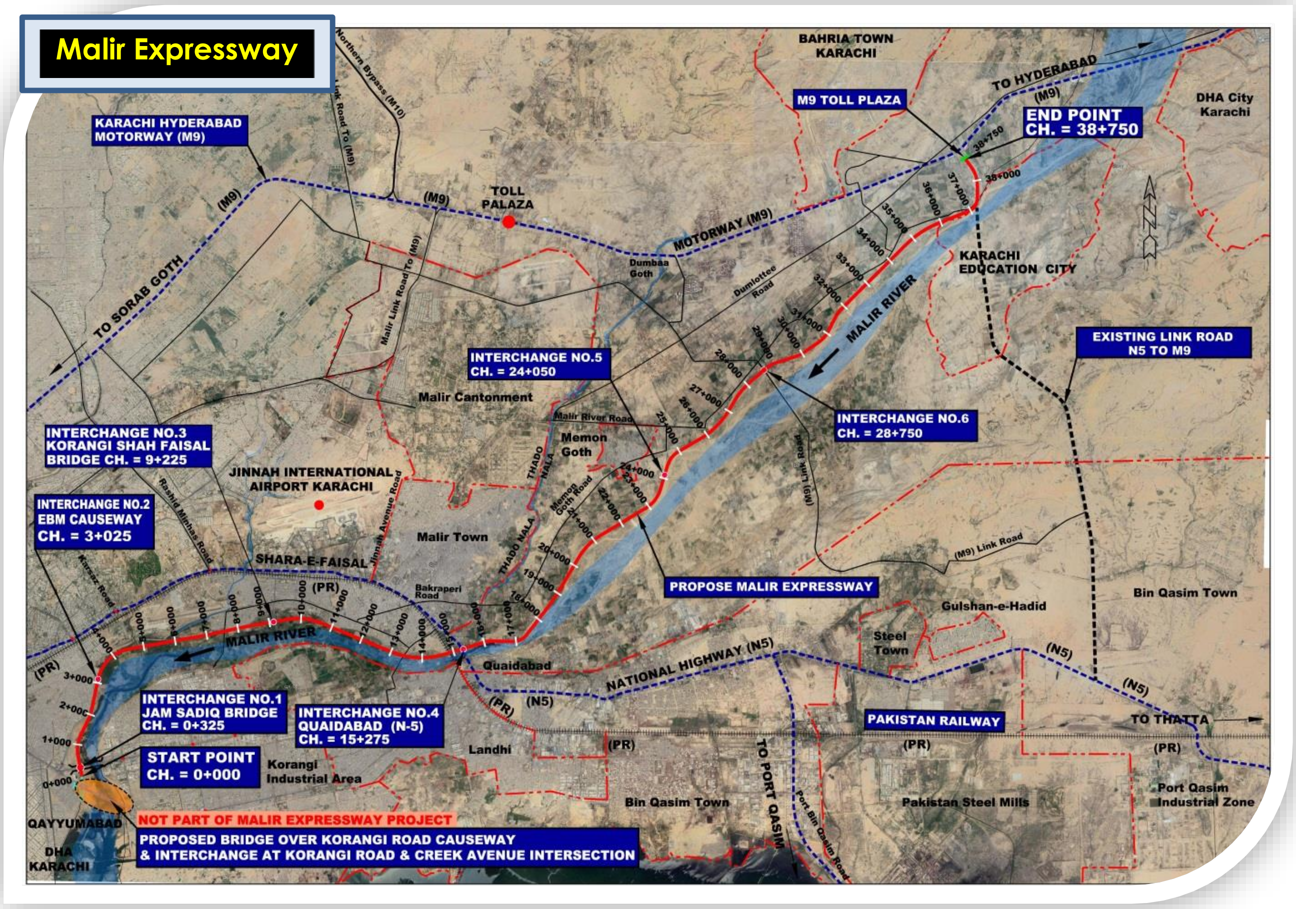
LOCAL GOVERNMENT DEPARTMENT
GOVERNMENT OF SINDH

MALIR EXPRESSWAY PROJECT
KARACHI

FINAL REPORT

October 2019



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CONSULTANCY / TRANSACTION ADVISROY SERVICES FOR DEVELOPMENT OF MALIR EXPRESSWAY

