and spirit.

It is mandatory upon every industry and city government to have a pre-treatment plant at their premises. There are well defined procedures and techniques being practiced all over the world for treating the industrial and municipal effluents before disposing off or using for agriculture/ lawn/ parks, irrigation etc. These include: i) physical treatment; ii) chemical treatment; and biological treatment.

Table-3.1: Water Quality of Sugar Mills Effluent during the Year 2011

Sr No.	Name of Sugar Mill	D.O mg/I	BOD mg/I	COD mg/I	TSS mg/I
1.	LAR Sugar Mills at Sujawal	2.1	980	1740	1250
2.	DEEWAN Sugar Mills at Badin	1.8	840	1690	1080
3.	Army Welfare SM#01 at	2.4	390	780	800
4.	Shah Murad Sugar Mill at	2.4	1100	1800	2600
5.	PANGRIO Sugar Mill at	2.2	740	1180	1800
6.	BAWANI at Talhar	2.7	180	260	340
7.	Tando Muhammad Khan Sugar Mill at	2.6	210	300	450
8.	SINDHABAD GAR Sugar Mill at	2.5	800	1200	2400
9.	SERI Sugar Mills at	1.9	920	1490	350
10.	KHOSKI Sugar Mill at	-	330	500	300
Permissible Limits		**>4**	**80 WHO**	**150 WHO**	**150 WHO**

Even the treated effluent should be allowed after recovering in advance 75% of the O&M cost of LBOD Drainage Network including operation cost of saline tube wells from the mill owners.

The effluent is destroying ecosystem of the area and spreading skin and digestive system diseases among local population. This needs to be checked with iron hand. Without proper cost recovery, no drainage project is going to be economically viable and timely successful.

As a precautionary measure it is proposed in this intervention that Mirpur Khas Main Drain carrying polluted effluent shall not be allowed to outfall into Dhoro Puran to spoil its water quality. It should be separated from Dhoro Puran to outfall directly into Spinal Drain.

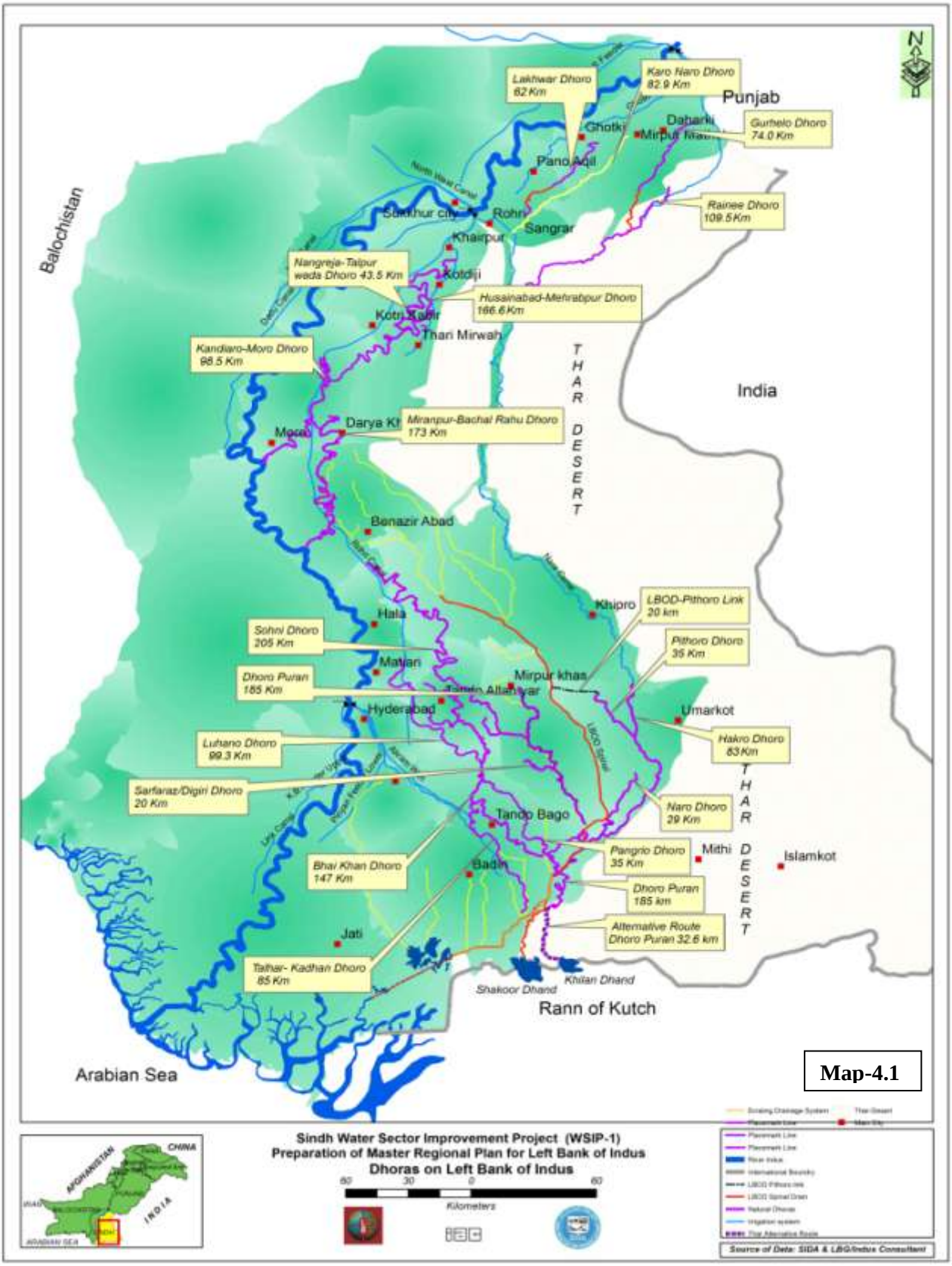
4 INVENTORY AND STATUS OF WATERWAYS

In Sindh there are many short and long reaches of the abandoned river courses on both sides of Indus. These abandoned river courses used to serve as natural waterways aka dhoras, for river and storm floods. Historically these dhoras braided with several small tributaries served as a network of natural drainage.

The most prominent and major dhoras identified in the study area on left bank of Indus river through satellite imagery and field visits are Karo Naro, Lakhwar, Gurhelo and Rainee dhoro in Ghotki area, Hussainabad-Mehrabpur (H.M)dhoro and Nangreja-Talpur Wada (N.T.W)dhoro in Khairpur area, Kandiaro- Moro (K.M) dhoro in Naushehro Feroze area, Miranpur-Bachal Rahu (M.B.R) dhoro in Shaheed Benazirabad / Matiari area, Luhano Dhoro in Hyderabad-Matiari area, Sohni dhoro in Tando Adam/ T.Allahyar area, Bhai Khan dhoro in T. M. Khan/ T. Ghulam Ali area, Puran dhoro in Mirpur Khas/ Badin area, Hakro dhoro in Umar Kot area, Sarfraz (Dighri) dhoro in Dighri area , Naro/ Fakir M. dhoro in Kunri/ Naukot area Talhar- Kadhan Dhoro in Badin area. Total length of these major dhoras is approximately 1733 kilometers. (Map-4.1)

In addition to the aforesaid major dhoras there are several small isolated reaches of dhoras on the left bank of Indus which do not have any drainage outlet. More than forty of them are found in Ghotki area and their combined length is 615 kms. It indicates that historically the Indus has extensively meandered in Ghotki area particularly in its north.

Flow of water in all the major and minor dhoras on left bank of Indus has been blocked by construction of infrastructure like roads, drains, settlements and irrigation channels. The crossing structures like culverts, pipes and bridges provided at few places on the dhoras are of inadequate size and are not capable to pass storm water. The major cause of obstruction in timely disposal of the storm water is these obstructions in the natural waterways aka dhoras. The dhoras particularly Puran Dhoro in southern part of Sindh on left bank of Indus used to be operational before the construction of the LBOD system. Later on, in four reaches of Puran Dhoro, LBOD Spinal Drain has been constructed exactly on the alignment of Puran Dhoro. Whereas few meandering reaches of Puran Dhoro have been cut off and isolated by construction of Mirpur Khas Main Drain (MMD) and Spinal drain on their left as well as right side. Storm water from adjoining high elevation lands accumulated in these isolated portions of Puran Dhoro having no drainage outlet, spills over and moves in the direction of ground slope in the shape of sheet flow. Consequently, it inundates settlements, crops, road infrastructure, factories and other types of private properties enroute. It is understood that 70% damages during 2011 storm water flooding were caused by these blocked sections of dhoras not LBOD. It warrants provision of adequate drainage outlets, culverts, bridges, Aqueducts and waterways to facilitate the prompt disposal of flood water.



The information about prominent dhoras (natural water ways) identified in the study area on left bank of Indus through satellite imagery and field visits is presented in Tablle-4.1 below.

Table-4.1: Detail of Major Dhoras (Waterways) on Left Bank Of Indus

S. No	Name of Dhoro	Originating Point		End Point		Length (KM)
		Easting	Northing	Easting	Northing	
1	Karo Naro	69°30'49.89"	28° 1'9.07"	69° 1'3.45"	27°35'5.00"	82.9
2	Gurhelo	69°48'20.46"	28° 5'15.66"	69°33'45.24"	27°46'44.94"	74.0
3	Lakhwar	69°23'14.70"	27°59'30.48"	69°11'34.20"	27°47'41.16"	62.0
4	Rainee	69°41'38.29"	27°47'24.51"	69° 0'21.84"	27°18'56.90"	109.5
5	H.M.	68°25'33.07"	27°03'39.19"	68°46'41.93"	27°27'40.50"	166.6
6	N.T.W	68°38'33.34"	27°17'49.63"	68°34'44.93"	27°09'00.25"	43.5
7	Kandiaro-Moro	68°11'40.68	27° 0'50.32"	67°56'51.58"	26°32'13.86"	98.5
8	Miranpur.B Rahu	68°13'53.37"	26°44'57.27"	68°11'42.46"	26°11'48.55"	173
9	Sohni	68°23'43.23"	26° 5'31.68"	69° 4'49.15"	25°17'28.93"	205
10	B.Khan	68°47'38.67"	25°26'49.52"	69° 9'4.41"	24°48'28.02"	147
11	Luhano	68°31'47.52"	25°38'50.87"	68°53'1.42"	25°10'36.79"	99.3
12	Dighri /Sarfraz	69° 4'13.70"	25°10'59.82"	69°11'41.23"	25° 8'53.60"	20
13	Puran	68°59'40.63"	25°35'56.99"	69° 9'20.21"	24°30'37.90"	185
14	Pangrio	69° 6'47.51"	24°50'9.43"	69°12'47.51"	24°40'48.53"	35
15	Hakro	69°32'42.40"	25°17'41.75"	69°19'50.20"	24°48'16.91"	83
16	Naro / Nabisar	69°27'29.54"	25°15'8.74"	69°24'17.44"	24°51'22.14"	29
17	Pithoro / Hiral	69°23'17.42"	25°29'44.48"	69°32'42.55"	25°17'41.77"	35
18	Talhar- Kadhan	68°50'42.92"	24°59'41.28"	69° 3'27.46"	24°30'5.72"	85
					TOTAL	**1733**

There are also several small tributaries of these dhoras which indicates that a network of natural drainage existed in past but has been obstructed by manmade infrastructure and encroachments which resulted in ponding of storm water and flooding of crops, orchards, poultry farms and settlements.

The isolated small pieces of dhoras particularly in Ghotki and other areas which have been cut off by canals require drainage outlet to avoid flooding in the form of sheet flow. Instead of providing costly cross drainage structures these isolated pieces of various lengths between canals have been provided drainage by connecting them through link channels and further to a proposed drain in the relevant area.

As stated earlier the revival of dhoras in lower Sindh shall be considered on priority. It is also technically desirable to activate any drainage network from the lower reach to give way to storm water coming from upstream.

5 LOWER SINDH DRAINAGE

The dhoras / natural waterways on left bank of Indus in lower Sindh are described as follows:

5.1 Old Dhoro Puran

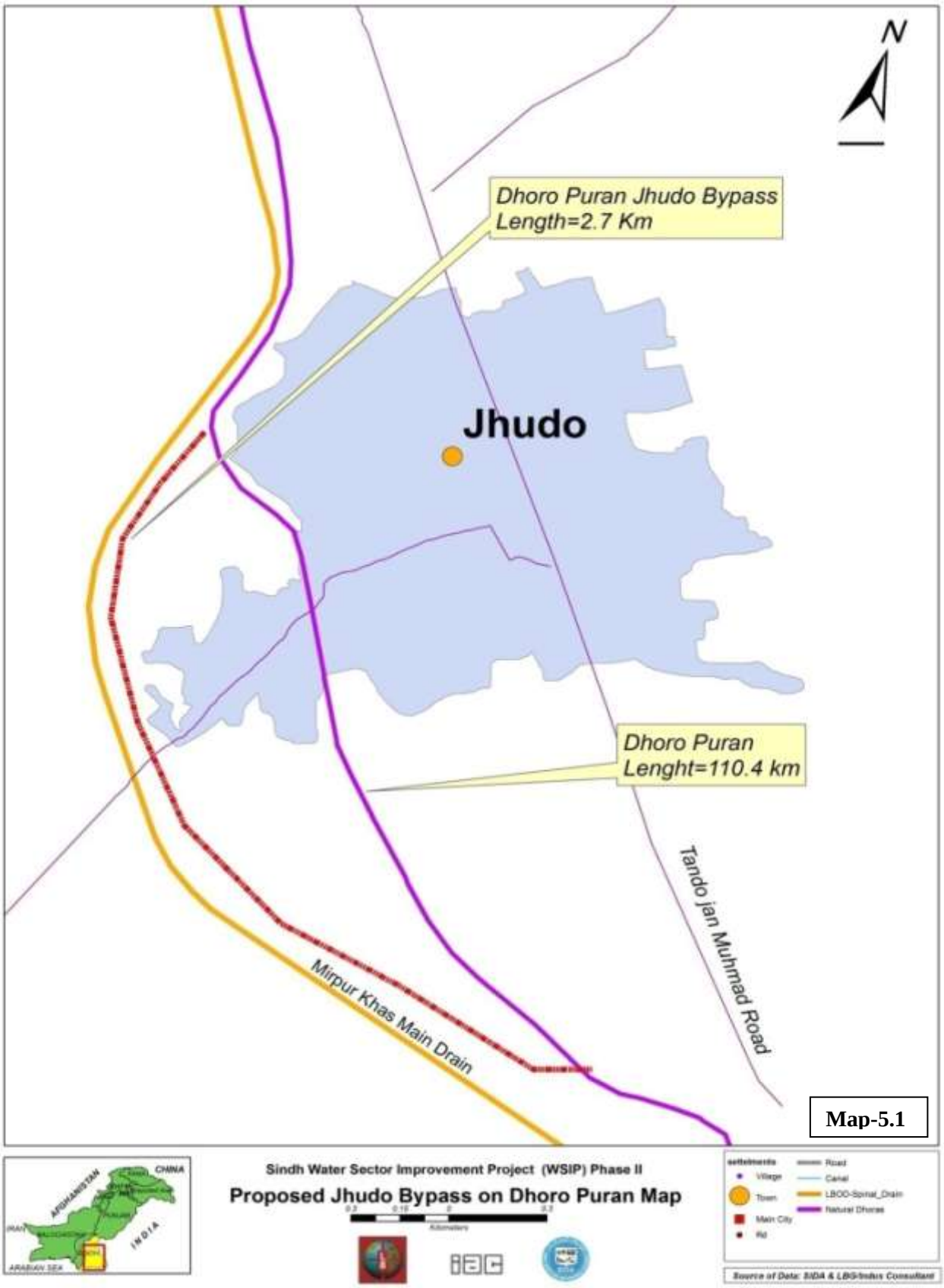
The major river course in this area next to Hakro Dhoro is Dhoro Puran, which is basically old bed of river Indus. This river course is intersected at number of places in its total length of 185 kms. Dhoro Puran originates in the North of Mirpurkhas city. After passing through Mirpurkhas it runs adjacent to left bank of Mirpurkhas Main Drain. (MMD) Thereafter it meanders in the East of Digri and Tando Jan Mohammad towns. Before passing through Jhudho town it turns west and crosses Mirpurkhas – Naukot railway line and road. Near Roshanabad village it turns south towards Shakoor Dhand via Kaloi. Shakoor Dhandh (lake) is 20% in Pakistan and 80% in Indian Territory. (Map-4.1)

With the passage of time Jhudo town has extended westwards encroaching natural course of Dhoro Puran. There are more than half dozen bottlenecks in Jhudo town and in its vicinity. At some places the width of Dhoro Puran has been reduced to only 20 to 30 feet against its average width of more than 250 feet and MMD appears to be wider than Dhoro Puran. Due to these bottlenecks flow of storm water is blocked and the accumulated water upstream of such blockages inundates Jhudo town in addition to other settlements and crops in the area. As such, revival of Dhoro Puran through Jhudo town or construction of its bypass parallel to MMD in the west of Jhudo town is imperative. The proposed bypass of Dhoro Puran for Jhudo is shown in Map-5.1.

Although the encroachments along Dhoro Puran in Jhudo town have been removed to some extent but it needs further widening or Bypass to safely pass storm water.

Mirpurkhas Main Drain merges into Dhoro Puran at its RD 29 and discharges polluted effluent of sugar mills / towns into Dhoro Puranwhich outfalls into the Spinal Drain at RD 297 instead of following its natural path.

It is proposed that MMD should be separated from Dhoro Puran to send its polluted effluent directly to LBOD Spinal Drain and Dhoro Puran should be connected to its original alignment, so that storm water in Dhoro Puran of comparatively better quality could be utilized for crops in its downstream reaches and Thar area where irrigation supplies are deficit.



Adjacent to Spinal Drain at RD 270, Hakro Dhoro combined with Naro Dhoro at Naokot joins Dhoro Puran. Between RD 297 and RD 159 the LBOD Spinal Drain has been constructed on the alignment of Dhoro Puran cutting off the curved portions of Dhoro Puran. These isolated curved sections of

Dhoro Puran varying in length from two to seven kilometers each, have no drainage outlet. As such, in the event of heavy rainfall, being in depression the water from higher lands accumulates in these cutoff portions and causes flooding in the adjoining crops and settlements on both sides. Similarly the storm water coming through Hakro Dhoro and its tributaries into Dhoro Puran is also blocked and moves towards its natural course in the shape of sheet flow damaging crops & settlements enroute.

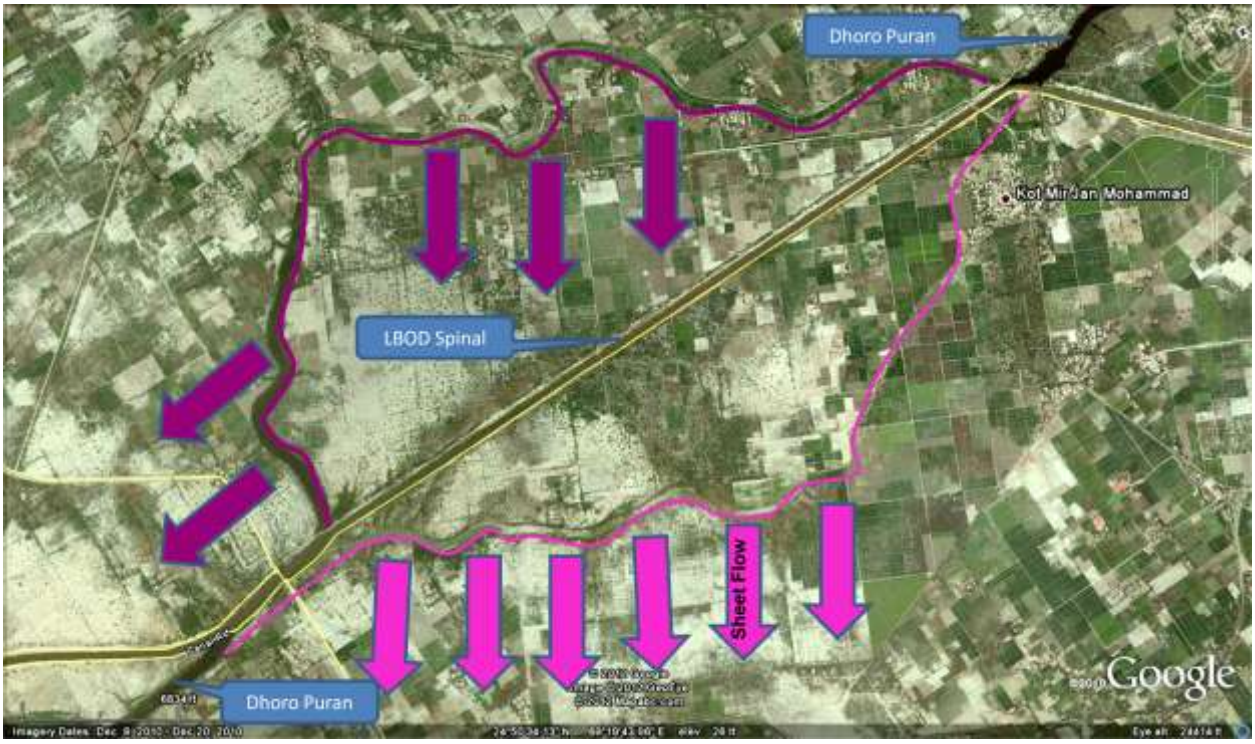


Image-5.1: Cutoff Sections of Dhoro Puran causing Sheet Flow

These isolated / undrained sections of Puran Dhoro together with Hakro Dhoro, Pangrio Dhoro and Naro Dhoro have created a cluster of Dhoras in this area. Consequently the area around Jhudo, Naukot, Roshanabad, Pangrio and Kaloi including all these towns has become the most vulnerable area during monsoon rains. As such activation of dhoras on left side of LBOD Spinal Drain and restoration of Dhoro Puran on its original natural route under passing the LBOD Spinal Drain is essential to avert devastation in this area in future. Four sections of Dhoro Puran brought under the alignment of LBOD Spinal Drain are to be reconstructed on left side of Spinal Drain to provide clear and controlled passage to storm water.

Similarly curved cutoff pieces of Dhoro Puran on right side of Spinal Drain and on right side of MMD including Pangrio Dhoro, Digri dhoro and Sohni dhoro should be provided outlet by constructing cross drainage structures / siphons to join with their mother channel i.e. Dhoro Puran on the left side. This arrangement will avert flooding of Digri, Tando Jan Mohammad, Pangrio, Khairpur Gambo, Roshanabad, Shadi Large and Khoski towns and surrounding areas. Eight siphons / cross drainage structures of varying sizes (four each across MMD and Spinal Drain) and ninth siphon of comparatively larger size for separating Dhoro Puran from MMD and crossing it under Spinal Drain have been proposed . Out of these nine siphons, construction of Siphon-4 can be avoided on economical grounds due its smaller capacity but excessive cost.

Considering recent intensity of rainfall / runoff generated and consequent losses / damages, full activation of Dhoro Puran from RD 297 of LBOD Spinal Drain (near Roshanabad Town) till Shakoor Dhand is essentially required.

Conceptual cost of activation of Dhoro Puran to its full length including bypasses for Mirpurkhas and Jhudo towns, Earth works, land and structures is estimated to 4,410 M.Rs. The Cost Summary for activation of all dhoras, Proposed Surface Drainage of left over areas and LBOD escapes is presented in Table- 1. Similarly the design criteria adopted for drains, design of drains in leftover areas, cut and

fill quantities of drains and dhoras including land to be acquired and cost summaries of each component are presented in Table-1to 74 at the end of this chapter.

Cost calculation of Dhoro Puran has been based on the remodeling of DPOD from RD 0 to 110 for a discharge of about 14,000 cusecs. It can be seen from the flow diagram of Dhoro Puran that it is the mother channel of all the dhoras in lower Sindh. The question arises that what will be the behavior of Shakoor Lake to receive such a huge discharge. After the extreme rainfall event of 2011the consultants constantly monitored the Shakoor Lake through Satellite imagery every month. It was noticed that after filling the Shakoor Lake the storm water spills over to other lakes in its east and west and to Kori creek. (Map-5.1A). After filling the adjoining lakes the storm water further moves to east into a big reservoir in the Indian territory, which is about ten times the size of Shakoor Lake. As such, it appears that there is sufficient potential for storm water disposal in Rann of Kutch.

Two sample satellite imags taken in September 2011 just after the extreme rainfall of 2011 and in February 2012 are presented in Image-5.1B and 5.1C which reflect the filling of coastal lakes and their normal condition. The size of these lakes further reduces in dry years as evident from Image-5.1A.

Image-5.1A: Indo-Pak Coastal Area and lakes

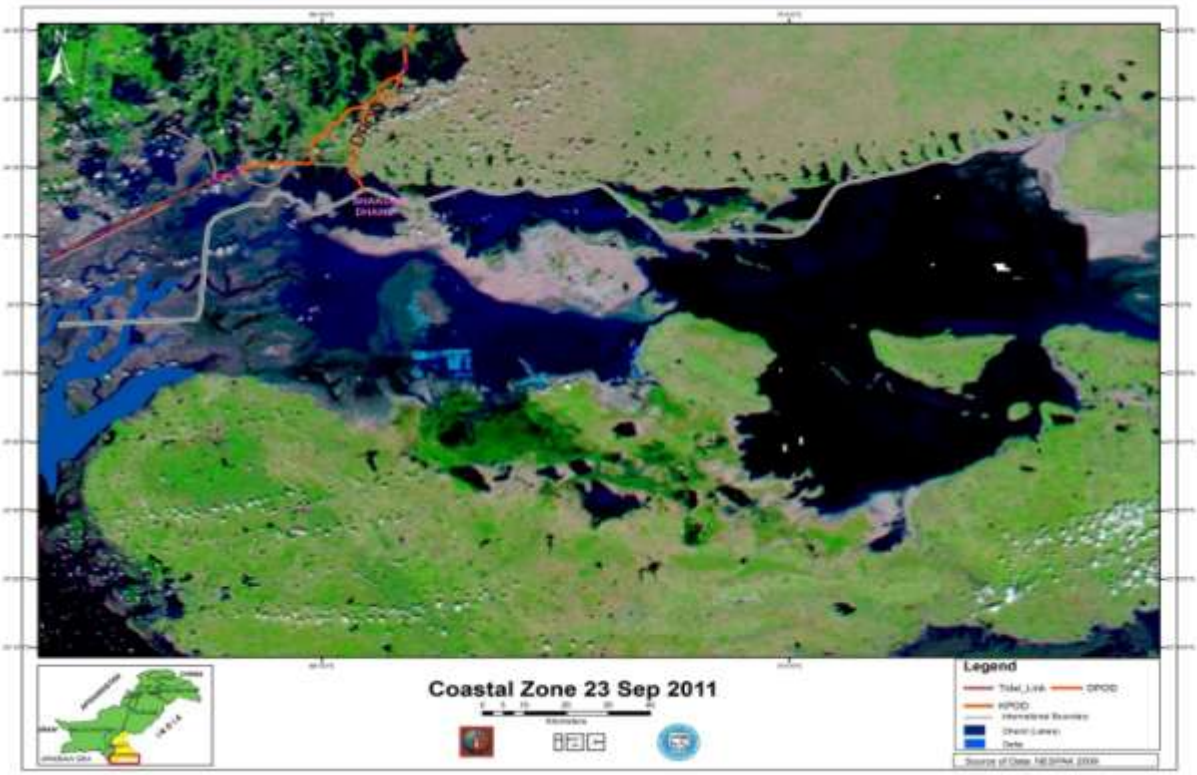


Image-5.1B: Indo-Pak Coastal Area and lakes September 23, 2011.

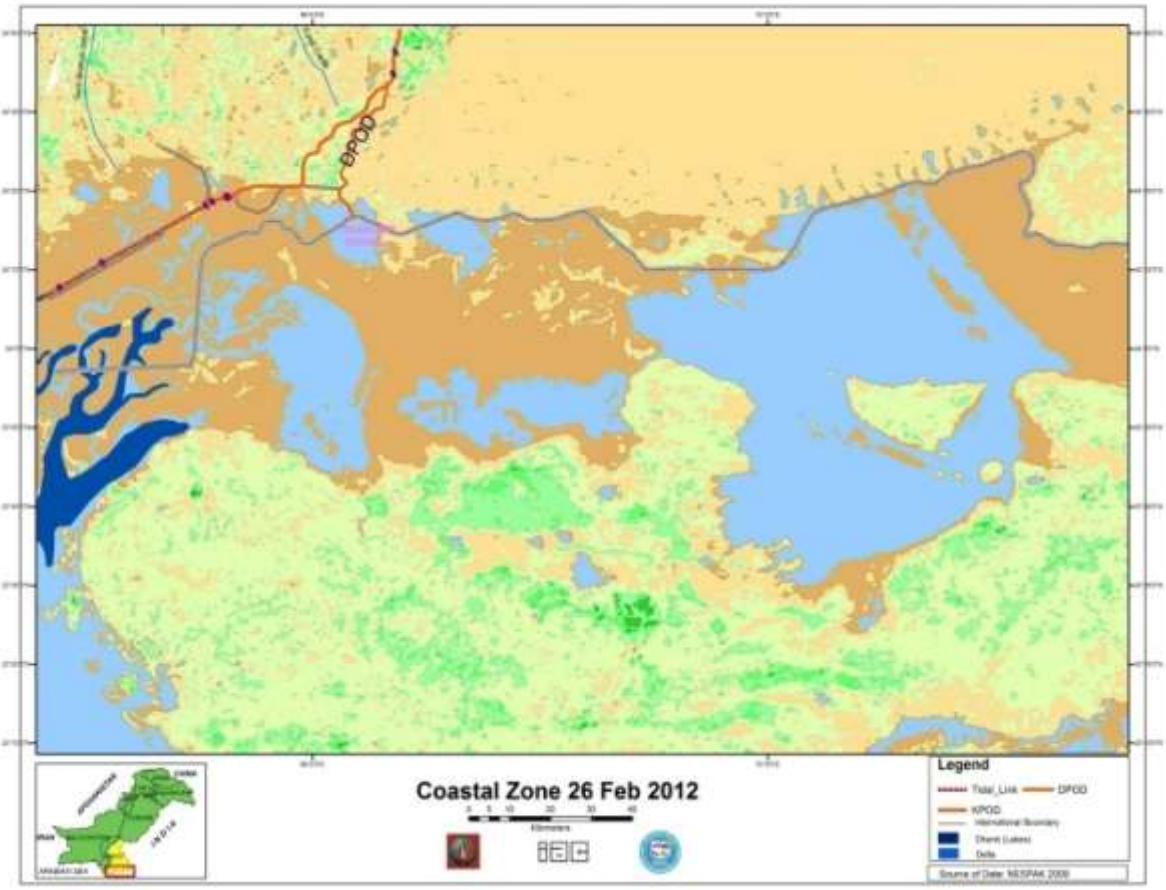


Image-5.1C: Indo-Pak Coastal Area and lakes February26, 2011.

Other options at the time of construction shall be considered to construct a parallel channel using left bank of DPOD as common bank like Twin Jamrao Canal. It will eliminate the remodeling of DPOD.

Another option to be considered is the alternate route for Phoro Puran following an old river course through Thar Desert. This 32.6 kms long route originates from Bahwar Lake between RD 130 and 134 of Dhoro Puran and passing in the west of Rahim Ki Bazar outfalls into Khilan Lake. Map-4.1. Survey of this route has been conducted and survey maps have been provided in the Atlus of this report. The survey indicates that except a few sand dunes of 30 to 40 ft height mostly the alignment is along the lower level. Moreover there are two lakes named Chimbni Sun Dhand and Looh Dhand on its alignment in Thar area where storm water can be stored for reuse by local population. It will eventually outfall into Khilan Lake which is about 50% in Pakistan territory. As such storm water in Khilan Lake can also be utilized by local community of Thar Desert. Distribution of storm water in two channels and disposal into two different lakes will facilitate its flow and early evacuation.

It is proposed that instead of constructing the bypass of Dhoro Puran on the eastern side of Mirpur Khas city the capacity of MMD flowing in west of Mirpur Khas city shall be increased to carry the storm water coming from north in addition to the sub drains of MMD. Moreover, it is further proposed that the sub drains on the left side of MMD which outfall into it after crossing over the Dhoro Puran shall be discharged into Dhoro Puran. It will not only eliminate the construction of cross drainage structures across Dhoro Puran but will also create provision for the storm water coming from north into MMD after increasing its capacity.

5.2 Hakro Dhoro System

Hakro Dhoro, Naro Dhoro along with Pithoro Dhoro / Hiral Escape on left side of Spinal Drain are old river courses, upstream of the Naukot town, Hakro Dhoro being the main dhoro. As like other dhoras all the three are abandoned, encroached and blocked by infrastructure at several places. Practically there is no flow in Hakro Dhoro and Naro Dhoro due to blockages.

5.2.1 Hakro Dhoro

About 109.7 kms in length with maximum width of 900 ft runs from north to south with an average width of about 250 ft. It originates at Farash regulator of Lower Nara Canal and Joins Dhoro Puran in the South of Naukot near RD 270 of LBOD. It is actually the abandoned course of Hakro River downstream the Farash Regulator.

Historicaly, it can be seen in map Map- 5.2 of 1333A.D that Hakro River used to flow in the east of Bahawalpur, Rahimyar Khan, Ubauro, Rohri and after passing in the west of Umarkot and Rahimki Bazar discharged into Arabian Sea via Rann of Kutch. As such it can be said that Dhoro Puran Joins Hakro Dhoro near RD 270 of LBOD. However, nowadays the portion of Hakro Dhoro downstream RD 270 of LBOD Spinal Drain is called Dhoro Puran as evident from the name of DPOD i.e. Dhoro Puran Outfall Drain.

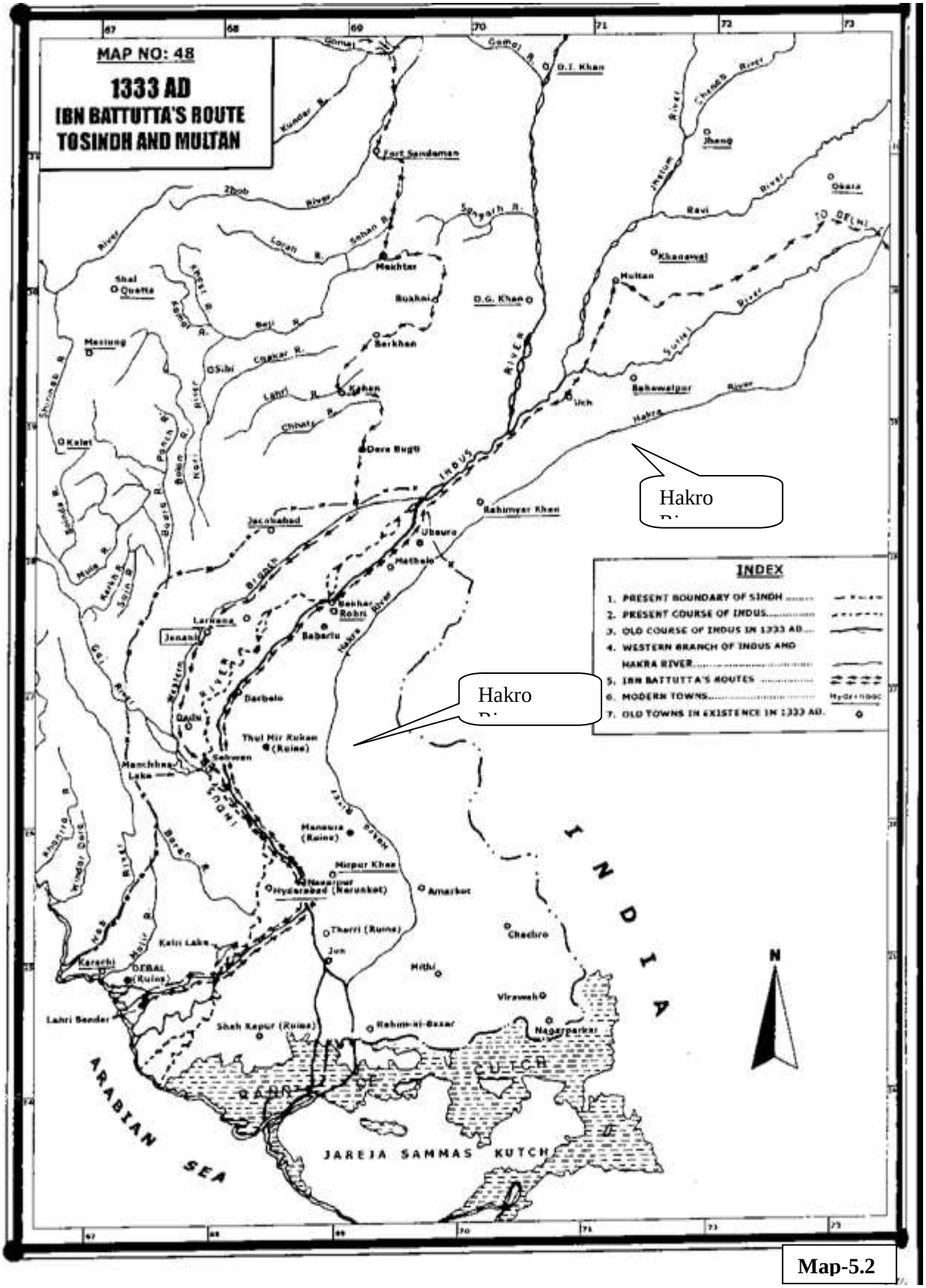
Hakro Dhoro has been sub divided into two parts. From Farash Regulator to Bodar it is called Dhoro Escape of Nara canal having designed capacity of 1,000 cusecs and downstream Bodar Farm to its junction with Dhoro Puran is called Hakro Dhoro.

At Bodar farm just downstream Samaro- Umerkot road Hiral Escape joins Hakro Dhoro. After passing in the east of Kunri and Samaro towns, it turns South west near Cheelh town and traverses along the edge of Thar Desert in the west of Nabisar and Hedo towns.

In the center of Naukot town, Dhoro Naro joins Hakro Dhoro. Further down, it merges into Dhoro Puran near RD 270 of LBOD Spinal Drain.

Flooding in Naukot and its surroundings mainly occurs because of Hakro Dhoro and Naro Dhoro due to encroachments and narrowing of sections of both from 500ft to 50 ft creating a bottle neck. As such, a bypass to both Hakro and Naro dhoro around Naukot town is required to provide safe and clear passage to storm water. Moreover, Naukot town must not be allowed to extend southward any more. The proposed bypasses of Hakro and Naro Dhoro are shown in Map-5.3.

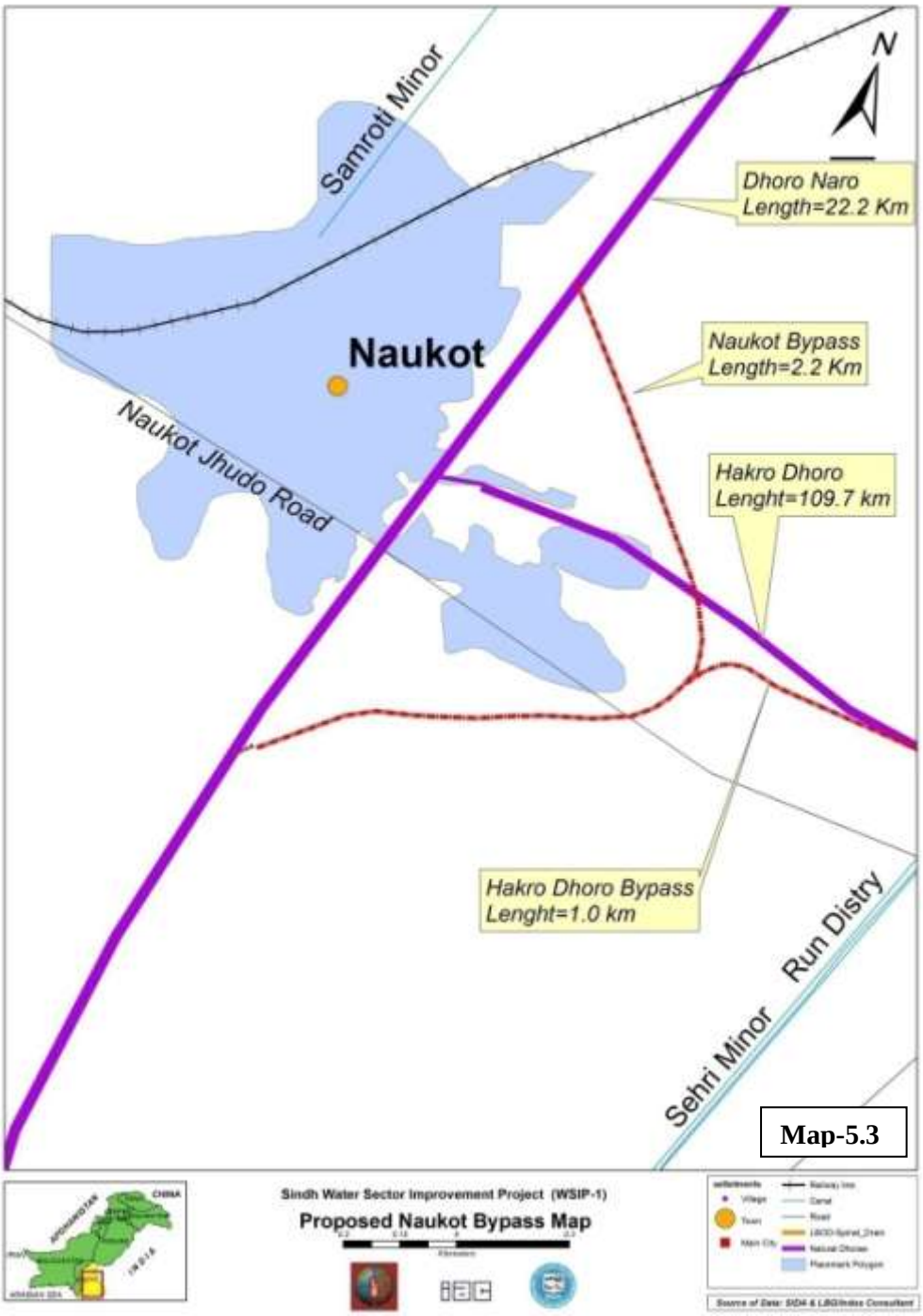
Estimated cost of activation of Hakro Dhoro to its full length including bypass for Naukot town, land acquisition and structures is approximately 2,867 M.Rs.



Map-5.2

5.2.2 Naro Dhoro (Nabisar Dhoro)

It originates from 10 Kms south west of Kunri town at the tail of Kunri Distributry, crosses Jhudo - Nabisar Road, Sher Distributry and Naukot Branch. At this point it runs parallel to Spinal Drain for about 1.5 Km at a distance of about 900 ft; traverses southward in zig zag style on western side of village Fazal Bhambhro, crosses again Naukot Branch and joins Hakro Dhoro on the eastern side of Naukot town.