(From Motorway, M9 to KPT Interchange)

FINAL REPORT

Contents

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EXECUTIVE SUMMARY

Located along the shores of Arabian Sea, Karachi is Pakistan's gateway and the largest metropolitan city. It is the capital of Sindh province and also the country's main seaport, economic and financial center sprawling over an area of about 3500 square kilometer. Like other major port cities and commercial centers in the World, Karachi also attracts people from all over the country and beyond in search of better economic prospects. Therefore, due to this high rate of in-migration, the population of this fast-expanding megacity has been growing annually by 4.2% since 1998. According to JICA Study 2012, Karachi Transport Improvement Plan - Final Report, it is projected to grow from 18.9million in 2010 to around 31.6million in 2030 and would thereby make it the fastest growing city in the World.

This rapid increase in population has put a lot of pressure on the city's infrastructure especially the urban transport system (UTS) which is not yet organized in a modern manner, and therefore barely caters to the mobility needs of the mega city. With limited infrastructure and low level of public services coupled with other factors such as weak traffic management, lack of modern mass transit network, a rapid level of motorization of roads has been observed during the last two decades resulting in severe traffic congestion and unnecessary delays, noise and air pollution along the main corridors of travel in the city and impeding the economic efficiency and growth.

Therefore, in view of the phenomenal population growth, increase in vehicular traffic and the consequent traffic congestion and delays across the city, the Local Government Department, Government of Sindh has envisaged to construct Malir River Expressway as a strategic expressway which will serve as the southern alternative route for carrying traffic of the port and industrial areas to the main highways and will also provide speedy access to key real estate schemes along the route. Location plan showing the proposed alignment of Malir Expressway is presented as Fig. 1.1.

Upon its completion, the travelling time from the Karachi-Hyderabad Motorway, M-9 to KPT interchange on the main Korangi Road (Formerly known as the Hino Chowk) will be reduced to only 30 minutes. Therefore, the daily commutation between Karachi Port, Industrial areas of Landhi and Korangi, and also between the CBD area, Clifton and DHA (Phase 1 to 8) and the proposed DHA City & the Education City would be more convenient, uninterrupted and economical. The traffic conditions on the urban road network in Karachi would also improve substantially as the external traffic would shift to Malir Expressway.

CONSULTANCY / TRANSACTION ADVISROY SERVICES FOR DEVELOPMENT OF MALIR EXPRESSWAY

(From Motorway, M9 to KPT Interchange)

FINAL REPORT

Professional services for Consultancy / Transaction Advisory Services have been awarded to the Consortium of EA Consulting (Pvt.) Ltd. (Lead Advisor), EY Ford Rhodes and Hyder mota BNR & Co. The Consultants have undertaken all necessary surveys, investigations, and studies as per Project requirements highlighted in the Terms of Reference for the Consultancy Services and already submitted to the PPP-Unit Govt. of Sindh. On the basis of these studies, surveys and investigations, this Final Report has been prepared towards completion of the deliverables under Phase-1(a) Technical part of the assignment.

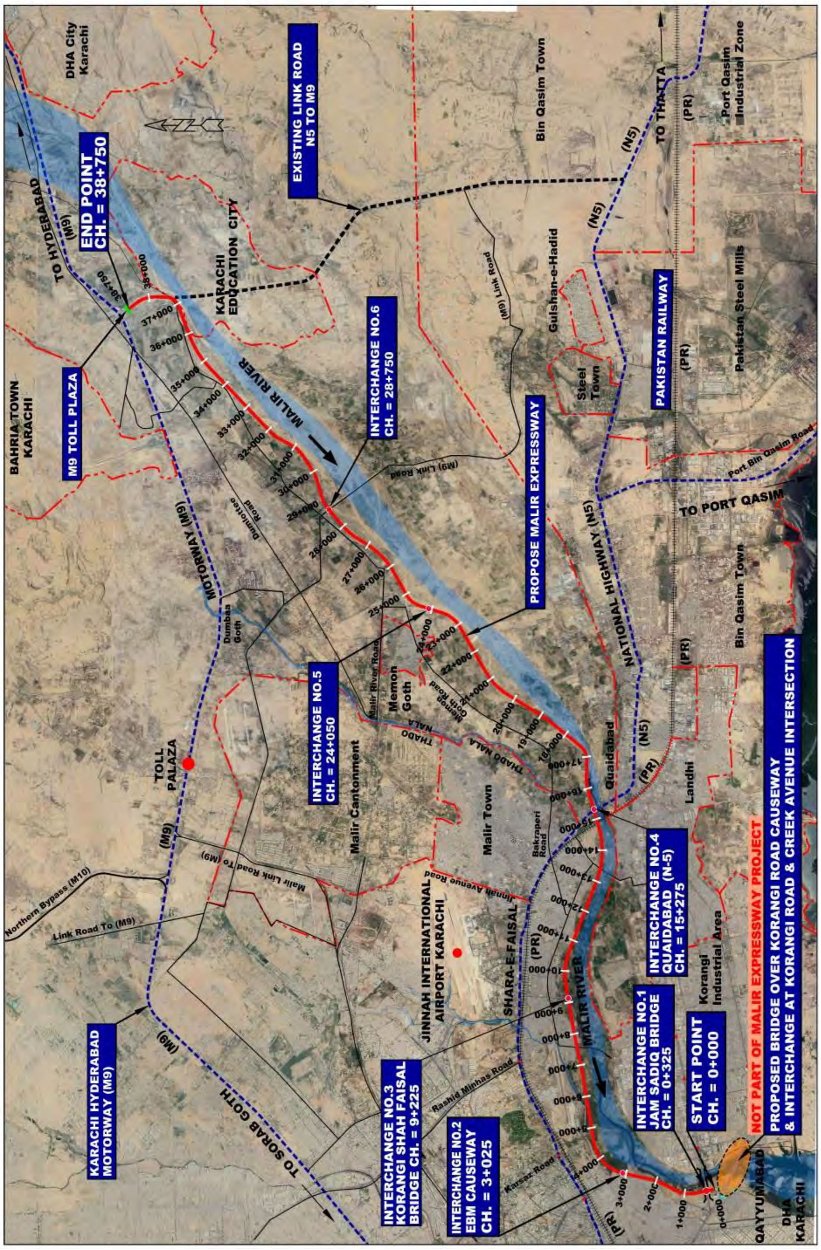
The Report covers the Reconnaissance Survey & Alignment Report, Topographic, Soil & Deep Soil Survey Reports, Hydrology Report and Traffic Study Report. It also includes the design standards and criteria and the detail of existing utilities passing through the corridor as provided by different utility agencies. A preliminary Cost Estimate based on the above mentioned studies and the tentative alignment shown in the corridor is also presented in this Report. Typical cross sections for the roadway and structures are also appended with the Report.

In brief, the various important developments taking place during the evolution of Malir Expressway from initiation of the concept to the compilation of the present stage-II RFP are comprehensively given in this Final Report.

1 INTRODUCTION

1.1 Project Location & Background

The Malir Expressway Project is located along the Malir River corridor starting near KPT Interchange at Korangi Road and ending at Motorway, M9 near Kathore. The location map of the Project is attached as Fig. 1.1.



During the last few decades, Karachi has mostly grown towards the North and many new residential areas, housing schemes and towns have been developed in the Northern suburbs to accommodate the increasing population and provide a relief to the already congested and overcrowded city areas. Besides residential and commercial areas, there have been some other initiatives like the shifting of vegetable and fruit whole sale market (Subzi Mandi) from University Road to its present location near Toll Plaza on M-9, development of new industrial areas including Super highway Industrial Area and North Karachi Industrial Area, a number of educational institutions planned in the Education City, new amusement parks and resorts like Dreamworld, Fiesta Water Park, Cosy Water Park, etc.