Many dry reaches of Naro Dhoro have been converted into agricultural lands and crops are being grown over there. Naro Dhoro crosses Naukot Branch of Mithrao Canal at three locations and no cross drainage structure has been provided at these points. It is blocked at number of places by roads and railway line. As such, it is a major cause of flooding in Fazal Bambhro town, Naukot town and

adjoining areas. An escape of LBOD Spinal Drain is proposed at RD 336 to off load excess storm water to the extent of 1000 cusecs into Naro Dhoro. (Image 1)

Image 2: LBOD Escape-2 RD 336

At this point Naro Dhoro is closest to LBOD Spinal Drain and Land Acquisition problem will be negligible. The capacity of Naro Dhoro requires to be enhanced to 1400 cusecs to provide drainage to the adjoining areas and take excess storm water of LBOD Spinal Drain.

In addition to above, the cross drainage structures will be required for roads, canals and railway line to activate this dhoro effectively.

Estimated cost for activation of this Dhoro to its full length including bypass for Naukot town, land acquisition and structures is approximately 327 M.Rs.

5.2.3 Pithoro Dhoro (Hiral Escape)

From its straight alignment without meandering this waterway way appears to be manmade. It originates from Pithoro town and runs in the north western direction. (Map-4.1) The remodeled top width of the dhoro is only 50 feet and its length is about 35 Km, which is inadequate to carry the storm water from its own catchment area. It merges with Hakro Dhoro in the west of Umerkot near Bodar farm. This dhoro can be utilized as an escape to offload 1000 cusecs of storm water coming from Benazirabad and Sanghar areas into LBOD Spinal Drain at RD 578 to reduce pressure on Badin area and to drain out storm water from Umarkot –Farash left over area.

For this purpose the capacity of Hiral escape shall be enhanced to 1675 cusecs to carry 1000 cusecs offloaded from LBOD System and 675 cusecs from its own catchment area through proposed drainage network of Khipro, Farash and Umarkot left over area.

A link channel 20 kms long and 1000 cusecs capacity will be required to connect LBOD Spinal Drain with Pithoro Dhoro / Hiral escape near Pithoro town. (Map- 4.1) A weir at RD 578, a cross drainage structure at Mithrao Canal, a few water course crossings and Village Road bridges will be required to be constructed across this channel. The approximate number of major and minor structures required on dhoras is provided in Table- 73. It indicates that about 1325 major and 3989 minor structures will be required to be constructed to activate all the dhoras.

Estimated *cost for* activation of this Dhoro to its full length including earth works, land acquisition and structures will be approximately 635 M.Rs.

5.3 Sohni Dhoro

It is old river bed of Indus without specific width and overall length of about 205.7 Kms with numerous obstructions caused by private lands, irrigation network and even built up areas like Tando Adam and Sanjar Chang. Sohni Dhoro is naturally a low lying area. (Map-4.1)

The Dhoro travels from North West of Shahdadpur towards Tando Adam between Rohri main Canal in its West and Jamrao canal in East. It then passes East of Tando Adam town and meanders south east to Mirpur Khas- Tando Allahyar road, crossing the road between Kamaro Shareef and Sultanabad.

The Dhoro can be subdivided into following segments:-

- Sarhari - Shadadpur
- Shadadpur - Tando Adam
- Tando Adam – Tando Allahyar
- Tando Allahyar – Old Puran Dhoro

Sarhari - Shadadpur segment: Sohni Dhoro originates from left side of Rohri Canal 12 kms south of Sarhari town and moves in a zigzag way towards Shahdadpur town. After passing through Shahdadpur it meanders towards Tando Adam. To activate this segment it is proposed that instead of bringing the storm water to Shahdadpur town it should be connected directly from Maldasi village to a lake in the west of Shahdadpur and then continued on its natural path towards Tando Adam. (Image-5.3)This will eliminate the potential risk of flooding in Shahdadpur town.

Image 5.3: Sohni Dhoro – Maldasi Link

Shadadpur - Tando Adam Segment: Sohni Dhoro after crossing Hala-Shahdadpur road moves southwards to Tando Adam in a curved shape. It crosses T Adam-Shahdadpur road, T Adam- Sanghar road near village Shahbeg Marri and T Adam-Nauabad road near Berani town before reaching T Adam. Lot of encroachments / obstructions are present in the form of private lands, irrigation channels like Sui Kandar Branch, Jam Branch, Berani Distributary and Noori Distributory etc.

Tando Adam – Tando Allahyar Segment: In this segment Sohni Dhoro is mostly dry and cultivated / encroached except few reaches which are prominent. However, its alignment is traceable between T

Adam-T Allahyar road and T Adam-Mirpurkhas road. It then crosses T.Allahyar-Mirpur Khas road between Kamaro Shareef and Sultanabad towns.

Tando Allahyar –Dhoro Puran Segment: This is the last segment of Sohni Dhoro where it follows its natural route and merges into Dhoro Puran in the East of Mirwah Gorchani. However, M-1L sub drain of MMD has been constructed along its alignment from right side of Jamrao West Canal up to its outfall into MMD. The width of M-1L sub drain is negligible as compared to the width of Dhoro. As such, Sohni Dhoro can be activated in its left over width on left side of M-1L drain. Another option is to enhance the size of sub drain M-1L to carry the effluent of Sohni Dhoro to Dhoro Puran. In the event the M-1L route is not acceptable to the local community then Sohni Dhoro can be joined with Dhoro Puran through M-2L sub drain by enhancing the capacity of later. The third possible option is to join it to Bhai Khan Dhoro after under passing Nasir branch. This option is however not desirable because it will increase the storm water pressure on Badin area. All three options have been shown in (Image-5.4).

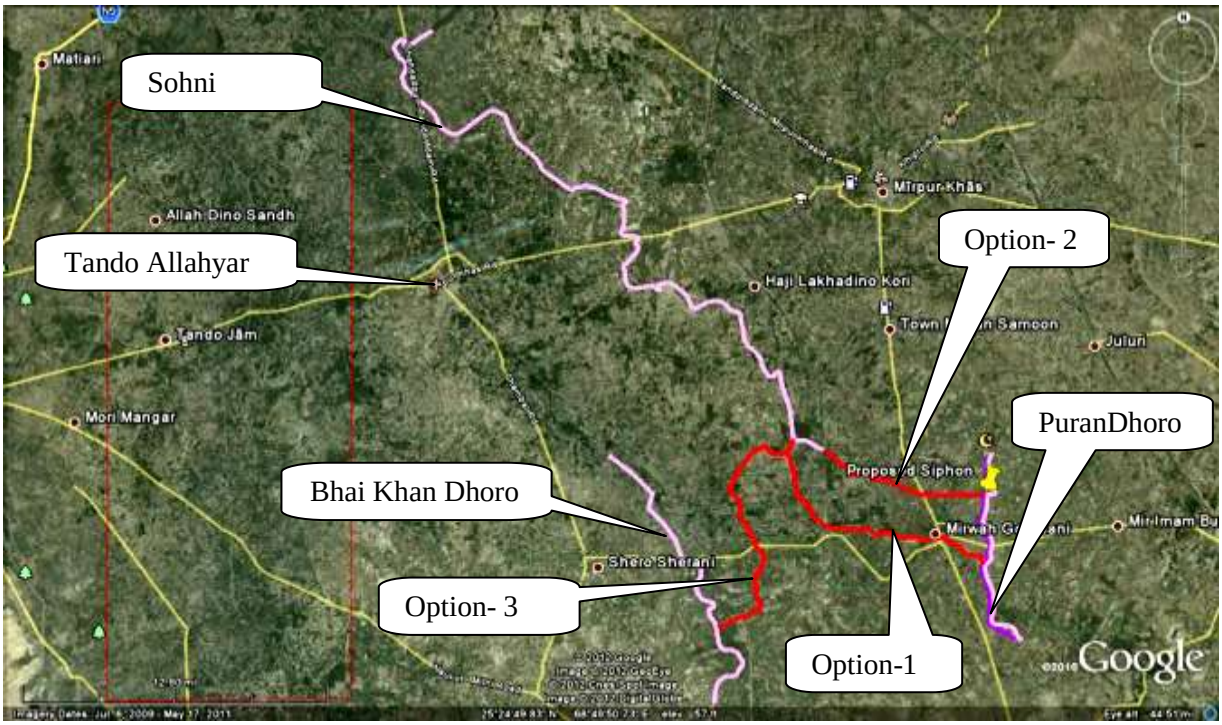
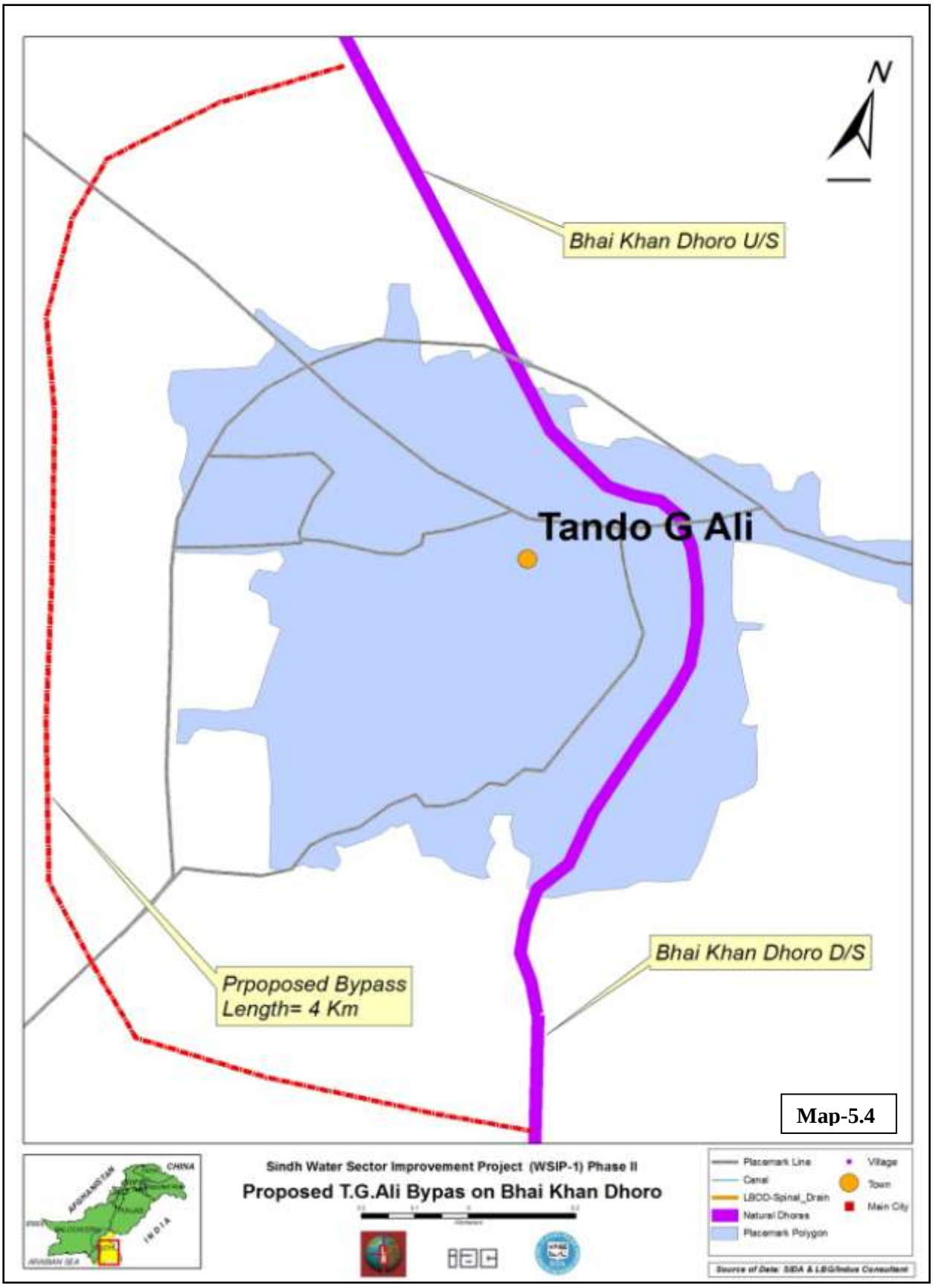


Image 3: Sohni Dhoro proposed Outfal options

Estimated cost of activation of Sohni Dhoro to its full length including land acquisition and structures is approximately 2624 M.Rs.

5.4 Bhai Khan Dhoro

It originates between Nasarpur and Tando Soomro towns on the right side of Nasir Branch. After crossing Nasir Branch in the north of Tando Allahyar town it turns south east and crosses Bulghi Distry, Nangna Distry and again Nasir Branch in the south of Tando Allahyar town. It then turns south and meaders parallel to Nasir Branch and Tando Ghulam Ali Distry on their right side up to Tando Ghulam Ali town. Near Rajo Khanani it splits into two channels leading to Pangrio and Kadhan towns respectively. The Pangrio route although encroached at several places is technically more feasible as it will join Pangrio Dhoro in the west of Pangrio town and ultimately will outfall into Puran Dhoro under passing the Spinal Drain at RD 211. Some reaches of Bhai Khan Dhoro are not prominent due to encroachments /crops and require to be reconstructed.



Whereas, the Kadhan route is comparatively less prominent and has no natural outlet after reaching the Akram Wah escape. It can be considered as alternate route by joining it with Akram Wah escape

and increasing the capacity of the later which has its outfall into DPOD. In this case a crossing structure of larger capacity will be required over or under KPOD.

As a third option both the routes could be utilized to distribute the storm water and reduce pressure on a single area.

The overall length of Bhai Khan Dhoro is 147.6 km. It is obstructed at Tando Ghulam Ali town by buildings and other structures and a bypass will be required to clear its route. Proposed bypass has been shown in (Map-5.4).Activation of Bhai Khan Dhoro can be utilized for storm water drainage of Tando Allahyar, Tando Ghulam Ali and Tando Bago left over areas outside the catchment of LBOD system.

Estimated cost of activation of Bhai Khan Dhoro to its full length including bypass for Tando Ghulam Ali town, land acquisition and structures is approximately 2,948 M.Rs.

5.5 Digri Dhoro (Sarfraz Dhoro)

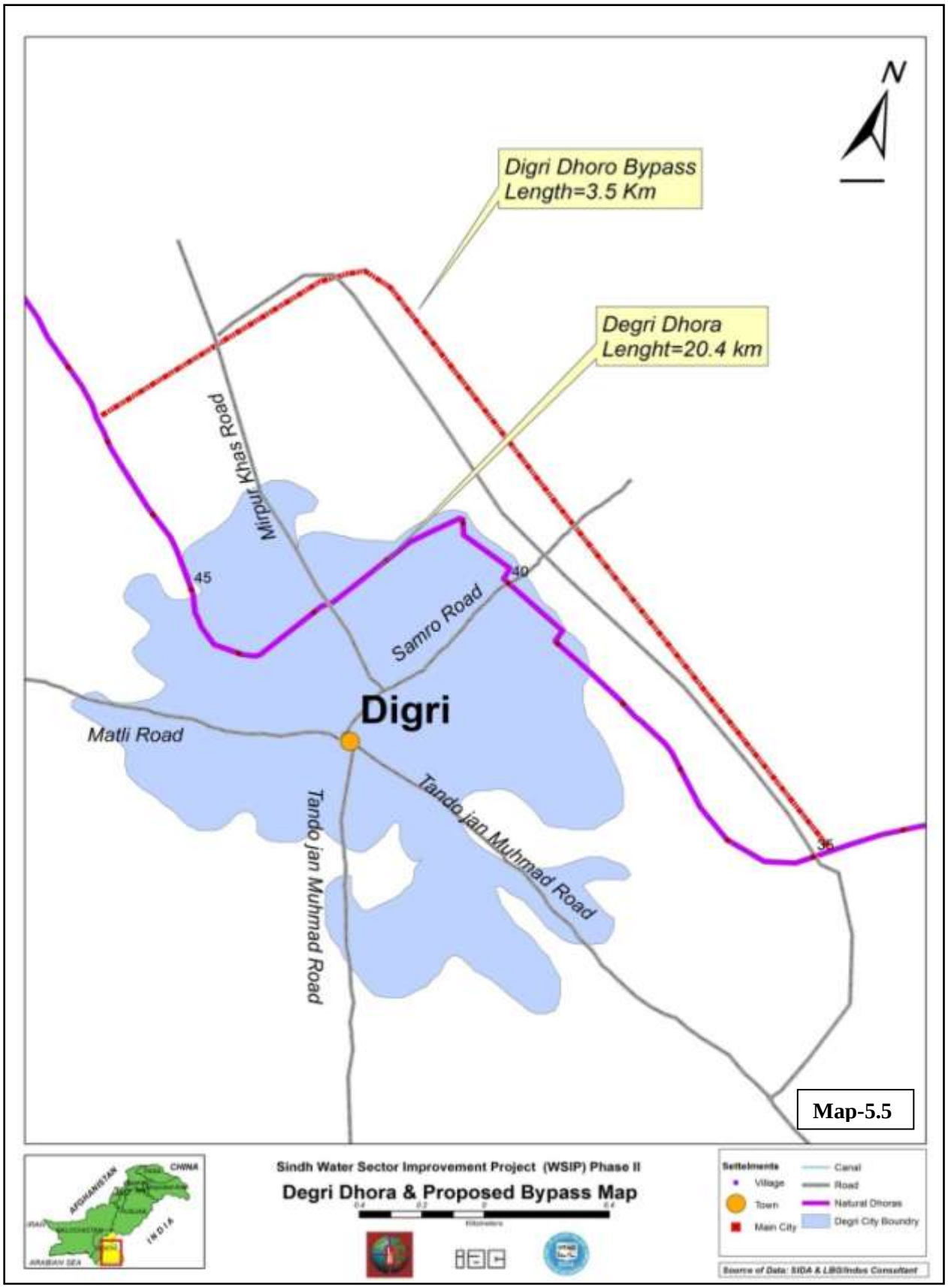
Digri Dhoro aka Sarfraz Dhoro originates in the west of Digri town. It appears to be a tributary of Dhoro Puran. (Map-4.1) At its starting point it moves east and then turns south and runs parallel to Digri-Mirpur Khas road. After crossing through Digri town it traverses south east and joins Dhoro Puran near RD 127 of Mirpur Khas Main Drain (MMD).

Its length is about 20.4 kms which is mostly encroached by local community inside Digri town and surrounding areas where its width has been reduced to 15-30 feet. Consequently, in the event of heavy rainfall it causes flooding in Digri town and adjoining areas. To avoid flooding of Digri town, settlements and crops it is proposed to activate this dhoro and construct a bypass of Digri Dhoro around Digri. Proposed bypass is shown in (Map-5.5).

A cross drainage structure is required under Mirpur Khas Main Drain at RD 127 to connect Digri Dhoro with Dhoro Puran.

Estimated cost for activation of Digri Dhoro to its full length including bypass for Digri town, land acquisition and structures is approximately 224 M.Rs.

Although the encroachments along Dighri Dhoro in Dighri town have been removed to some extent but it needs further widening or Bypass to safely pass storm water without damaging the properties and crops.



5.6 Left over Areas of Lower Sindh

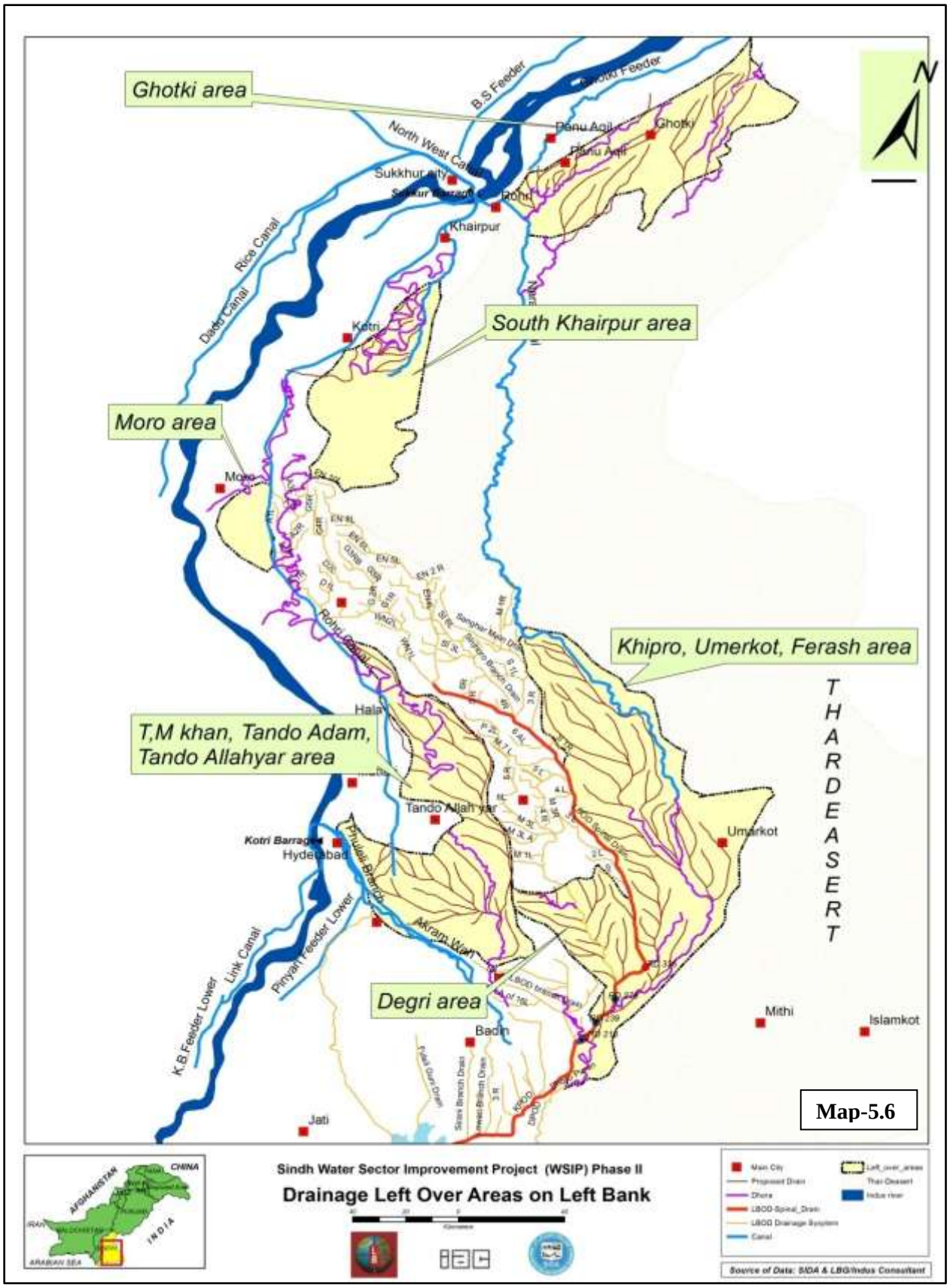
The areas on left bank of Indus which are outside the LBOD catchment and have not been provided any type of drainage like tube wells, tile drainage or surface drainage are known as Left over areas.

These are identified as Ghotki SDW area, Khairpur South area, Tando Adam- Tando Allahyar area, Tando M. Khan- Tando Ghulam Ali area, Digri area and Khipro- Farash- Umarkot area. (Map-5.6) These areas were to be included in LBOD Stage-II project which could not be implemented until now after the completion of Stage-1.

Surface drainage system of LBOD Stage-1 covers the areas of S. Benazirabad, Sanghar, Mirpur Khas and Badin districts in the southern Sindh. During the unprecedented heavy rainfall of 2011 the following three left over areas were the worst affected areas of lower Sindh. Due to lack of any drainage outlet, evacuation of storm water took more than six months as compared to LBOD catchment areas where it was drained out within three and half months. Moreover, millions of rupees were spent to pump out storm water of these areas through irrigation channels. As such, the left over areas particularly in southern Sindh urgently need efficient and effective surface drainage system to evacuate the storm water in future. These priority areas are;

- Tando Adam Left Over Area
- Tando M Khan Left Over Area
- Digri Left Over Area,
- Khipro- Farash- Umarkot Left Over Area

These areas had been heavily inundated during 2011 monsoon rains because the storm water coming into low lying natural Dhoras was trapped at a number of places due to obstructions by manmade infrastructure like roads, drains and canal systems. Large pockets of trapped water were created which took greater efforts and finances to evacuate. In order to alleviate this situation a surface drainage network for storm water has been proposed for each of these areas which comprises of the sub drains, branch drains and main drains. The drains have been designed for rainfall of 20 years return period and 10 days evacuation period based on Metrological data for respective areas, as decided by the technical experts in a meeting held in the office of provincial Secretary Irrigation Department at Karachi. (Table-71).These drains will outfall into the natural Dhoras. The discharge / section of all the water ways (dhoras) passing through these areas has been determined on the basis of the effluent coming from the drainage network plus direct outlets on dhoras wherever possible.



The route of each individual drain has been marked between the command areas of the two adjoining irrigation channels. It is proposed that the alignment of drains shall be fixed at the command boundary of the adjoining irrigation channels being the lowest point, to facilitate proper drainage of storm water and the unutilized irrigation water coming at the tails of water courses due to no demand by farmers in

the event of heavy rainfall. It will also minimize the number of Water Course aqueducts across the drains. As the alignment of drains could not exactly follow the command boundary of two irrigation channels due to too many curves, some aqueducts will be required where large area of a water course command is cutoff by a drain. For small areas it will not be economical to construct an aqueduct, such area shall be transferred by Irrigation Department to the command of water course feeding the other side of drain.

The design criteria adopted for proposed drains is presented in (Table-72) . To observe economy and to avoid deep excavation under water the dhora sections with greater design depth have been designed as compound sections with maximum water level above the berms, whereas the sections of dhoras with smaller depth and less discharge have been designed with conventional sections. Typical cross sections for dhoras and drains are placed at Figure-6.1, 6.2 & 6.3.

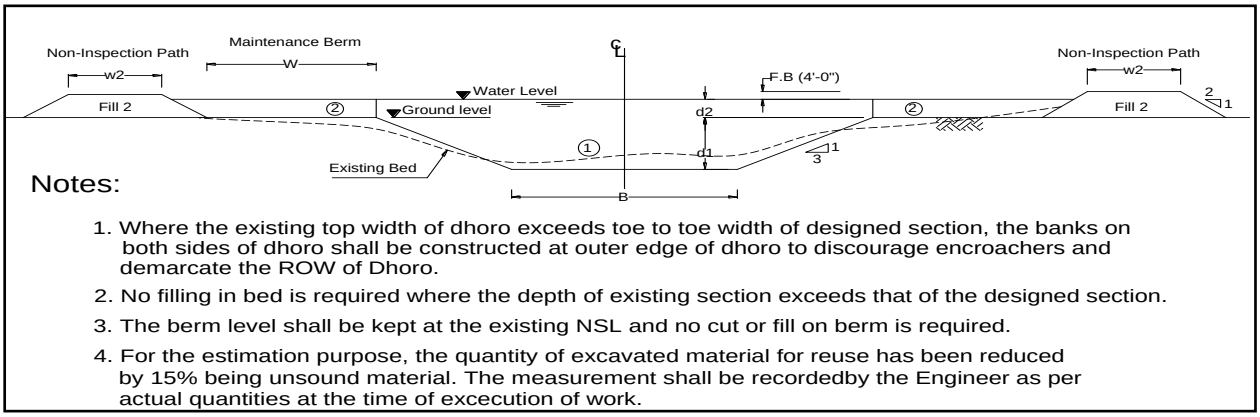


Figure-5.1: TYPICAL DHORO CROSS SECTION (Compound)

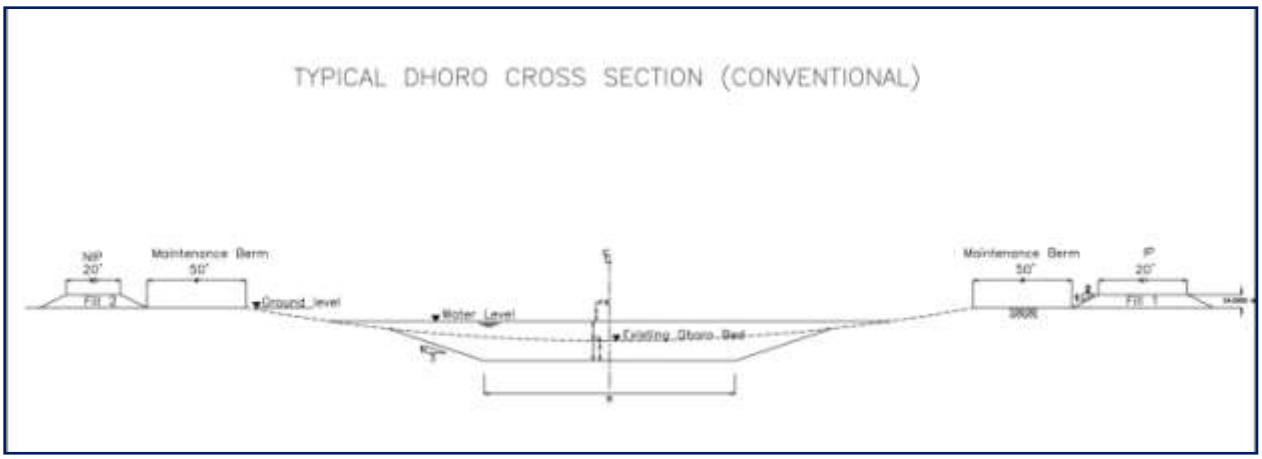


Figure-5.2: TYPICAL DHORO CROSS SECTION (Conventional)

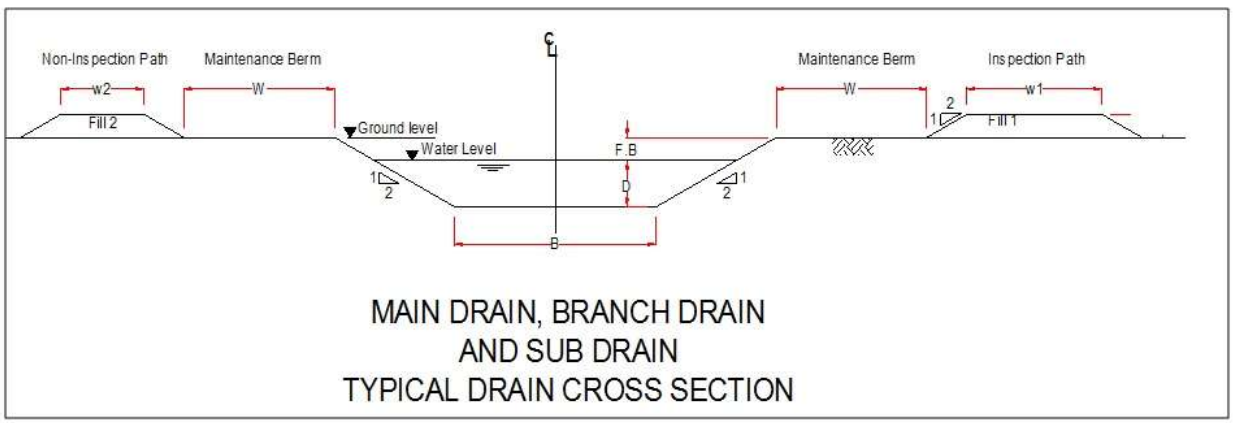


Figure-5.3: TYPICAL DRAIN CROSS SECTION

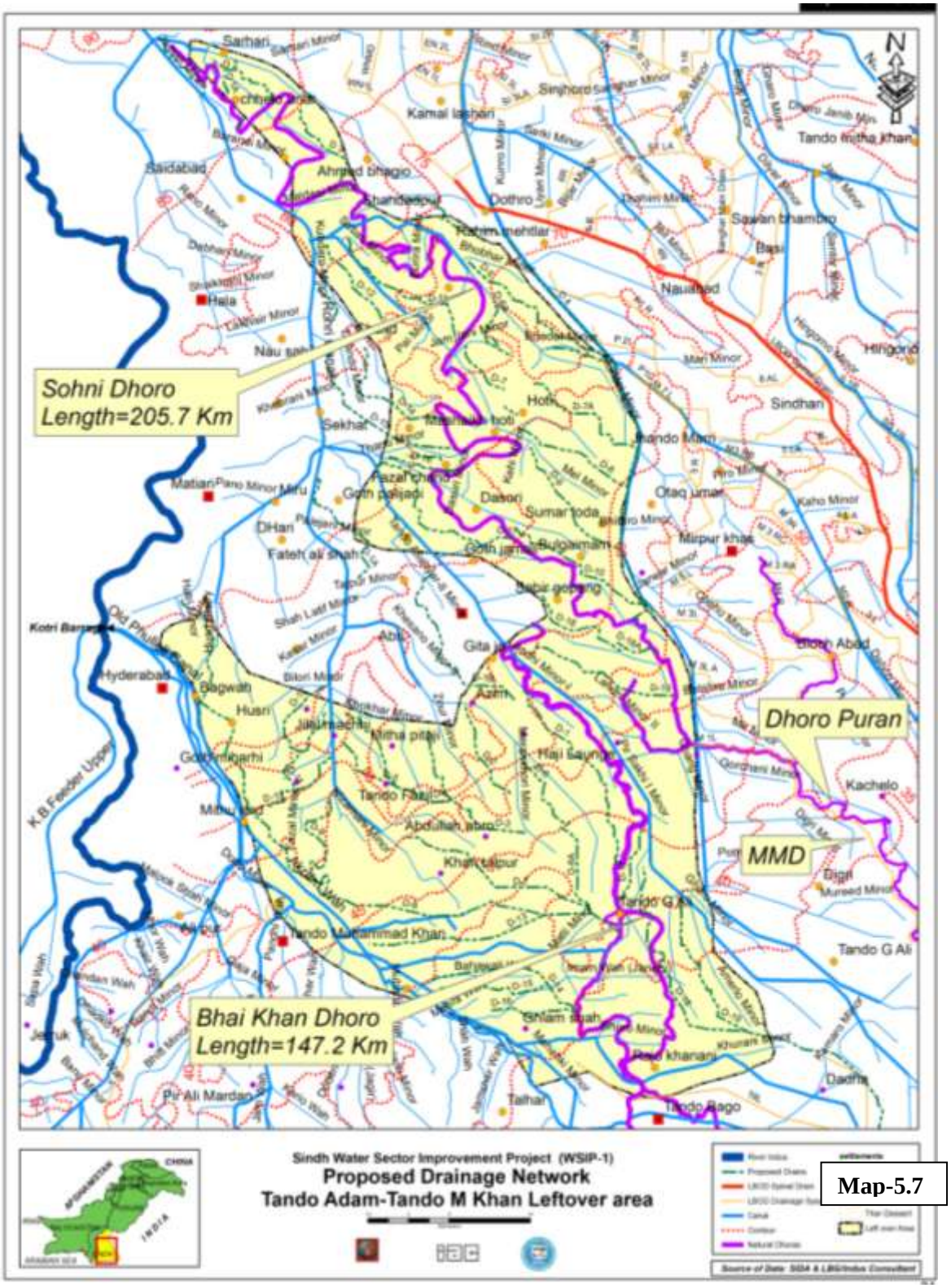
5.6.1 Tando Adam Left Over Area

This area about 410,245 acres lies mainly on both sides of Sohni Dhoro between Rohri Canal and Jamrao West Branch. For the design of drains in this area a Drainage coefficient of 2.54 cusecs / sq. mile has been adopted for the calculation of discharge.

There are twenty four proposed drains in the catchment of Sohni Dhoro. Total length of drains in this component including 03 Branch and 13 sub drains is 364 Kilometers. The total quantity of storm water coming in Sohni Dhoro through proposed drainage network is 1400 cusecs. The proposed drains and dhoras in Tando Adam and Tando Muhammad Khan areas are shown in Map-5.7.

Earth work quantities for excavation of drains and construction of banks including land are produced in Table- 52. The total quantity of earth work for excavation (cut) and banks (fill) is 266 M.cft and 99 M.cft respectively. Land required for ROW of drains is 2838 acres.

Total cost of Earthworks, Stuctures and Land comes out to be 2,367 M.Rs.



5.6.2 Tando M Khan Left Over Area

This component about 529,755 acres of gross area lies mainly on right side of Naseer Branch of Rohri Canal system. A Drainage coefficient of 2.54 cusecs/ sq. mile has been adopted for the calculation of discharge / design of drains in this area. The storm water of this area is to be drained out through Bhai Khan Dhoro which passes through the area.

There are twenty two proposed drains in the catchment of Bhai Khan Dhoro. Total length of drains in this component including 02 Main, 05 Branch and 15 sub drains is 473 Kilometers. The total quantity of storm water coming in Bhai Khan Dhoro through proposed drainage network is 2950 cusecs.

Earth work quantities for excavation of drains and construction of banks including land are produced in Table- 57. The total quantity of earth work for excavation (cut) and banks (fill) is 457 M.cft and1145 M.cft respectively. Land required for ROW of drains is 3815 acres.

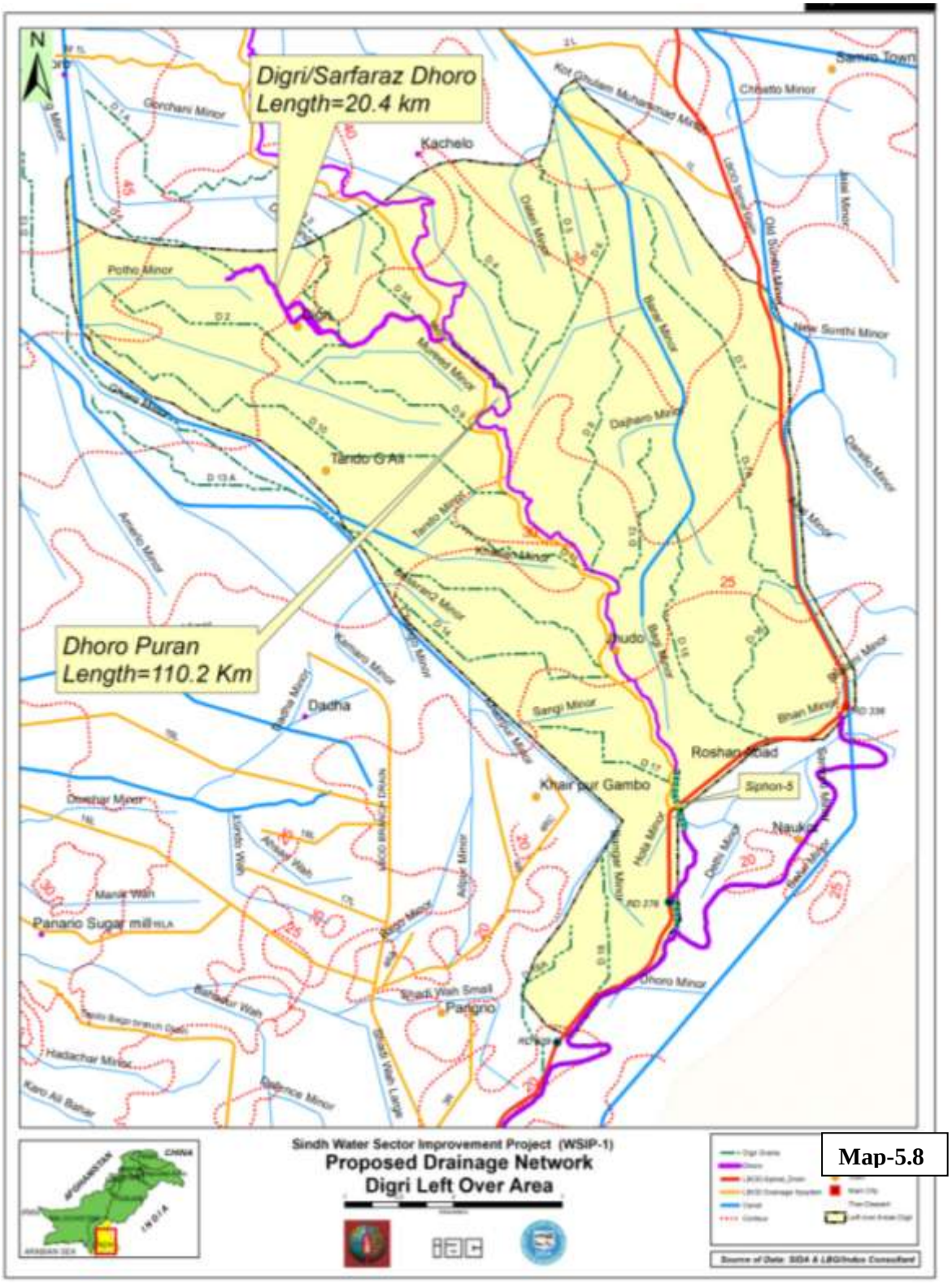
Total cost of Earthworks, Structures and Land including Tando Ghulam Ali Bypass comes out to be 3,680 M.Rs.

5.6.3 Digri Left over Area

This component approximately 302,000 acres of gross area is situated at the outfall point of Mirpurkhas Main Drain / Dhoro Puran into LBOD Spinal Drain and was one of the worst affected areas in the 2011 storm water floods. Although Mirpurkhas Main Drain and LBOD Spinal Drain both are passing through this area but no drainage network was provided to it in LBOD Stage-1. Mirpurkhas Main Drain runs parallel and on right side of Dhoro Puran and finally merges into Dhoro Puran at RD 27 just downstream of Jhudo town.

The proposed drainage system comprises of twenty sub-drains and 03 branch drains. Out of which four drains outfall into Digri Dhoro, five drains into Dhoro Puran, eight drains into Mirpurkhas Main Drain and six drains into LBOD Spinal drain. Map-5.8.The drainage coefficient of 2.59 cusecs / sq. mile for this area has been taken for the calculation of design of the drains. Total length of drains in this component including Branch and sub drains is 369 kilometers. The total quantity of storm water generated through proposed drainage network is 235 cusecs.

Earth work quantities for excavation of drains and construction of banks including typical cross sections are produced in Table- 62. The total quantity of earth work for excavation (cut) and banks (fill) is 201 M.cft and 88 M.cft respectively. Land required for ROW of drains is 3295 acres. Total cost of Earthworks, Structures and Land including Digri Bypass comes out to be 2223 M.Rs.



5.6.4 Umer Kot, Farash and Khipro Leftover Area

This sub component covers mostly the left over area of Umer Kot and Khipro approximately 1,055,000 acres. The main dhoras passing through the area are Hakro Dhoro, Pithoro Dhoro / Hiral Escape and Nabisar Dhoro / Naro Dhoro. The worst hit areas by storm water include Naukot, Nabisar, Fazal Banbhro, Kunri, Samaro and Khipro. Nara canal escape called Dhoro Escape of 1,000 cusecs discharges directly into Hakro Dhoro. Hiral escape joins Hakro Dhoro downstream of Samaro-Umarkot road near Bodar Farm and Nabisar Dhoro merges into Hakro Dhoro in Naukot town. The

drainage system comprises of 33 sub drains, branch drains and main drains. Out of which 19 drains outfall into Hakro Dhoro, seven in Nabisar Dhoro and seven in Pithoro Dhoro. The drainage coefficient of 1.43 cusecs / sq. mile has been adopted for the calculation of the discharges of the drains.

Total length of drains in this component including Main, Branch and sub drains is 824 Kilometers. The total quantity of storm water coming in Hakro Dhoro through proposed drainage network is 1011 cusecs.

Earth work quantities for excavation of drains and construction of banks are produced in Table-8.The total quantity of earth work for excavation (cut) and banks (fill) is 342 M.cft and 269 M.cft respectively. Land required for ROW of drains is 7,697 acres.

Total cost of Earthworks, Structures and Land including Naukot Bypass is 5,080 M.Rs.

This component was farmed out by the client to Associated Consulting Engineers (ACE) Karachi so further study on this area was not carried out after Pre Feasibility stage Phase-II.

5.7 Dhora Bypasses

It was observed during the walkthrough survey of dhoras and through satellite imagery that due to extension of towns and cities owing to population growth the waterways of dhoras were encroached / obstructed by the local populace. Consequently, due to very narrow passage available to the storm water it caused wide spread flooding in and around these towns / cities. It will be difficult if not impossible to demolish / evacuate the constructed concrete houses and other commercial urban properties costing millions of rupees. Legal, social and environmental issues may arise during the evacuation process. It is proposed that the encroachers may be offered to retain the encroached land of dhoras on payment of market value to the government. This cost can be then utilized to acquire the land for proposed bypasses.

As such, four bypasses have been proposed to avoid inundation of the big towns / cities which were severely hit in 2011 storm water floods. The proposed bypasses are as follows:

- Jhudo bypass of Puran Dhoro 2.7 kms
- Digri bypass on Digri / Sarfraz Dhoro 3.5 kms
- Naukot bypass on Hakro and Nabisar dhoro 3.2 kms
- T. G. Ali bypass on Bhai Khan Dhoro 4.0 kms.

The cost of construction of these Bypasses has been included in the cost of their respective dhoras.

5.8 LBOD Escapes

In order to provide relief to the existing LBOD system and to reduce pressure of storm water on Badin and coastal population, it is proposed to off load at least 3000 cusecs storm water from LBOD Spinal Drain at three different locations and divert to the Dhoro Puran. The location of three proposed escapes is as follows:

- Escape - 1 at RD 578 of LBOD
- Escape - 2 at RD 336 of LBOD
- Escape - 3 at RD 212 of LBOD

At each of the above locations 1000 cusecs of excess storm water from LBOD Spinal drain will be diverted through side weirs. A link channel 66 RD long will be required for Escape-1from LBOD Spinal Drain RD 578 to Pithoro Dhoro / Hiral escape which ultimately terminates in Hakro Dhoro. It will require enhancing the capacity of Hiral escape to 1675 cusecs, catering for 675 cusecs from its own catchment and 1000 cusecs from LBOD system. This escape will offload excess storm water coming from S.Benazirabad and Sanghar districts before reaching to Badin area. (Map- 4.1)

Link channels of Escape- 2 & Escape -3 at RD 336 and 212 of Spinal Drain will be 1 to 2 RDs long and will off load 1000 cusecs each from LBOD system to Nabisar /Naro Dhoro and Puran Dhoro respectively. Escape- 2 has been proposed just upstream of outfall point of MMD so that sufficient

capacity in Spinal Drain should be available to receive storm water from MMD. Similarly, Escape- 3 (Image-5.5) has been proposed just upstream of outfall point of LBOD Branch Drain so that the water level in Spinal Drain should not rise above the water level of LBOD Branch drain to avoid back flow in the later, which was observed during monsoon 2011.

Off loading 3000 cusecs through escapes and separating of Dhoro Puran (about 2700 cusecs) from MMD by under passing Spinal Drain the existing LBOD system will get considerable relief and it is expected that overtopping of structures and back flow in sub drains and branch drains will be eliminated to a great extent. Moreover, the bypasses to the structures will also be avoided.

The conceptual cost of three escapes including link channels, Structures and weirs has been calculated as 490 M.Rs.

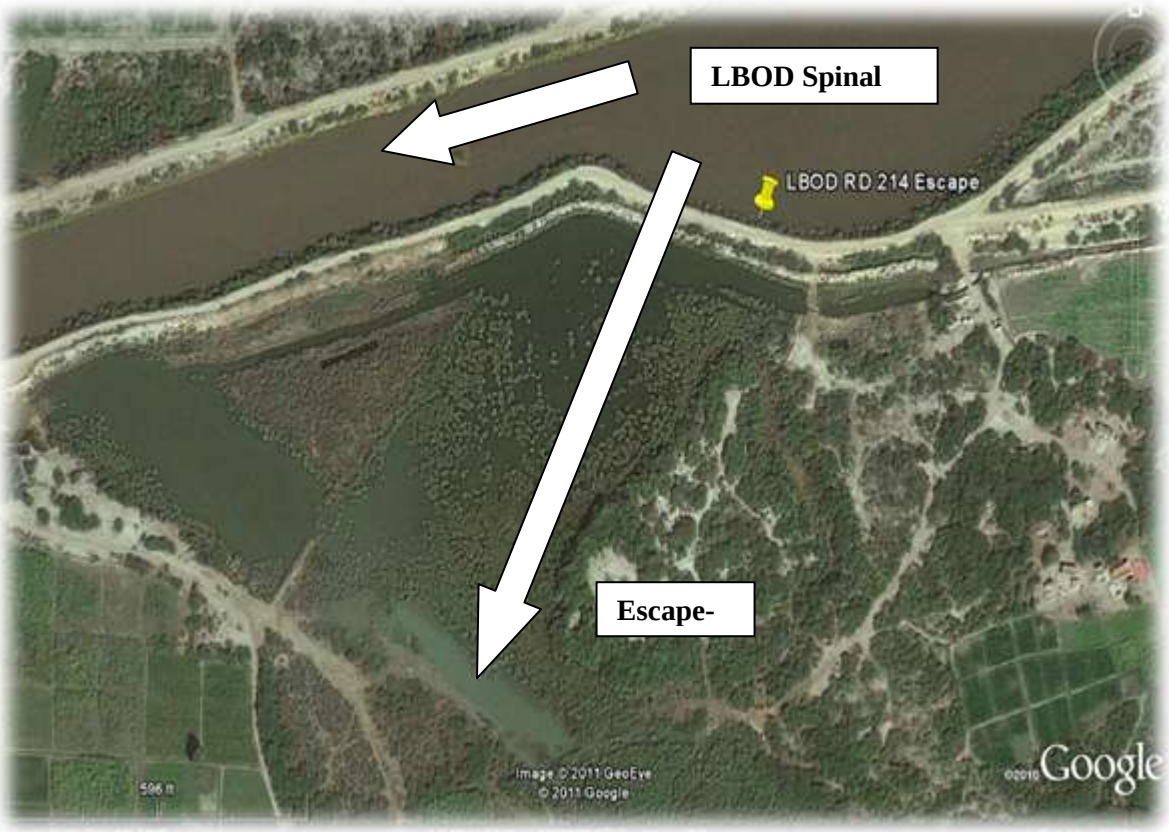


Image 5.5: Proposed LBOD Escape- 3 RD-212

5.9 Siphons and Superpassages

To provide safe passage to the storm water coming into the dhoras on left side of MMD and Spinal drain one Super Passage and seven siphons have been proposed in addition to other structures for crossing irrigation channels, roads, pedestrians and railway lines. (Table-73). These siphons and Superpassage will join the blocked dhoras and their cut off pieces to mother channel Dhoro Puran. Their detail is provided as follows,

Super Passage-1: Sohni Dhoro (1,400 cusecs) outfalls into Puran Dhoro under passing Mirpurkhas Main Drain (MMD).

Syphon-2: Digri Dhoro (235 cusecs) outfalls into Puran Dhoro under passing Mirpurkhas Main Drain (MMD).

Syphon-3: Tando Jan Muhammad Loop-1 (25 cusecs) outfalls into Puran Dhoro under passing Mirpurkhas Main Drain (MMD).

Syphon-4: TJM Loop-2 outfalls into Puran Dhoro (Technically and Financially not Feasible, hence not required).

Syphon-5: Dhoro Puran (2880 cusecs) itself passes under LBOD Spinal Drain.

Syphon-6: Khairpur Gambo Dhoro (57 cusecs) outfalls into Puran Dhoro under passing LBOD SpinalDrain.

Syphon-7: Pangrio Loop-1 (18 cusecs) outfalls into Puran Dhoro under passing LBOD Spinal Drain.

Syphon-8: Pangrio Loop-2 (18 cusecs) outfalls into Puran Dhoro under passing LBOD Spinal Drrain.

Syphon-9: Bhai Khan Dhoro (1947 cusecs) outfalls into Puran Dhoro under passing LBOD Spinal Drain.

5.10 Suggested Implementation Plan for drainage in Lower Sindh

In view of huge cost involved in the activation of natural waterways it is proposed that the plan may be implemented in phases according to the availability of funds and priority of works.

5.10.1 Top Priority works

Activation of dhoras on left side of LBOD Spinal Drain i.e. Hakro Dhoro, Naro Dhoro and Pithoro Dhoro / Hiral Escape.

Activation of full length of Dhoro Puran from Mirpurkhas to RD 110 of DPOD including Mirpurkhas bypass.

Separate outfall for Mirpurkhas Main Drain carrying highly polluted effluent, into LBOD Spinal Drain.

After separation of MMD, Dhoro Puran shall be routed to its natural path under passing LBOD Spinal Drain.

Reconstruction of Dhoro Puran sections which have been utilized in the alignment of LBOD Spinal Drain to provide clear passage to storm water.

Construction of dhora bypasses proposed for Jhudo, Digri and Naukot towns.

It is strongly recommended that activation or channelization of dhoras should be started from the lowest point of each dhoro moving upstream by removing all bottlenecks and obstructions. In the event it is started from upstream end without giving clear passage to storm water, it may cause wide spread flooding in lower reaches and damages could be greater than 2011 storm.

5.10.2 Priority-2 works

Providing drainage to cutoff portions of Dhoro Puran on right side of LBOD Spinal Drain and Mirpurkhas Main Drain by constructing Super Passage / siphons across Mirpurkhas Main Drain and LBOD Spinal Drain.

Activation of Digri Dhoro, Sohni Dhoro and Bhai Khan Dhoro and connecting them with Dhoro Puran by constructing under passes across Mirpurkhas Main Drain and LBOD Spinal Drain.

Construction of dhora bypasses proposed for Mirpur Khas and Tando Ghulam Ali towns.

5.10.3 Priority-3 Works

Construction of adequate sized structures across the dhoras based on 20 years return period. The construction of numerous structures can take longer time and cannot be completed earlier. As such, in the event of any heavy rainfall, relief cuts to roads with inadequate sized culverts and bridges could be given to smoothly pass storm water. However, boats will be required tofacilitate local people on either side to cross the dhoras.

Construction of drainage net work including structures, proposed for the left over areas of Umarkot, Digri, Tando Adam, Tando Allahyar and Tando Ghulam Ali outside the catchment of LBOD system.

6 Northern Sindh Storm Water Drainage

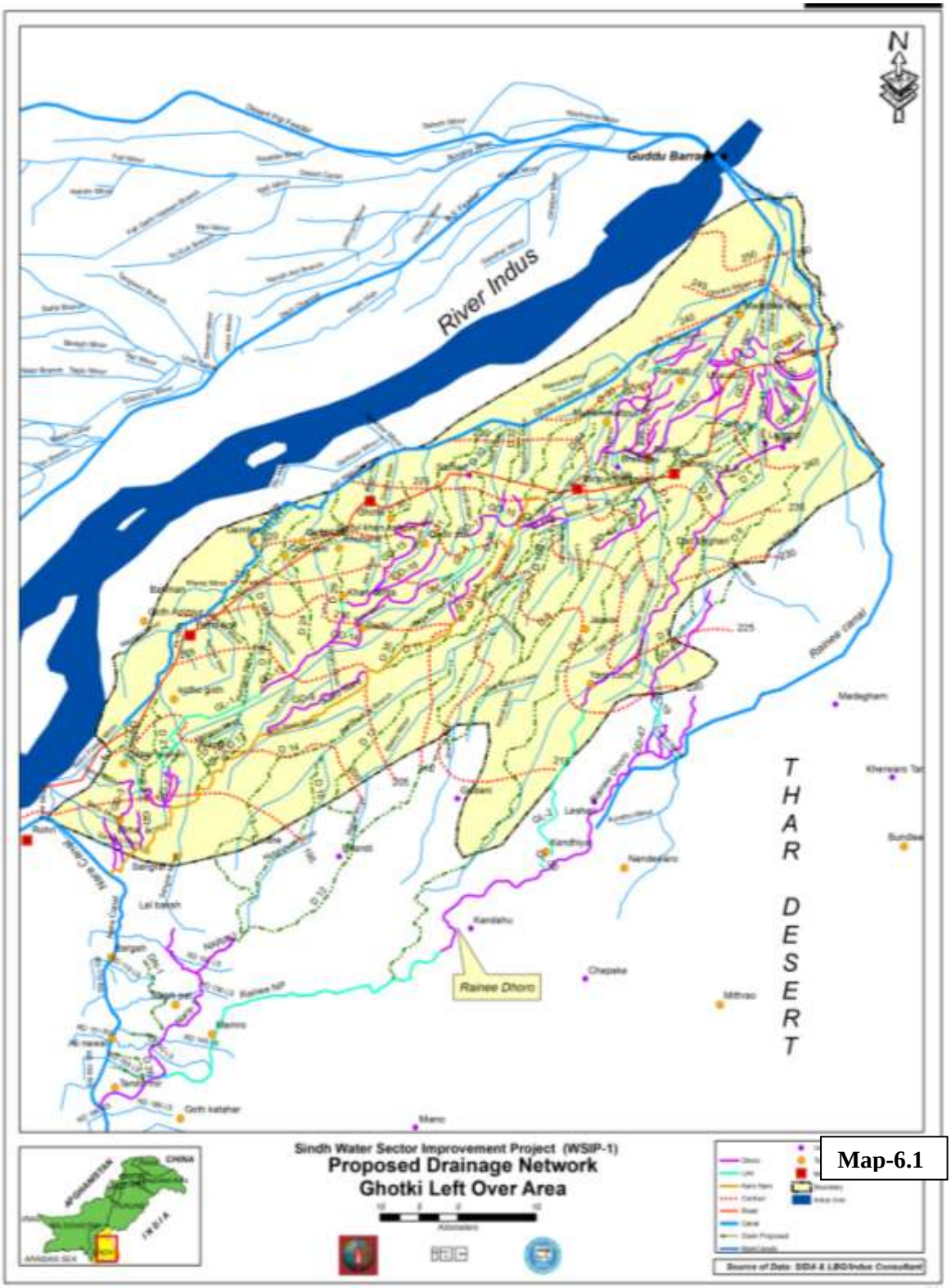
The two left over areas in upper Sindh where no drainage (vertical or horizontal) system has been provided so far are Ghotki Saline and Khairpur South. The idea of installation of tube wells to control rising water table in both these areas has been considered and dropped due to non availability of any disposal source for brackish water. Although the saline effluent of Khaipur South area could be disposed through LBOD system via Nawabshah component, but the people in Mirpurkhas and Badin areas are deadly against any further enhancement of LBOD system. As such, only drainage of storm water by constructing an efficient drainage network and activating of natural water ways could be achieved. However, activation of waterways will also serve as interceptor drains for rising water table.

6.1 Ghotki Leftover Area

In phase-II report the Consultants had proposed storm water drainage for Ghotki Saline zone. After the extreme rainfall of 2012 to the extent of 150 mm to 300 mm in a single day it was observed that due to non availability of any drainage network except Karo Naro, the storm water was being drained out by giving relief cuts to irrigation channels wherever gravity flow was possible. Alternately, tractor driven pumps and electric pumps were being utilized to send the water into irrigation channels. Moreover the storm water pumped into irrigation channels was causing additional flooding in the tail reaches of such channels due to narrowing section at the tails and non utilization of pumped storm water by farmers. As such the flood condition in the tail reaches was the worst of all.

From the lessons learnt during recent unprecedented rains of monsoon 2012 in Ghotki area, storm water drainage system is equally important for Ghotki Fresh zone. As such the drainage network proposed for Saline zone requires to be extended to Fresh water zone. For this purpose the natural waterways including Karo Naro already identified by consultants can be utilized. Capacity of Karo Naro and allied structures is to be enhanced to accommodate the storm water of additional areas. Other major dhoras identified in Ghotki area like Lakhwar Dhoro, Gurhelo Dhoro and Rainee Dhoro can also be utilized for storm water drainage.

In addition to the aforesaid major dhoras there are many isolated and cut off pieces of river course in Ghotki area particularly in the north east of Ubauro town a cluster of dhoras can be seen, which caused severe damaged to settlements and crops in and around Ubauro town . (Map-6.1) The Ubauro area is the most vulnerable part of Ghotki district in the event of storm water flood as well as river flood. It indicates that Indus River has been frequently meandering in this narrow strip of land between Thar Desert and Indus. About 45 bow shaped and straight pieces of dhoras have been identified in Ghotki alone. Their combined length is approximately 300 kms. In the proposed drainage network these small isolated pieces very close to each other have been connected through link channels and drained out into a major dhoro or drain.



Map-6.1

It was noticed that at the time of construction of railway lines all the major and minor natural waterways were provided adequate crossing structures. Unfortunately this was not done while constructing roads and canal system, which appears to be the major cause of storm water flooding. However ,the proposed drainage net work; the existing unused railway crossings (approximately 40 Nos.) must be utilized to drain out storm water to Karo Naro or any other waterway particularly from the area between Ghotki Feeder and main railway line to avoid construction of costly and time consuming railway structures.

The major dhoras identified in Ghotki area are described below.

6.1.1 Karo Naro

Karo Naro 82.9 kms long initiates near National Highway in west of Mirpur Mathelo town and outfalls at Nara Canal RD 73. Karo Naro is a combination of natural waterways and manmade channels. (Image-6.1)Its natural sections are wider than the manmade sections. Weed growth and narrow structures are causing hindrance to storm water flow although it has an excellent gradient of approximately 1:9000. Karo Naro running in the east of historical Mathelo village and passing in the west of Khangarh town outfalls into Nara Main Canal after under passig Sangrar minor.

Remodelling of Karo Naro will provide drainage to the area in its west up to Ghotki Feeder in addition to Khangarh and Mathelo area on its east. The effluent of 03 Branch drains and 26 sub drains to the extent of 1190 cusecs will be drained out through Karo Naro into Nara Canal. Total length of drains in Karo Naro system is 442 kms.

Image-6.1: Natural and manmade sections of Karo Naro

6.1.2 Lakhwar Dhoro

Lakhwar Dhoro 62 kms long, initiates in the north of Ghotki –Mathelo road and joins Karo Naro in south east of Pano Aqil town. After passing between Adilpur and Changlani villages it runs parallel to Qazi wah. Its route in the east of Pano Aqil town is less prominent. As such a link channel is proposed to join the prominent pieces and provide safe and controlled passage to storm water.

The effluent of 02 Branch drains and 7 sub drains will be drained out through Lakhwar Dhoro into Karo Naro. It is a part of proposed Karo Naro system.

6.1.3 Gurhelo Dhoro

Gurhelo Dhoro 74 kms long initiates south east of Daharki town from a lake. After meandering in the east of Daharki and Dad Laghari village it traverses parallel to Dahar Wah Lower upto Yaro Lund village. Its alignment downstream of Yaro Lund is non prominent. As such a link channel is proposed to join it with Rainee Dhoro.

Gurhelo Dhoro will provide storm water drainage to Ubauro, Reti, Daharki, Dad Laghari and Yaro Lund areas. The effluent of 01 Branch drain and 05 sub drains and a cluster of dhoras in Ubauro area

to the extent of 390 cusecs will be drained out through Gurhelo Dhoro into Rainee Dhoro. Total length of drains in Gurhelo Dhoro system is 72 kms.

6.1.4 Rainee Dhoro

Historically Rainee Dhoro is the old course of Hakro River. Its prominent path originates from Peer Pakhroi in the east of Yaro Lund to the point where it has been plugged by local community. (Image-6.2). Its route downstream of the plug is not prominently visible due to absence of water. Similarly it is not prominent upstream in northern part of Ghotki district and Punjab. it is very clearly shown in the historical map flowing in the east of Bahawalpur, Rahimyar Khan and Alore. Downstream of Alore the existing Nara Canal flows on the same route. The possible route of Rainee Dhoro is shown in (Image-6.3). However it requires on ground verification by detailed surveying.

The effluent of 03 Branch drains and 06 sub drains and few isolated pieces of dhoras including Gurhelo Dhoro to the extent of 1765 cusecs will be drained out through Rainee Dhoro into Nara Canal. Total length of drains in Rainee system excluding Gurhelo Dhoro system is 192 kms.

Approximate cost for activation of dhoras in Ghotki area including earth works, structures and land for link channels is estimated as 4,367 M.Rs. Similarly the cost of proposed drains in Ghotki area including earth works, structures and land for link channels is estimated to be 3,660 M.Rs.

Image-6.2: Rainee Dhoro completely plugged by local community

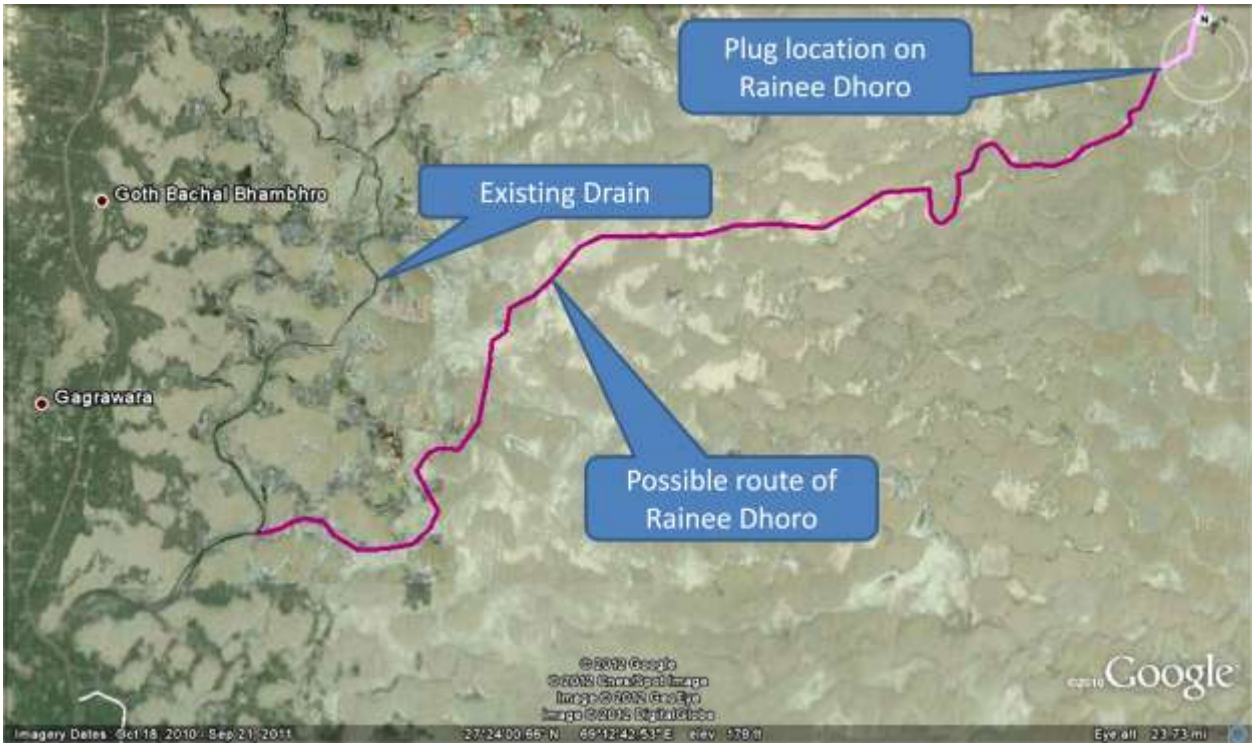


Image-6.3: Possible route of Rainee Dhoro

Earth work quantities for excavation of drains and construction of banks are produced in Table-62. The total quantity of earth work for excavation (cut) and banks (fill) is 602 M.cft and 222M.cft respectively. Land required for ROW of drains is 7,534 acres.

6.2 Khairpur South Area

The main dhoro in this area is Hussainabad- Mehrabpur (HM) dhoro (including Kandiaro- Moro Dhoro) about 167 kms long. It originates from Hussainabad village and traverses south west upto Mehrabpur town and further to south of Moro town. It is proposed that after its activation the storm water coming into this dhoro shall be drained out to Indus River. (Map-6.2) A siphon under Rohri Canal and other cross drainage structures will be required to activate it.

Another dhoro in this area is Nangreja- Talpur Wada (NTW) dhoro, which appears to be a tributary of HM dhoro. It separates from HM dhoro 2.5 kms south of Jiskani village and after meandering near Kumb, Nangreja and Talpur Wada villages again joins HM dhoro about 5 kms upstream of Veesar village.

Both the dhoras are situated in the northern portion of Khairpur south sub project and there is not any natural dhoro in its southern part. However, southern part being in the tail reaches of Khairpur Feeder East has negligible water logging and drainage problem. Whereas, the northern part is the most vulnerable area to flooding during heavy rainfall owing to number of blockages on both the dhoras.

Vertical drainage to the southern part can be provided by installing tubewells but due to non availability of any outlet for extremely saline ground water this proposal hardly appears to be viable.

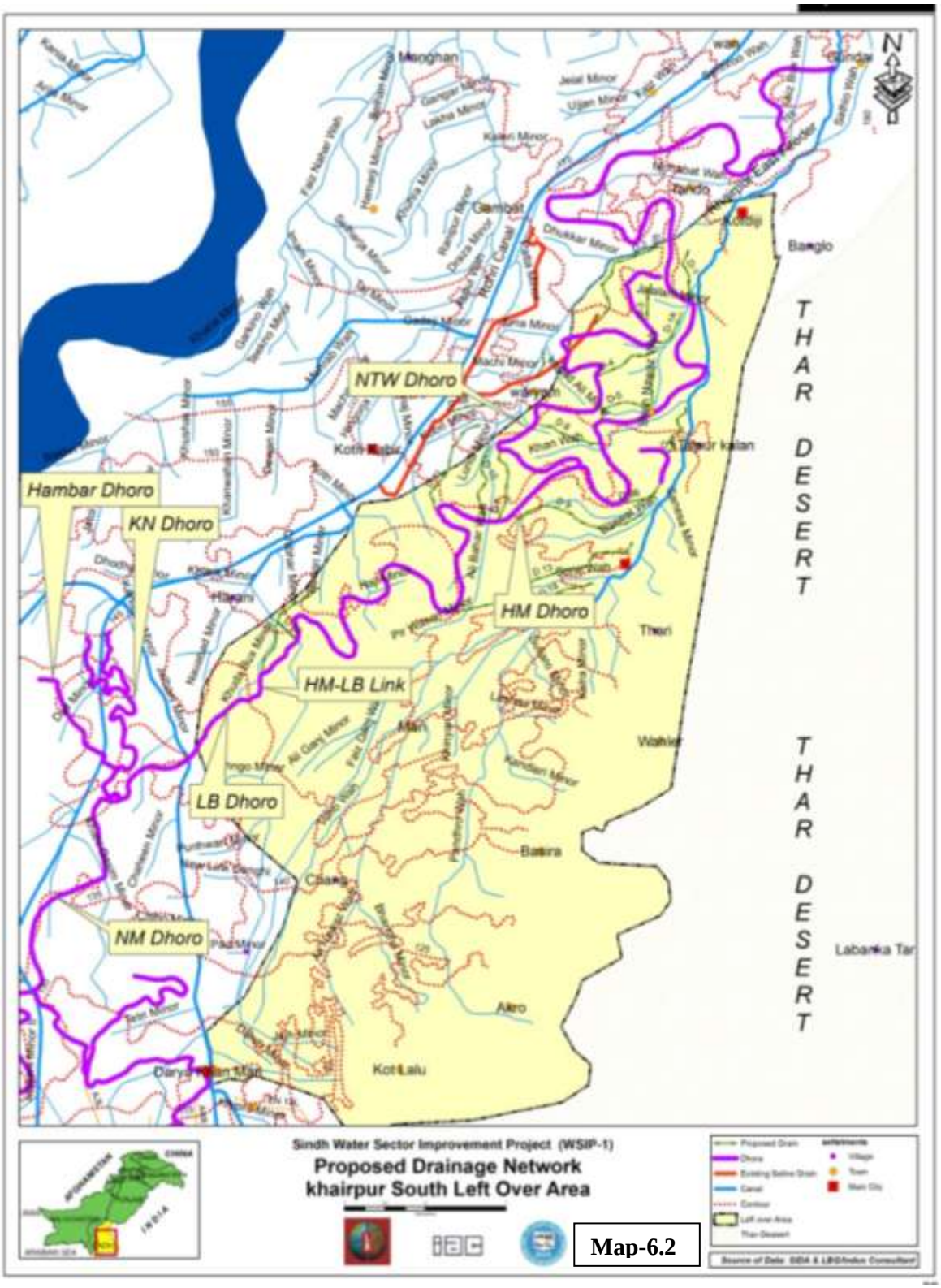
The estimated rough cost for activation of these two dhoras including earthworks and structures will be approximately 2,961 M.Rs.

As like Ghotki Saline area this component approximately 475,000 acres of gross area is situated between SCARP Khairpur area on its west and Thar Desert on the east. The proposed drainage system comprises of 19 sub-drains. The drainage coefficient of 2.25 cusecs / sq. mile for this area has been taken for the design of the drains.

Total length of drains in this component is 131 kilometers. The total quantity of storm water generated through proposed drainage network will be approximately 554 cusecs.

Earth work quantities for excavation of drains and construction of banks are produced in Table-47. The total quantity of earth work for excavation (cut) and banks (fill) is 36 M.cft and 23M.cft respectively. Land required for ROW of drains is 975 acres.

Total cost of Earthworks, Structures and Land for drains comes out to be 551 M.Rs.

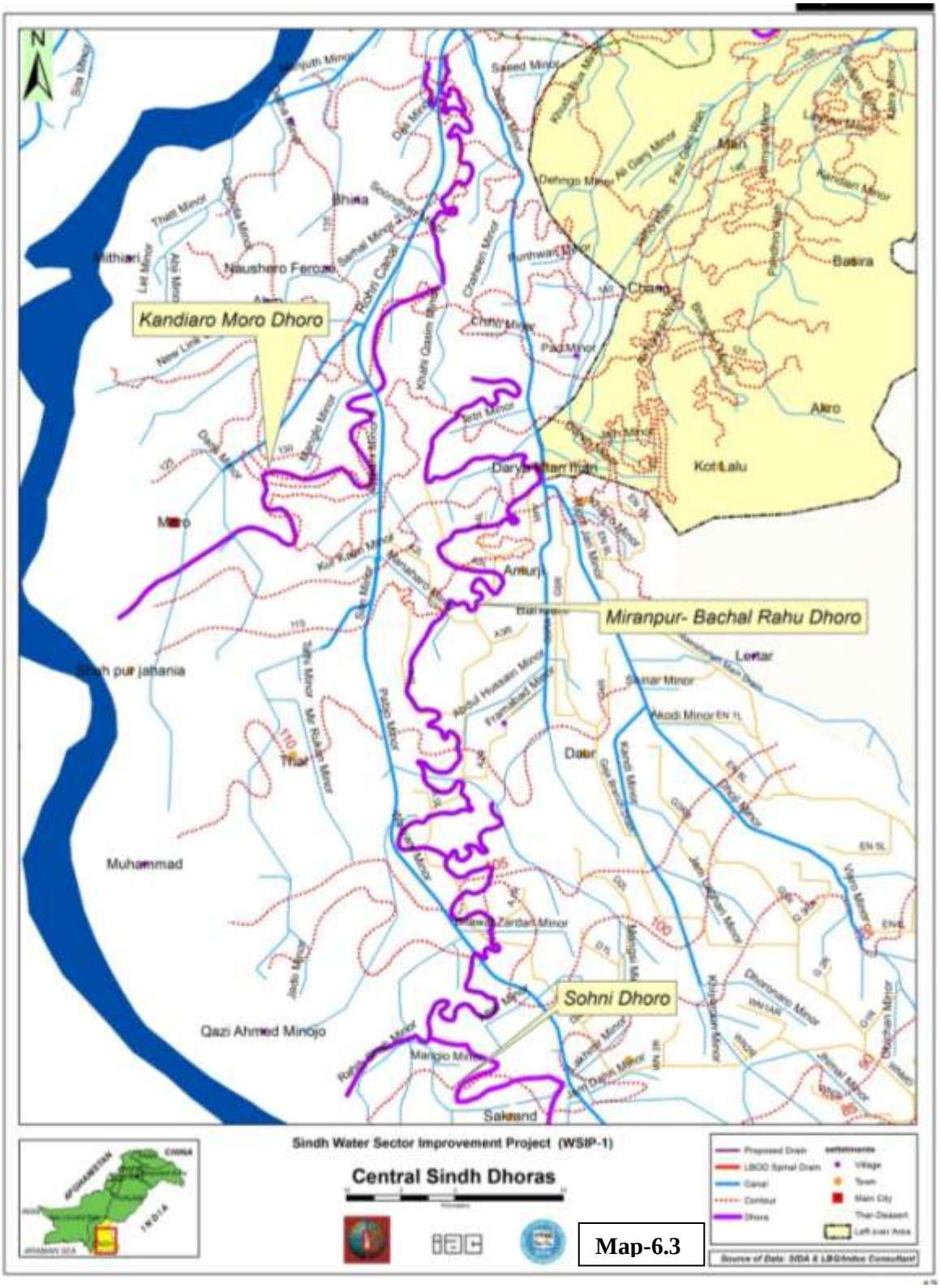


6.3 Natural Water Ways of Central Sindh

In addition to the dhoras existing in the left over areas of upper and lower Sindh, two major dhoras passing through central Sindh districts of Naushehro Feroze, S. Benazirabad and Matiari are Miranpur- Bachal Rahu (MBR) dhoro (173 kms) and Kandiaro- Moro (98.5KM) dhoro (98.5 kms). (Map- 6.3)

Tube well drainage on right side of Rohri Canal and LBOD network of tube wells and surface drains on left side of Rohri Canal has been provided in this area. But due to numerous obstructions across the dhoras the storm water in the event of heavy rainfall accumulates in isolated portions of dhoras and causes flooding in the adjoining lands and settlements resulting in damage to life, properties, crops and livestock. Wide spread devastation was observed in these districts during unprecedented rains of 2011. In most of the areas like Sakrand, Naushehro Feroze, Matiari, Kandiaro etc storm water could not be drained out until six months after the rainfall due to non availability of any drainage outlet. Because fresh water tube wells on right side of Rohri Canal directly discharge into canals to supplement deficit irrigation supplies and bed levels of surface drains of LBOD system on left side of Rohri Canal were above the bed of natural dhoras. As such, these drains cannot drain out the storm water ponded in the dhoras.

Activation of these dhoras will not only provide storm water drainage but also will intercept the rising water table in three districts of central Sindh. Storm water coming through these two dhoras could be sent through its natural route to Dhoro Puran via Sohni Dhoro. But this option is not desirable in view of reservations by people of lower reaches.


N
Kandiaro Moro Dhoro
Miranpur- Bachal Rahu Dhoro
Sohni Dhoro
Naushero Feroze
Mithiani
Bhiria
Chang
Kot Lalu
Mehro
Shah pur jahania
Muhammad
Qazi Ahmed Mirojo
Sakrand
Sindh Water Sector Improvement Project (WSIP-1)
Central Sindh Dhoras
Map-6.3

6.4 Output

The main outputs that would be accomplished include:

Revival of Dhoras

- Activation of Dhoro Puran from Mirpur Khas up to Shakoor dhand.
- Activation of Sohni dhoro from Shahdadpur to Mirwah Gorchani.
- Activation of Bhai Khan dhoro from Tando Allahyar to Pangrio
- Construction of dhora bypasses for Dighri, Jhuddo, Tando Ghulam Ali and Naukot towns.
- Activation Hiral escape/ Pithoro Dhoro, Hakro Dhoro & Naro (Nabisar) Dhoro.
- Activation of Sarfaraz (Digri) Dhoro, Pangrio, Khairpur Gumbo & Roshanabad dhoras
- Activation of Khairpur South dhoras
- Activation of Ghotki dhoras
- Activation of Miranpur-Bachal Rahu Dhoro, Kandiaro-Moro Dhoro

Leftover Areas (LOA)

- Construction of surface drains in T.Adam, T.Allahyar, T.M Khan and T.G. Ali area
- Construction of surface drains in Dighri area
- Construction of surface drains in Umerkot, Farash and Khipro area
- Construction of surface drains in Khairpur South area
- Construction of surface drains in Ghotki area

LBOD Escapes

Construction of 3X Escapes on LBOD i/c Side Weirs and Link Channels to offload 1000 cusecs through each escape to dhoras.

6.5 Implementation Period and Arrangement

In view of urgency due to unexpected heavy rainfall during last two monsoons of 2011 and 2012 in southern and northern Sindh respectively, the overall time period for this intervention has been restricted to eight years from 2011 through 2020. The detail of financial year (FY) wise expenditure on major activities, including emergency works is presented in Table 6 below.

Table-6.5: Indicative Cost Estimates for the Revival of Dhoras including bypasses (Rs. Million)

S.No	Main Outputs	2011/12	2012/13	2013/14	2014/20	Total
	Revival of Dhoras					
1	Activation of dhoras, Puran upto Shakoor dhand, Sohni dhoro & Bhai Khan dhoro and bypasses of Mirpurkhas, Jhuddo, Tando Ghulam Ali	65	615	1,320	16,409	18,409
2	Activation & Restoration of pocket drains along Hiral escape/ Pithoro Dhoro, Hakro Dhoro & Naro (Nabisar) Dhoro i/c Naukot bypass	30	180	200	4,303	4,713
3	Activation of Sarfaraz (Digri) Dhoro, including Digri bypasses	7	27	271	286	591
4	Excavation and revival of Pangrio, Khairpur Gumbo & Roshanabad dhoras	-	-	-	703	703
5	Excavation and revival of Ghotki dhoras	-	-	-	2,160	2,160
6	Excavation and revival of Khairpur South dhoras	-	-	-	3,057	3,057
	Leftover Areas					
7	Construction of surface drains in T.Adam, T.Allahyar, T.M Khan and T.G. Ali area	-	-	-	4,668	4,668
8	Construction of surface drains in Digri area	-	-	-	1,149	1,149
9	Construction of surface drains in Umerkot, Farash and Khipro area	-	-	-	5,080	5,080
10	Construction of surface drains in Ghotki area	-	-	-	2,111	2,111
11	Construction of surface drains in Khairpur South area	-	-	-	434	434
	LBOD Escapes					
12	Construction of 3X Escapes on LBOD i/c Weirs and Link Channels	-	-	-	490	490
	Grand Total	**102**	**822**	**1,791**	**40,850**	**43,565**

The project works are to be executed through competitive bidding by inviting International and National civil construction firms ensuring full transparency. The construction works are to be supervised for both quality and quantity through renowned international and national Consultants.

6.6 Monitoring Framework

It is imperative to monitor the performance of drainage in leftover *areas* on continuous basis by installing staff gages at control points. The rating tables shall be formulated and updated after every flood season by the Consultants or O&M staff. Permanent gauges shall be installed and observed regularly at outfall point of each dhoro and at Shakoor Dhand in addition to the outfall points of drains into dhoras. The depth to water table throughout the left bank area shall be observed before and after each crop season for which SMO WAPDA has already developed an extensive network of observation points like piezometers and tube wells. As the storm water coming into the dhoras is to be utilized for agriculture purpose by the farmers of deficit tail reaches of irrigation channels, it should be pollution free. A number of Sugar Mills and other industries are operating in the command area of drainage networks and are adding highly toxic effluent into drains. They should ensure at source treatment of industrial effluent before it is discharged into the drainage network. In addition to this environmental monitoring will be required during construction and maintenance phases of the project on regular basis through an environmental monitoring cell to be established in the SIDA. The maintenance works of the drainage infra structure and dhoras shall also be monitored for discharge capacity and structural safety. The changes in the ground water level and quality of storm water in drains and dhoras shall be determined to develop a data base for monitoring the level of the ground water and reuse of storm water.

The full benefits of drainage networks can only be achieved if proper management of irrigation is implemented. There is a potential risk that at field level, the farmers may be encouraged by the

drainage to be wasteful with water. The drainage benefits may decrease gradually due to poor management and maintenance.

6.7 Due Diligence

The operating agencies responsible for O&M of drainage networks shall ensure the following actions after the forecast of very high storm:

All the storm water drainage of the Left Bank are unregulated, and so are not subject to good water management during the passage of floods.

Canal supplies shall be stopped as early as possible keeping in view the distance of Head Regulator from the region to be affected by extreme rainfall event.

Base flow from tube wells and irrigation water from canal escapes shall be completely stopped to allow the full drain / dhoro capacity to be used for storm water drainage.

Gauge readings at major control points in the drainage networks of leftover areas and on dhoras including Spinal drain shall be monitored on hourly basis, to adopt precautionary measures in time.

Vigilant patrolling of the drains and dhoras shall be carried out to stop unauthorized relief cuts by farmers and to identify the vulnerable points if any. Relief cuts given by farmers create hindrance in the movement of machinery and staff in the event of an emergency.

All the required machinery shall be repaired and mobilized to vulnerable points of the to meet an emergency.

Before releasing the base flow into the after passing the storm water, the banks and allied structures on drains/ dhoras shall be inspected for rain damages and rain cuts and all urgent remedial / repair works shall be completed.

Sufficient funds and resources including manpower and machines shall be made available to Operating Agency for efficient handling of emergent situation.

Reliable and timely information about extreme rainfall events shall be provided to relevant Operating Agency to avoid loss to standing crops due to longer periods of canal closure.

Budget provision for storm emergency shall always be made in the yearly plans and re appropriated in development works if no extreme rainfall event occurs by 30th September every year.

Flood / storm information in Operating Agency shall be improved for quick communication from Head of Agency to the lowest rank.