Most of this expansion has taken place along the Karachi – Hyderabad Motorway, M9, including some mega-scale private residential schemes, DHA Phase-9 and the

Education City. Due to higher costs and lucrative prospects in these projects, the residents of posh areas of Clifton and Defence have substantially invested in them and upon their completion, there will be a good deal of commute between these areas. On the other hand the existing road network is already under a heavy burden of increasing traffic volumes resulting in severe traffic congestion, higher travel times and often deteriorating security conditions. Therefore, the provision of an exclusive, high speed access controlled corridor with modern facilities along the bank of Malir River is seen as an effective solution to link the new developments like the DHA City, Bahria Town, Gulshan-e-Maymar and other adjoining areas to the posh areas of Clifton and DHA Phases 1 to 8.

The Govt. of Sindh has therefore conceived the Malir Expressway Project along the right bank of Malir River from the Motorway, M9 to Korangi Road near KPT Interchange to provide a direct route to facilitate this traffic between the posh areas in the Southern end of Karachi and the upcoming Northern developments. In addition to light traffic, this route will also serve the heavy traffic generated from the Karachi Port and the Landhi - Korangi Industrial area and going towards Motorway, M9 for onwards journey upcountry. Accordingly, the traffic study carried out for the Project has taken into account the light traffic as well as the heavy traffic. While the heavy traffic already plies through different available routes, much of the light traffic will be generated over a period of time, depending upon the pace of development of the aforementioned schemes along M9.

1.2 Project Objectives

The main objectives of this project are as under:

- To establish a direct Southern transport link between the Karachi Port including the allied facilities of SAPT, PICT, KICT and the Keamari Oil Terminal and the Karachi – Hyderabad Motorway, M9.
- To facilitate the movement of goods between Karachi Port and its allied facilities, Industrial areas of Landhi and Korangi and the up-country locations.
- To provide a safer and faster link between the planned developments of the Education City, the DHA City and Bahria Town in along the Motorway M9 in the Northern suburbs of the city to the main business center (CBD area) near the Karachi Port and also to the DHA and Clifton areas.
- To link Malir Cantonment directly to the Karachi – Hyderabad Motorway, M9 through a faster route for swift and easier movement of military troops in case of any emergency situation.
- To help reduce traffic congestion, delays, economic losses and environmental pollution on the city road network by exclusion of the external-external traffic i.e., traffic having both its origins and destinations outside the city or on its periphery, from the present routes to the proposed Malir Expressway.

1.3 References & Sources of Data

The various sources of data and documents referred during the study included:

- Historic traffic data obtained from various sources including the Traffic Engineering Bureau, KDA and the previous studies by the then T&CD, CDGK.
- Reconnaissance Survey carried out along the entire project route from M9 to the KPT Interchange at Korangi Road
- Fresh Traffic Surveys carried out for the Project by the Consultant
- Notional Review of:
    - Education City Master Plan,
    - Bahria Town Master Plan and
    - DHA City Master Plan
- Various previous studies for Malir Expressway Project
- PC-I Document for Malir Expressway Project dated July 2016, PPP Unit, Govt. of Sindh
- JICA Study 2012 for Karachi Transport Improvement Plan
- Traffic Study for Karachi – Hyderabad Motorway, M9, Final Report, July 2012
- Update of Feasibility Study - Karachi Harbor Crossing Project– Final Report, April 2011
- Topographic Survey for the Project carried out by the Consultants
- Soil & Deep Soil Reports for the Project
- Proceedings of the various meetings including Policy Board Decisions

1.4 Acknowledgements

The cooperation extended by various Departments of the Govt. of Sindh, especially the PPP-Unit, Finance Department, TEB, KDA, & the KMC in the preparation of this Report is gratefully acknowledged.