6.8 Technical Feasibility

Originally the LBOD surface drainage was designed for a runoff based on five years return period and five days evacuation period keeping in view the frequency of rainfall at that time. Since the year 2003 the climate cycle has changed and extreme events of rainfall have occurred in lower Sindh during the years 2003, 2006 and 2011. This phenomenon has now extended to the northern part of Sindh where unprecedented rainfall to the extent of 300 mm occurred in a single day in the year 2012. The losses and damages caused by the storm of 2011 and 2012 have been mentioned earlier in this Report.

The changed climatic conditions have necessitated to review the storm drainage capacity of existing surface drainage s and to provide drainage to leftover areas where no surface drainage has been provided so for. Earlier the WAPDA consultants in their report had proposed to raise the banks of Spinal Drain by 2.0 ft. above the last designed water level. Although this option will avert the overtopping of Spinal drain and will thus reduce the flood damages to some extent. However there is potential risk of submergence of structures and back flow in few drains including Mirpur Khas Main drain and LBOD Branch drain. The deck slabs of bridges can be lifted to the new level but water course and canal aqueducts feeding the lands on either side of drain cannot be raised due to technical grounds. To overcome this problem the possible solution appears to be the offloading of excess storm water coming from upper reaches, to natural waterways / dhoras. As such, three side weirs are

proposed at RD 578, RD 336 and RD 212 of Spinal drain to offload storm water coming from S.Benazirabad Sanghar and Mirpur Khas areas. About 1000 cusecs will be offloaded at each escape weir and will be sent through link channels to nearby dhoras.

Similarly, the storm water coming from the proposed surface drainage systems of Left Over Areas shall be drained out through natural waterways / dhoras passing through respective areas.

Moreover, it is proposed that MMD presently outfalling into Puran Dhoro at RD 29 should be separated from Puran Dhoro to outfall into Spinal Drain at RD 295 to send its polluted effluent into the sea. The Puran Dhoro which was cut off from its natural route shall be allowed to underpass Spinal Drain through a siphon and follow its original path to Shakoor Lake. By this arrangement about 2000 to 3000 cusecs of storm water will be offloaded from Spinal Drain. After offloading 5000 to 6000 cusecs of storm water from Spinal drain it is expected that submergence of structures and back flow in drains would be reduced to a great extent.

6.9 Economic Justification

With the passage of time and execution of development works the natural waterways which used to provide storm water drainage in Sindh, have been completely blocked by inadequate or none crossing structures, roads, railways, irrigation canals and even surface drains. Generally, shorter reaches on all dhoras have been filled up and are being utilized for crop cultivation. Also fish ponds have been established in few non operational reaches of dhoras. However, the Government of Sindh has recently enacted legislation in this regard, and it needs to be enforced and complied with. It appears that after the unprecedented rainfall events of 2011 & 2012 there is strong political will to activate the natural waterways /dhoras to drain out storm water.

Table-3 indicates that a maximum of 75,757 cusecs of water are drawn from Indus River through eight major canals off taking from three barrages, which irrigate 8.589 M.Acres of land on left bank of Indus. Roughly one third of irrigation supplies to crops percolates through soil and is added to underground water. Consequently the ground water level (water table) has gone up and created water logging and salinity problems on the left bank of Indus. This problem has been further aggravated by heavy rainfall events due to global climate changes combined with inadequate or no drainage network in most of the areas.

In view of foregoing, it is imperative to provide drainage network to Leftover Areas by activation of dhoras and improve the efficiency of the existing drainage s to sustain irrigated agriculture and economic activity in the study area.

7 Hydraulic Modeling of Dhoras With HEC-RAS

7.1 Introduction

As a result of high rainfall during the monsoon 2011 in Sindh and looking at the existing drainage facilities in the province, the need for additional facilities to cater for the removal of excess flood water was felt. It was also seen that the natural waterways (dhoras) where ever were in good shape helped a lot in disposal of quick storm water from the area. A survey was thus carried out to look into the prospect of utilizing these waterways in case a more than normal rainfall again occurs in the area. The survey through satellite images and field visits showed a number of dhora systems present in the study area which if revived could be very beneficial in the quick disposal of storm water from the area.

7.2 Natural waterways (dhoras) system in the area:

The first task after the heavy monsoon of 2011 was the identification of the natural waterways (dhoras) systems. These systems have been in place since centuries but have been disturbed in the name of development from time to time. A comprehensive survey was carried out in the area to look into the areas where the rainwater converged. This was a difficult task but was amicably done with the help of satellite images and field visits to the areas which were under water for a long time.

Table 7.1 shows the names of dhora systems found in the area with names and lengths of sub-dhoras identified within each system. These systems are actually the drainage basins or watersheds within the whole area. The drainage basins identified are Puran, Hakro, Central, Khairpur and Ghotki systems. The length of the each system vary and the total length of whole structure is 1406 km.

As the drainage system comprised of a very large area with large number of smaller sub-systems, it was decided to do the hydraulic analysis of some of these drainage basins to ascertain the workability of the whole system.

Table 7.1: The dhoras in the area with their individual lengths.

Name of the system	Dhoras identified within the system	Length (km)
Puran	Main Puran	185
	Sohni	205
	Dighri	20
	Pangrio	35
	Bhai Khan	147
	Luhano	99.3
Hakro	Pithoro / Hiral	35
	Naro	29
	Hakro	83
Central	Miranpur-Bachal Rahu	173
	Kandiaro – Moro	98.5
Khairpur	Hussainabad-Mehrabpur	166.6
	Nangreja-Talpur Wada	43.5
Ghotki	Karo Naro	82.9
	Lakhwar	62
	Gurhelo	74.0
	Rainee	109.5
Talhar	Talhar- Kadhan	85
	Total	**1733**

7.3 Dhoras Modeled:

Four dhoras were carefully selected to be modeled in the HEC-RAS software for the hydraulic analysis.

Table **7. 2** lists the dhoras with their lengths in reduced distance (RD) as well as the length that has been modeled.

Table 7. 2: The total lengths and the lengths of dhoras modeled.

Dhoro	Total Length (RDs)	Modeled Length (RDs)
Pithoro	90	90
Hakro	273	273
Nabisar	49	49
Puran	606	212
Total		**624**

The four dhoras that were selected are Pithoro, Hakro, Nabisar and Puran with a combined length of 624 RDs. A complete field survey was carried out in each of these dhoras at 5 RDs or less. The survey included the cross sections of these dhoras as well as any structures built across or beside it. It may be mentioned here that the cross sections of the channels as an input are the pre-requisites of the software. The cross sections of the dhoras were surveyed after every 5 RDs or less. The sites wherever there was some abrupt change in width of the channel or in curvature were considered.

Table 7. 3: The number of cross sections of each dhora modeled.

Dhoro	No. of cross sections modeled
Pithoro	24
Hakro	74
Nabisar	18
Puran	57
Total	**173**

Table 7. **3** shows the number of cross sections modeled in each of the drainage basin. In all 173 cross sections of the four basins were surveyed and modeled in the software. Similarly Table7.4 shows the exact RD in each of the basin where the cross sections were taken and input into the software for the hydraulic analysis.

These cross sections showed the variation in quality of the drain at various places. At some places the drain was in a good shape to carry out a large amount of the storm water whereas at many other sections it was found to be in a very poor shape.

Table7.4: The number of the RD at which cross section is modeled for each dhora.

	Dhoro	RD		Dhoro	RD		Dhoro	RD		Dhoro	RD		Dhoro	RD
1	Pithoro	90+427	36	Nabisar	15+883	71	Hakro	159+095	106	Hakro	20+689	141	Puran	242+524
2	Pithoro	88+787	37	Nabisar	13+778	72	Hakro	154+990	107	Hakro	17+674	142	Puran	239+159
3	Pithoro	83+682	38	Nabisar	11+684	73	Hakro	149+205	108	Hakro	14+554	143	Puran	235+739
4	Pithoro	80+257	39	Nabisar	9+696	74	Hakro	144+670	109	Hakro	13+532	144	Puran	229+146
5	Pithoro	77+337	40	Nabisar	6+855	75	Hakro	139+980	110	Hakro	12+393	145	Puran	226+896
6	Pithoro	74+637	41	Nabisar	4+894	76	Hakro	134+840	111	Hakro	11+370	146	Puran	224+254
7	Pithoro	74+007	42	Nabisar	1+903	77	Hakro	130+360	112	Hakro	8+201	147	Puran	217+619
8	Pithoro	69+997	43	Hakro	273+770	78	Hakro	125+930	113	Hakro	7+008	148	Puran	215+313
9	Pithoro	66+452	44	Hakro	273+260	79	Hakro	121+770	114	Hakro	5+195	149	Puran	211+202
10	Pithoro	63+347	45	Hakro	270+350	80	Hakro	118+700	115	Hakro	3+531	150	Puran	207+882
11	Pithoro	59+212	46	Hakro	267+370	81	Hakro	111+870	116	Hakro	0+199	151	Puran	203+167
12	Pithoro	54+842	47	Hakro	262+570	82	Hakro	108+320	117	Puran	322+882	152	Puran	199+115
13	Pithoro	49+347	48	Hakro	259+235	83	Hakro	104+720	118	Puran	319+687	153	Puran	194+569
14	Pithoro	43+787	49	Hakro	255+550	84	Hakro	99+040	119	Puran	317+381	154	Puran	189+346
15	Pithoro	37+637	50	Hakro	251+700	85	Hakro	93+170	120	Puran	313+974	155	Puran	187+101
16	Pithoro	34+637	51	Hakro	246+170	86	Hakro	87+670	121	Puran	312+083	156	Puran	185+715
17	Pithoro	29+852	52	Hakro	242+400	87	Hakro	81+550	122	Puran	311+017	157	Puran	181+509
18	Pithoro	24+187	53	Hakro	237+540	88	Hakro	74+550	123	Puran	306+944	158	Puran	178+972
19	Pithoro	22+787	54	Hakro	233+680	89	Hakro	71+920	124	Puran	305+462	159	Puran	175+467
20	Pithoro	16+172	55	Hakro	230+900	90	Hakro	68+170	125	Puran	303+701	160	Puran	170+893
21	Pithoro	12+837	56	Hakro	226+030	91	Hakro	62+445	126	Puran	300+510	161	Puran	164+979
22	Pithoro	9+152	57	Hakro	220+920	92	Hakro	57+920	127	Puran	295+180	162	Puran	160+604
23	Pithoro	4+852	58	Hakro	215+020	93	Hakro	53+640	128	Puran	290+138	163	Puran	157+836
24	Pithoro	2+697	59	Hakro	210+670	94	Hakro	49+570	129	Puran	289+206	164	Puran	154+294
25	Nabisar	49+000	60	Hakro	206+465	95	Hakro	46+530	130	Puran	285+848	165	Puran	152+328
26	Nabisar	44+796	61	Hakro	201+940	96	Hakro	44+250	131	Puran	282+442	166	Puran	149+778
27	Nabisar	41+725	62	Hakro	196+830	97	Hakro	41+870	132	Puran	279+739	167	Puran	145+654
28	Nabisar	36+091	63	Hakro	191+265	98	Hakro	41+000	133	Puran	276+211	168	Puran	141+071
29	Nabisar	32+358	64	Hakro	185+550	99	Hakro	39+805	134	Puran	272+659	169	Puran	135+754
30	Nabisar	29+831	65	Hakro	181+670	100	Hakro	36+330	135	Puran	266+903	170	Puran	123+009
31	Nabisar	26+551	66	Hakro	178+760	101	Hakro	33+831	136	Puran	263+817	171	Puran	117+254
32	Nabisar	24+974	67	Hakro	175+770	102	Hakro	31+597	137	Puran	259+654	172	Puran	112+017
33	Nabisar	22+065	68	Hakro	171+050	103	Hakro	29+613	138	Puran	255+454	173	Puran	110+000
34	Nabisar	18+973	69	Hakro	167+270	104	Hakro	24+404	139	Puran	250+023			
35	Nabisar	17+758	70	Hakro	162+170	105	Hakro	22+779	140	Puran	243+987			

As an example two sections are shown here. Figure 7.1 shows the cross of Nabisar Dhoro at RD 29+831 and Figure 7. **2** shows the cross section of Hakro Dhoro at RD 33+831. These two cross sections are miles apart as far as the quality of the drain to carry out storm water is concerned.

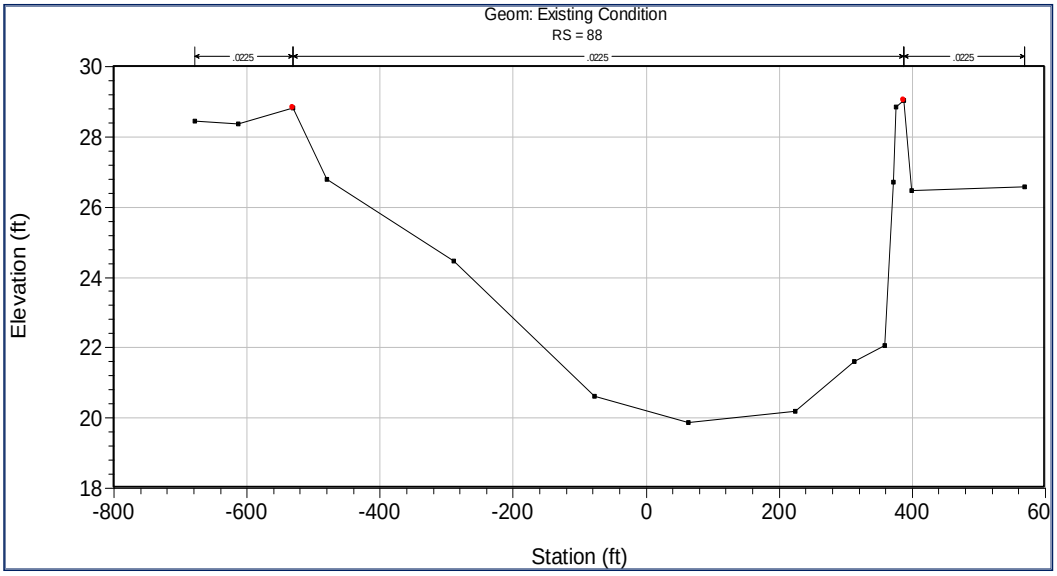


Figure 7.1: Cross section of Nabisar Dhoro at RD 29+831.

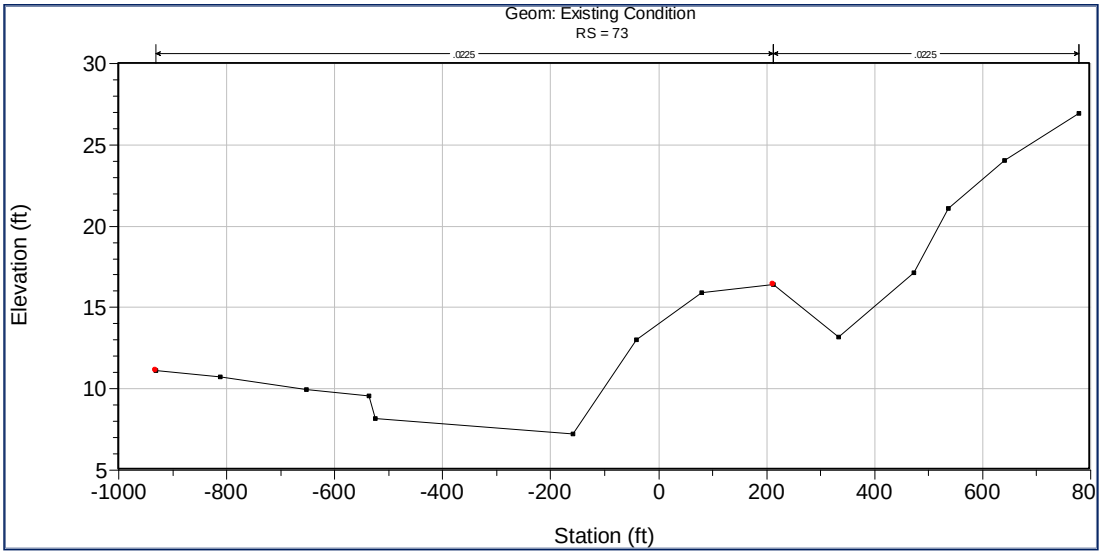


Figure 7. 2: Cross section of Hakro Dhoro at RD 33+831.

The first cross section shows the ability of the drain to carry good amount of storm water whereas the second shows a silted up section, not able to carry much water in it. An analysis was carried out to ascertain the ability of the dhoras to carry the storm water in its existing condition. A design discharge of 20 year return period is selected for the analysis.

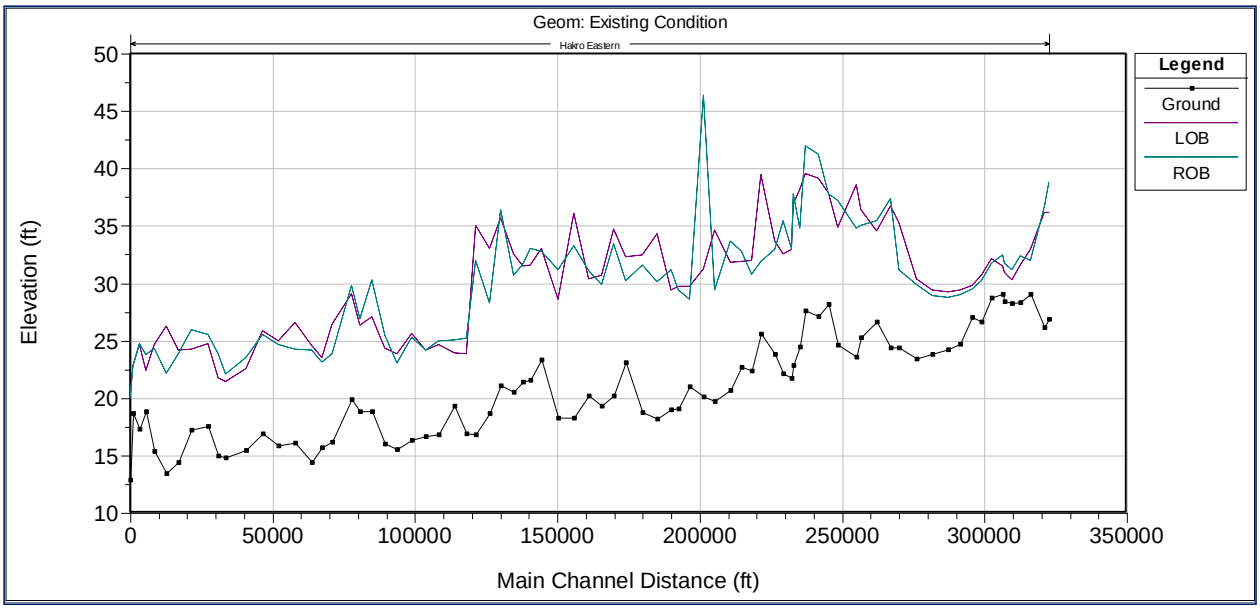


Figure 7. 3: Longitudinal section of Pithoro and Hakro Dhoras.

Figure 7. **3** shows the longitudinal section of the Pithoro and Hakro Dhoras with the lowest bed levels and the two bank/ground levels. It can be seen that the dhoras are silted up or have been filled up by the local people at various places and these are the vulnerable sections which create hindrances in the flow of water and need urgent attention.

7.4 Hydraulic analysis for existing condition:

Hydraulic analysis for existing condition of the dhoras is done. The purpose was to see if these dhoras are able to carry out the storm water as intended during a high rainfall event. Table 7. 5 shows the discharge calculated in various dhoras as a result of rainfall of 20 years return period. The hydraulic analysis of the dhoras was done with these discharges.

Table 7. 5: Design discharges for various dhoras

Dhoro	RD	Discharge (cusecs)
Pithoro/Hiral	Complete	**1675**
Nabisar	Complete	**1400**
Hakro	273+383	2685
	0+000	**3686**
Puran	324 to 242	7535
	242 to 110	**10525**

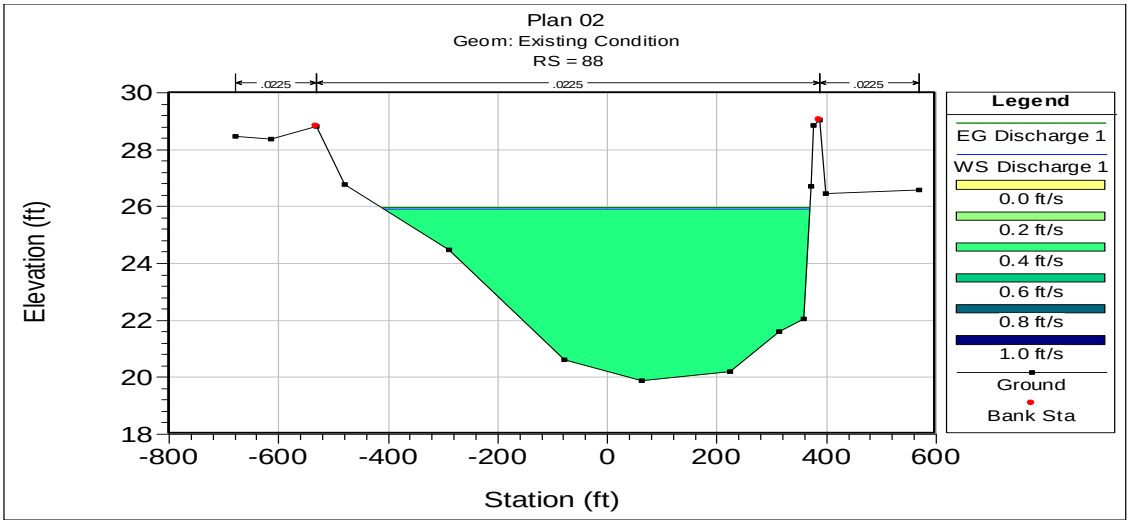


Figure 7.4: Existing cross section of Nabisar Dhoro at RD 29+831 with a discharge of 1400 cusecs.

Figure 7.4 shows the section of Nabisar Dhoro at RD 29+831 with the discharge of 1400 cusecs flowing inside it. It is clearly seen that the water is well within the boundaries of the channel and is flowing with a good velocity. This is a good section as discussed earlier and this is confirmed by looking at the results.

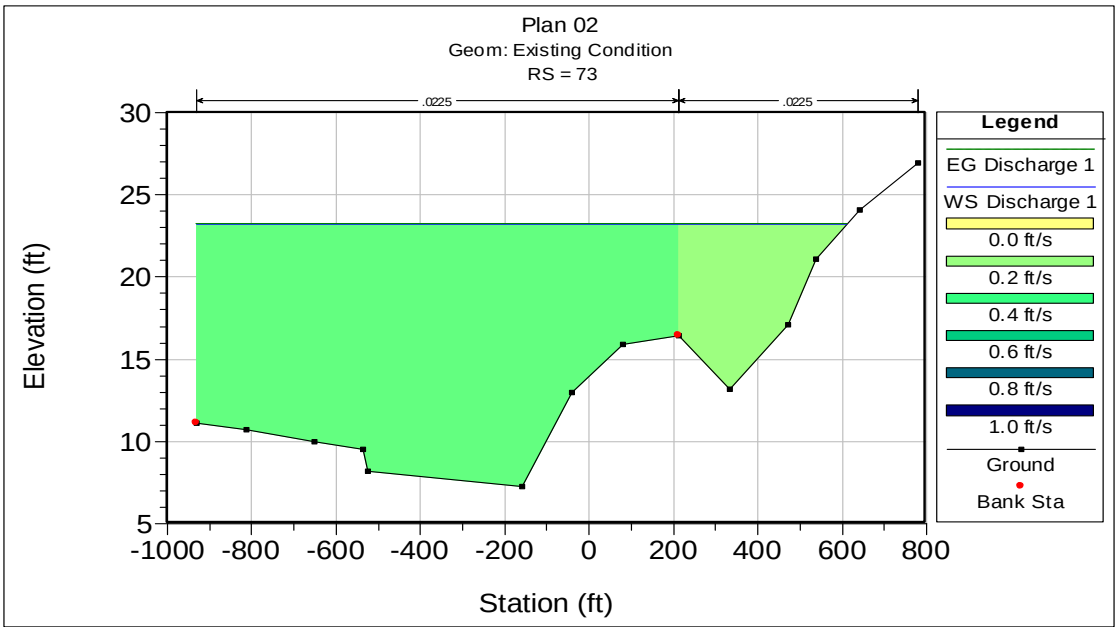


Figure 7. 5: Existing cross section of Hakro Dhoro at RD 33+831 with a discharge of 5085 cusecs.

Figure 7. 5 shows the section of Hakro Dhoro at RD 33+831 with the discharge of 5085 cusecs flowing inside it. It is clearly seen that the water is not flowing well within the boundaries of the channel and is found to be overflowing on the left bank. An embankment needs to be constructed along this section so as to convey the storm water within the channel.

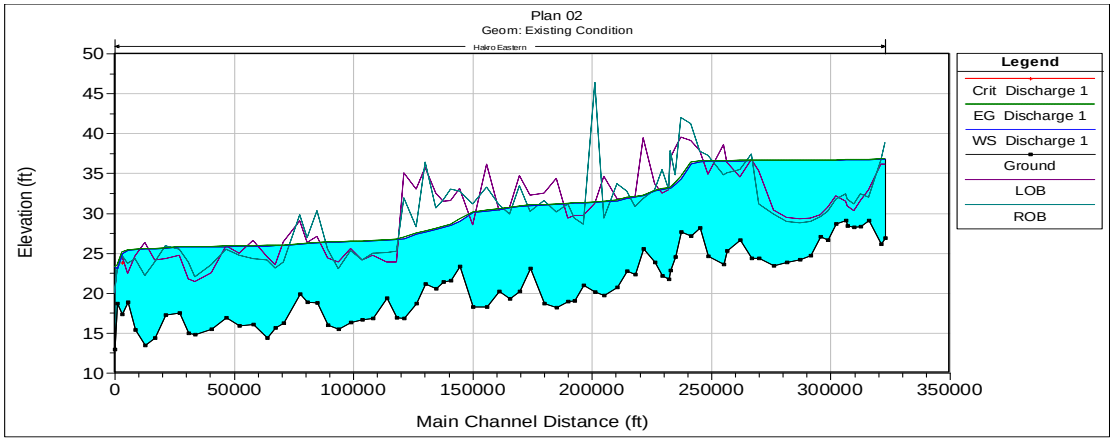


Figure 7. 6: Existing longitudinal cross section of Pithoro and Hakro Dhoras with design discharge.

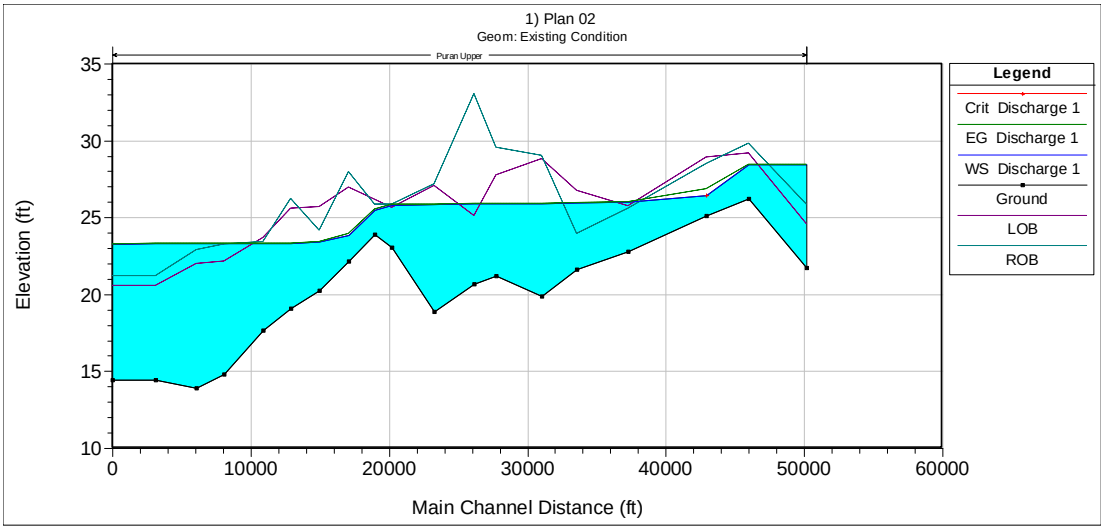


Figure 7. 7: Existing longitudinal cross section of Nabisar Dhoro with design discharge.

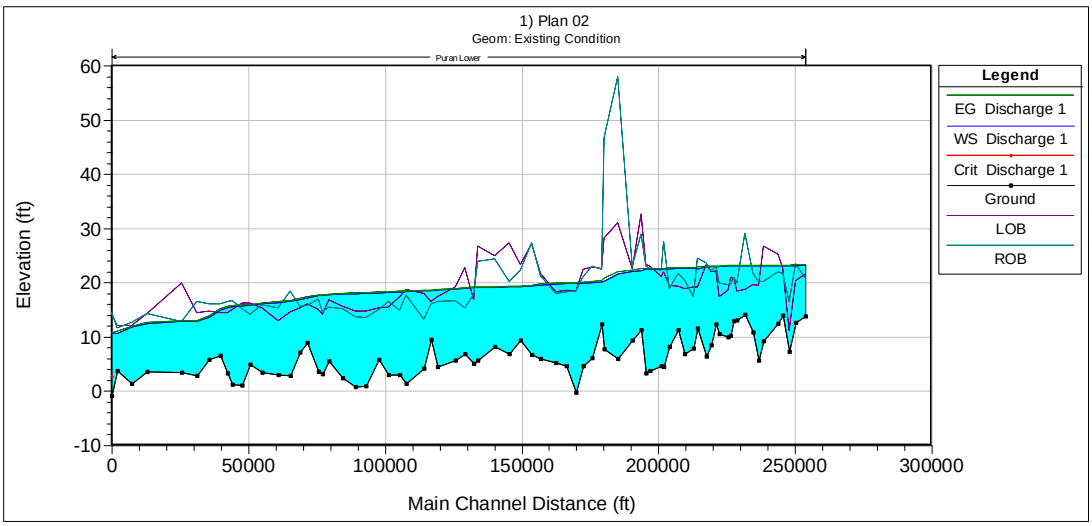


Figure 7.8: Existing longitudinal cross section of Puran Dhoro with design discharge.

Figure 7. **6**, 7.7 and 7.8 show the longitudinal sections of all the four dhoras with their respective design discharges. It can be seen that the dhoras are not able to carry the design discharges and are found to be overflowing are various sections along their path.

7.5 Hydraulic analysis for proposed channels:

Hydraulic analysis for proposed channels the dhoras is done. The purpose was to see if these dhoras will be able to carry out the storm water as intended during a high rainfall event i.e. for a flood of 20 year return period.

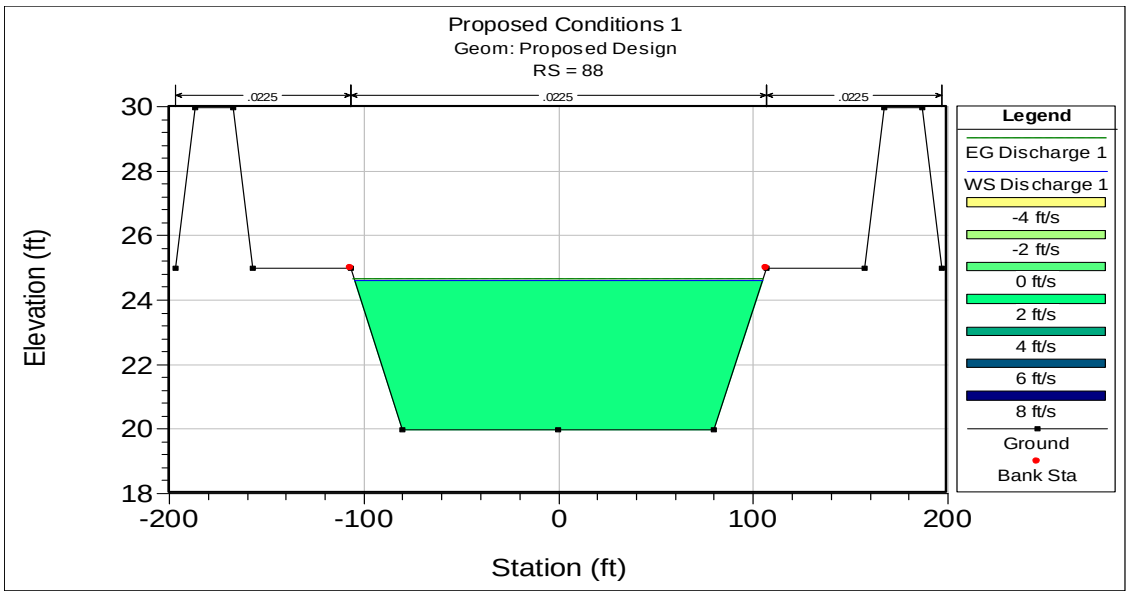


Figure 7.9: Proposed cross section of Nabisar Dhoro at RD 29+831 with a discharge of 1400 cusecs.

Figure 7.9 shows the section of Nabisar Dhoro at RD 29+831 with the discharge of 1400 cusecs flowing inside it. It is clearly seen that the water is well within the boundaries of the channel and is flowing with a good velocity. This is a good section as discussed earlier and this is confirmed by looking at the results.

Figure 7.10 shows the section of Hakro Dhoro at RD 33+831 with the discharge of 5085 cusecs flowing inside it. It is clearly seen that the water is flowing well within the boundaries of the channel unlike the section of the existing condition when it was found to be overflowing on the left bank.

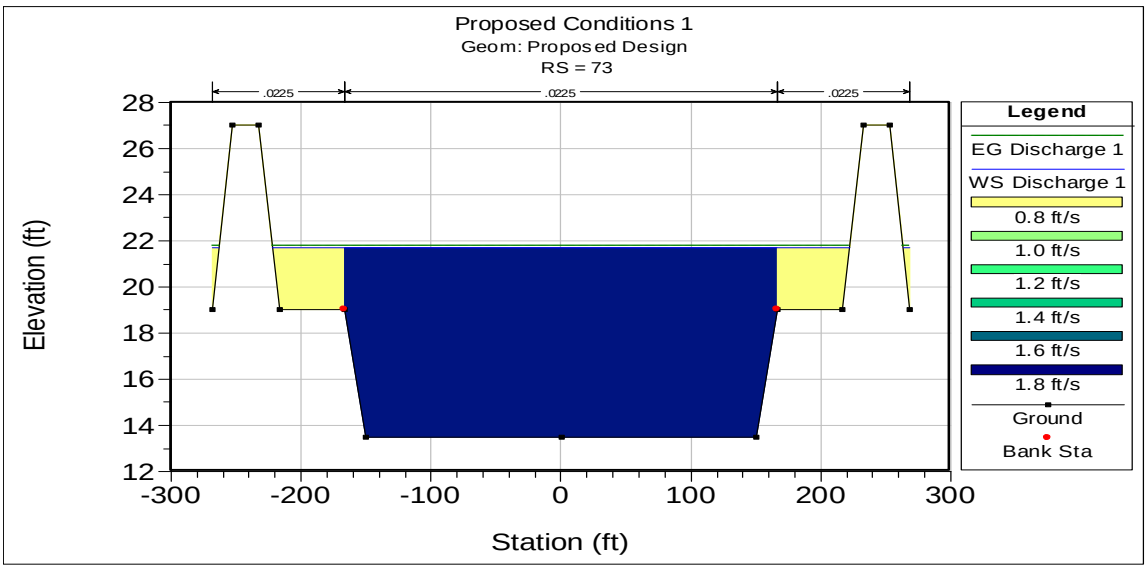


Figure 7.10: Proposed cross section of Hakro Dhoro at RD 33+831 with a discharge of 5085 cusecs.

Figure 7.11, 7.12 and 7.13 show the longitudinal sections of all the four dhoras with their respective design discharges. It can be seen that the dhoras are able to carry the design discharges and are found to be flowing within their boundaries.

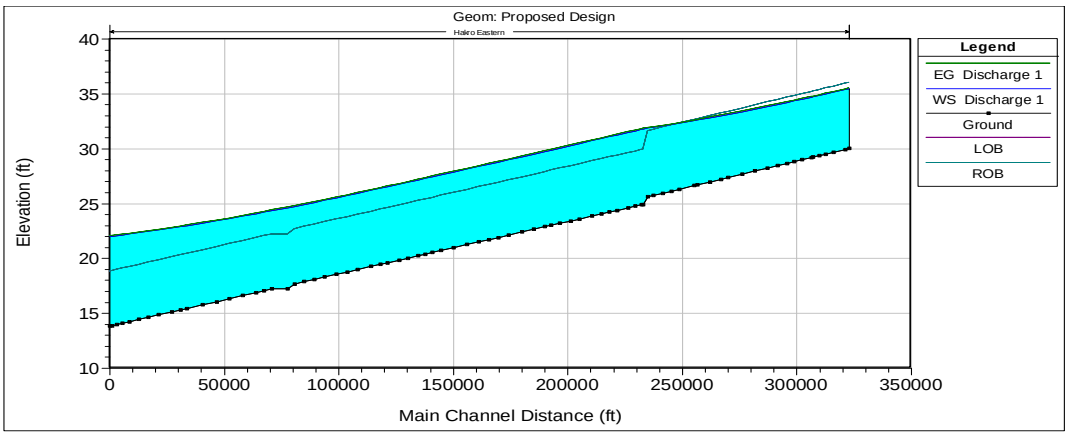


Figure 7.11: Proposed longitudinal cross section of Pithoro and Hakro Dhoras with design discharge.

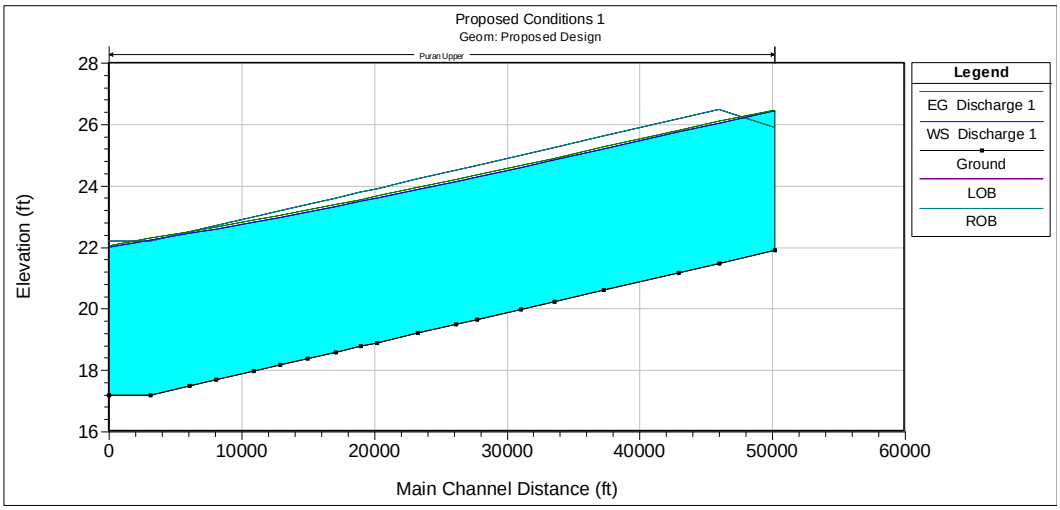


Figure 7.12: Proposed longitudinal cross section of Nabisar Dhoro with design discharge.

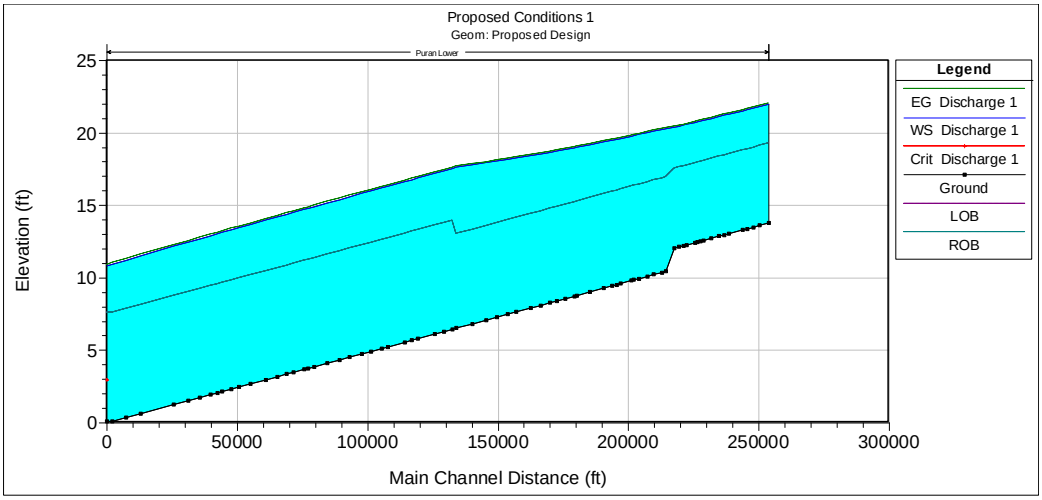


Figure 7.13: Proposed longitudinal cross section of Puran Dhoro with design discharge.

The hydraulic analysis for the following parameters was done with the help of the software:

- Minimum channel elevation
- Water surface elevation
- Energy grade line slope
- Average velocity of flow
- Cross sectional area of flow
- Top width of flow
- Froude number
- Hydraulic radius
- Wetted perimeter
- Maximum flow depth

7.6 Analysis of results:

Figure 7.14 shows the Free board available below the top of the bank of the proposed channel inside Dhoro Puran from RD 322+882 to RD 110+000. It can be seen that there is a clear free board of four to six feet is available throughout the whole length of the channel. The availability of the free board shows that the channel is flowing well below the top of the banks and will be able to accommodate additional storm water in case of higher rainfall events.

Figure 7.15 shows the depth of water in the proposed channel inside Dhoro Puran from RD 322+882 to RD 110+000. The depth is found to be around 10 to 11 feet. The rise in the water depth in the upstream part is due to the addition of water in the channel from Bhai Khan Dhoro and then it starts to recede.

Figure 7.16 shows the top width of water in the proposed channel inside Dhoro Puran from RD 322+882 to RD 110+000. This is an important parameter for the design of the open channels and is thus analysed here as well.

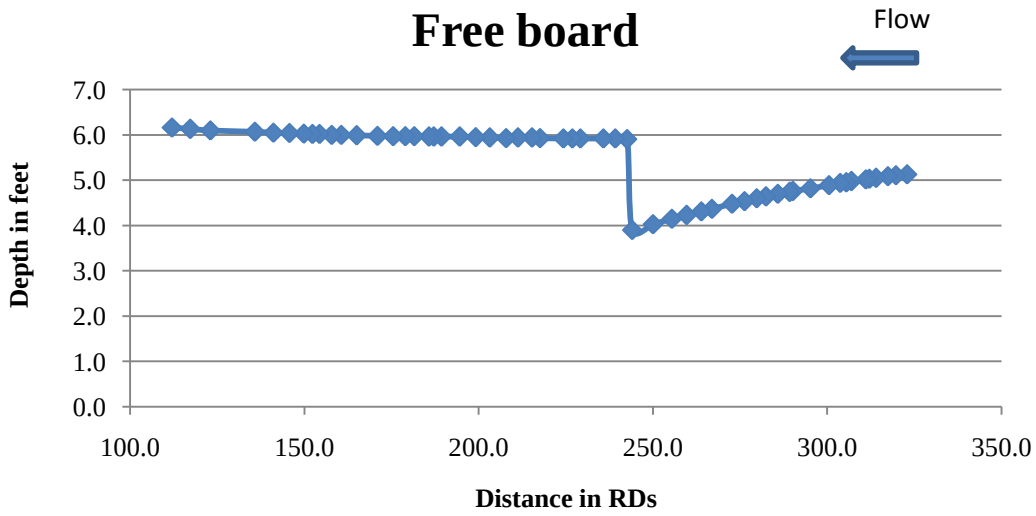


Figure 7.14: Free board available below the top of the bank of the proposed channel inside Dhoro Puran from RD 322+882 to RD 110+000.

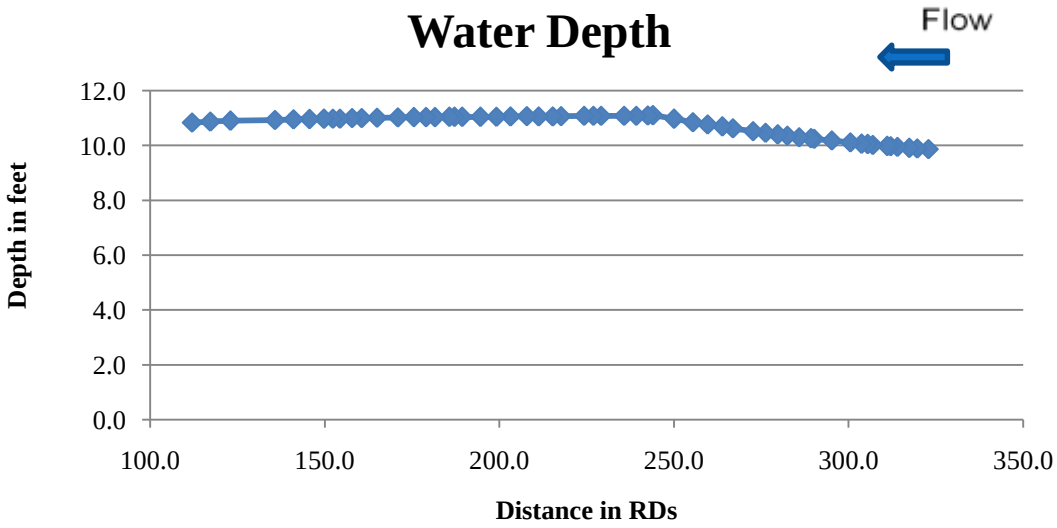


Figure 7.15: Water depth of the proposed channel inside Dhoro Puran from RD 322+882 to RD 110+000.

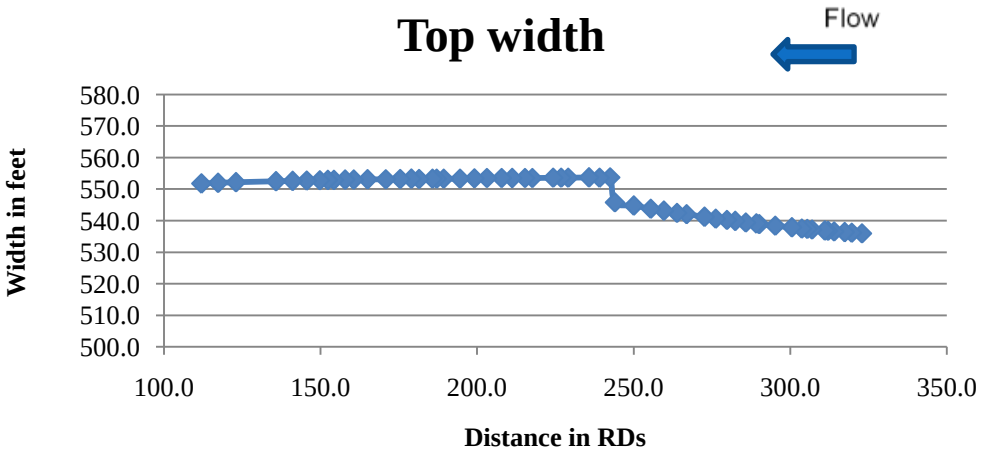


Figure 7.16: Top width of the proposed channel inside Dhoro Puran from RD 322+882 to RD 110+000.

7.7 Conclusions:

The following conclusions are drawn in the light of the above analysis:

- There is great potential of conveyance / disposal of flood water through the revival of natural waterways (dhoras).
- At some of the places these dhoras are in good shape and can be utilized efficiently.
- In some sections these dhoras have silted up / filled up and need to be cleared.
- Some sections specially the ones passing through towns have been encroached upon and may be reconstructed bypassing the town.
- Some of these dhoras have been blocked by irrigation canals where additional hydraulic structures such as siphons / Aquiducts may be constructed.

CHAPTER-8 ECONOMIC ANALYSIS

8 Economic Analysis

8.1 General

The main purpose of the economic evaluation is to assess the viability of the project from the viewpoint of the national development strategy. In this context, the economic viability measured in terms of Internal Economic Rate of Return (IERR), and Net Present Value (NPV) provides an appraisal of the project's capacity to maximize the efficient use of nation's resources in generating economic growth. The following methodology has been followed in carrying out the economic evaluation.

8.2 Economic Life of Project

The economic life of the project has been assumed at 50 years after the completion of the project. The intervention will generate significant quantifiable and non quantifiable benefits. A preliminary assessment of the anticipated benefits is presented in with and without intervention analytical framework. The results of financial and economic assessment are as follows:

8.3 Standard conversion Factor

The standard conversion factor (SCF) represents the ration of prices of all goods within the economy to their international prices. The SCF is mainly influenced by the trade policies of the Government. It is approximated by the weighted average of import and export tariffs, with subsidies excluded. The weights used are based on the magnitude of imports and exports in the total trade during the recent years.

8.4 Sensitivity Analysis

Sensitivity analysis has been undertaken to assess the impacts of possible decreases/negative effects on benefits because agricultural benefits are function of many variables like irrigation, other farm inputs, credit and agro, technology etc. similarly many elements of risks and uncertainties are uncounted at the construction and operation stages, which are likely to occur in this project as well. These elements result in increased projects costs tied with delayed construction i.e. increase in construction period. For analyzing the impact of such risks and uncertainties 3 possibly relevant scenarios have been documented as under:

1. Decrease in Benefits (10%) in project benefits
2. Increase in costs (10%) in project cost
3. Simultaneous change by (10%) in project costs and benefits

IERR and Sensitivity Analysis

No.	Scenario	NPV @12%	IERR	Switching Value
1	Base Case	14.1	24.0%	
2	Decrease in Benefits (10%)		18.4%	25.9%
3	Increase in Costs (10%)		18.9%	34.8%
4	Simultaneous Change by 10%		14.9%	14.9%

The estimated IERR has been computed at 24.0%, hence the project is economically viable. The NPV at 12% is Rs.14.1billion. The sensitivity analysis presented in the above table shows that with 10% decrease in the benefits the IERR is 18.4 % while with 10% increase in the cost the IERR is about 18.9%. Both of these are above 12%. The simultaneous 10% decrease in benefits and increase in cost suggests the IERR is still above 12%, hence is robust.
The switching value indicate that if the benefits decrease by 25.9%, and costs increase by 34.8%, while even if both may change by 14.9% the project will still be viable.

Combined Economic Analysis of Rehabilitation of LBOD & Revival of Natural Water Ways (Dhora's)

Without Project Damages	1	2	3	4	5	6	7	8	9	10	20	30	40	50
Agriculture	122.0	122.0	122.0	122.0	122.0	122.0	122.0	122.0	122.0	122.0	122.0	122.0	122.0	122.0
Livestock	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2
Housing	120.3	120.3	120.3	120.3	120.3	120.3	120.3	120.3	120.3	120.3	120.3	120.3	120.3	120.3
Roads	31.9	31.9	31.9	31.9	31.9	31.9	31.9	31.9	31.9	31.9	31.9	31.9	31.9	31.9
Irrigation	46.6	46.6	46.6	46.6	46.6	46.6	46.6	46.6	46.6	46.6	46.6	46.6	46.6	46.6
Health	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Education	27.4	27.4	27.4	27.4	27.4	27.4	27.4	27.4	27.4	27.4	27.4	27.4	27.4	27.4
Urban Muncipal	35.8	35.8	35.8	35.8	35.8	35.8	35.8	35.8	35.8	35.8	35.8	35.8	35.8	35.8
Government Infrastructure	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
Sub Total (Rs. Billion)	**406.7**	**406.7**	**406.7**	**406.7**	**406.7**	**406.7**	**406.7**	**406.7**	**406.7**	**406.7**	**406.7**	**406.7**	**406.7**	**406.7**
With Project Damages	1	2	3	4	5	6	7	8	9	10	20	30	40	50
Agriculture	120.1	120.1	120.1	120.1	120.1	120.1	120.1	120.1	120.1	120.1	120.1	120.1	120.1	120.1
Livestock	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1
Housing	118.5	118.5	118.5	118.5	118.5	118.5	118.5	118.5	118.5	118.5	118.5	118.5	118.5	118.5
Roads	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5
Irrigation	45.9	45.9	45.9	45.9	45.9	45.9	45.9	45.9	45.9	45.9	45.9	45.9	45.9	45.9
Health	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
Education	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0
Urban Muncipal	35.3	35.3	35.3	35.3	35.3	35.3	35.3	35.3	35.3	35.3	35.3	35.3	35.3	35.3
Government Infrastructure	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8
Sub Total (Rs. Billion)	**400.5**	**400.5**	**400.5**	**400.5**	**400.5**	**400.5**	**400.5**	**400.5**	**400.5**	**400.5**	**400.5**	**400.5**	**400.5**	**400.5**
Incremental Benefits (Rs. Billion)	6.13	6.13	6.13	6.13	6.13	6.13	6.13	6.13	6.13	6.13	6.13	6.13	6.13	6.13
Incremental Cost of LBOD	0.6	2.6	1.8	0.9	0.6	2.5								
Incremental Cost of Dhoras	3.8	3.8	3.8	3.8	3.8	3.8								
Incremental Cost of New Drains (Leftover Areas)	2.9	2.9	2.9	2.9	2.9	2.9								
Incremental Cost of Project Management	0.1	0.1	0.1	0.1	0.1	0.1								
O&M Cost	0	0	0	0	0	0	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74
Sub Total (Rs. Billion)	7.37	9.30	8.49	7.59	7.34	9.19	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74
Incremental Cash Flow	-1.24	-3.17	-2.36	-1.46	-1.21	-3.06	5.39	5.39	5.39	5.39	5.39	5.39	5.39	5.39
NPV @ 12 %	14.1													
IERR	24.0%													

LIST OF TABLES

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP) Preparation of Regional Plan for Left Bank Of Indus River, Delta & Costal Zone.

Table-1: COST SUMMARY OF DHORAS AND LOAs (M.Rs.)

.

S.No	Description	Earthwork	Structures	Civil works Cost (4+5)	Miscellaneous Unforeseen Items @10% on (5)	Sub Total (5+6)	Contingencies @ 2% on (7)	Consultancy @ 2% on (7)	Sub-Total (7+8+9)	Land Acquisition	Grand Total (10+11)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
A	**Surface Drains Left Over Areas**										
	a) T.Adam	908.06	317.82	1225.88	122.59	1348.47	26.97	26.97	1402.41	964.74	2367.16
	b) T.M.Khan	1513.12	529.59	2042.71	204.27	2246.98	44.94	44.94	2336.86	1297.15	3634.01
	c) Umarkot, Faresh and Khipro	1793.89	358.78	2152.67	215.27	2367.94	47.36	47.36	2462.65	2616.86	5079.52
	d) Digri	714.22	249.98	964.20	96.42	1060.62	21.21	21.21	1103.04	1120.28	2223.32
	e) Ghotki	2228.56	719.36	2947.92	294.79	3242.72	64.85	64.85	3372.42	287.57	3660.00
	f) South Khairpur	141.85	49.65	191.49	19.15	210.64	4.21	4.21	219.07	331.56	550.63
B	**Dhoras**										
	a) Puran i/c MPk and Jhudo Bypass	2222.13	1333.28	3555.41	355.54	3910.95	78.22	78.22	4067.38	342.97	4410.36
	b) Nabisar / Naro	178.67	107.20	285.88	28.59	314.47	6.29	6.29	327.05	0.00	327.05
	c) Hakro i/c Naukot Bypass	1439.13	1032.26	2471.39	247.14	2718.53	54.37	54.37	2827.27	39.51	2866.77
	d) Sohni	1433.44	860.06	2293.51	229.35	2522.86	50.46	50.46	2623.77	0.00	2623.77
	e) Bhai Khan i/c T.G. Ali Bypass	1899.74	1139.84	3039.58	303.96	3343.54	66.87	66.87	3477.28	33.64	3510.92
	f) Digri i/c Digri Bypass	99.90	59.94	159.83	15.98	175.82	3.52	3.52	182.85	41.16	224.01
	g) Pithoro	347.01	208.21	555.22	55.52	610.74	12.21	12.21	635.17	0.00	635.17
	h) Pangrio and Ohers	274.79	164.88	439.67	43.97	483.63	9.67	9.67	502.98	0.00	502.98
	i) Ghotki Dhoras	2228.56	1337.14	3565.69	356.57	3922.26	78.45	78.45	4079.15	287.57	4366.73
	j) South Khairpur Dhoras	1560.38	936.23	2496.60	249.66	2746.27	54.93	54.93	2856.12	105.06	2961.18
C	**LBOD Escapes i/c Weirs**	97.66	34.18	131.84	13.18	145.03	2.90	2.90	150.83	13.18	164.01
D	**Syphons**		3450								3450.00
	Total	**19081.11**	**12888.39**	**28519.50**	**2851.95**	**31371.46**	**627.43**	**627.43**	**32626.31**	**7481.26**	**43,557.6**

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)
Preparation of Regional Plan for Left Bank Of Indus River, Delta & Costal Zone.
TABLE-2: SUMMARY-PURAN DHORO

S.No.	Item Description	Source	Unit	Quantity	Rate (Rs.)	Amount (M-Rs.)
1	Jungle Clearance and removing within 100 feet. (a)Light	Item -4 (a), p- 94, S CR- 2012	% 0 S ft	21296.00	75.63	16.1
2	Earthworks excavation by by hydraulic excavator leads upto 50 ft. (b) Ordinary Soil	Item-105 (b), p-112, S CR- 2012	%0 Cft	365885.72	1748.57	639.8
3	Extra for Slush or Daldal including dewatering.	Item-16, p-4, SCR-2012	%0 Cft	292708.57	2420.00	708.4
4	Rehandling of Earth work. (b) upto a 50 ft lead.	Item-9(b), p-2, SCR-2012	%0 Cft	311002.86	1085.75	337.7
5	Extra for every 50 ft additional lead or part thereof (a) For earthwork	I te m -8 (a), p- 2, S CR- 2012	% 0 Cft	311002.86	100.87	31.4
6	Earthworks by tractor with scraper i/c compaction, dressing, leveling complete etc: in accordance to profile in ordinary soil lead upto 100 ft.	Item-104, p-112, SCR-2012	%0 Cft	237520.69	2058.13	488.8
7	Sub-Total (1+2+3+4+5+6)					2222.13
8	Structures					1333.28
9	Miscellaneous Unforeseen @ 10%					355.54
10	Land Acquisition	Total Land Required	Acre	1008.74		
	a) Urban Area (20%)	Market Rates	Acre	201.75	500000	100.87
	b) Rural Area (80%)	Market Rates	Acre	806.99	300000	242.10
11	Total (7+8+9+10)					4253.92
12	Contingencies @2%					85.08
13	Total Cost					4339.00

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)
Preparation of Regional Plan for Left Bank Of Indus River, Delta & Costal Zone.
TABLE-3: SUMMARY- HAKRO DHORO

S.No.	Item Description	Source	Unit	Quantity	Rate (Rs.)	Amount (M-Rs.)
1	Jungle Clearance and removing within 100 feet. (a)Light	Item -4 (a), p- 94, S CR- 2012	% 0 S ft	6877.34	75.63	5.2
2	Earthworks excavation by by hydraulic excavator leads upto 50 ft. (b) Ordinary Soil	Item-105 (b), p-112, S CR- 2012	%0 Cft	244165.24	1748.57	426.9
3	Extra for Slush or Daldal including dewatering.	Item-16, p-4, SCR-2012	%0 Cft	195332.19	2420.00	472.7
4	Rehandling of Earth work. (b) upto a 50 ft lead.	Item-9(b), p-2, SCR-2012	%0 Cft	207540.46	1085.75	225.3
5	Extra for every 50 ft additional lead or part thereof (a) For earthwork	I te m -8 (a), p- 2, S CR- 2012	% 0 Cft	207540.46	100.87	20. 9
6	Earthworks by tractor with scraper i/c compaction, dressing, leveling complete etc: in accordance to profile in ordinary soil lead upto 100 ft.	Item-104, p-112, SCR-2012	%0 Cft	139938.50	2058.13	288.0
7	Sub-Total (1+2+3+4+5+6)					1439.13
8	Structures					1032.26
9	Miscellaneous Unforeseen @ 10%					247.14
10	Land Acquisition	Total Land Required	Acre	116.20		
	a) Urban Area (20%)	Market Rates	Acre	23.24	500000	11.62
	b) Rural Area (80%)	Market Rates	Acre	92.96	300000	27.89
11	Total (7+8+9+10)					2758.03
12	Contingencies @2%					55.16
13	**Total Cost**					**2813.19**

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)
Preparation of Regional Plan for Left Bank Of Indus River, Delta & Costal Zone.
TABLE-4: SUMMARY-NABISAR DHORO

.No.	Item Description	Source	Unit	Quantity	Rate (Rs.)	Amount (M-Rs.)
1	Jungle Clearance and removing within 100 feet. (a)Light	Item -4 (a), p- 94, S CR- 2012	0 S ft	9920.00	75.63	7.5
2	Earthworks excavation by by hydraulic excavator leads upto 50 ft. (b) Ordinary Soil	Item-105 (b), p-112, S CR- 2012	0 Cft	16949.69	1748.57	29.6
3	Extra for Slush or Daldal including dewatering.	Item-16, p-4, SCR-2012	0 Cft	13559.76	2420.00	32.8
4	Rehandling of Earth work. (b) upto a 50 ft lead.	Item-9(b), p-2, SCR-2012	0 Cft	14407.24	1085.75	15.6
5	Extra for every 50 ft additional lead or part thereof (a) For earthwork	I te m -8 (a), p- 2, S CR- 2012	0 Cft	14407. 24	100.87	1.5
6	Earthworks by tractor with scraper i/c compaction, dressing, leveling complete etc: in accordance to profile in ordinary soil lead upto 100 ft.	Item-104, p-112, SCR- 2012	0 Cft	44518.10	2058.13	91.6
7	Sub-Total (1+2+3+4+5+6)					178.67
8	Structures					107.20
9	Miscellaneous Unforeseen @ 10%					28.59
10	Land Acquisition	Total Land Required	cre	0.00		
	a) Urban Area (20%)	Market Rates	cre	0.00	500000	0.00
	b) Rural Area (80%)	Market Rates	cre	0.00	300000	0.00
11	Total (7+8+9+10)					314.47
12	Contingencies @2%					6.29
13	Total Cost					320.76

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)
Preparation of Regional Plan for Left Bank Of Indus River, Delta & Costal Zone.
TABLE-5: SUMMARY-PITHORO DHORO

S.No.	Item Description	Source	Unit	Quantity	Rate (Rs.)	Amount (M-Rs.)
1	Jungle Clearance and removing within 100 feet. (a)Light	Item -4 (a), p- 94, S CR- 2012	% 0 S ft	1808.54	75. 63	1.4
2	Earthworks excavation by by hydraulic excavator leads upto 50 ft. (b) Ordinary Soil	Item-105 (b), p-112, S CR- 2012	%0 Cft	50934.94	1748.57	89.1
3	Extra for Slush or Daldal including dewatering.	Item-16, p-4, SCR-2012	%0 Cft	40747.95	2420.00	98.6
4	Rehandling of Earth work. (b) upto a 50 ft lead.	Item-9(b), p-2, SCR-2012	%0 Cft	43294.70	1085.75	47.0
5	Extra for every 50 ft additional lead or part thereof (a) For earthwork	I te m -8 (a), p- 2, S CR- 2012	% 0 Cft	43294. 70	100.87	4.4
6	Earthworks by tractor with scraper i/c compaction, dressing, leveling complete etc: in accordance to profile in ordinary soil lead upto 100 ft.	Item-104, p-112, SCR-2012	%0 Cft	51792.53	2058.13	106.6
7	Sub-Total (1+2+3+4+5+6)					347.01
8	Structures					208.21
9	Miscellaneous Unforeseen @ 10%					55.52
10	Land Acquisition	Total Land Required	Acre	0.00		
	a) Urban Area (20%)	Market Rates	Acre	0.00	500000	0.00
	b) Rural Area (80%)	Market Rates	Acre	0.00	300000	0.00
11	Total (7+8+9+10)					610.74
12	Contingencies @2%					12.21
13	**Total Cost**					**622.95**

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)
Preparation of Regional Plan for Left Bank Of Indus River, Delta & Costal Zone.
TABLE-6: SUMMARY- SOHNI DHORO

S.No.	Item Description	Source	Unit	Quantity	Rate (Rs.)	Amount (M-Rs.)
1	Jungle Clearance and removing within 100 feet. (a)Light	Item -4 (a) , p-94, S CR- 2012	% 0 S ft	15340.00	75.63	11. 6
2	Earthworks excavation by by hydraulic excavator leads upto 50 ft. (b) Ordinary Soil	Item-105 (b), p-112, S C R - 2 01 2	%0 Cft	250483.77	1748.57	438.0
3	Extra for Slush or Daldal including dewatering.	Item-16, p-4, SCR-2012	%0 Cft	200387.02	2420.00	484.9
4	Rehandling of Earth work. (b) upto a 50 ft lead.	Item-9(b), p-2, SCR-2012	%0 Cft	212911.20	1085.75	231.2
5	Extra for every 50 ft additional lead or part thereof (a) For earthwork	Ite m - 8 (a) , p-2, S CR- 2012	% 0 Cft	2 129 1 1. 20	100.87	21. 5
6	Earthworks by tractor with scraper i/c compaction, dressing, leveling complete etc: in accordance to profile in ordinary soil lead upto 100 ft.	Item-104, p-112, SCR-2012	%0 Cft	119657.20	2058.13	246.3
7	Sub-Total (1+2+3+4+5+6)					1433.44
8	Structures					860.06
9	Miscellaneous Unforeseen @ 10%					229.35
10	Land Acquisition	Total Land Required	Acre	0.00		
	a) Urban Area (20%)	Market Rates	Acre	0.00	500000	0.00
	b) Rural Area (80%)	Market Rates	Acre	0.00	300000	0.00
11	Total (7+8+9+10)					2522.86
12	Contingencies @2%					50.46
13	**Total Cost**					**2573.31**

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)
Preparation of Regional Plan for Left Bank Of Indus River, Delta & Costal Zone.
TABLE-7: SUMMARY-BHAI KHAN DHORO

S.No.	Item Description	Source	Unit	Quantity	Rate (Rs.)	Amount (M-Rs.)
1	Jungle Clearance and removing within 100 feet. (a)Light	Item -4 (a), p- 94, S CR- 2012	% 0 S ft	9399.98	75.63	7.1
2	Earthworks excavation by by hydraulic excavator leads upto 50 ft. (b) Ordinary Soil	Item-105 (b), p-112, S CR- 2012	%0 Cft	354528.52	1748.57	619.9
3	Extra for Slush or Daldal including dewatering.	Item-16, p-4, SCR-2012	%0 Cft	283622.81	2420.00	686.4
4	Rehandling of Earth work. (b) upto a 50 ft lead.	Item-9(b), p-2, SCR-2012	%0 Cft	301349.24	1085.75	327.2
5	Extra for every 50 ft additional lead or part therof (a) For earthwork	Item -8 (a), p- 2, S CR- 2012	% 0 Cft	301349.24	100.87	30. 4
6	Earthworks by tractor with scraper i/c compaction, dressing, leveling complete etc: in accordance to profile in ordinary soil lead upto 100 ft.	Item-104, p-112, SCR-2012	%0 Cft	111148.45	2058.13	228.8
7	Sub-Total (1+2+3+4+5+6)					1899.74
8	Structures					1139.84
9	Miscellaneous Unforeseen @ 10%					303.96
10	Land Acquisition	Total Land Required	Acre	98.94		
	a) Urban Area (20%)	Market Rates	Acre	19.79	500000	9.89
	b) Rural Area (80%)	Market Rates	Acre	79.15	300000	23.75
11	Total (7+8+9+10)					3377.18
12	Contingencies @2%					67.54
13	**Total Cost**					**3444.72**

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)
Preparation of Regional Plan for Left Bank Of Indus River, Delta & Costal Zone.
TABLE-8: SUMMARY-DIGRI DHORO

S.No.	Item Description	Source	Unit	Quantity	Rate (Rs.)	Amount (M-Rs.)
1	Jungle Clearance and removing within 100 feet. (a)Light	Ite m -4 (a), p- 94, S CR- 2012	% 0 S ft	1980.92	7 5 . 63	1 . 5
2	Earthworks excavation by by hydraulic excavator lead upto 50 ft. (b) Ordinary Soil	Item-105 (b), p-112, S CR- 2012	%0 Cft	10694.12	1748.57	18.7
3	Extra for Slush or Daldal including dewatering.	Item-16, p-4, SCR-2012	%0 Cft	8555.29	2420.00	20.7
4	Rehandling of Earth work. (b) upto a 50 ft lead.	Item-9(b), p-2, SCR-2012	%0 Cft	9090.00	1085.75	9.9
5	Extra for every 50 ft additional lead or part therof (a) For earthwork	I te m -8 (a), p- 2, S CR- 2012	% 0 Cft	9090.00	1 0 0 .8 7	0 . 9
6	Earthworks by tractor with scraper i/c compaction, dressing, leveling complete etc: in accordance to profile in ordinary soil lead upto 100 ft.	Item-104, p-112, SCR-2012	%0 Cft	23423.05	2058.13	48.2
7	Sub-Total (1+2+3+4+5+6)					99.90
8	Structures					59.94
9	Miscellaneous Unforeseen @ 10%					15.98
10	Land Acquisition	Total Land Required	Acre	121.05		
	a) Urban Area (20%)	Market Rates	Acre	24.21	500000	12.11
	b) Rural Area (80%)	Market Rates	Acre	96.84	300000	29.05
11	Total (7+8+9+10)					216.97
12	Contingencies @2%					4.34
13	Total Cost					221.31

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)
Preparation of Regional Plan for Left Bank Of Indus River, Delta & Costal Zone.
TABLE-9: SUMMARY-PANGRIO AND OTHER DHORAS

S.No.	Item Description	Source	Unit	Quantity	Rate (Rs.)	Amount (M-Rs.)
1	Jungle Clearance and removing within 100 feet. (a)Light	Item -4 (a), p- 94, SCR-2012	% 0 S f t	4 172 .00	7 5 . 6 3	3 . 2
2	Earthworks excavation by hydraulic excavator leads upto 50 ft. (b) Ordinary Soil	Item-105 (b), p-112, S CR- 2012	%0 Cft	28940.00	1748.57	50.6
3	Extra for Slush or Daldal including dewatering.	Item-16, p-4, SCR-2012	% 0 Cft	23 152.00	2420.00	56.0
4	Rehandling of Earth work. (b) upto a 50 ft lead.	Item-9(b), p-2, SCR-2012	%0 Cft	24599.00	1 0 85.75	26.7
5	Extra for every 50 ft additional lead or part therof (a) For earthwork	I te m -8 (a), p- 2, SCR-2012	% 0 Cft	24599.00	1 0 0 . 8 7	2 . 5
6	Earthworks by tractor with scraper i/c compaction, dressing, leveling complete etc: in accordance to profile in ordinary soil lead upto 100 ft.	Item-104, p-112, SCR-2012	% 0 Cft	65990.00	2 0 58.13	135.8
7	Sub-Total (1+2+3+4+5+6)					274.79
8	Structures					164.88
9	Miscellaneous Unforeseen @ 10%					43.97
10	Land Acquisition	Total Land Required	Acre	0.00		
	a) Urban Area (20%)	Market Rates	Acre	0.00	500000	0.00
	b) Rural Area (80%)	Market Rates	Acre	0.00	300000	0.00
11	Total (7+8+9+10)					483.63
12	Contingencies @2%					9.67
13	Total Cost					493.31

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)
Preparation of Regional Plan for Left Bank Of Indus River, Delta & Costal Zone.
TABLE-10: SUMMARY-GHOTKI DHORAS

S.No.	Item Description	Source	Unit	Quantity	Rate (Rs.)	Amount (M-Rs.)
1	Jungle Clearance and removing within 100 feet. (a)Light	Ite m -4 (a), p- 94, S CR- 2012	% 0 S ft	1550.6 1	7 5 . 6 3	1.2
2	Earthworks excavation by by hydraulic excavator lead upto 50 ft. (b) Ordinary Soil	Item-105 (b), p-112, S CR- 2012	%0 Cft	310179.65	1748.57	542.4
3	Extra for Slush or Daldal including dewatering.	Item-16, p-4, SCR-2012	%0 Cft	248143.72	2420.00	600.5
4	Rehandling of Earth work. (b) upto a 50 ft lead.	Item-9(b), p-2, SCR-2012	%0 Cft	263652.70	1085.75	286.3
5	Extra for every 50 ft additional lead or part thereof (a) For earthwork	I te m -8 (a), p- 2, S CR- 2012	% 0 Cft	263652.70	1 0 0 .8 7	2 6 . 6
6	Earthworks by tractor with scraper i/c compaction, dressing, leveling complete etc: in accordance to profile in ordinary soil lead upto 100 ft.	Item-104, p-112, SCR-2012	%0 Cft	374928.79	2058.13	771.7
7	Sub-Total (1+2+3+4+5+6)					2228.56
8	Structures					1337.14
9	Miscellaneous Unforeseen @ 10%					356.57
10	Land Acquisition	Total Land Required	Acre	845.80		
	a) Urban Area (20%)	Market Rates	Acre	169.16	500000	84.58
	b) Rural Area (80%)	Market Rates	Acre	676.64	300000	202.99
11	Total (7+8+9+10)					4209.84
12	Contingencies @2%					84.20
13	Total Cost					4294.03

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)
Preparation of Regional Plan for Left Bank Of Indus River, Delta & Costal Zone.
TABLE-11: SUMMARY-SOUTH KHAIRPUR DHORAS

S.No.	Item Description	Source	Unit	Quantity	Rate (Rs.)	Amount (M-Rs.)
1	Jungle Clearance and removing within 100 feet. (a)Light	Item -4 (a), p- 94, S CR- 2012	% 0 S ft	20315. 35	75.63	15. 4
2	Earthworks excavation by hydraulic excavator leads upto 50 ft. (b) Ordinary Soil	Item-105 (b), p-112, S CR- 2012	%0 Cft	225940.05	1748.57	395.1
3	Extra for Slush or Daldal including dewatering.	Item-16, p-4, SCR-2012	%0 Cft	180752.04	2420.00	437.4
4	Rehandling of Earth work. (b) upto a 50 ft lead.	Item-9(b), p-2, SCR-2012	%0 Cft	192049.04	1085.75	208.5
5	Extra for every 50 ft additional lead or part thereof (a) For earthwork	Item -8 (a), p- 2, S CR- 2012	% 0 Cft	192049.04	100.87	19. 4
6	Earthworks by tractor with scraper i/c compaction, dressing, leveling complete etc: in accordance to profile in ordinary soil lead upto 100 ft.	Item-104, p-112, SCR-2012	%0 Cft	235472.10	2058.13	484.6
7	Sub-Total (1+2+3+4+5+6)					1560.38
8	Structures					936.23
9	Miscellaneous Unforeseen @ 10%					249.66
10	Land Acquisition	Total Land Required	Acre	309.00		
	a) Urban Area (20%)	Market Rates	Acre	61.80	500000	30.90
	b) Rural Area (80%)	Market Rates	Acre	247.20	300000	74.16
11	Total (7+8+9+10)					2851.33
12	Contingencies @2%					57.03
13	**Total Cost**					**2908.35**

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)
Preparation of Regional Plan for Left Bank Of Indus River, Delta & Costal Zone.
TABLE-12: SUMMARY-T.ADAM LEFT OVER AREA

S.No	Item Description	Source	Unit	Quantity	Rate (Rs.)	Amount (M-Rs.)
1	Earth work Excavation in Irrigation Channels, drains etc, dressed to designed section grades and profiles excavated material disposed off and dressed within 50 ft lead. (a) Ordinary Soil	Item-5(a), p-1, SCR-2012	% 0 Cft	265570.00	2420. 00	642.7
2	Extra for Slush or Daldal including dewatering.	Item-16, p-4, SCR-2012	% 0 Cft	13278.50	2420.00	32.1
3	Rehandling of Earth work. (b) upto a 50 ft lead.	Item-9(b), p-2, SCR-2012	% 0 Cft	26557.00	1085.75	28.8
4	Extra for every 50 ft additional lead or part thereof (a) For earthwork	Item - 8 (a) , p-2, SCR-2012	% 0 Cft	13278.50	100.87	1.3
5	Earthworks by tractor with scraper i/c compaction, dressing, leveling complete etc: in accordance to profile in ordinary soil lead upto 100 ft.	Item-104, p-112, SCR-2012	% 0 Cft	98670.00	2058.13	203.1
6	Sub-Total (1+2+3+4+5)					908.06
7	Structures					317.82
8	Miscellaneous Unforeseen @ 10%					122.59
9	Land Acquisition	Total Land	Acre	2837.48		
	a) Urban Area (20%)	Market Rates	Acre	567.50	500000	283.75
	b) Rural Area (80%)	Market Rates	Acre	2269.99	300000	681.00
10	Total (6+7+8+9)					2313.22
11	Contingencies @2%					46.26
12	**Total Cost**					**2359.48**

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)
Preparation of Regional Plan for Left Bank Of Indus River, Delta & Costal Zone.
TABLE-13: SUMMARY-T.M KHAN LEFT OVER AREA

S.No	Item Description	Source	Unit	Quantity	Rate (Rs.)	Amount (M-Rs.)
1	Earth work Excavation in Irrigation Channels, drains etc, dressed to designed section grades and profiles excavated material disposed off and dressed within 50 ft lead. (a) Ordinary Soil	Item-5(a), p-1, SCR-2012	% 0 Cft	457080.00	2420.00	1106.1
2	Extra for Slush or Daldal including dewatering.	Item-16, p-4, SCR-2012	% 0 Cft	22854.00	2 20.00	55.3
3	Rehandling of Earth work. (b) upto a 50 ft lead.	Item-9(b), p-2, SCR-2012	% 0 Cft	45708.00	1085.75	49.6
4	Extra for every 50 ft additional lead or part thereof (a) For earthwork	Item - 8 (a) , p-2, SCR-2012	% 0 Cft	2 2 85 4 . 0 0	100.87	2.3
5	Earthworks by tractor with scraper i/c compaction, dressing, leveling complete etc: in accordance to profile in ordinary soil lead upto 100 ft.	Item-104, p-112, SCR-2012	% 0 Cft	145640.00	2058.13	299.7
6	Sub-Total (1+2+3+4+5)					1513.12
7	Structures					529.59
8	Miscellaneous Unforeseen @ 10%					204.27
9	Land Acquisition	Total Land Required	Acre	3815.16		
	a) Urban Area (20%)	Market Rates	Acre	763.03	500000	381.52
	b) Rural Area (80%)	Market Rates	Acre	3052.13	300000	915.64
10	Total (6+7+8+9)					3544.13
11	Contingencies @2%					70.88
12	**Total Cost**					**3615.02**

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)
Preparation of Regional Plan for Left Bank Of Indus River, Delta & Costal Zone.
TABLE-14: SUMMARY-DIGRI LEFT OVER AREA

S.No	Item Description	Source	Unit	Quantity	Rate (Rs.)	Amount (M-Rs.)
1	Earth work Excavation in Irrigation Channels, drains etc, dressed to designed section grades and profiles excavated material disposed off and dressed within 50 ft lead.	Item-5(a), p-1, SCR-2012	% 0 Cft	200620.00	2420.00	485.5
2	Extra for Slush or Daldal including dewatering.	Item-16, p-4, SCR-2012	%0 Cft	10031.00	2420.00	24.3
3	Rehandling of Earth work. (b) upto a 50 ft lead.	Item-9(b), p-2, SCR-2012	% 0 Cft	20062.00	1085.75	21.8
4	Extra for every 50 ft additional lead or part therof (a) For earthwork	Item -8 (a), p- 2, SCR-2012	% 0 Cft	10 0 3 1 . 0 0	100. 87	1.0
5	Earthworks by tractor with scraper i/c compaction, dressing, leveling complete etc: in accordance to profile in ordinary soil lead upto 100 ft.	Item-104, p-112, SCR-2012	% 0 Cft	88260.00	2058. 13	181.7
6	Sub-Total (1+2+3+4+5)					714.22
7	Structures					249.98
8	Miscellaneous Unforeseen @ 10%					96.42
9	Land Acquisition	Total Land	Acre	3294.94		
	a) Urban Area (20%)	Market Rates	Acre	658.99	500000	329.49
	b) Rural Area (80%)	Market Rates	Acre	2635.95	300000	790.79
10	Total (6+7+8+9)					2180.90
11	Contingencies @2%					43.62
12	**Total Cost**					**2224.51**

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)
Preparation of Regional Plan for Left Bank Of Indus River, Delta & Costal Zone.
TABLE-15: SUMMARY-SOUTH KHAIRPUR LEFT OVER AREA

S.No	Item Description	Source	Unit	Quantity	Rate (Rs.)	Amount (M-Rs.)
1	Earth work Excavation in Irrigation Channels, drains etc, dressed to designed section grades and profiles excavated material disposed off and dressed within 50	Item-5(a), p-1, SCR-2012	% 0 Cft	35680.00	2420.00	86. 3
2	Extra for Slush or Daldal including dewatering.	Item-16, p-4, SCR-2012	% 0 Cft	1784.00	2420.00	4.3
3	Rehandling of Earth work. (b) upto a 50 ft lead.	Item-9(b), p-2, SCR-2012	%0 Cft	3568.00	1085.75	3.9
4	Extra for every 50 ft additional lead or part thereof (a) For earthwork	Item - 8 (a) , p-2, SCR-2012	% 0 Cft	1 7 8 4 . 00	100.87	0.2
5	Earthworks by tractor with scraper i/c compaction, dressing, leveling complete etc: in accordance to profile in ordinary soil lead upto 100 ft.	Item-104, p-112, SCR-2012	% 0 Cft	22900.00	2058.13	47.1
6	Sub-Total (1+2+3+4+5)					141.85
7	Structures					49.65
8	Miscellaneous Unforeseen @ 10%					19.15
9	Land Acquisition	Total Land	Acre	975.18		
	a) Urban Area (20%)	Market Rates	Acre	195.04	500000	97.52
	b) Rural Area (80%)	Market Rates	Acre	780.14	300000	234.04
10	Total (6+7+8+9)					542.21
11	Contingencies @2%					10.84
12	**Total Cost**					**553.05**

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)
Preparation of Regional Plan for Left Bank Of Indus River, Delta & Costal Zone.
TABLE-16: SUMMARY-GHOTKI LEFT OVER AREA

S.No	Item Description	Source	Unit	Quantity	Rate (Rs.)	Amount (M-Rs.)
1	Earth work Excavation in Irrigation Channels, drains etc, dressed to designed section grades and profiles excavated material disposed off and dressed within 50 ft lead.	Item-5(a), p-1, SCR-2012	% 0 Cft	602361.31	2420.00	1457.7
2	Extra for Slush or Daldal including dewatering.	Item-16, p-4, SCR-2012	% 0 Cft	30118.07	2420.00	72.9
3	Rehandling of Earth work. (b) upto a 50 ft lead.	Item-9(b), p-2, SCR-2012	% 0 Cft	60236. 13	1085.75	65. 4
4	Extra for every 50 ft additional lead or part thereof (a) For earthwork	Item - 8 (a) , p-2, SCR-2012	% 0 Cft	30118.07	100.87	3.0
5	Earthworks by tractor with scraper i/c compaction, dressing, leveling complete etc: in accordance to profile in ordinary soil lead upto 100 ft.	Item-104, p-112, SCR-2012	% 0 Cft	221700.00	2058.13	456. 3
6	Sub-Total (1+2+3+4+5)					2055.33
7	Structures					719.36
8	Miscellaneous Unforeseen @ 10%					277.47
9	Land Acquisition	Total Land	Acre	7533.63		
	a) Urban Area (20%)	Market Rates	Acre	1506.73	500000	753.36
	b) Rural Area (80%)	Market Rates	Acre	6026.90	300000	1808.07
10	Total (6+7+8+9)					5613.59
11	Contingencies @2%					112.27
12	**Total Cost**					**5725.87**

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)
Preparation of Regional Plan for Left Bank Of Indus River, Delta & Costal Zone.
TABLE-17: SUMMARY-LBOD ESCAPES

S.No	Item Description	Source	Unit	Quantity	Rate (Rs.)	Amount (M-Rs.)
1	Earth work Excavation in Irrigation Channels, drains etc, dressed to designed section grades and profiles excavated material disposed off and dressed within 50 ft lead. (a) Ordinary Soil	Item-5(a), p-1, SCR-2012	%0 Cft	32200.00	2420.00	77.9
2	Extra for Slush or Daldal including dewatering.	Item-16, p-4, SCR-2012	%0 Cft	16 10. 00	2420.00	3.9
3	Rehandling of Earth work. (b) upto a 50 ft lead.	Item-9(b), p-2, SCR-2012	%0 Cft	3220.00	1085.75	3.5
4	Extra for every 50 ft additional lead or part thereof (a) For earthwork	Item-8 (a) , p-2, SCR-2012	%0 Cft	16 10. 00	100.87	0.2
5	Earthworks by tractor with scraper i/c compaction, dressing, levelling complete etc: in accordance to profile in ordinary soil lead upto 100 ft.	Item-104, p-112, SCR-2012	%0 Cft	5920.00	2058.13	12.2
6	Sub-Total (1+2+3+4+5)					97.66
7	Structures					34.18
8	Miscellaneous Unforeseen @ 10%					13.18
9	Land Acquisition	Total Land Required	Acre	197.20		
	a) Urban Area (20%)	Market Rates	Acre	39.44	500000	19.72
	b) Rural Area (80%)	Market Rates	Acre	157.76	300000	47.33
10	Total (6+7+8+9)					212.08
11	Contingencies @2%					4.24
12	**Total Cost**					**216.32**