1.5 Disclaimer

The Technical Studies, Data, Reports, Surveys including Riverine Survey, Traffic Surveys, Analysis, Conclusions and recommendations, Drawings and information therein or any part thereof (the Technical Reports) for Malir Expressway Project, were carried out for the sole purpose, use and consumption of the Local Government Department, Government of Sindh. All such Technical Reports and information therein or any part thereof, are of preliminary nature, and may be used for the purposes of reference only, without any prejudice and claim to the Local Government Department, Government of

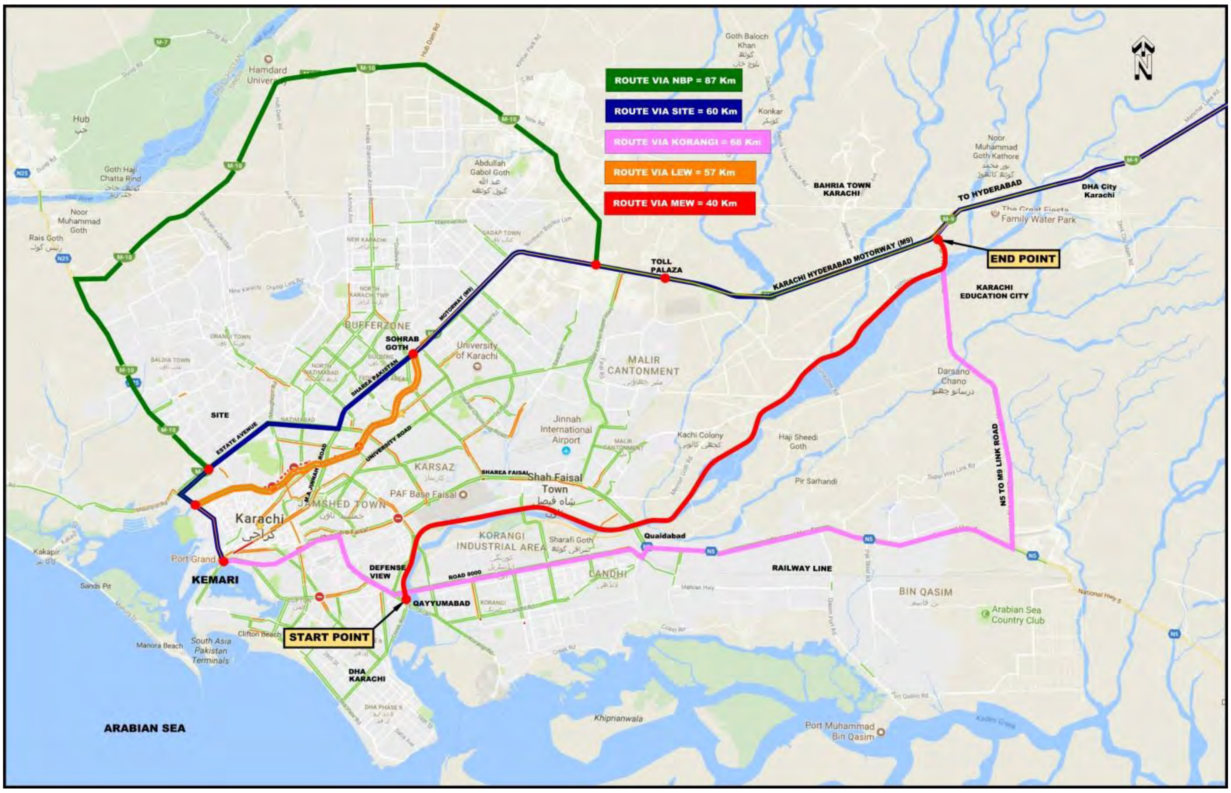
Sindh and/or their consultants. The Technical Reports and information therein or any part thereof shall not form the basis for bid preparation for any Bidder. All Bidders would be required to carry out and collect independently their own Technical Reports and any other information/data for the preparation of their Bids and shall be responsible for its correctness and accuracy.

2 ALIGNMENT AND COMPETITIVE ROUTES STUDY

2.1 Reconnaissance Study

A detailed reconnaissance study of the proposed route alignment was undertaken by the Consultant in connection with the Traffic Study focusing on the areas being served by the proposed Malir Expressway, the existing travel pattern and traffic movement characteristics in the corridor to be served by it, the main roads and drainage features crossing the alignment, the upcoming residential schemes along the route or in its close vicinity and other relevant features.