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)
Preparation of Regional Plan for Left Bank Of Indus River, Delta & Costal Zone.
TABLE-18: COST SUMMARY GENERAL

S.No	Description	Cost (M.Rs.)	Remarks
A	Surface Drains, Land Acquisition and Structures Left Over Areas:		
	a) T.Adam	2,367.2	
	b) T.M.Khan	3,634.0	
	c) Digri	5,079.5	
	d) Digri	2,223.3	
	e) Ghotki	3,660.0	
	f) South Khairpur	550.6	
	Total (A)	17,514.64	
B	Dhoras Earthworks (Excavation and Banks), Land Acquisition and Structures including Bypasses		
	a) Puran	4,410.4	
	b) Nabisar	327.0	
	c) Naro/Hakro	2,866.8	
	d) Sohni	2,623.8	
	e) Bhai Khan	3,510.9	
	f) Digri	224.0	
	g) Pithoro	635.2	
	h) Pangrio, Khairpur Gambo and Roshanabad	503.0	
	i) Ghotki Dhoras	4,366.7	
	j) South Khairpur Dhoras	2,961.2	
	Total (B)	22,428.9	
C	LBOD Escapes i/c Weirs (C)	164.0	
	(3 Nr. From RD 578, 336 and 214 of LBOD)		
D			
	SYPHONES		
		3,450.0	
	Total (A+B+C+D)	**43,557.6**	

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE- 19: Gradient Calculation of Ghurelo System Drains of Ghotki LOA

Sr. No.	Drain Name	Length (RD)	Start Elev. (ft)	End Elev. (ft)	Available Gradient	(say)	Oufalling Into
1	D1	17.384	237.00	239.00	8,692	8,700	Ghurelo Dhoro-42
2	D2	24.600	237.00	240.50	7,029	7,100	D3
3	D2A	18.040	236.50	240.50	4,510	4,500	Ghurelo Dhoro-42
4	D3	37.720	228.00	238.75	3,509	3,500	D4
5	D4	102.664	228.00	239.50	8,927	9,000	Ghurelo Dhoro-42
6	D5	37.392	232.00	236.00	9,348	9,400	Ghurelo Dhoro-42
7	D6	78.064	227.00	240.00	6,005	6,000	GD-45
8	D7	64.616	223.00	238.50	4,169	4,200	GD-45
9	D8	250.592	196.00	233.00	6,773	6,800	Rainee Dhoro
10	D9	127.592	215.00	231.50	7,733	7,800	D12
11	D9A	26.240	229.00	233.00	6,560	6,600	GD-43
13	D10	44.936	222.50	232.00	4,730	4,800	GL-17
14	D11	68.552	206.00	219.50	5,078	5,100	Karo Naro
15	D11A	24.600	213.00	222.00	2,733	2,800	D11
16	D12	183.680	190.00	217.50	6,679	6,700	D11
17	D13	112.504	196.50	212.50	7,032	7,100	D12
18	D14	123.328	192.00	204.50	9,866	9,900	D15
19	D15	95.120	190.00	199.00	10,569	10,600	Nara-2
20	D16	21.648	203.00	206.00	7,216	7,200	GL-1
21	D16A	50.840	202.50	212.50	5,084	5,100	GL-1
22	D16B	78.720	206.00	223.00	4,631	4,700	D16A
23	D17	19.680	199.00	201.50	7,872	7,900	Karo Naro
24	D18	27.224	197.00	201.00	6,806	6,800	D19
25	D19	31.816	198.00	202.00	7,954	8,000	Karo Naro
26	D20	9.840	197.50	198.50	9,840	9,900	GD-7
27	D21	45.592	194.00	201.50	6,079	6,100	Karo Naro
28	D22	27.224	198.00	202.50	6,050	6,100	D21
29	D23	32.144	197.00	201.50	7,143	7,200	GD-3
30	D24	69.864	202.00	221.50	3,583	3,600	GD-13
31	D25	13.776	200.00	202.00	6,888	7,000	Nara-1
32	D26	18.696	201.00	203.75	6,799	7,000	D27
33	D27	16.072	2012.00	213.00	(9)	7,000	Nara-1
34	D28	62.320	212.00	224.00	5,193	5,200	D24
35	D29	22.632	212.00	217.50	4,115	4,200	GL-3
36	D30	39.360	216.50	226.00	4,143	4,200	GD-15
37	D31	62.320	220.00	231.00	5,665	5,700	GD-16
38	D32	28.864	226.00	231.00	5,773	5,800	GD-10
39	D33	72.160	225.00	236.00	6,560	6,600	GD-18
40	D34	55.760	223.00	234.00	5,069	5,100	GD-18
41	D35	47.888	207.50	216.50	5,321	5,400	Karo Naro
42	D36	16.072	218.00	221.00	5,357	5,400	GD-9

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-20: Design Parameters of Ghurelo Dhoro Drains

Drainage Coefficient = 2

20 yr period (10 days Evacuation)

Sr. No.	Drain	Type	Catchment Area	D. Discharge	Length	Bed Width	Flow Depth	Gradient	Side Slope	Area	Wetted Perimeter	Hydraulic Radius	Manning's 'n'	Flow Velocity	Section Discharge
			(Sq. Mile)	(cusecs)	(RDs)	(ft)	(ft)			(sq.ft)	(ft)	(ft)		(ft/sec)	(cusec)
1	D1	Sub-Drain	3.30	6.61	17.384	4.00	2.00	8700	2.0	16.0	12.9	1.2	0.025	0.73	11.7
2	D2	Sub-Drain	5.24	10.48	24.600	4.00	2.00	7100	2.0	16.0	12.9	1.2	0.025	0.81	13.0
3	D2A	Sub-Drain	3.17	6.33	18.040	4.00	2.00	4500	2.0	16.0	12.9	1.2	0.025	1.02	16.3
4	D3	Sub-Drain	7.97	15.95	37.720	4.00	2.00	3500	2.0	16.0	12.9	1.2	0.025	1.16	18.5
5	D4	Branch-Drain	30.96	100.14	102.664	18.00	3.50	9000	2.0	87.5	33.7	2.6	0.025	1.18	103.7
6	D5	Sub-Drain	10.63	21.27	37.392	7.50	2.25	9400	2.0	27.0	17.6	1.5	0.025	0.82	22.0

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-21: Gradient Calculation and Design of Ghurelo Dhoro

Sr. Nr.	Section			RDs	Discharge Required Q	Bed Width	Depth of Flow	Gradient	Side Slope	Area	Wetted Perimeter	Hydraulic	Manning N	Velocity of Flow	Discharge As per Design
					(cusecs)	(ft)	(ft)			(sq.ft)	(ft)	(ft)		(ft/sec)	(cusec)
1	0.000	to	136.448	136.448	390.68	38.00	5.00	8700	3.0	265.0	69.6	3.8	0.025	1.55	411.7
2	136.448	to	167.605	31.156	186.08	26.00	4.00	8700	3.0	152.0	51.3	3.0	0.025	1.31	199.8
3	167.605	to	201.679	34.074	164.81	22.00	4.00	8700	3.0	136.0	47.3	2.9	0.025	1.29	175.2
4	201.679	to	212.130	10.451	158.20	20.00	4.00	8700	3.0	128.0	45.3	2.8	0.025	1.27	163.0
5	212.130	to	214.694	2.564	151.87	19.00	4.00	8700	3.0	124.0	44.3	2.8	0.025	1.27	157.0
6	214.694	to	247.241	32.547	125.11	15.00	4.00	8700	3.0	108.0	40.3	2.7	0.025	1.23	132.8

Calculation of Gradient:			
	RDs		Elevations
Start	0.00		213
End	247.24		241.5
Reach	247.24	Drop	28.5
Available Gradient			8675.1
		say	8700

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-22 Earth Work of Ghurelo Dhoro

Sr. No.	Section RDs			RDs	Bed Width	Depth of Flow	Free Board	Total Depth	Side Slope	Berm W	Height of IP Above GL	Net Cut Area	Cut Volume	W1	W2	Fill 1 Area	Fill 2 Area	Total Fill Area	Fill Volume	Jungle Clarence area	ROW Width	ROW
					ft	ft	ft	ft		ft	ft	ft	cft	ft	ft	sft	sft	sft	cft	sft	ft	Acres
1	0.000	to	136.448	136.4	38.00	5.00	3.00	8.00	3	50	5.0	200.0	27289680	20.0	20.0	175.0	175.0	350.0	47756940	18556982	270	845.8
2	136.448	to	167.605	31.16	26.00	4.00	3.00	7.00	3	50	5.0	105.0	3271422	20.0	20.0	175.0	175.0	350.0	10904740	4237270		
3	167.605	to	201.679	34.07	22.00	4.00	3.00	7.00	3	50	5.0	93.0	3168854	20.0	20.0	175.0	175.0	350.0	11925795	4634023		
4	201.679	to	212.130	10.45	20.00	4.00	3.00	7.00	3	50	5.0	87.0	909263	20.0	20.0	175.0	175.0	350.0	3657955	1421377		
5	212.130	to	214.694	2.564	19.00	4.00	3.00	7.00	3	50	5.0	84.0	215393	20.0	20.0	175.0	175.0	350.0	897470	348731		
6	214.694	to	247.241	10.5	15.00	4.00	3.00	7.00	3	50	5.0	72.0	756000	20.0	20.0	175.0	175.0	350.0	3675000	1428000		

												Total	**35610612**					**Total**	**78817900**	6125277	sft	
													35.61	**M-cft**					**78.82**	**M-cft**		

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE -23: Earth Work of Gurhelo Drain System Of Ghotki Left Over Area

(Summary Sheet)

Sr. No.	DRAIN NAME	TYPE	Cut Volume	Fill Volume	ROW	Jungle Clarence area
			(M-cft)	(cft)	(acres)	(sft)
1	D1	Sub-Drain	0.83	0.87	35.12	
2	D2	Sub-Drain	1.18	1.23	49.70	
3	D2A	Sub-Drain	0.87	0.90	36.44	
4	D3	Sub-Drain	1.81	1.89	76.20	
5	D4	Branch-Drain	8.85	8.93	276.67	
6	D5	Sub-Drain	1.79	1.87	75.61	
		Total	**15.33**	**15.69**	**549.74**	
		Unsound 5%	**0.77**			
		Available Fill	**14.56**			
		Raquired Fill	**15.69**			
		Borrow Mat.	**-1.13**			
7	GurheloDhoro-42	Dhoro	35.61	78.82	0.00	1225055.36
		Unsound 5%	**1.78**			
		Available Fill	**33.83**			
		Raquired Fill	**78.82**			
		Borrow Mat.	**-44.99**			

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-24 Design of Karo Naro System Drains of Ghotki LOA

Drainage Coefficient = 2

20 yr period (10 days Evacuation)

Sr. No.	Drain	Type	Catchment Area	D. Discharge	Length	Bed Width	Flow Depth	Gradient	Side Slope	Area	Wetted Perimeter	Hydraulic Radius	Manning's 'n'	Flow Velocity	Section Discharge
			(Sq. Mile)	(cusecs)	(RDs)	(ft)	(ft)			(sq.ft)	(ft)	(ft)		(ft/sec)	(cusec)
1	D7	Sub-Drain	21.58	43.15	64.616	9.00	2.50	4200	2.0	35.0	20.2	1.7	0.025	1.32	46.3
3	D10	Sub-Drain	13.63	27.26	44.936	7.00	2.25	4800	2.0	25.9	17.1	1.5	0.025	1.13	29.3
5	D11	Sub-Drain	14.05	34.90	68.552	32.00	4.25	5100	2.0	172.1	51.0	3.4	0.025	1.87	322.3
7	D11A	Sub-Drain	3.40	6.80	24.600	4.00	2.00	2800	2.0	16.0	12.9	1.2	0.025	1.29	20.7
9	D16	Sub-Drain	7.17	14.33	21.648	5.00	2.00	7200	2.0	18.0	13.9	1.3	0.025	0.83	14.9
11	D17	Sub-Drain	3.67	7.35	19.680	4.00	2.00	7900	2.0	16.0	12.9	1.2	0.025	0.77	12.3
13	D16A	Sub-Drain	10.17	51.24	50.840	8.00	3.00	5100	2.0	42.0	21.4	2.0	0.025	1.30	54.8
15	D16B	Sub-Drain	15.45	30.89	78.720	8.00	2.25	4700	2.0	28.1	18.1	1.6	0.025	1.16	32.8
17	D18	Sub-Drain	4.37	22.09	27.224	4.00	2.00	6800	2.0	16.0	12.9	1.2	0.025	0.83	13.3
19	D19	Sub-Drain	6.68	13.35	31.816	7.50	2.25	8000	2.0	27.0	17.6	1.5	0.025	0.89	23.9
21	D20	Sub-Drain	1.87	3.74	9.840	4.00	2.00	9900	2.0	16.0	12.9	1.2	0.025	0.69	11.0
23	D21	Sub-Drain	11.51	40.93	45.592	8.00	2.75	6100	2.0	37.1	20.3	1.8	0.025	1.14	42.3
25	D22	Sub-Drain	4.41	8.83	27.224	4.00	2.00	6100	2.0	16.0	12.9	1.2	0.025	0.88	14.0
27	D23	Sub-Drain	8.96	17.91	32.144	7.00	2.00	7200	2.0	22.0	15.9	1.4	0.025	0.87	19.1
29	D24	Branch-Drain	30.88	101.32	69.864	10.50	3.50	3600	2.0	61.3	26.2	2.3	0.025	1.75	107.0
31	D28	Sub-Drain	19.79	39.57	62.320	9.00	2.50	5200	2.0	35.0	20.2	1.7	0.025	1.19	41.6
33	D29	Sub-Drain	15.68	31.37	22.632	7.50	2.25	4200	2.0	27.0	17.6	1.5	0.025	1.22	33.0
35	D30	Sub-Drain	21.87	43.74	39.360	9.00	2.50	4200	2.0	35.0	20.2	1.7	0.025	1.32	46.3
37	D31	Sub-Drain	32.96	65.92	62.320	14.00	2.75	5700	2.0	53.6	26.3	2.0	0.025	1.27	67.9

Drainage Coefficient = 2

20 yr period (10 days Evacuation)

Sr. No.	Drain	Type	Catchment Area	D. Discharge	Length	Bed Width	Flow Depth	Gradient	Side Slope	Area	Wetted Perimeter	Hydraulic Radius	Manning's 'n'	Flow Velocity	Section Discharge
			(Sq. Mile)	(cusecs)	(RDs)	(ft)	(ft)			(sq.ft)	(ft)	(ft)		(ft/sec)	(cusec)
39	D32	Sub-Drain	11.16	22.32	28.864	6.00	2.25	5800	2.0	23.6	16.1	1.5	0.025	1.01	23.8
41	D33	Sub-Drain	24.67	49.33	72.160	11.00	2.75	6600	2.0	45.4	23.3	1.9	0.025	1.14	51.8
43	D34	Sub-Drain	11.93	23.86	55.760	8.00	2.00	5100	2.0	24.0	16.9	1.4	0.025	1.05	25.2
45	D35	Sub-Drain	9.19	18.39	47.888	6.00	2.00	5400	2.0	20.0	14.9	1.3	0.025	0.98	19.6
47	D36	Sub-Drain	4.64	9.29	16.072	4.00	2.00	5400	2.0	16.0	12.9	1.2	0.025	0.93	14.9
49	D 11 C	Sub-Drain	2.08	4.16	16.400	4.00	2.00	6000	2.0	16.0	12.9	1.2	0.025	0.88	14.1
51	D 11B	Sub-Drain	6.55	13.10	47.232	4.00	2.00	6000	2.0	16.0	12.9	1.2	0.025	0.88	14.1
53	D 10B	Sub-Drain	14.52	29.03	65.600	6.50	2.50	6000	2.0	28.8	17.7	1.6	0.025	1.06	30.5
54	GD-13	Branch-Drain	73.73	251.71	194.654	6.50	2.50	6000	2.0	28.8	17.7	1.6	0.025	1.06	30.5
55	GD-14	Branch-Drain	38.49	104.25	101.621	6.50	2.50	6000	2.0	28.8	17.7	1.6	0.025	1.06	30.5

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-25: Design and Gradient Calculation of GD-13 Dhoro

Sr. Nr.	Section			RDs	Discharge Required Q	Bed Width	Depth of Flow	Gradient	Side Slope	Area	Wetted Perimeter	Hydraulic	Manning N	Velocity of Flow	Discharge As per Design
					(cusecs)	(ft)	(ft)			(sq.ft)	(ft)	(ft)		(ft/sec)	(cusec)
1	0.000	to	57.101	57.10	481.51	48.00	5.00	8900	3.0	315.0	79.6	4.0	0.025	1.58	496.5
2	57.101	to	65.701	8.60	387.01	38.00	5.00	8900	3.0	265.0	69.6	3.8	0.025	1.54	407.0
3	65.701	to	95.153	29.45	366.16	35.00	5.00	8900	3.0	250.0	66.6	3.8	0.025	1.52	380.4
4	95.153	to	121.458	26.31	242.53	35.00	4.00	8900	3.0	188.0	60.3	3.1	0.025	1.34	252.8
5	121.458	to	139.991	18.53	191.23	26.00	4.00	8900	3.0	152.0	51.3	3.0	0.025	1.30	197.6
6	139.991	to	155.297	15.31	85.14	18.00	3.00	8900	3.0	81.0	37.0	2.2	0.025	1.06	86.1
7	155.297	to	194.643	39.35	29.81	7.00	2.50	8900	3.0	36.3	22.8	1.6	0.025	0.86	31.1

Calculation of Gradient:

	RDs		Elevations
Start	0.00		198
End	194.64		220
Reach	194.64	Drop	22
Available Gradient			8847.4
		say	8900

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-26: Earth Work of GD-13 Dhoro

Sr. No.	Section RDs			RDs	Bed Width	Depth of Flow	Free Board	Total Depth	Side Slope	Berm W	Height of IP Above GL	Net Cut Area	Cut Volume	W1	W2	Fill 1 Area	Fill 2 Area	Total Fill Area	Fill Volume	Jungle Clarence area	ROW Width	ROW
					ft	ft	ft	ft		ft	ft	ft	cft	ft	ft	sft	sft	sft	cft	sft	ft	Acres
1	0.000	to	57.101	57.101	48.00	5.00	4.00	9.00	3	50	5.0	315.0	17986784	20.0	20.0	175.0	175.0	350.0	19985315	8450933		
2	57.101	to	65.701	8.6	38.00	5.00	4.00	9.00	3	50	5.0	265.0	2279027	20.0	20.0	175.0	175.0	350.0	3010035	1272815		
3	65.701	to	95.153	29.45	35.00	5.00	4.00	9.00	3	50	5.0	250.0	7362875	20.0	20.0	175.0	175.0	350.0	10308025	4358822		
4	95.153	to	121.458	26.31	35.00	4.00	4.00	8.00	3	50	5.0	188.0	4945359	20.0	20.0	175.0	175.0	350.0	9206785	3893155		
5	121.458	to	139.991	18.53	26.00	4.00	4.00	8.00	3	50	5.0	152.0	2817046	20.0	20.0	175.0	175.0	350.0	6486620	2742914		
6	139.991	to	155.297	10.5	18.00	3.00	4.00	7.00	3	50	5.0	81.0	850500	20.0	20.0	175.0	175.0	350.0	3675000	1554000		
7	155.297	to	194.643	10.5	7.00	2.50	4.00	6.50	3	50	5.0	36.3	380625	20.0	20.0	175.0	175.0	350.0	3675000	1554000		
												Total	**36622215**					**Total**	**56346780**	**23826638**	**sft**	
													36.62	**M-cft**					**56.35**	**M-cft**		

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-27 Design and Gradient Calculation of Karo Naro Dhoro

Sr. Nr.	Section			RDs	Discharge Required Q	Bed Width	Depth of Flow	Gradient	Side Slope	Area	Wetted Perimeter	Hydraulic	Manning N	Velocity of Flow	Discharge As per Design
					cusecs	ft	Ft			sq. ft	ft	ft		ft/sec	cusec
1	0.000	to	3.405	3.40	1190.92	80.00	6.50	8700	3.0	646.8	121.1	5.3	0.025	1.95	1259.2
2	3.405	to	11.241	7.84	1173.15	80.00	6.50	8700	3.0	646.8	121.1	5.3	0.025	1.95	1259.2
3	11.241	to	18.111	6.87	1162.75	80.00	6.50	8700	3.0	646.8	121.1	5.3	0.025	1.95	1259.2
4	18.111	to	20.408	2.30	1113.53	80.00	6.25	8700	3.0	617.2	119.5	5.2	0.025	1.90	1175.0
5	20.408	to	53.318	32.91	1100.51	80.00	6.25	8700	3.0	617.2	119.5	5.2	0.025	1.90	1175.0
6	53.318	to	70.605	17.29	573.25	58.00	5.00	8700	3.0	365.0	89.6	4.1	0.025	1.63	593.2
7	70.605	to	93.020	22.42	564.51	58.00	5.00	8700	3.0	365.0	89.6	4.1	0.025	1.63	593.2
8	93.020	to	115.526	22.51	545.86	55.00	5.00	8700	3.0	350.0	86.6	4.0	0.025	1.62	565.8
9	115.526	to	177.065	61.54	504.18	50.00	5.00	8700	3.0	325.0	81.6	4.0	0.025	1.60	520.3
10	177.065	to	182.159	5.09	195.65	26.00	4.00	8700	3.0	152.0	51.3	3.0	0.025	1.31	199.8
11	182.159	to	217.043	34.88	177.26	23.00	4.00	8700	3.0	140.0	48.3	2.9	0.025	1.30	181.4
12	217.043	to	265.495	48.45	153.84	20.00	4.00	8700	3.0	128.0	45.3	2.8	0.025	1.27	163.0
13	265.495	to	271.935	6.44	100.44	18.00	3.25	8700	3.0	90.2	38.6	2.3	0.025	1.12	101.3

Calculation of Gradient:

	RDs		Elevations
Start	0.00		192
End	265.49		222.5
Reach	265.49	Drop	30.5
Available Gradient			8704.8
		say	8700

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-28: Earth Work of Naro Dhoro

Sr. No.	Section RDs			RDs	Bed Width	Depth of Flow	Free Board	Total Depth	Side Slope	Berm W	Height of IP Above GL	Net Cut Area	Cut Volume	W1	W2	Fill 1 Area	Fill 2 Area	Total Fill Area	Fill Volume	Jungle Clarence area	ROW Width	ROW
					ft	ft	ft	ft		ft	ft	ft	cft	ft	ft	sft	sft	sft	cft	sft	ft	Acres
1	0.000	to	3.405	3.405	80.00	6.50	4.00	10.50	3	50	5.0	646.8	2201925	20.0	20.0	175.0	175.0	350.0	1191610	503881		
2	3.405	to	11.241	7.836	80.00	6.50	4.00	10.50	3	50	5.0	646.8	5068127	20.0	20.0	175.0	175.0	350.0	2742705	1159772		
3	11.241	to	18.111	6.87	80.00	6.50	4.00	10.50	3	50	5.0	646.8	4443108	20.0	20.0	175.0	175.0	350.0	2404465	1016745		
4	18.111	to	20.408	2.297	80.00	6.25	4.00	10.25	3	50	5.0	617.2	1417927	20.0	20.0	175.0	175.0	350.0	804090	340015		
5	20.408	to	53.318	32.91	80.00	6.25	4.00	10.25	3	50	5.0	617.2	20311209	20.0	20.0	175.0	175.0	350.0	11518255	4870576		
6	53.318	to	70.605	10.5	58.00	5.00	4.00	9.00	3	50	5.0	365.0	3832500	20.0	20.0	175.0	175.0	350.0	3675000	1554000		
7	70.605	to	93.020	10.5	58.00	5.00	4.00	9.00	3	50	5.0	365.0	3832500	20.0	20.0	175.0	175.0	350.0	3675000	1554000		
8	93.020	to	115.526	10.5	55.00	5.00	4.00	9.00	3	50	5.0	350.0	3675000	20.0	20.0	175.0	175.0	350.0	3675000	1554000		
9	115.526	to	177.065	10.5	50.00	5.00	4.00	9.00	3	50	5.0	325.0	3412500	20.0	20.0	175.0	175.0	350.0	3675000	1554000		
10	177.065	to	182.159	10.5	26.00	4.00	4.00	8.00	3	50	5.0	152.0	1596000	20.0	20.0	175.0	175.0	350.0	3675000	1554000		
11	182.159	to	217.043	10.5	23.00	4.00	4.00	8.00	3	50	5.0	140.0	1470000	20.0	20.0	175.0	175.0	350.0	3675000	1554000		
12	217.043	to	265.495	10.5	20.00	4.00	4.00	8.00	3	50	5.0	128.0	1344000	20.0	20.0	175.0	175.0	350.0	3675000	1554000		
13	265.495	to	271.935	10.5	18.00	3.25	4.00	7.25	3	50	5.0	90.2	946969	20.0	20.0	175.0	175.0	350.0	3675000	1554000		
												Total =	**53551764**					**Total =**	**48061125**	20322990		
													53.55	**M-Cft**					**48.06**			

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-29: Earth Work of Karo Naro Drain System of Ghotki Left Over Area

(Summary Sheet)

Sr. No.	Drain Name	Type	Cut Volume	Fill Volume	ROW	Jungle Clarence Area
			M-cft	cft	Acres	sft
1	D7	Sub-Drain	18.08	3.12	3.12	
2	D10	Sub-Drain	2.52	2.25	0.00	
3	D11	Sub-Drain	3.92	3.43	92.67	
4	D11A	Sub-Drain	1.18	1.23	141.85	
5	D16	Sub-Drain	1.13	1.08	49.70	
6	D17	Sub-Drain	0.94	0.98	44.23	
7	D16A	Sub-Drain	5.32	2.85	39.76	
8	D16B	Sub-Drain	4.56	3.94	117.58	
9	D18	Sub-Drain	8.67	1.36	163.21	
10	D19	Sub-Drain	1.87	1.59	76.93	
11	D20	Sub-Drain	0.47	0.49	66.17	
12	D21	Sub-Drain	3.14	2.28	19.88	
13	D22	Sub-Drain	6.98	1.36	96.71	
14	D23	Sub-Drain	1.93	1.61	71.56	
15	D24	Branch-Drain	4.90	4.61	67.15	
16	D28	Sub-Drain	18.08	3.12	119.06	
17	D29	Sub-Drain	4.44	1.13	166.70	
18	D30	Sub-Drain	9.59	1.97	56.35	
19	D31	Sub-Drain	27.01	3.49	101.56	
20	D32	Sub-Drain	1.55	1.44	184.61	
21	D33	Sub-Drain	26.67	3.61	59.19	
22	D34	Sub-Drain	3.17	2.79	202.88	
23	D35	Sub-Drain	2.52	2.39	115.50	
24	D36	Sub-Drain	1.90	0.80	98.01	
25	D11C	Sub-Drain	33.13	0.82	33.13	
26	D11B	Sub-Drain	2.27	2.36	95.42	
27	D10B	Sub-Drain	4.10	3.28	137.12	
		Total	**200.04**	**59.38**	**2420.03**	
		Unsound 5%	**10.00**			
		Available Fill	**190.04**			
		Required Fill	**59.38**			
		Surplus Mat.	**130.66**			
28	GD13	Dhoro	36.62	56.35	0.00	0.00
29	Karo Naro Dhoro	Dhoro	53.55	48.06	0.00	20322990.00
		Total	**90.17**	**104.41**	**0.00**	**4064598.00**
		Unsound 5%	**4.51**			
		Available Fill	**85.67**			
		Required Fill	**104.41**			
		Borrow Mt.	**-18.74**			

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-30: Design Parameters of Nara System of Drains and Dhoras Ghotki

Drainage Coefficient = 2

20 yr period (10 days Evacuation)

Sr. No.	Drain	Type	Catchment Area	D. Discharge	Length	Bed Width	Flow Depth	Gradient	Side Slope	Area	Wetted Perimeter	Hydraulic Radius	Manning's 'n'	Flow Velocity	Section Discharge
			Sq. Mile	cusecs	RDs	ft	ft			sq. ft	ft	ft		ft/sec	cusec
1	D9	Main-Drain	51.86	501.92	127.592	44.00	5.25	7800	2.0	286.1	67.5	4.2	0.025	1.76	504.5
2	D9A	Branch-Drain	5.47	398.20	26.240	38.00	4.75	6600	2.0	225.6	59.2	3.8	0.025	1.78	402.6
3	D9B	Branch-Drain	63.01	387.26	21.648	60.00	5.25	22000	2.0	370.1	83.5	4.4	0.025	1.08	400.3
4	D12	Main-Drain	40.78	671.82	183.680	61.00	5.00	6700	2.0	355.0	83.4	4.3	0.025	1.91	677.3
5	D13	Sub-Drain	44.17	88.35	112.504	13.00	3.50	7100	2.0	70.0	28.7	2.4	0.025	1.28	89.6
6	D14	Branch-Drain	54.76	109.52	123.328	21.00	3.50	9900	2.0	98.0	36.7	2.7	0.025	1.15	112.8
7	D15	Main-Drain	21.20	823.74	95.120	85.00	5.50	10600	2.0	528.0	109.6	4.8	0.025	1.65	869.5
8	GD27	Dhora	38.28	131.74	101.055	32.00	4.00	24000	3.0	176.0	57.3	3.1	0.025	0.81	142.7
9	Nara-1	Dhora	33.63	909.76	88.795	85.00	5.25	8700	3.0	528.9	118.2	4.5	0.025	1.73	915.3
10	Nara-2	Dhora	9.38	842.49	24.750	85.00	5.00	8700	3.0	500.0	116.6	4.3	0.025	1.68	840.9

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank Of Indus River, Delta & Costal Zone

TABLE-31: Design Parameters and Gradient Calculation of Nara-2 Dhoro

Sr. Nr.	Section			RDs	Discharge Required Q	Bed Width	Depth of Flow	Gradient	Side Slope	Area	Wetted Perimeter	Hydraulic Radius	Manning N	Velocity of Flow	Discharge As per Design
					cusecs	ft	Ft			sq. ft	ft	ft		ft/sec	cusec
1	0.000	to	24.750		842.49	85.00	5.00	8700	3.0	500.0	116.6	4.3	0.025	1.68	840.9

Calculation of Gradient:

	RDs		Elevations
Start	0.00		185
End	24.75		194
Reach	24.75	Drop	9
Available Gradient			2750.0
		say	8700

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-32: Earth Work of Nara-1 Dhoro

Sr. No.	Section RDs			RDs	Bed Width	Depth of Flow	Free Board	Total Depth	Side Slope	Berm W	Height of IP Above GL	Net Cut Area	Cut Volume	W1	W2	Fill 1 Area	Fill 2 Area	Total Fill Area	Fill Volume
					ft	ft	ft	ft		ft	ft	ft	cft	ft	ft	sft	sft	sft	cft
1	0.000	to	24.750	24.750	85.00	5.00	4.00	9.00	3	50	5.0	500.0	12375000	20.0	20.0	175.0	175.0	350.0	8662500
												Total	**12375000**					**Total**	**8662500**
													12.38	**M-cft**					**8.66**

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-33: Design and Grained Calculation of GD-27 Dhoro

Sr. No.	Section			RDs	Discharge Required Q	Bed Width	Depth of Flow	Gradient	Side Slope	Area	Wetted Perimeter	Hydraulic	Manning N	Velocity of Flow	Discharge As per Design
					cusecs	ft	Ft			sq. ft	ft	ft		ft/sec	cusec
1	0.000	to	101.055		131.74	32.00	4.00	11300	3.0	176.0	57.3	3.1	0.025	1.18	208.0

Calculation of Gradient:

	RDs		Elevations
Start	0.00		231
End	101.05		240
Reach	101.05	Drop	9
Available Gradient			11228.3
		say	11300

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-34: Earth Work of GD-27 Dhoro

Sr. No.	Section RDs	RDs	Bed Width	Depth of Flow	Free Board	Total Depth	Side Slope	Berm W	Height of IP Above GL	Net Cut Area	Cut Volume	W1	W2	Fill 1 Area	Fill 2 Area	Total Fill Area	Fill Volume	Jungle Clarence area
			ft	ft	ft	ft		ft	ft	ft	cft	ft	ft	sft	sft	sft	cft	sft
1	0.000 to101.055	101.055	32.00	4.00	4.00	8.00	3	50	5.0	176.0	17785645	20.0	20.0	175.0	175.0	350.0	35369180	14956110
										Total	**17785645**					**Total**	**35369180**	**29912221**
											17.79	**M-cft**					**35.37**	

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-35: Design and Gradient Calculation of Nara-1 Dhoro

Sr. No.	Section	RDs	Discharge Required Q	Bed Width	Depth of Flow	Gradient	Side Slope	Area	Wetted Perimeter	Hydraulic Radius	Manning N	Velocity of Flow	Discharge As per Design
			cusecs	ft	ft			sq. ft	ft	ft		ft/sec	cusec
1	0.000 to88.795		909.76	85.00	5.25	8700	3.0	528.9	118.2	4.5	0.025	1.73	915.3

Calculation of Gradient:

	RDs		Elevations
Start	0.00		185
End	88.80		194
Reach	88.80	Drop	9
Available Gradient			9866.1
		say	8700

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-36: Earth Work of Nara-1 Dhoro

Sr. No.	Section RDs	RDs	Bed Width	Depth of Flow	Free Board	Total Depth	Side Slope	Berm W	Height of IP Above GL	Net Cut Area	Cut Volume	W1	W2	Fill 1 Area	Fill 2 Area	Total Fill Area	Fill Volume
			ft	ft	ft	ft		ft	ft	ft	cft	ft	ft	sft	sft	sft	cft
1	0.000 to88.795	88.795	85.00	5.25	4.00	9.25	3	50	5.0	528.9	46967005	20.0	20.0	175.0	175.0	350.0	31078250
										Total	**46967005**					**Total**	**31078250**
											46.97	**M-cft**					**31.08**

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-37: Earth Work of Nara Dhora and Drains System of Ghotki Left Over Areas

(Summary Sheet)

Sr. No.	Drain Name	Type	Cut Volume	Fill Volume	ROW	Jungle Clarence Area
			M-cft	cft	Acres	sft
1	D9	Branch-Drain	59.64	14.93	507.19	
2	D9A	Branch-Drain	10.95	3.07	101.37	
3	D9B	Branch-Drain	13.66	2.53	95.42	
4	D12	Main-Drain	102.32	25.90	862.89	
5	D13	Sub-Drain	16.24	10.80	296.91	
6	D14	Branch-Drain	22.92	14.43	400.11	
7	D15	Main-Drain	55.56	13.41	450.28	
		Total	**281.29**	**85.07**	**2714.17**	
		Unsound 5%	**14.06**			
		Available Fill	**267.23**			
		Required Fill	**85.07**			
		Borrow Mat.	**182.16**			
8	GD27	Dhora	17.79	35.37	0.00	0.00
9	Nara-1	Dhora	46.97	31.08	0.00	5785370.12
10	Nara-2	Dhora	12.38	8.66	0.00	6496881.50
		Total	**77.13**	**75.11**	**0.00**	**2456450.32**
		Unsound 15%	**11.57**			
		Available Fill	**65.56**			
		Required Fill	**75.11**			
		Borrow Mat.	**-9.55**			

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-38: Design Parameters of Rainee System Drains Ghotki

Drainage Coefficient = 2

20 yr period (10 days Evacuation)

Sr. No.	Drain	Type	Catchment Area	D. Discharge	Length	Bed Width	Flow Depth	Gradient	Side Slope	Area	Wetted Perimeter	Hydraulic Radius	Manning's 'n'	Flow Velocity	Section Discharge
			Sq. Mile	cusecs	RDs	ft	ft			sq. ft	ft	ft		ft/sec	cusec
1	D1	Sub-Drain	3.30	6.61	17.384	4.00	2.00	8700	2.0	16.0	12.9	1.2	0.025	0.73	11.7
2	D2	Sub-Drain	5.24	10.48	24.600	4.00	2.00	7100	2.0	16.0	12.9	1.2	0.025	0.81	13.0
3	D2A	Sub-Drain	3.17	6.33	18.040	4.00	2.00	4500	2.0	16.0	12.9	1.2	0.025	1.02	16.3
4	D3	Sub-Drain	7.97	15.95	37.720	4.00	2.00	3500	2.0	16.0	12.9	1.2	0.025	1.16	18.5
5	D4	Branch-Drain	30.96	101.23	102.664	18.00	3.50	9000	2.0	87.5	33.7	2.6	0.025	1.18	103.7
6	D5	Sub-Drain	10.63	21.27	37.392	7.50	2.25	9400	2.0	27.0	17.6	1.5	0.025	0.82	22.0
7	D6	Branch-Drain	54.90	109.79	78.064	18.00	3.25	6000	2.0	79.6	32.5	2.4	0.025	1.39	111.0
8	D7	Sub-Drain	21.58	43.15	64.616	8.50	2.50	4200	2.0	33.8	19.7	1.7	0.025	1.31	44.3
9	D8	Branch-Drain	96.61	193.22	250.592	25.00	4.00	6800	2.0	132.0	42.9	3.1	0.025	1.53	201.3

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-39: Design and Gradient Calculation of Rainee Dhoro

Sr. No.	Section			RDs	Discharge Required Q	Bed Width	Depth of Flow	Gradient	Side Slope	Area	Wetted Perimeter	Hydraulic Radius	Manning N	Velocity of Flow	Discharge As per Design
					cusecs	ft	ft			sq. ft	ft	ft		ft/sec	cusec
1	0.000	to	31.215	31.22	1765.79	70.00	6.50	10800	3.0	581.8	111.1	5.2	0.025	1.72	1003.3
2	31.215	to	143.712	112.50	923.30	55.00	6.00	10800	3.0	438.0	92.9	4.7	0.025	1.61	704.2
3	143.712	to	245.059	101.35	644.78	45.00	4.00	10800	3.0	228.0	70.3	3.2	0.025	1.25	285.7
4	245.059	to	318.316	73.26	254.78	43.00	4.00	10800	3.0	220.0	68.3	3.2	0.025	1.25	274.5
5	318.316	to	322.623	4.31	247.36	9.00	2.50	10800	3.0	41.3	24.8	1.7	0.025	0.80	33.1
6	322.623	to	358.545	35.92	27.23	9.00	2.50	10800	3.0	41.3	24.8	1.7	0.025	0.80	33.1

Calculation of Gradient:

	RDs		Elevations
Start	0.00		192
End	322.62		222.5
Reach	322.62	Drop	30.5
Available Gradient			10577.8
		say	10800

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-40: Earth Work of Rainee Dhoro

Sr. No.	Section RDs			RDs	Bed Width	Depth of Flow	Free Board	Total Depth	Side Slope	Berm W	Height of IP Above GL	Net Cut Area	Cut Volume	W1	W2	Fill 1 Area	Fill 2 Area	Total Fill Area	Fill Volume	Jungle Clarence area
					ft	ft	ft	ft		ft	ft	ft	cft	ft	ft	sft	sft	sft	cft	sft
1	0.000	to	31.215	31.215	70.00	6.50	4.00	10.50	3	50	5.0	581.8	18159326	20.0	20.0	175.0	175.0	350.0	10925250	4619820
2	31.215	to	143.712	112.4972	55.00	6.00	4.00	10.00	3	50	5.0	438.0	49273774	20.0	20.0	175.0	175.0	350.0	39374020	16649586
3	143.712	to	245.059	101.3468	45.00	4.00	4.00	8.00	3	50	5.0	228.0	23107070	20.0	20.0	175.0	175.0	350.0	35471380	14999326
4	245.059	to	318.316	73.2565	43.00	4.00	4.00	8.00	3	50	5.0	220.0	16116430	20.0	20.0	175.0	175.0	350.0	25639775	10841962
5	318.316	to	322.623	4.3075	9.00	2.50	4.00	6.50	3	50	5.0	41.3	177684	20.0	20.0	175.0	175.0	350.0	1507625	637510
6	322.623	to	358.545	10.5	9.00	2.50	4.00	6.50	3	50	5.0	41.3	433125	20.0	20.0	175.0	175.0	350.0	3675000	1554000
												Total	**107267410**					**Total**	**116593050**	**49302204**
													107.27						**116.59**	
													M-cft						**M-cft**	

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-41: Earth Work of Rainee Dhora and Drains System of Ghotki Left Over Areas

(Summary Sheet)

Sr. No.	DRAIN	TYPE	Cut Volume	Fill Volume	ROW	Jungle Clarence Area
			M-cft	cft	(acres)	(sft)
1	D1	Sub-Drain	0.83	0.87	35.12	
2	D2	Sub-Drain	1.18	1.23	49.70	
3	D2A	Sub-Drain	0.87	0.90	36.44	
4	D3	Sub-Drain	1.81	1.89	76.20	
5	D4	Branch-Drain	17.79	12.01	327.87	
6	D5	Sub-Drain	2.51	1.87	79.26	
7	D6	Branch-Drain	16.96	9.13	261.00	
8	D7	Sub-Drain	4.64	3.23	138.14	
9	D8	Branch-Drain	60.42	30.43	847.27	
		Total	**107.01**	**61.56**	**1851.01**	
		Unsound 5%	**5.35**			
		Available Fill	**101.66**			
		Raquired Fill	**61.56**			
		Surplus Mat.	**40.10**			
10	Rainee Dhoro	Dhora	107.27	116.59	0.00	49302204.00
						9860440.80
		Unsound 15%	**5.36**			
		Available Fill	**101.90**			
		Raquired Fill	**116.59**			
		Borrow Mat.	**-14.69**			

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-42: Earth Work of Ghotki Left Over Area

(Summary Sheet)

Sr. No.	Drain Name	Type	Cut Volume	Fill Volume	ROW	Jungle Clarence Area
			M-cft	cft	Acres	sft
1	Karo Naro	LOA	200.04	59.38	2420.03	
2	Gurhelo	LOA	15.33	15.69	549.74	
3	Rainee	LOA	107.01	61.56	1851.01	
4	Nara	LOA	279.98	85.07	2712.84	
		Total	**602.36**	**221.70**	**7533.63**	
		Unsound 5%	**30.12**			
		Available Fill	**572.24**			
		Required Fill	**221.70**			
		Surplus Mat.	**350.54**			
1	Karo Naro	Dhoro	90.17	104.41	0.00	4064598.00
2	Gurhelo	Dhoro	35.61	78.82	0.00	1225055.36
3	Rainee	Dhoro	107.27	116.59	0.00	1972088.16
4	Nara	Dhoro	77.13	75.11	0.00	491290.06
		Total	**310.18**	**374.93**	**0.00**	**7753031.58**
		Unsound 5%	**15.51**			
		Available Fill	**294.67**			
		Required Fill	**374.93**			
		Borrow	**-80.26**			

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-43: Design Parameters of South Khairpur LOA

Drainage Coefficient = 1.15

20 yr period (10 days Evacuation)

Sr. No.	Drain	Type	Catchment Area	D. Discharge	Length	Bed Width	Flow Depth	Gradient	Side Slope	Area	Wetted Perimeter	Hydraulic Radius	Manning's 'n'	Flow Velocity	Section Discharge
			Sq. Mile	cusecs	RDs	ft	ft			sq. ft	ft	ft		ft/sec	cusec
1	D1	Sub-Drain	21.58	24.81	15.322	6.00	2.25	5100	2.0	23.6	16.1	1.5	0.025	1.08	25.4
2	D1A	Sub-Drain	13.63	15.67	12.468	6.00	2.25	12500	2.0	23.6	16.1	1.5	0.025	0.69	16.2
3	D2	Sub-Drain	14.05	16.16	38.978	6.50	2.25	13000	2.0	24.8	16.6	1.5	0.025	0.68	16.9
4	D3	Sub-Drain	3.40	3.91	11.221	4.00	2.00	11300	2.0	16.0	12.9	1.2	0.025	0.64	10.3
5	D4	Sub-Drain	7.17	8.24	18.374	4.00	2.00	9200	2.0	16.0	12.9	1.2	0.025	0.71	11.4
6	D4A	Sub-Drain	3.67	4.22	8.203	4.00	2.00	16400	2.0	16.0	12.9	1.2	0.025	0.53	8.6
7	D4B	Sub-Drain	10.17	11.70	16.733	6.50	2.00	16800	2.0	21.0	15.4	1.4	0.025	0.56	11.8
8	D5	Sub-Drain	15.45	17.76	27.560	6.50	2.25	11100	2.0	24.8	16.6	1.5	0.025	0.74	18.3
9	D6	Sub-Drain	4.37	5.03	18.702	4.00	2.00	9400	2.0	16.0	12.9	1.2	0.025	0.71	11.3
10	D6B	Sub-Drain	6.68	19.24	13.124	6.00	2.00	5300	2.0	20.0	14.9	1.3	0.025	0.99	19.8
11	D7	Sub-Drain	1.87	2.15	21.327	4.00	2.00	5400	2.0	16.0	12.9	1.2	0.025	0.93	14.9
12	D8	Sub-Drain	11.51	13.23	17.389	6.00	2.25	17400	2.0	23.6	16.1	1.5	0.025	0.58	13.8
13	D9	Sub-Drain	4.41	5.07	38.388	4.00	2.00	15400	2.0	16.0	12.9	1.2	0.025	0.55	8.8
14	D10	Sub-Drain	8.96	10.30	23.623	4.00	2.00	7800	2.0	16.0	12.9	1.2	0.025	0.78	12.4
15	D11	Sub-Drain	30.88	35.51	31.498	9.00	2.25	4500	2.0	30.4	19.1	1.6	0.025	1.21	36.7
16	D12	Sub-Drain	19.79	22.75	22.475	11.00	2.50	22500	2.0	40.0	22.2	1.8	0.025	0.59	23.5
17	D12A	Sub-Drain	15.68	18.04	15.421	5.50	2.00	5200	2.0	19.0	14.4	1.3	0.025	0.99	18.8
18	D13	Sub-Drain	21.87	25.15	39.372	7.50	2.25	6600	2.0	27.0	17.6	1.5	0.025	0.97	26.3
19	D14	Sub-Drain	32.96	63.05	39.372	14.00	3.00	7900	2.0	60.0	27.4	2.2	0.025	1.13	67.6

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-43A: Design and Gradient Calculation of Hussainabad Mehrabpur Dhoro

Sr. No.	Section			RDs	Discharge Required Q	Bed Width	Depth of Flow	Gradient	Side Slope	Area	Wetted Perimeter	Hydraulic Radius	Manning N	Velocity of Flow	Discharge As per Design
					cusecs	ft	ft			sq. ft	ft	ft		ft/sec	cusec
1	0.000	to	293.029	293.029	554.72	95.00	4.50	15800	3.0	488.3	123.5	4.0	0.025	1.18	577.4
2	293.029	to	307.016	13.987	409.04	70.00	4.50	15800	3.0	375.8	98.5	3.8	0.025	1.15	433.9
3	307.016	to	434.187	127.171	386.28	65.00	4.50	15800	3.0	353.3	93.5	3.8	0.025	1.15	405.3
4	434.187	to	449.270	15.083	295.38	47.00	4.50	15800	3.0	272.3	75.5	3.6	0.025	1.11	302.8
5	449.270	to	453.657	4.387	290.31	47.00	4.50	15800	3.0	272.3	75.5	3.6	0.025	1.11	302.8
6	453.657	to	457.934	4.277	288.15	45.00	4.50	15800	3.0	263.3	73.5	3.6	0.025	1.11	291.5
7	457.934	to	482.512	24.578	283.08	45.00	4.50	15800	3.0	263.3	73.5	3.6	0.025	1.11	291.5
8	482.512	to	499.270	16.759	192.68	38.00	4.00	15800	3.0	200.0	63.3	3.2	0.025	1.02	203.6
9	499.270	to	527.420	28.150	163.32	40.00	3.50	15800	3.0	176.8	62.1	2.8	0.025	0.95	167.8
10	527.420	to	589.540	62.120	145.56	35.00	3.50	15800	3.0	159.3	57.1	2.8	0.025	0.94	149.1
11	589.540	to	866.727	277.187	120.74	30.00	3.50	15800	3.0	141.8	52.1	2.7	0.025	0.92	130.6

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-44: Earth Work of Hussainabad Mehrabpur Dhoro

Sr. No.	Section RDs			RDs	Bed Width	Depth of Flow	Free Board	Total Depth	Side Slope	Berm W	Height of IP Above GL	Net Cut Area	Cut Volume	W1	W2	Fill 1 Area	Fill 2 Area	Total Fill Area	Fill Volume	Jungle Clarence area	ROW Width	ROW
					ft	ft	ft	ft		ft	ft	ft	cft	ft	ft	sft	sft	sft	cft	sft	ft	Acres
1	0.000	to	293.029	293.029	95.00	4.50	4.00	8.50	3	50	5.0	488.3	143071507	20.0	20.0	175.0	175.0	350.0	102560220	43368322	329	2213.2
2	293.029	to	307.016	13.987	70.00	4.50	4.00	8.50	3	50	5.0	375.8	5255540	20.0	20.0	175.0	175.0	350.0	4895380	2070046		
3	307.016	to	434.187	127.171	65.00	4.50	4.00	8.50	3	50	5.0	353.3	44922979	20.0	20.0	175.0	175.0	350.0	44509675	18821234		
4	434.187	to	449.270	15.083	47.00	4.50	4.00	8.50	3	50	5.0	272.3	4106456	20.0	20.0	175.0	175.0	350.0	5279190	2232343		
5	449.270	to	453.657	4.387	47.00	4.50	4.00	8.50	3	50	5.0	272.3	1194306	20.0	20.0	175.0	175.0	350.0	1535380	649246		
6	453.657	to	457.934	10.500	45.00	4.50	4.00	8.50	3	50	5.0	263.3	2764125	20.0	20.0	175.0	175.0	350.0	3675000	1554000		
7	457.934	to	482.512	10.500	45.00	4.50	4.00	8.50	3	50	5.0	263.3	2764125	20.0	20.0	175.0	175.0	350.0	3675000	1554000		
8	482.512	to	499.270	11.500	38.00	4.00	4.00	8.00	4	50	5.0	216.0	2484000	20.0	20.0	200.0	200.0	400.0	4600000	2116000		
9	499.270	to	527.420	12.500	40.00	3.50	4.00	7.50	5	50	5.0	201.3	2515625	20.0	20.0	225.0	225.0	450.0	5625000	2750000		
10	527.420	to	589.540	13.500	35.00	3.50	4.00	7.50	6	50	5.0	196.0	2646000	20.0	20.0	250.0	250.0	500.0	6750000	3456000		
11	589.540	to	866.727	14.500	30.00	3.50	4.00	7.50	7	50	5.0	190.8	2765875	20.0	20.0	275.0	275.0	550.0	7975000	4234000		
												Total	**214490538**					**Total**	**191079845**	82805192		
													214.49	**M-cft**					**191.08**			

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank Of Indus River, Delta & Costal Zone

TABLE-45: Design and Gradient Calculation of Nangreja-Talpur Wada Dhoro

Sr. No.	Section			RDs	Discharge Required Q	Bed Width	Depth of Flow	Gradient	Side Slope	Area	Wetted Perimeter	Hydraulic Radius	Manning N	Velocity of Flow	Discharge As per Design
					cusecs	ft	ft			sq. ft	ft	ft		ft/sec	cusec
1	0.000	to	71.088	8.24	90.40	25.00	3.00	12700	3.0	102.0	44.0	2.3	0.025	0.92	94.3
2	71.088	to	98.520	16.16	72.63	19.00	3.00	12700	3.0	84.0	38.0	2.2	0.025	0.90	75.2
3	98.520	to	120.553	15.67	62.24	15.50	3.00	12700	3.0	73.5	34.5	2.1	0.025	0.87	64.2
4	120.553	to	126.835	3.91	13.01	10.00	2.50	12700	3.0	43.8	25.8	1.7	0.025	0.75	32.8

Calculation of Gradient:

	RDs		Elevations
Start	0.00		155
End	126.84		165
Reach	126.84	Drop	10
Available Gradient			12683.5
		say	12700

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-46: Earth Work of Nangreja-Talpur Wada Dhoro

Sr. No.	Section RDs			RDs	Bed Width	Depth of Flow	Free Board	Total Depth	Side Slope	Berm W	Height of IP Above GL	Net Cut Area	Cut Volume	W1	W2	Fill 1 Area	Fill 2 Area	Total Fill Area	Fill Volume	Jungle Clarence area
					ft	ft	ft	ft		ft	ft	ft	cft	ft	ft	sft	sft	sft	cft	sft
1	0.000	to	71.088	71.088	25.00	3.00	4.00	7.00	3	50	5.0	102.0	7250925	20.0	20.0	175.0	175.0	350.0	24880625	10520950
2	71.088	to	98.520	27.43	19.00	3.00	4.00	7.00	3	50	5.0	84.0	2304305	20.0	20.0	175.0	175.0	350.0	9601270	4059966
3	98.520	to	120.553	22.03	15.50	3.00	4.00	7.00	3	50	5.0	73.5	1619440	20.0	20.0	175.0	175.0	350.0	7711620	3260914
4	120.553	to	126.835	6.282	10.00	2.50	4.00	6.50	3	50	5.0	43.8	274842	20.0	20.0	175.0	175.0	350.0	2198735	929751
												Total	**11449512**					**Total**	**44392250**	18771580
													11.45	**M-cft**					**44.39**	

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

Table- 47: Summary Earth Work of South Khairpur Left over Areas

Sr. No.	Drain Name	Type	Cut Volume	Fill Volume	ROW	Jungle Clarence Area
			M-cft	cft	Acres	sft
1	D1	Sub-Drain	0.87	0.77	31.64	
2	D1A	Sub-Drain	0.68	0.62	25.60	
3	D2	Sub-Drain	1.97	1.95	79.23	
4	D3	Sub-Drain	1.07	0.56	24.71	
5	D4	Sub-Drain	2.23	0.92	42.28	
6	D4A	Sub-Drain	0.80	0.41	18.12	
7	D4B	Sub-Drain	0.89	0.84	34.29	
8	D5	Sub-Drain	1.54	1.38	56.80	
9	D6	Sub-Drain	2.82	1.38	61.39	
10	D6B	Sub-Drain	0.69	0.66	26.83	
11	D7	Sub-Drain	1.81	1.07	46.10	
12	D8	Sub-Drain	0.94	0.87	35.68	
13	D9	Sub-Drain	3.93	1.92	85.55	
14	D10	Sub-Drain	3.93	1.92	85.55	
15	D11	Sub-Drain	1.90	1.57	65.70	
16	D12	Sub-Drain	1.72	1.12	48.73	
17	D12A	Sub-Drain	0.79	0.77	31.43	
18	D13	Sub-Drain	2.29	1.97	81.61	
19	D14	Sub-Drain	4.81	2.20	93.95	
		Total	**35.68**	**22.90**	**975.18**	
		Unsound 5%	**1.78**			
		Available Fill	**33.90**			
		Raquired Fill	**22.90**			
		Surplus Mat.	**11.00**			
20	MH Dhoro	Dhoro	214.49	191.08	0.00	82805192
21	NTW Dhoro	Dhoro	11.45	44.39	0.00	18771580
		Total	**225.94**	**235.47**	**0.00**	**101576772**
		Unsound 15%	**33.89**			
		Available Fill	**192.05**			
		Raquired Fill	**235.47**			
		Borrow Mat.	**-43.42**			

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)
Preparation of Regional Plan for Left Bank Of Indus River, Delta & Costal Zone.
TABLE- 48 GRADIENT CALCULATION TANDO ADAM LOA DRAINS

S.No.	Drain Name	Length (RD)	Start Elev. (ft)	End Elev. (ft)	Available Gradient	(say)	Outfalling
1	D1	23.760	87.00	89.00	11,880	11,900	Sohni Dhoro At RD: 29+615
2	D2A	6.600	86.90	87.80	7,333	7,400	Sohni Dhoro At RD: 28+680
3	D2	34.267	86.50	88.50	17,134	17,200	Sohni Dhoro At RD: 27+820
4	D3	40.445	82.00	85.00	13,482	13,400	Sohni Dhoro At RD: 23+275
5	D4	231.792	57.00	81.00	9,658	9,700	Sohni Dhoro At RD: 4+476
6	D5	68.640	66.50	72.00	12,480	12,500	D4 At RD: 5+308
7	D6A	24.235	70.00	72.50	9,694	9,700	Sohni Dhoro At RD: 12+255
8	D6	26.558	68.00	71.00	8,853	8,900	D4 AT RD: 5+097
9	D7A	55.968	60.00	65.00	11,194	11,200	D4 AT RD: 3+514
10	D7	24.869	67.50	73.00	4,522	4,600	Sohni Dhoro At RD: 12+255
11	D8	48.312	60.50	65.50	9,662	9,700	D4 AT RD: 2+826
12	D9	56.496	60.00	65.00	11,299	11,300	D4 AT RD: 1+729
13	D10	62.304	60.00	66.00	10,384	10,400	D4 AT RD: 0+658
14	D11	69.696	76.00	80.00	17,424	17,500	Sohni Dhoro at RD: 16+190
15	D12	46.042	75.00	82.00	6,577	6,600	Sohni Dhoro At RD: 15+886
16	D13	21.278	77.00	80.00	7,093	7,100	Sohni Dhoro At RD: 15+889
17	D14	57.552	70.00	75.00	11,510	11,500	Sohni Dhoro At RD:13+802
18	D15	71.808	67.00	77.00	7,181	7,200	Sohni Dhoro At RD:13+2931
19	D16A	18.638	67.00	72.00	3,728	3,700	D16 AT RD: 0+1626
20	D16	27.245	67.50	71.00	7,784	7,800	Sohni Dhoro At RD:10+8206
21	D17	75.504	66.50	72.00	13,728	13,800	Sohni Dhoro At RD: 8+0531
22	D18	45.883	53.00	60.50	6,118	6,200	D18-A At RD: 0+643
23	D18A	17.424	53.00	54.50	11,616	11,700	Sohni Dhoro At RD: 3+8019
24	D19	59.136	51.50	56.00	13,141	13,200	Sohni Dhoro At RD: 2+861

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)
Preparation of Regional Plan for Left Bank Of Indus River, Delta & Costal Zone.
TABLE-49 DESIGN PARAMETERS OF DRAINAS OF TANDO ADAM LOA

Drainage Coefficient = 2.54
20 yr period (10 days Evacuation)

Sr. Nr.	Drain Name	Type	Catchment Area (Sq-Mile)	Discharge Required Q (cusecs)	LENGTH RDs	Bed Width (ft)	Depth of Flow (ft)	Gradient	SideSlop	Area (sq.ft)	Wetted Perimeter (ft)	Hydraulic Radius (ft)	Manning N	Velocity of Flow (ft/sec)	Discharge As Per Design (cusec)
1	D1	Sub-Drain	3.75	9.53	4.000	4.00	2.00	11900	2.0	16.0	12.9	1.2	0.025	0.63	10.0
2	D2A	Sub-Drain	1.32	3.35	6.600	4.00	2.00	7400	2.0	16.0	12.9	1.2	0.025	0.80	12.7
3	D2	Sub-Drain	10.72	27.24	34.267	12.00	2.50	17200	2.0	42.5	23.2	1.8	0.025	0.68	28.9
4	D3	Sub-Drain	15.71	39.90	40.445	16.00	2.50	13400	2.0	52.5	27.2	1.9	0.025	0.80	41.8
5	D4	Branch-Drain	42.91	479.30	231.792	80.00	4.00	9700	2.0	352.0	97.9	3.6	0.025	1.42	498.6
6	D5	Sub-Drain	22.10	56.13	68.640	15.00	3.00	12500	2.0	63.0	28.4	2.2	0.025	0.90	56.9
7	D6A	Sub-Drain	14.63	37.15	24.235	12.00	2.50	9700	2.0	42.5	23.2	1.8	0.025	0.90	38.4
8	D6	Sub-Drain	4.53	11.51	26.558	4.00	2.00	8900	2.0	16.0	12.9	1.2	0.025	0.73	11.6
9	D7A	Branch-Drain	42.23	107.26	55.968	22.00	3.50	11200	2.0	101.5	37.7	2.7	0.025	1.09	110.4
10	D7	Sub-Drain	11.79	29.94	24.869	7.50	2.25	4600	2.0	27.0	17.6	1.5	0.025	1.17	31.5
11	D8	Sub-Drain	22.50	57.16	48.312	17.00	2.75	9700	2.0	61.9	29.3	2.1	0.025	0.99	61.5
12	D9	Sub-Drain	34.35	87.24	56.496	24.00	3.00	11300	2.0	90.0	37.4	2.4	0.025	1.00	90.3
13	D10	Sub-Drain	20.08	51.01	62.304	18.00	2.50	10400	2.0	57.5	29.2	2.0	0.025	0.92	52.7
14	D11	Sub-Drain	24.05	61.09	69.696	20.00	3.00	17500	2.0	78.0	33.4	2.3	0.025	0.79	61.7
15	D12	Sub-Drain	24.17	61.40	46.042	17.00	2.50	6600	2.0	55.0	28.2	2.0	0.025	1.14	62.8
16	D13	Sub-Drain	4.38	11.12	21.278	4.00	2.00	7100	2.0	16.0	12.9	1.2	0.025	0.81	13.0
17	D14	Sub-Drain	21.31	54.14	57.552	17.00	2.75	11500	2.0	61.9	29.3	2.1	0.025	0.91	56.5
18	D15	Sub-Drain	33.07	84.00	71.808	21.00	2.75	7200	2.0	72.9	33.3	2.2	0.025	1.18	86.1
19	D16A	Sub-Drain	4.53	11.51	18.638	4.00	2.00	3700	2.0	16.0	12.9	1.2	0.025	1.13	18.0
20	D16	Sub-Drain	3.91	21.46	27.245	7.00	2.25	7800	2.0	25.9	17.1	1.5	0.025	0.89	23.0
21	D17	Sub-Drain	32.49	82.53	75.504	25.00	3.00	13800	2.0	93.0	38.4	2.4	0.025	0.91	84.8
22	D18	Sub-Drain	15.60	55.03	45.883	15.00	2.50	6200	2.0	50.0	26.2	1.9	0.025	1.16	58.1
23	D18A	Sub-Drain	6.06	15.40	17.424	7.50	2.00	11700	2.0	23.0	16.4	1.4	0.025	0.69	15.8
24	D19	Branch-Drain	40.39	102.60	59.136	26.00	3.25	13200	2.0	105.6	40.5	2.6	0.025	0.98	103.5

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)
Preparation of Regional Plan for Left Bank Of Indus River, Delta & Costal Zone.
TABLE-50 DESIGN PARAMETERS OF SOHNI DHORO

Sr.Nr.	Section			RDs	Q	Discharg Required Q (cusecs)	Bed Width (ft)	Depth of Flow (ft)	Gradient	Side Slope	Area (sq.ft)	Wetted Perimeter (ft)	Hydraulic Radius (ft)	Manning N	Velocity of Flow (ft/sec)	Discharge As per Design (cusec)
1	0.000	to	65.143	65.14	57.16	1400.14	150.00	6.00	16700	3.0	1008.0	187.9	5.4	0.025	1.41	1420.6
2	65.143	to	86.693	21.55	15.40	1342.98	145.00	6.00	16700	3.0	978.0	182.9	5.3	0.025	1.41	1375.3
3	86.693	to	103.627	16.93	479.30	1327.57	140.00	6.00	16700	3.0	948.0	177.9	5.3	0.025	1.40	1330.1
4	103.627	to	183.364	79.74	82.53	848.27	130.00	5.00	16700	3.0	725.0	161.6	4.5	0.025	1.25	907.0
5	183.364	to	246.378	63.01	21.46	765.74	150.00	4.50	16700	3.0	735.8	178.5	4.1	0.025	1.18	870.1
6	246.378	to	279.045	32.67	121.20	744.29	162.00	4.50	16700	3.0	789.8	190.5	4.1	0.025	1.19	937.6
7	279.045	to	302.674	23.63	84.00	623.09	143.00	4.00	16700	3.0	620.0	168.3	3.7	0.025	1.10	680.2
8	302.674	to	314.274	11.60	54.14	539.08	138.00	4.00	16700	3.0	600.0	163.3	3.7	0.025	1.10	657.1
9	314.274	to	361.656	47.38	207.22	484.95	140.00	3.50	16700	3.0	526.8	162.1	3.2	0.025	1.01	531.5
10	361.656	to	368.655	7.00	61.09	277.72	120.00	3.50	16700	3.0	456.8	142.1	3.2	0.025	1.00	457.5
11	368.655	to	529.954	161.30	39.90	216.63	110.00	3.00	16700	3.0	357.0	129.0	2.8	0.025	0.91	323.7
12	529.954	to	633.458	103.50	27.24	176.73	95.00	3.00	16700	3.0	312.0	114.0	2.7	0.025	0.90	280.8
13	633.458	to	674.324	40.87	38.48	149.49	90.00	2.75	16700	3.0	270.2	107.4	2.5	0.025	0.85	229.9
14	674.324	to	767.000	92.68	111.00	111.00	70.00	2.50	16700	3.0	193.8	85.8	2.3	0.025	0.79	153.4

Calculation of Gradient:			
	RDs		Elevations
Start	0.00		43
End	767.00		89
Reach	767.00	Drop	46
Available radient			16673.9
		say	16700

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)
Preparation of Regional Plan for Left Bank Of Indus River, Delta & Costal Zone.
TABLE-51 EARTH WORK OF SOHNI DHORO

Sr.	SECTION RDs			RDs	Bed Width (ft)	Depth of Flow (ft)	Free Board (ft)	Total Depth (ft)	Side Slope	Berm W (ft)	Height of IP above GL (ft)	Net Cut Area (sft)	Cut Volume (cft)	W1 (ft)	W2 (ft)	Fill 1 Area (sft)	Fill 2 Area (sft)	Total Fill Area (sft)	Vol Fill ume (cft)	Jun gle Clea renc e (sft)
1	0.000	to	65.143	65.143	150.00	6.00	4.00	10.00	3	50	5.0	1008.0	65663640	20	20	175.0	175.0	350.0	22799875	6514250
2	65.143	to	86.693	21.55	145.00	6.00	4.00	10.00	3	50	5.0	978.0	21076389	20	20	175.0	175.0	350.0	7542675	2155050
3	86.693	to	103.627	16.93	140.00	6.00	4.00	10.00	3	50	5.0	948.0	16053148	20	20	175.0	175.0	350.0	5926795	1693370
4	103.627	to	183.364	79.74	130.00	5.00	4.00	9.00	3	50	5.0	725.0	57809398	20	20	175.0	175.0	350.0	27907985	7973710
5	183.364	to	246.378	63.01	150.00	4.50	4.00	8.50	3	50	5.0	735.8	46362477	20	20	175.0	175.0	350.0	22054865	6301390
6	246.378	to	279.045	10.5	162.00	4.50	4.00	8.50	3	50	5.0	789.8	8292375	20	20	175.0	175.0	350.0	3675000	3266770
7	279.045	to	302.674	10.5	143.00	4.00	4.00	8.00	3	50	5.0	620.0	6510000	20	20	175.0	175.0	350.0	3675000	2362830
8	302.674	to	314.274	10.5	138.00	4.00	4.00	8.00	3	50	5.0	600.0	6300000	20	20	175.0	175.0	350.0	3675000	1159980
9	314.274	to	361.656	10.5	140.00	3.50	4.00	7.50	3	50	5.0	526.8	5530875	20	20	175.0	175.0	350.0	3675000	4738270
10	361.656	to	368.655	10.5	120.00	3.50	4.00	7.50	3	50	5.0	456.8	4795875	20	20	175.0	175.0	350.0	3675000	699910
11	368.655	to	529.954	10.5	110.00	3.00	4.00	7.00	3	50	5.0	357.0	3748500	20	20	175.0	175.0	350.0	3675000	16129900
12	529.954	to	633.458	10.5	95.00	3.00	4.00	7.00	3	50	5.0	312.0	3276000	20	20	175.0	175.0	350.0	3675000	10350350
13	633.458	to	674.324	10.5	90.00	2.75	4.00	6.75	3	50	5.0	270.2	2836969	20	20	175.0	175.0	350.0	3675000	4086570
14	674.324	to	767.000	11.5	70.00	2.50	4.00	6.50	3	50	5.0	193.8	2228125	20	20	175.0	175.0	350.0	4025000	9267650
												Total =	**250483770**					**Total =**	**119657195**	**76700000**
													250.48	**M-Cft**					**119.66**	

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)
Preparation of Regional Plan for Left Bank Of Indus River, Delta & Costal Zone.
TABLE-52 EARTH WORK OF TANDO ADAM LEFT OVER AREA
(Summary Sheet)

Sr. Nr.	DRAIN NAME	TYPE	Cut Volume (M-cft)	Fill Volume (cft)	ROW (Acres)	Jungle Clearance (Sft)
1	D1	Sub-Drain	0.52	0.20	9.32	
2	D2A	Sub-Drain	0.61	0.33	14.45	
3	D2	Sub-Drain	2.77	1.71	75.04	
4	D3	Sub-Drain	3.34	2.02	88.71	
5	D4	Branch-Drain	137.33	42.54	480.68	
6	D5	Sub-Drain	8.46	3.84	164.66	
7	D6A	Sub-Drain	2.18	1.21	53.97	
8	D6	Sub-Drain	3.75	1.33	63.11	
9	D7A	Branch-Drain	10.39	6.80	181.17	
10	D7	Sub-Drain	1.45	1.24	51.58	
11	D8	Sub-Drain	6.27	2.71	117.33	
12	D9	Sub-Drain	9.69	3.16	146.01	
13	D10	Sub-Drain	7.88	3.49	150.76	
14	D11	Sub-Drain	10.66	3.90	174.47	
15	D12	Sub-Drain	5.62	2.58	110.52	
16	D13	Sub-Drain	2.95	1.06	50.37	
17	D14	Sub-Drain	7.47	3.22	139.31	
18	D15	Sub-Drain	10.49	4.02	178.62	
19	D16A	Sub-Drain	2.63	0.93	44.29	
20	D16	Sub-Drain	1.56	1.36	56.33	
21	D17	Sub-Drain	12.92	4.38	192.30	
22	D18	Sub-Drain	5.23	2.57	108.57	
23	D18A	Sub-Drain	1.03	0.87	36.32	
24	D19	Branch-Drain	10.37	3.20	149.60	
		Total	**265.57**	**98.67**	**2837.48**	
Unsound 5%			**13.28**			
Available Fill			**252.29**			
Required Fill			**98.67**			
Surplus Mat.			**153.62**			
	Sohni	Dhoro	**250.48**	**119.66**	**0.00**	**76700000**
Unsound 15%			**37.57**			
Available Fill			**212.91**			
Required Fill			**119.66**			
Surplus Mat.			**93.25**			

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone.

TABLE-53: Gradient Calculations of T.M Khan LOA Drains

S.No.	Drain Name	Length (RD)	Start Elev. (ft)	End Elev. (ft)	Available Gradient	(say)	Out falling	at RD
1	D1A	57.552	76.00	78.00	28,776	28,000	BHAI KHAN 4	82+1103
2	D1B	81.840	57.00	65.00	10,230	10,300	BHAI KHAN 3	6+4977
3	D1	88.704	47.00	59.00	7,392	7,400	BHAI KHAN 2	285+1144
4	D2	42.768	57.00	69.00	3,564	3,600	Luhano Dhoro	73+4971
5	D3	67.584	63.00	65.00	33,792	33,800	Luhano Dhoro	52+7980
6	D4	62.832	61.00	69.00	7,854	7,900	D-3	35+4051
7	D5	31.310	59.00	62.00	10,437	10,500	D-5	22+8142
8	D6A	41.395	44.00	57.00	3,184	3,200	Luhano Dhoro	12+4560
9	D6	41.184	61.00	65.00	10,296	10,300	Luhano Dhoro	35+1723
10	D7	79.170	52.00	63.00	7,197	7,200	D-6A	3+5206
11	D8	277.200	44.00	81.00	7,492	7,500	Bhai Khan Dhoro	256+5270
12	D9	49.526	53.00	65.00	4,127	4,200	D8	137+6300
13	D10	40.075	58.00	63.00	8,015	8,000	D8	175+1397
14	D11	40.603	58.00	72.00	2,900	2,900	D-10	23+9531
15	D12	38.386	58.00	71.00	2,953	3,000	D-11	20+5568
16	D13	67.056	51.00	56.00	13,411	13,400	D8	31+4260
17	D14	62.304	44.00	51.00	8,901	8,900	Bhai Khan Dhoro	219+4403
18	D15	43.930	47.00	49.00	21,965	22,000	D14	16+0401
19	D16	33.845	45.00	47.00	16,922	16,900	Bhai Khan Dhoro	217+8572
20	D17	35.270	49.00	53.00	8,818	18,800	Bhai Khan Dhoro	2710003
21	D18	97.680	37.00	57.00	4,884	4,900	D-19	104+6470
22	D19	171.072	25.00	50.00	6,843	6,900	Pangrio-2	27+8163

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-54: Design Parameters of Drains Of Tando Muhammad Khan LOA

Drainage Coefficient = 2.54

20 yr period (10 days Evacuation)

Sr. No.	Drain	Type	Catchment Area	D. Discharge	Length	Bed Width	Flow Depth	Gradient	Side Slope	Area	Wetted Perimeter	Hydraulic Radius	Manning's 'n'	Flow Velocity	Section Discharge
			Sq. Mile	cusecs	RDs	ft	ft			sq.ft	(ft)	ft		ft/sec	cusec
1	D1	Sub-Drain	3.30	6.61	17.384	4.00	2.00	8700	2.0	16.0	12.9	1.2	0.025	0.73	11.7
2	D2	Sub-Drain	5.24	10.48	24.600	4.00	2.00	7100	2.0	16.0	12.9	1.2	0.025	0.81	13.0
3	D2A	Sub-Drain	3.17	6.33	18.040	4.00	2.00	4500	2.0	16.0	12.9	1.2	0.025	1.02	16.3
4	D3	Sub-Drain	7.97	15.95	37.720	4.00	2.00	3500	2.0	16.0	12.9	1.2	0.025	1.16	18.5
5	D4	Branch-Drain	30.96	100.14	102.664	18.00	3.50	9000	2.0	87.5	33.7	2.6	0.025	1.18	103.7
6	D5	Sub-Drain	10.63	21.27	37.392	7.50	2.25	9400	2.0	27.0	17.6	1.5	0.025	0.82	22.0

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-55: Design and Gradient Calculation of Bhai Khan Dhoro

Sr. Nr.	Section			RDs	Discharge Required Q	Bed Width	Depth of Flow	Gradient	Side Slope	Area	Wetted Perimeter	Hydraulic	Manning N	Velocity of Flow	Discharge As per Design
					(cusecs)	(ft)	(ft)			(sq.ft)	(ft)	(ft)		(ft/sec)	(cusec)
1	0.000	to	35.131	35.13	2950.78	180.00	7.00	9300	3.0	1407.0	224.3	6.3	0.025	2.10	2949.9
2	35.131	to	232.990	197.86	2498.13	173.00	6.50	9300	3.0	1251.3	214.1	5.8	0.025	2.00	2502.2
3	232.990	to	234.360	1.37	2197.30	152.00	6.50	9300	3.0	1114.8	193.1	5.8	0.025	1.98	2211.0
4	234.360	to	271.710	37.35	2130.67	146.00	6.50	9300	3.0	1075.8	187.1	5.7	0.025	1.98	2127.9
5	271.710	to	286.067	14.36	607.77	106.00	3.75	9300	3.0	439.7	129.7	3.4	0.025	1.39	611.5
6	286.067	to	300.175	14.11	584.71	102.00	3.75	9300	3.0	424.7	125.7	3.4	0.025	1.39	589.3
7	300.175	to	411.079	110.90	380.43	65.00	3.75	9300	3.0	285.9	88.7	3.2	0.025	1.34	384.5
8	411.079	to	567.560	156.48	225.83	56.00	3.00	9300	3.0	195.0	75.0	2.6	0.025	1.17	227.3

Calculation of Gradient:			
	RDs		Elevations
Start	0.00		13
End	567.56		74
Reach	567.56	Drop	61
Available Gradient			9304.3
		say	9300

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-56: Earthwork of Bhai Khan Dhoro

Sr. No.	SECTION RDs			RDs	Bed Width (ft)	Depth of Flow (ft)	Free Board (ft)	Total Depth (ft)	Side Slope	Berm W (ft)	Height of IP above GL (ft)	Net Cut Area (sft)	Cut Volume (cft)	W1 (ft)	W2 (ft)	Fill 1 Area (sft)	Fill 2 Area (sft)	Total Fill Area (sft)	Fill Volume (cft)	Jungle Clarence area (Sft)
1	0.000	to	35.131	35.131	180.00	7.00	4.00	11.00	3	50	5.0	1407.0	49429317	20.0	20.0	175.0	175.0	350.0	12295850	5199388
2	35.131	to	232.990	197.9	173.00	6.50	4.00	10.50	3	50	5.0	1251.3	247571074	20.0	20.0	175.0	175.0	350.0	69250650	29283132
3	232.990	to	234.360	1.37	152.00	6.50	4.00	10.50	3	50	5.0	1114.8	1527208	20.0	20.0	175.0	175.0	350.0	479500	202760
4	234.360	to	271.710	37.35	146.00	6.50	4.00	10.50	3	50	5.0	1075.8	40179263	20.0	20.0	175.0	175.0	350.0	13072500	5527800
5	271.710	to	286.067	14.36	106.00	3.75	4.00	7.75	3	50	5.0	439.7	6312593	20.0	20.0	175.0	175.0	350.0	5024950	2124836
6	286.067	to	300.175	10.5	102.00	3.75	4.00	7.75	3	50	5.0	424.7	4459219	20.0	20.0	175.0	175.0	350.0	3675000	1554000
7	300.175	to	411.079	10.5	65.00	3.75	4.00	7.75	3	50	5.0	285.9	3002344	20.0	20.0	175.0	175.0	350.0	3675000	1554000
8	411.079	to	567.560	10.5	56.00	3.00	4.00	7.00	3	50	5.0	195.0	2047500	20.0	20.0	175.0	175.0	350.0	3675000	1554000
												Total	**354528517**					**Total =**	**111148450**	46999916
													354.53						**111.15**	

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-57: Earthwork Of T.M Khan Left Over Area

(Summary Sheet)

Sr. Nr.	DRAIN NAME	TYPE	Cut Volume (M-cft)	Fill Volume (M-cft)	ROW (Acres)	Jungle Clarence area (Sft)
1	D1A	Sub-Drain	14.35	6.96	202.07	
2	D1B	Sub-Drain	4.39	4.09	167.57	
3	D1	Branch-Drain	14.71	10.73	279.44	
4	D2	Branch-Drain	6.04	5.18	131.28	
5	D3	Branch-Drain	49.38	8.10	328.85	
6	D4	Sub-Drain	9.41	3.52	157.26	
7	D5	Sub-Drain	2.53	1.57	68.64	
8	D6A	Main-Drain	27.68	5.84	212.07	
9	D6	Sub-Drain	3.66	2.06	91.90	
10	D7	Branch-Drain	13.44	9.61	254.21	
11	D8	Main-Drain	223.06	39.09	187.33	
12	D9	Sub-Drain	3.03	2.48	103.47	
13	D10	Sub-Drain	5.71	2.24	99.07	
14	D11	Sub-Drain	2.41	2.03	84.44	
15	D12	Sub-Drain	1.84	1.92	77.55	
16	D13	Sub-Drain	12.06	3.76	176.07	
17	D14	Sub-Drain	7.99	3.49	151.53	
18	D15	Sub-Drain	4.28	2.20	99.34	
19	D16	Sub-Drain	3.31	1.69	76.52	
20	D17	Sub-Drain	2.58	1.76	75.75	
21	D18	Sub-Drain	13.07	5.47	238.67	
22	D19	Branch-Drain	32.15	21.85	552.13	
		Total	**457.08**	**145.64**	**3815.16**	
		Unsound 5%	**22.85**			
		Available Fill	**434.23**			
		Raquired Fill	**145.64**			
		Surplus Mat.	**288.59**			
29	Bhaikhan	Dhoro	354.53	111.15	0.00	46999916.00
		Unsound 15%	**53.18**			
		Available Fill	**301.35**			
		Raquired Fill	**111.15**			
		Surplus Mat.	**190.20**			

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-58: Gradient Calculations of Digri LOA Drains

Sr. No.	Drain Name	End RD	Start Elev. (ft)	End Elev. (ft)	Gradient	(say)	Out falling
1	D1A	55.694	40.00	46.00	9,282	9,300	MMD
2	D1	44.772	39.00	47.00	5,597	7,000	Digree Dhoro at RD 59+568
3	D2	57.826	34.50	37.50	19,275	19,300	Digree Dhoro at RD 25+434
4	D3	35.555	35.00	38.50	10,159	10,200	Digree Dhoro at RD 28+338
5	D3A	30.996	35.50	39.00	8,856	8,900	Digree Dhoro at RD 8+3325
6	D4	55.170	29.00	35.00	9,195	9,200	Dhoro Puran at RD 112+574
7	D5	52.480	35.50	40.00	11,662	11,700	D4 at RD 53+759
8	D6	26.896	34.00	40.50	4,138	7,000	D5 at RD 19+954
9	D7	55.760	30.00	39.00	6,196	7,000	LBOD
10	D7A	48.216	26.00	32.50	7,418	7,500	LBOD
11	D8	58.942	30.00	35.50	10,717	10,700	Dhoro Puran at RD 52+305
12	D9	35.096	31.00	34.00	11,699	11,700	
13	D10	128.904	30.00	40.50	12,277	9,400	MMD
14	D12	36.080	27.50	32.50	7,216	7,200	Dhoro Puran at RD 46+4877
15	D13	191.552	26.00	46.00	9,578	9,600	MMD
16	D13A	49.528	33.00	38.00	9,906	9,900	D13 at RD 80+577
17	D14	51.693	25.00	30.00	10,339	10,300	MMD
18	D15	59.040	19.00	22.00	19,680	19,700	LBOD
19	D16	35.424	22.00	26.00	8,856	8,800	D15 At 6+900
20	D17	32.472	22.00	25.00	10,824	10,800	MMD
21	D18	29.848	21.00	22.50	19,899	20,000	LBOD
22	D18A	38.376	19.00	21.50	15,350	15,300	LBOD

SINDH WATER SCTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-58: Design Parameters of Drains Digri

Drainage Coefficient = 2.59

20 yr period (10 days Evacuation)

Sr. No.	Drain Name	Type	Catchment Area	Discharge Required Q	Length	Bed Width	Depth of Flow	Gradient	Side Slope	Area	Wetted Perimeter	Hydraulic Radius	Manning N	Velocity of Flow	Discharge Q
			sq-mile	cusecs	RDs	ft	ft			sq.ft	ft	ft		ft/se	cfs
1	D1A	Sub-Drain	21.88	56.68	55.694	12.50	3.00	9300	2.0	55.5	25.9	2.1	0.025	1.02	56.8
2	D1	Sub-Drain	23.74	61.49	44.772	12.00	3.00	7000	2.0	54.0	25.4	2.1	0.025	1.17	63.4
3	D2	Sub-Drain	22.29	57.73	57.826	10.00	4.00	19300	2.0	72.0	27.9	2.6	0.025	0.81	58.0
4	D3	Sub-Drain	11.06	28.66	35.555	11.00	2.25	10200	2.0	34.9	21.1	1.7	0.025	0.82	28.7
5	D3A	Sub-Drain	7.63	19.76	30.996	8.50	2.00	8900	2.0	25.0	17.4	1.4	0.025	0.80	20.0
6	D4	Branch-Drain	25.03	133.58	55.170	25.00	3.50	9200	2.0	112.0	40.7	2.8	0.025	1.22	136.4
7	D5	Sub-Drain	12.59	68.76	52.480	15.50	3.25	11700	2.0	71.5	30.0	2.4	0.025	0.98	70.1
8	D6	Sub-Drain	13.96	36.15	26.896	12.00	2.25	7000	2.0	37.1	22.1	1.7	0.025	1.01	37.3
9	D7	Sub-Drain	21.65	56.07	55.760	10.50	3.00	7000	2.0	49.5	23.9	2.1	0.025	1.15	57.1
10	D7A	Sub-Drain	27.08	70.14	48.216	14.50	3.00	7500	2.0	61.5	27.9	2.2	0.025	1.16	71.5
11	D8	Sub-Drain	36.94	95.68	58.942	18.50	3.50	10700	2.0	89.3	34.2	2.6	0.025	1.09	97.3
12	D9	Sub-Drain	11.95	30.96	35.096	10.50	2.50	11700	2.0	38.8	21.7	1.8	0.025	0.81	31.4
13	D10	Branch-Drain	61.25	158.63	128.904	35.00	3.25	9400	2.0	134.9	49.5	2.7	0.025	1.20	161.2
15	D12	Sub-Drain	12.96	33.57	36.080	11.00	2.25	7200	2.0	34.9	21.1	1.7	0.025	0.98	34.2
16	D13	Branch-Drain	68.47	212.53	191.552	43.00	3.50	9600	2.0	175.0	58.7	3.0	0.025	1.26	220.0
17	D13A	Sub-Drain	13.58	35.18	49.528	11.00	2.50	9900	2.0	40.0	22.2	1.8	0.025	0.89	35.4
18	D14	Sub-Drain	14.59	37.78	51.693	12.50	2.50	10300	2.0	43.8	23.7	1.8	0.025	0.88	38.6
19	D15	Sub-Drain	21.55	88.99	59.040	25.00	3.50	19700	2.0	112.0	40.7	2.8	0.025	0.83	93.2
20	D16	Sub-Drain	12.81	33.18	35.424	12.25	2.25	8800	2.0	37.7	22.3	1.7	0.025	0.90	33.9
21	D17	Sub-Drain	10.89	28.21	32.472	11.50	2.25	10800	2.0	36.0	21.6	1.7	0.025	0.80	29.0

22	D18	Sub-Drain	8.98	23.25	29.848	11.00	2.50	20000	2.0	40.0	22.2	1.8	0.025	0.62	24.9
23	D18A	Sub-Drain	12.26	31.76	38.376	11.00	2.75	15300	2.0	45.4	23.3	1.9	0.025	0.75	34.0

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-59: Design Parameters of Drains Digri

Drainage Coefficient = 2.59

20 yr period (10 days Evacuation)

Sr. No.	Drain Name	Type	Catchment Area	Discharge Required Q	Length	Bed Width	Depth of Flow	Gradient	Side Slope	Area	Wetted Perimeter	Hydraulic Radius	Manning N	Velocity of Flow	Discharge Q
			sq-mile	cusecs	RDs	ft	ft			sq.ft	ft	ft		ft/se	cfs
1	D1A	Sub-Drain	21.88	56.68	55.694	12.50	3.00	9300	2.0	55.5	25.9	2.1	0.025	1.02	56.8
2	D1	Sub-Drain	23.74	61.49	44.772	12.00	3.00	7000	2.0	54.0	25.4	2.1	0.025	1.17	63.4
3	D2	Sub-Drain	22.29	57.73	57.826	10.00	4.00	19300	2.0	72.0	27.9	2.6	0.025	0.81	58.0
4	D3	Sub-Drain	11.06	28.66	35.555	11.00	2.25	10200	2.0	34.9	21.1	1.7	0.025	0.82	28.7
5	D3A	Sub-Drain	7.63	19.76	30.996	8.50	2.00	8900	2.0	25.0	17.4	1.4	0.025	0.80	20.0
6	D4	Branch-Drain	25.03	133.58	55.170	25.00	3.50	9200	2.0	112.0	40.7	2.8	0.025	1.22	136.4
7	D5	Sub-Drain	12.59	68.76	52.480	15.50	3.25	11700	2.0	71.5	30.0	2.4	0.025	0.98	70.1
8	D6	Sub-Drain	13.96	36.15	26.896	12.00	2.25	7000	2.0	37.1	22.1	1.7	0.025	1.01	37.3
9	D7	Sub-Drain	21.65	56.07	55.760	10.50	3.00	7000	2.0	49.5	23.9	2.1	0.025	1.15	57.1
10	D7A	Sub-Drain	27.08	70.14	48.216	14.50	3.00	7500	2.0	61.5	27.9	2.2	0.025	1.16	71.5
11	D8	Sub-Drain	36.94	95.68	58.942	18.50	3.50	10700	2.0	89.3	34.2	2.6	0.025	1.09	97.3
12	D9	Sub-Drain	11.95	30.96	35.096	10.50	2.50	11700	2.0	38.8	21.7	1.8	0.025	0.81	31.4
13	D10	Branch-Drain	61.25	158.63	128.904	35.00	3.25	9400	2.0	134.9	49.5	2.7	0.025	1.20	161.2
15	D12	Sub-Drain	12.96	33.57	36.080	11.00	2.25	7200	2.0	34.9	21.1	1.7	0.025	0.98	34.2
16	D13	Branch-Drain	68.47	212.53	191.552	43.00	3.50	9600	2.0	175.0	58.7	3.0	0.025	1.26	220.0
17	D13A	Sub-Drain	13.58	35.18	49.528	11.00	2.50	9900	2.0	40.0	22.2	1.8	0.025	0.89	35.4

Drainage Coefficient = 2.59

20 yr period (10 days Evacuation)

Sr. No.	Drain Name	Type	Catchment Area	Discharge Required Q	Length	Bed Width	Depth of Flow	Gradient	Side Slope	Area	Wetted Perimeter	Hydraulic Radius	Manning N	Velocity of Flow	Discharge Q
			sq-mile	cusecs	RDs	ft	ft			sq.ft	ft	ft		ft/se	cfs
18	D14	Sub-Drain	14.59	37.78	51.693	12.50	2.50	10300	2.0	43.8	23.7	1.8	0.025	0.88	38.6
19	D15	Sub-Drain	21.55	88.99	59.040	25.00	3.50	19700	2.0	112.0	40.7	2.8	0.025	0.83	93.2
20	D16	Sub-Drain	12.81	33.18	35.424	12.25	2.25	8800	2.0	37.7	22.3	1.7	0.025	0.90	33.9
21	D17	Sub-Drain	10.89	28.21	32.472	11.50	2.25	10800	2.0	36.0	21.6	1.7	0.025	0.80	29.0
22	D18	Sub-Drain	8.98	23.25	29.848	11.00	2.50	20000	2.0	40.0	22.2	1.8	0.025	0.62	24.9
23	D18A	Sub-Drain	12.26	31.76	38.376	11.00	2.75	15300	2.0	45.4	23.3	1.9	0.025	0.75	34.0

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-60: Design and Gradient Calculation of Digri Dhoro

Sr. Nr.	Section			RDs	Discharge Required Q	Bed Width	Depth of Flow	Gradient	Side Slope	Area	Wetted Perimeter	Hydraulic	Manning N	Velocity of Flow	Discharge As per Design
					(cusecs)	(ft)	(ft)			(sq.ft)	(ft)	(ft)		(ft/sec)	(cusec)
1	0.000	to	35.131	35.13	2950.78	180.00	7.00	9300	3.0	1407.0	224.3	6.3	0.025	2.10	2949.9
1	0.00	to	8.333	8.333	235.00	50.00	3.75	13400	3.0	229.7	73.7	3.1	0.025	1.10	251.6
2	8.33	to	25.434	17.10	213.53	50.00	3.50	13400	3.0	211.8	72.1	2.9	0.025	1.05	222.9
3	25.43	to	28.338	2.90	155.80	35.00	3.50	13400	3.0	159.3	57.1	2.8	0.025	1.02	162.0
4	28.34	to	59.568	31.23	127.14	27.00	3.50	13400	3.0	131.3	49.1	2.7	0.025	0.99	129.7
	59.57	to	66.923	7.36	65.66	25.00	2.50	13400	3.0	81.3	40.8	2.0	0.025	0.81	66.0
				66.92	65.65551894										

Note: -

Length 20.4 km = 66+923 RDs =		12.68	Miles
Catchment Area = 12.68*2		25.36	Sq-Miles
Runoff =25.35x2.59=	65.66	say 66	Cusecs
Add discharge of drains		167	Cusecs
D1, D2, D3 and D3A			
Total= 167+66 = 233	say	**235**	**Cusecs**

Calculation of Gradient:

			Elevations
Start RD	0.000		32.5
End RD	66.932		37.5
Reach	66.93	Drop	5
Available Gradient			13386.4
		say	13400

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-61: Earth Work of Digri Dhoro

Sr. No.	Section RDs			RDs	Bed Width	Depth of Flow	Free Board	Total Depth	Side Slope	Berm W	Height of IP Above GL	Net Cut Area	Cut Volume	W1	W2	Fill 1 Area	Fill 2 Area	Total Fill Area	Fill Volume	Jungle Clarence area
					ft	ft	ft	ft		ft	ft	ft	cft	ft	ft	sft	sft	sft	cft	sft
1	0.000	to	8.333	8.333	50.00	3.75	4.00	7.75	3	50	5.0	229.7	1913986	20.0	20.0	175.0	175.0	350.0	2916550	1233284
2	8.333	to	25.434	17.1	50.00	3.50	4.00	7.50	3	50	5.0	211.8	3621137	20.0	20.0	175.0	175.0	350.0	5985350	2530948
3	25.434	to	28.338	2.904	35.00	3.50	4.00	7.50	3	50	5.0	159.3	462462	20.0	20.0	175.0	175.0	350.0	1016400	429792
4	28.338	to	59.568	31.23	27.00	3.50	4.00	7.50	3	50	5.0	131.3	4098938	20.0	20.0	175.0	175.0	350.0	10930500	4622040
5	59.568	to	66.923	7.355	25.00	2.50	4.00	6.50	3	50	5.0	81.3	597594	20.0	20.0	175.0	175.0	350.0	2574250	1088540
												Total	**10694116**					**Total**	**23423050**	9904604
													10.69	**M-cft**					**23.42**	

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-62: Earth Work of Digri Left Over Areas

(Summary Sheet)

Sr. No.	Drain Name	Type	Cut Volume	Fill Volume	ROW	Jungle Clarence Area
			(M-cft)	(cft)	(acres)	(sft)
1	D1A	Sub-Drain	7.04	3.12	133.51	
2	D1	Sub-Drain	5.39	2.51	106.22	
3	D2	Sub-Drain	8.41	3.24	141.11	
4	D3	Sub-Drain	2.72	1.78	77.35	
5	D3A	Sub-Drain	1.92	1.55	65.07	
6	D4	Branch-Drain	11.71	6.45	184.55	
7	D5	Sub-Drain	6.30	2.94	126.33	
8	D6	Sub-Drain	2.13	1.34	58.94	
9	D7	Sub-Drain	6.62	3.12	132.14	
10	D7A	Sub-Drain	5.97	2.70	115.28	
11	D8	Sub-Drain	10.26	3.30	150.98	
12	D9	Sub-Drain	2.71	1.75	75.88	
13	D10	Branch-Drain	34.84	15.08	460.49	
15	D12	Sub-Drain	2.63	1.80	77.76	
16	D13	Branch-Drain	60.05	22.41	709.37	
17	D13A	Sub-Drain	4.04	2.48	108.61	
18	D14	Sub-Drain	4.33	2.58	113.94	
19	D15	Sub-Drain	12.20	3.31	157.38	
20	D16	Sub-Drain	2.89	1.77	78.08	
21	D17	Sub-Drain	2.55	1.62	70.99	
22	D18	Sub-Drain	2.59	1.49	66.15	
23	D18A	Sub-Drain	3.32	1.92	84.80	
		Total	**200.62**	**88.26**	**3294.94**	
		Unsound 5%	**10.03**			
		Available Fill	**190.59**			
		Required Fill	**88.26**			
		Surplus Mat.	**102.33**			
23	Dirgree	Dhora	10.69	23.42	**0.00**	1980920.8
		Unsound 15%	**1.60**			
		Available Fill	**9.09**			
		Required Fill	**23.42**			
		Borrow Mat.	**-14.33**			

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-63 Design of Puran Dhoro

Sr. No.	Section			RDs	Discharge Required Q	Bed Width	Depth of Flow`	Depth of Flow D2	Gradient	Side Slope	Bank Slop	Berm W	Manning	Velocity of Flow V1	Velocity of Flow V2	Discharge Q1	Discharge Q2	Total Discharge Q
					cusecs	ft	ft	ft				ft	n	ft/sec	ft/sec	cusec	cusec	cusec
1	0.000	to	110.000	110.00	14025.00	350.00	11.00	5.50	20500	3.0	2.0	50.0	0.030	2.150	1.00	13978.20	609.29	14587.5
2	110.000	to	242.000	132.00	10525.00	340.00	9.00	5.00	20500	3.0	2.0	50.0	0.030	1.941	0.94	10232.48	518.24	10750.7
3	242.000	to	265.000	23.00	7575.00	310.00	7.00	5.00	20500	3.0	2.0	50.0	0.030	1.763	0.94	7189.48	518.24	7707.7
4	265.000	to	289.000	24.00	7555.00	310.00	7.00	5.00	20500	3.0	2.0	50.0	0.030	1.763	0.94	7189.48	518.24	7707.7
5	289.000	to	313.000	24.00	7555.00	310.00	7.00	5.00	20500	3.0	2.0	50.0	0.030	1.763	0.94	7189.48	518.24	7707.7
6	313.000	to	324.000	11.00	7535.00	310.00	7.00	5.00	20500	3.0	2.0	50.0	0.030	1.763	0.94	7189.48	518.24	7707.7
7	324.000	to	327.170	3.17	2450.00	250.00	6.50	0.00	13200	3.0	2.0	50.0	0.030	1.426	0.00	2498.58	0.00	2498.6
8	327.170	to	353.510	26.34	2450.00	250.00	6.50	0.00	13200	3.0	2.0	50.0	0.030	1.426	0.00	2498.58	0.00	2498.6
9	353.510	to	387.360	33.85	2390.00	240.00	6.50	0.00	13200	3.0	2.0	50.0	0.030	1.424	0.00	2401.29	0.00	2401.3
10	387.360	to	394.750	7.39	2390.00	240.00	6.50	0.00	13200	3.0	2.0	50.0	0.030	1.424	0.00	2401.29	0.00	2401.3
11	394.750	to	444.970	50.22	2390.00	240.00	6.50	0.00	13200	3.0	2.0	50.0	0.030	1.424	0.00	2401.29	0.00	2401.3
12	444.970	to	492.715	47.74	2365.00	240.00	6.50	0.00	13200	3.0	2.0	50.0	0.030	1.424	0.00	2401.29	0.00	2401.3
13	492.715	to	592.135	99.42	1865.00	200.00	6.25	0.00	13200	3.0	2.0	50.0	0.030	1.377	0.00	1882.58	0.00	1882.6
14	592.135	to	680.230	88.10	465.00	70.00	5.00	0.00	13200	3.0	2.0	50.0	0.030	1.119	0.00	475.63	0.00	475.6
15	680.230	to	715.500	35.27	35.00	20.00	2.25	0.00	13200	3.0	2.0	50.0	0.030	0.628	0.00	37.80	0.00	37.8

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-64: Earth Work of Puran Dhoro

Sr. No.	RDs	Cut Area	Cut Volume	Fill Area	Fill Volume	Jungle Clearance Area
		sft	cft	sft	cft	sft
1	10.000	204	2,038	483	4,825	1,540,000
2	20.000	204	2,037,500	483	4,825,000	1,540,000
3	30.000	204	2,037,500	483	4,825,000	1,540,000
4	40.000	204	2,037,500	483	4,825,000	1,540,000
5	50.000	204	2,037,500	483	4,825,000	1,540,000
6	60.000	204	2,037,500	483	4,825,000	1,540,000
7	70.000	204	2,037,500	483	4,825,000	1,540,000
8	80.000	204	2,037,500	483	4,825,000	1,540,000
9	90.000	204	2,037,500	483	4,825,000	1,540,000
10	100.000	204	2,037,500	483	4,825,000	1,540,000
11	110.000	204	2,037,500	483	4,825,000	1,540,000
13	112.017	2,238	2,462,757	387	877,082	298,516
14	117.254	780	7,903,576	359	1,954,894	775,076
15	123.009	1,797	7,416,066	536	2,575,017	851,740
16	135.754	1,441	20,633,008	1,280	11,572,014	1,886,260
17	141.071	1,225	7,087,907	174	3,865,326	786,916
18	145.654	2,264	7,995,685	449	1,425,817	678,284
19	149.778	2,730	10,298,144	277	1,496,249	610,352
20	152.328	1,347	5,199,055	229	644,908	377,400
21	154.294	2,141	3,428,547	326	545,624	290,968
22	157.836	214	4,169,802	358	1,211,807	524,216
23	160.604	1,398	2,230,537	523	1,219,954	409,664
24	164.979	1,249	5,790,553	572	2,395,356	647,500

Sr. No.	RDs	Cut Area	Cut Volume	Fill Area	Fill Volume	Jungle Clearance Area
		sft	cft	sft	cft	sft
25	170.893	1,094	6,928,133	411	2,906,938	875,272
26	175.467	1,868	6,772,036	250	1,512,439	676,952
27	178.972	2,349	7,390,240	261	895,422	518,740
28	181.509	287	3,344,743	2,699	3,754,329	375,476
29	185.715	386	1,415,950	854	7,472,106	622,488
30	187.101	667	729,875	425	886,825	205,128
31	189.346	380	1,175,381	2,061	2,791,063	332,260
32	194.569	10,348	28,016,616	-	5,382,980	773,004
33	199.115	529	24,724,739	481	1,094,290	672,808
34	203.167	9,244	19,799,875	-	975,377	599,696
35	207.882	985	24,113,453	471	1,110,571	697,820
36	211.202	92	1,787,886	518	1,641,308	491,360
37	215.313	507	1,231,429	453	1,995,130	608,428
38	217.619	62	655,653	375	954,430	341,288
39	224.254	514	1,911,577	240	2,038,040	981,980
40	226.896	1,567	2,749,146	449	909,852	391,016
41	229.146	70	1,840,928	563	1,138,849	333,000
42	235.739	-	229,766	343	2,985,904	975,764
43	239.159	3,103	5,305,788	608	1,626,501	506,160
44	242.524	272	5,678,118	1,562	3,651,210	498,020
45	243.987	669	688,619	467	1,484,243	216,524
46	250.023	855	4,600,307	694	3,505,860	893,328
47	255.454	600	3,950,564	1,069	4,787,807	803,788
48	263.817	2,640	13,546,262	451	6,355,002	1,237,724
49	266.903	1,525	6,425,901	381	1,283,899	456,728

Sr. No.	RDs	Cut Area	Cut Volume	Fill Area	Fill Volume	Jungle Clearance Area
		sft	cft	sft	cft	sft
50	272.659	761	6,580,058	319	2,016,298	851,888
51	279.739	190	3,369,160	351	2,372,012	1,047,840
52	282.442	1,489	2,269,439	212	759,867	400,044
53	285.848	1,123	4,448,508	167	644,756	504,088
54	290.138	38	2,490,345	6,379	14,040,591	634,920
55	295.180	38	190,336	4,487	27,392,152	746,216
56	300.510	663	1,868,405	4,192	23,128,522	788,840
57	303.701	3,336	6,381,505	-	6,687,953	472,268
58	305.462	3,537	6,051,606	836	735,746	260,628
59	306.944	748	3,174,696	482	976,490	219,336
60	311.017	2,140	20,031,245	566	2,135,331	602,804
61	312.083	17	1,149,468	416	523,363	157,768
62	313.974	297	296,556	361	734,578	279,868
63	317.381	674	1,653,059	558	1,565,891	504,236
64	319.687	332	1,159,019	385	1,086,726	341,288
65	322.882	-	529,635	1,331	2,741,438	472,860
66	324.253	2,915	1,998,232	385	1,176,729	202,908
67	329.000	181	7,348,949	224	1,445,818	702,556
68	334.000	181	906,250	224	1,120,000	740,000
69	339.000	181	906,250	224	1,120,000	740,000
70	344.000	181	906,250	224	1,120,000	740,000
71	349.000	181	906,250	224	1,120,000	740,000
72	354.000	181	906,250	224	1,120,000	740,000
73	359.000	181	906,250	224	1,120,000	740,000
74	364.000	181	906,250	224	1,120,000	740,000

Sr. No.	RDs	Cut Area	Cut Volume	Fill Area	Fill Volume	Jungle Clearance Area
		sft	cft	sft	cft	sft
75	369.000	181	906,250	224	1,120,000	740,000
76	374.000	181	906,250	224	1,120,000	740,000
77	379.000	181	906,250	224	1,120,000	740,000
78	384.000	181	906,250	224	1,120,000	740,000
79	389.000	181	906,250	224	1,120,000	740,000
80	394.000	181	906,250	224	1,120,000	740,000
81	399.000	181	906,250	224	1,120,000	740,000
82	404.000	181	906,250	224	1,120,000	740,000
83	409.000	181	906,250	224	1,120,000	740,000
84	414.000	181	906,250	224	1,120,000	740,000
85	419.000	181	906,250	224	1,120,000	740,000
86	424.000	181	906,250	224	1,120,000	740,000
87	429.000	181	906,250	224	1,120,000	740,000
88	434.000	181	906,250	224	1,120,000	740,000
89	439.000	181	906,250	224	1,120,000	740,000
90	444.000	181	906,250	224	1,120,000	740,000
91	449.000	181	906,250	224	1,120,000	740,000
92	454.000	181	906,250	224	1,120,000	740,000
93	459.000	181	906,250	224	1,120,000	740,000
94	464.000	181	906,250	224	1,120,000	740,000
95	469.000	181	906,250	224	1,120,000	740,000
96	474.000	181	906,250	224	1,120,000	740,000
97	479.000	181	906,250	224	1,120,000	740,000
98	484.000	181	906,250	224	1,120,000	740,000
99	489.000	181	906,250	224	1,120,000	740,000

Sr. No.	RDs	Cut Area	Cut Volume	Fill Area	Fill Volume	Jungle Clearance Area
		sft	cft	sft	cft	sft
100	492.000	181	543,750	224	672,000	444,000
101	497.000	68	623,125	224	1,120,000	740,000
102	502.000	68	340,000	224	1,120,000	740,000
103	507.000	68	340,000	224	1,120,000	740,000
104	512.000	68	340,000	224	1,120,000	740,000
105	517.000	68	340,000	224	1,120,000	740,000
106	522.000	68	340,000	224	1,120,000	740,000
107	527.000	68	340,000	224	1,120,000	740,000
108	532.000	68	340,000	224	1,120,000	740,000
109	537.000	68	340,000	224	1,120,000	740,000
110	542.000	68	340,000	224	1,120,000	740,000
111	547.000	68	340,000	224	1,120,000	740,000
112	552.000	68	340,000	224	1,120,000	740,000
113	557.000	68	340,000	224	1,120,000	740,000
114	562.000	68	340,000	224	1,120,000	740,000
115	567.000	68	340,000	224	1,120,000	740,000
116	572.000	68	340,000	224	1,120,000	740,000
117	577.000	68	340,000	224	1,120,000	740,000
118	582.000	68	340,000	224	1,120,000	740,000
119	587.000	68	340,000	224	1,120,000	740,000
120	592.000	68	340,000	224	1,120,000	740,000
121	597.000	68	340,000	224	1,120,000	740,000
122	602.000	68	340,000	224	1,120,000	740,000
123	607.000	68	340,000	224	1,120,000	740,000
124	612.000	68	340,000	224	1,120,000	740,000

Sr. No.	RDs	Cut Area	Cut Volume	Fill Area	Fill Volume	Jungle Clearance Area
		sft	cft	sft	cft	sft
125	617.000	68	340,000	224	1,120,000	740,000
126	622.000	68	340,000	224	1,120,000	740,000
127	627.000	68	340,000	224	1,120,000	740,000
128	632.000	68	340,000	224	1,120,000	740,000
129	637.000	68	340,000	224	1,120,000	740,000
130	642.000	68	340,000	224	1,120,000	740,000
131	647.000	68	340,000	224	1,120,000	740,000
132	652.000	68	340,000	224	1,120,000	740,000
133	657.000	68	340,000	224	1,120,000	740,000
134	662.000	68	340,000	224	1,120,000	740,000
135	667.000	68	340,000	224	1,120,000	740,000
136	672.000	68	340,000	224	1,120,000	740,000
137	677.000	68	340,000	224	1,120,000	740,000
138	682.000	68	340,000	224	1,120,000	740,000
139	687.000	68	340,000	224	1,120,000	740,000
140	692.000	68	340,000	224	1,120,000	740,000
141	697.000	68	340,000	224	1,120,000	740,000
142	702.000	68	340,000	224	1,120,000	740,000
143	707.000	68	340,000	224	1,120,000	740,000
144	712.000	68	340,000	224	1,120,000	740,000
145	715.000	68	204,000	224	672,000	444,000
	Total Cut		**365,885,716**	**Total Fill**	**237,520,686**	**106,480,000**
	Total Mct		**366**	**Total Mct**	**238**	
	Less 15% Unsound Material		**55**	**Less Ava. Fill Material**	**311**	
	Available Fill Material		**311**	**Net Borrow Material**	**(73)**	

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-65: Design of Hakro Dhoro

Sr. No.	Section			RDs	Discharge Required Q	Bed Width	Depth of Flow `	Depth of Flow D2	Gradient	Side Slope	Bank Slop	Berm W	Manning	Velocity of Flow V1	Velocity of Flow V2	Discharge Q1	Discharge Q2	Total Discharge Q
					cusecs	ft	ft	ft				ft	n	ft/sec	ft/sec	cusec	cusec	cusec
1	0.00	to	41.00	41.00	4903.00	300.00	5.50	4.00	21000	3.0	2.0	50.0	0.030	1.498	0.81	4604.22	350.98	4955.2
2	41.00	to	212.00	171.00	3634.00	300.00	5.00	3.00	21000	3.0	2.0	50.0	0.030	1.337	0.68	3429.02	216.13	3645.2
3	212.00	to	273.40	61.40	3134.00	255.00	5.00	3.00	21000	3.0	2.0	50.0	0.030	1.332	0.68	2937.17	216.13	3153.3
4	273.40	to	297.15	23.75	1623.00	150.00	4.50	2.75	21000	3.0	2.0	50.0	0.030	1.233	0.64	1507.21	186.72	1693.9
5	297.15	to	363.98	66.83	1300.00	140.00	4.00	2.50	21000	3.0	2.0	50.0	0.030	1.148	0.61	1169.11	159.09	1328.2

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-66: Earth Work of Hakro Dhoro

Sr. No.	RD	Cut Area	Cut Volume	Fill Area	Fill Volume	Jungle Clearance
		(sft)	(cft)	(sft)	(cft)	(stf)
1	0+199	853	169,731	1,269	252,531	27064
2	3+531	1,672	4,207,333	407	2,791,949	453152
3	5+195	1,367	2,528,947	420	688,297	226304
4	7+008	1,000	2,146,039	411	753,601	246568
5	8+201	408	839,854	822	735,496	162248
6	11+370	547	1,512,580	833	2,622,839	430984
7	12+393	1,092	838,057	515	689,778	139128
8	13+532	1,050	1,219,835	906	809,362	154904
9	14+554	779	934,931	992	969,909	138992
10	17+674	505	2,003,945	964	3,051,766	424320
11	20+689	-	761,891	1,029	3,004,779	410040
12	22+779	-	-	1,475	2,616,565	284240
13	24+404	241	195,796	1,354	2,298,538	221000
14	29+613	284	1,366,321	692	5,328,911	708424
15	31+597	727	1,002,436	957	1,635,223	269824
16	33+831	310	1,158,195	1,643	2,904,323	303824
17	36+330	517	1,033,324	788	3,038,509	339864
18	39+805	238	1,311,482	865	2,873,130	472600
19	41+000	755	592,917	478	802,401	162520
20	41+870	2,177	1,275,350	112	256,289	118320
21	44+250	2,953	6,104,902	94	244,854	295120
22	46+530	2,051	5,704,868	151	279,482	282720
23	49+570	819	4,362,491	282	657,734	376960

Sr. No.	RD	Cut Area	Cut Volume	Fill Area	Fill Volume	Jungle Clearance
		(sft)	(cft)	(sft)	(cft)	(stf)
24	53+640	436	2,552,582	133	844,973	504680
25	57+920	463	1,922,747	199	710,908	530720
26	62+445	1,797	5,112,526	59	582,368	561100
27	68+170	1,506	9,453,979	549	1,740,371	709900
28	71+920	-	2,823,394	999	2,903,138	465000
29	74+550	60	79,189	904	2,502,642	326120
30	81+550	-	210,770	970	6,559,210	868000
31	87+670	533	1,631,745	406	4,211,325	758880
32	93+170	-	1,466,438	1,048	3,998,583	682000
33	99+040	62	182,821	713	5,167,478	727880
34	104+720	-	176,904	800	4,296,011	704320
35	108+320	-	-	797	2,873,808	446400
36	111+870	192	340,782	734	2,718,093	440200
37	121+770	459	3,224,480	839	7,787,934	1227600
38	125+930	822	2,665,125	301	2,371,075	515840
39	130+360	-	1,820,486	997	2,875,912	549320
40	134+840	217	486,595	674	3,742,726	555520
41	139+980	-	558,281	455	2,901,299	637360
42	144+670	-	-	772	2,877,010	581560
43	149+250	-	-	486	2,851,109	562340
44	154+99	572	1,655,146	449	2,705,008	717340
45	159+095	415	2,027,111	435	1,815,005	509020
46	162+170	1,689	3,235,008	207	987,060	381300
47	171+05	692	10,570,397	48	1,131,490	1101120
48	175+770	366	2,496,786	263	734,243	585280

Sr. No.	RD	Cut Area	Cut Volume	Fill Area	Fill Volume	Jungle Clearance
		(sft)	(cft)	(sft)	(cft)	(stf)
49	178+780	770	1,709,921	82	519,707	373240
50	181+670	587	1,961,761	31	163,906	358360
51	185+550	1,983	4,986,460	51	158,905	481120
52	191+265	1,244	9,220,438	244	840,305	708660
53	196+830	1,228	6,878,451	127	1,030,248	690060
54	201+94	1,341	6,563,361	217	877,387	633640
55	206+465	829	4,908,177	286	1,137,879	561100
56	210+67	1,780	5,485,128	587	1,836,912	521420
57	215+020	1,040	6,132,848	356	2,051,678	539400
58	220+920	349	4,096,724	646	2,955,664	731600
59	226+030	1,175	3,894,101	494	2,911,857	633640
60	290+300	902	5,058,664	304	1,942,789	603880
61	233+68	267	1,625,035	368	933,872	344720
62	237+540	130	765,573	533	1,738,969	478640
63	242+400	4,986	12,431,054	-	1,296,259	602640
64	246+17	459	10,262,845	471	888,570	467480
65	251+700	4,663	14,162,607	-	1,303,393	685720
86	255.000	1,773	10,619,813	412	679,800	409200
87	259+235	181	4,138,590	337	1,585,309	525140
88	262+570	5,708	9,820,991	-	561,397	413540
89	267+370	1,109	16,361,232	344	825,072	595200
90	270+350	1,305	3,596,175	457	1,193,535	369520
91	273+26	1,115	3,520,780	443	1,310,038	360840
		Total Cut	**244,165,242**	**Total Fill**	**139,938,497**	**34,386,680**
		Total Mct	**244**	**Total Mct**	**140**	

Sr. No.	RD	Cut Area	Cut Volume	Fill Area	Fill Volume	Jungle Clearance
		(sft)	(cft)	(sft)	(cft)	(stf)
	Less 15% Unsound Material		37	Available Fill Material	208	
	Available Fill Material		208	Surplus Material	(68)	

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-67: Design of Nabisar Dhoro

Drainage Coefficient =2.013

Sr. Nr.	Section			RDs	Discharge Required Q	Bed Width	Depth of Flow	Gradient	Side Slope	Area	Wetted Perimeter	Hydraulic Radius	Manning N	Velocity of Flow	Discharge As per Design
					cusecs	ft	Ft			sq. ft	ft	ft		ft/sec	cusec
1	0.00	to	46.50	46.50	1400.00	160.00	5.00	10000	3.0	875.0	191.6	4.6	0.025	1.64	1431.5
2	46.50	to	80.00	33.50	400.00	65.00	4.00	10000	3.0	308.0	90.3	3.4	0.025	1.35	414.8
3	80.00	to	111.55	31.55	131.00	40.00	2.75	10000	3.0	132.7	57.4	2.3	0.025	1.04	137.9
				111.55											
*	Drainage Coefficient is assumed to be Average of Thar and Umarkot														

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone

TABLE-68: Earth Work of Naro/Nabisar/FM Dhoro

Sr. No.	RD	Cut Area	Cut Volume	Fill Area	Fill Volume	Jungle Clearance
		sft	cft	sft	cft	stf
1						100000
2	1+903	0.0	0.0	921.8	1754147.3	200000
3	4+894	87.5	130871.2	847.6	2646167.6	300000
4	6+855	46.8	131691.0	967.3	1779509.5	400000
5	11+684	0.0	112998.6	716.5	4065317.8	500000
6	13+778	334.7	350389.0	553.1	1329197.9	600000
7	15+883	782.6	1175958.3	322.5	921547.9	700000
8	17+758	780.4	1465350.0	287.1	571490.6	800000
9	18+973	780.4	948186.0	287.1	348814.4	900000
10	22+065	320.6	1702130.5	660.0	1464185.7	1000000
11	24+974	323.9	937352.5	514.6	1708470.2	1100000
12	26+551	340.0	523430.0	558.9	846494.2	1200000
13	29+831	0.0	557550.8	659.0	1997421.6	1300000
14	32+358	274.7	347020.3	547.1	1523894.7	1400000
15	36+091	380.0	1221904.2	532.6	2015260.1	1500000
16	41+725	292.1	1893333.9	853.3	3904052.1	1600000
17	44+796	104.3	608610.8	508.6	2091090.0	1700000
18	49+000	104.3	438267.0	224.0	1539841.1	1800000
19	54+000	104.3	521250.0	224.0	1120000.0	1900000
20	59+000	104.3	521250.0	224.0	1120000.0	2000000
21	64+000	104.3	521250.0	224.0	1120000.0	2100000
22	69+000	104.3	521250.0	224.0	1120000.0	2200000
23	74+000	104.3	521250.0	224.0	1120000.0	2300000
24	80+000	43.0	441750.0	224.0	1344000.0	2400000
25	85+000	43.0	215000.0	224.0	1120000.0	2500000
26	90+000	43.0	215000.0	224.0	1120000.0	2600000
27	95+000	43.0	215000.0	224.0	1120000.0	2700000
28	100+000	43.0	215000.0	224.0	1120000.0	2800000
29	105+000	43.0	215000.0	224.0	1120000.0	2900000
30	110+000	43.0	215000.0	224.0	1120000.0	3000000
31	111+550	43.0	66650.0	224.0	347200.0	3100000
		Total	**16949694**		**44518103**	**49600000**
	Total Mct		**17**	**Total Mct**	**45**	
	Less 15% Unsound Material		**3**	**Less Ava. Fill Material**	**14**	
	Available Fill Material		**14**	**Net Borrow material**	**30**	

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank Of Indus River, Delta & Costal Zone

TABLE-69: Design of Pithoro Dhoro

Drainage Coefficient =1.43

Sr. Nr.	Section			RDs	Discharge Required Q	Bed Width	Depth of Flow	Gradient	Side Slope	Area	Wetted Perimeter	Hydraulic Radius	Manning N	Velocity of Flow	Discharge As per Design
					cusecs	ft	Ft			sq. ft	ft	ft		ft/sec	cusec
1	0.00	to	90.427	90.427	1675.00	205.00	6.00	20000	3.0	1338.0	242.9	5.5	0.025	1.31	1753.8
Note															
1	D12 is falling in Pithoro Dhoro 623.04 Cusec														
2	1000 cusec Escape from LBOD at RD 578 is falling in Pithoro Dhoro														
3	Additionally 51.726 cusecs from its own catchment area through inlets on either side														

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone.

TABLE-70 EARTH WORK OF PITHORO DHORO

Sr. Nr.	RD	Cut Area (sft)	Cut Volume (cft)	Fill Area (sft)	Fill Volume (cft)	Jungle Clearence (stf)
1	2+697	1,622	4,374,723	172	462,805	269700
2	4+852	2,150	4,064,341	57	245,950	215500
3	12+837	1,432	14,299,578	264	1,280,834	798500
4	16+172	550	3,304,685	508	1,287,393	333500
5	22+787	493	3,451,046	450	3,166,898	661500
6	24+187	881	962,178	325	542,507	140000
7	29+852	881	4,990,667	395	2,041,213	566500
8	34+637	817	4,060,790	399	1,900,195	478500
9	34+637	423	1,859,445	649	1,571,715	300000
10	43+787	65	1,501,338	586	3,797,102	615000
11	49+347	44	302,381	1,025	4,477,496	556000
12	54+842	9	145,315	1,015	5,602,839	549500
13	59+212	45	118,624	873	4,124,406	437000
14	63+347	51	198,170	908	3,681,949	413500
15	66+452	73	192,370	806	2,661,513	310500
16	69+997	238	551,283	735	2,732,433	354500
17	74+007	289	1,057,156	679	2,834,870	401000
18	77+337	233	869,596	693	2,284,613	333000
19	80+257	319	805,701	622	1,919,769	292000
20	83+682	388	1,209,573	611	2,111,119	342500
21	88+787	637	2,615,981	589	3,064,914	510500
22	90+427	881	1,244,809	329	753,416	164000
		Total Cut	**50,934,940**	**Total Fill**	**51,792,533**	**9,042,700**

Total Mct	**51**	**Total Mct**	**52**
Less 15% Unsound Material	**8**	**Available Fill Material**	**43**
Available Fill Material	**43**	**Surplus Materila**	**8**

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank Of Indus River, Delta & Costal Zone.

TABLE-71: ESTIMATION OF RUNOFF, DRAINAGE THROUGH LBOD AND NUMBER OF DAYS REQURED FOR EVACUATION

10 & 20 years return period

Area	Return Period	Area	Rain	Gross Rain Vol.	Irrig. R.F	Adjust.	Drainage flow	DrainAge coeff	Evacuation Period
		acres	mm	maf	cfs	Factor	cfs	cfs/sq.mi	Days
Sanghar - khiprao	10	5,390,408	140	2.457	1617.122	0.22	17944	2.13	5
Sanghar - khiprao	20	5,390,408	164	2.878	1617.122	0.22	23779	2.82	5
Sanghar - khiprao	20	5,390,408	164	2.878	1617.122	0.22	12063	1.43	10
UmerKot+Thar	10	797,207	74.4	0.193	159.4414	0.30	797	0.64	5
UmerKot+Thar	20	797,207	97.2	0.252	159.4414	0.30	1542	1.24	5
UmerKot+Thar	20	797,207	97.2	0.252	159.4414	0.30	795	0.64	10
Mirpur Khas	10	296,728	140	0.135	415.4192	0.35	1721	3.71	5
Mirpur Khas	20	296,728	164	0.158	415.4192	0.35	2258	4.87	5
Mirpur Khas	20	296,728	164	0.158	415.4192	0.35	1202	2.59	10
Sanghar Area-1	10	153,800	140	0.070	215.32	0.39	1004	4.18	5
Sanghar Area-1	20	153,800	164	0.082	215.32	0.39	1309	5.45	5
Sanghar Area-1	20	153,800	164	0.082	215.32	0.39	697	2.90	10
Hyderabad	10	96,500	115	0.036	28.95	0.43	437	2.90	5
Hyderabad	20	96,500	146	0.046	28.95	0.43	687	4.56	5
Hyderabad	20	96,500	146	0.046	28.95	0.43	350	2.32	10
T.M.Khan	10	56,700	115	0.021	17.01	0.47	281	3.18	5
T.M.Khan	20	56,700	146	0.027	17.01	0.47	442	4.99	5
T.M.Khan	20	56,700	146	0.027	17.01	0.47	225	2.54	10

Area	Return Period	Area	Rain	Gross Rain Vol.	Irrig. R.F	Adjust.	Drainage flow	DrainAge coeff	Evacuation Period
		acres	mm	maf	**cfs**	Factor	cfs	cfs/sq.mi	Days
Badin	20	280832	187	0.155	355.6938	0.36	2649	6.67	5
Badin	20	280832	187	0.155	355.6938	0.36	1389	3.50	10
South Kharipur	10	177,740	82.1	0.048	35.548	0.38	346	1.25	5
South Kharipur	20	177,740	107.2	0.062	35.548	0.38	624	2.25	5
South Kharipur	20	177,740	107.2	0.062	35.548	0.38	319	1.15	10
Ghotki	10	671217	120	0.262	134.2434	0.31	2359	2.25	5
Ghotki	20	671217	161	0.352	134.2434	0.31	4066	3.88	5
Ghotki	20	671217	161	0.352	134.2434	0.31	2053	1.96	10

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank of Indus River, Delta & Costal Zone.

Table- 72: Adopted Design Criteria

Sr. Nr.	TYPE	Discharge Q (cusecs)	F.B (ft)	Berm Width (ft)	IP Width (ft)	NIP Width (ft)	Min. Height of IP above GL (ft)	ROW IP/NIP (ft)
1	Sub Drain	0 to 50	2.00	7.50	12.00	5.00	2.00	5/10
2	Sub Drain	50 to 100	3.00	7.50	12.00	8.00	2.00	5/10
3	Branch Drain	100 to 500	3.00	14.00	15.00	12.00	3.00	5/10
4	Main Drain	More than 500	3.00	20.00	20.00	15.00	3.00	5/10
5	Dhoro	More than 500	4.00	50.00	20.00	20.00	5.00	--

SINDH WATER SECTOR IMPROVEMENT PROJECT (WSIP)

Preparation of Regional Plan for Left Bank Of Indus River, Delta & Costal Zone.

Table- 73: SUMMARY OF STRUCTURES ON DHORAS

	Major Structure Type										Minor Structure Type			
	VRB	DRB	AQ	FB	AQ/FB	SI	OF	RB	VRB/Aq		IN-B	IN-P		
Dhoro	Village Road Bridge	District Road Bridge	Aqueduct	Foot Bridge	Aqueduct / Foot bridge	Siphon	Out fall Structure	Railway Bridge	Village Road Bridge / Aqueduct	Sub Total	Box Inlet 6.5'x5' (200 Cfs)	Pipe Inlet 4ft Dia (50 Cfs)	Sub Total	Total
1) Puran	31	7	12	21	2	5	1	1	0	80	142	568	710	**790**
2) Hakro	24	5	7	15	7	0	1	1	0	60	55	218	273	**333**
3) Sohni	49	14	20	20	0	1	1	0	0	105	22	89	111	**216**
4) Bhai Khan	80	7	216	73	21	1	1	0	15	414	113	454	567	**981**
5) Digri	7	1	4	2	0	1	1	0	0	16	13	53	66	**82**
6) Pithoro	17	2	5	16	8	0	1	0	4	53	18	72.5	90.5	**144**
7) Nabisar/Naro	32	4	15	29	3	0	1	0	3	87	22	90	112	**199**
8) South Khairpuir	96	16	85	86	71	0	2	0	10	366	198	794	992	**1358**
10) Ghotki Dhoras	97	14	74	38	4	0	3	2	9	144	213	854	1067	**1211**