The main roads crossing the proposed alignment of Malir Expressway are Korangi Road (Road 8000) near the start point, EBM Causeway link, National Highway, N5 near Quaidabad, Link Road between N5 and M9 and finally the Motorway, M9 at the end point. A number of other local roads also touch the alignment including the Shah Faisal Colony – Korangi Road with its long bridge over Malir River, Memon Goth / Malir - Shah Latif Town Road, Haji Sheedi Goth Road, Dumlotee Road, etc. These roads carry the localized traffic mostly consisting of light vehicles that may or may not directly feed the Expressway.



2.2 Start Point

The Start point of the proposed Malir Expressway is located on Main Korangi Road, near the existing Jam Sadiq Bridge & KPT Interchange.

At the start point an interchange is being proposed to provide direct access to Malir Expressway to facilitate movement of vehicles without any conflict with traffic of Korangi Road and Creek Avenue. From Start point to left bank of river, there will be a bridge having about 1.5 km length. In this 1.5 km elevated portion, the alignment will also overpass the existing Jam Sadiq Bridge. From this point on, the alignment remains on the left side of the river.

At a short distance from the start point, a four-lane dual carriageway, Creek Avenue joins the Main Korangi Road and links it to DHA via Khayaban-e-Ittehad and further ahead to Clifton Via Sea-view Road and thereafter to the SAPT / Shirin Jinnah Colony, Keamari via Marine Prominade.

2.3 Interchanges En-route

As per conceptual design of the proposed Malir Expressway, 5 Nos. interchanges have been proposed at the following locations:

Location of the Proposed Interchanges
1. Jam Sadiq Interchange
2. EBM Causeway Interchange
3. Korangi – Shah Faisal Colony Interchange
4. Quaidabad Interchange on National Highway, N-5
5. Interchange near Km 24+050 (Exact Location to be decided)
6. Interchange near Km 28+750 (Exact Location to be decided)

2.4 Required Configuration Of Interchanges/intersection

The Project Expressway being an access-controlled facility, therefore following entry and exit points at Interchanges are envisaged at this stage, which shall be followed by all Bidders:

I. Jam Sadiq Interchange to provide only following conflict free movements:

(At this location Malir Expressway will be grade separated from the existing bridge crossing Malir River connecting Sunset Boulevard / Korangi Road with Korangi Industrial Area)

Entry to Malir Expressway

- Left turn for North bound traffic coming from Shaheed-e-Millat Expressway and moving towards M-9
- Left turn traffic for North Bound expressway which is coming from Sunset Boulevard / Korangi road from KPT Flyover Bridge should have grade separated conflict free entry from traffic going towards Jam Sadiq Bridge.

Exit from Malir Expressway

- Right turn for south bound traffic coming from M-9 and moving towards KPT Interchange
- Left turn for south bound traffic coming from M-9 and traveling towards Korangi Industrial Area

II. EBM Causeway Interchange:

(At this location Malir Expressway will be grade separated from the existing causeway across the Malir River connecting Baloch Colony and Korangi Industrial Area)

Entry to Malir Expressway

- Left turn for traffic coming from Baloch colony Bridge and going towards M9.
- Right turn for traffic coming from Korangi Industrial Area and going towards M9.

Exit from Malir Expressway

- Left turn for traffic coming from M9 and going towards Korangi Industrial Area.
- Right turn for traffic coming from M9 and going towards Baloch colony Bridge.

III. Korangi-Shah Faisal Interchange to provide only following conflict free movements:

(At this location Malir Expressway will be grade separated from the existing bridge across the Malir River connecting Shah Faisal Colony to Korangi).

Entry to Malir Expressway

- Left turn for north bound traffic coming from Shah Faisal Colony to move towards M-9.
- Right turn for north bound traffic coming from Korangi Industrial Area to move towards M-9
- Right turn for south bound traffic coming from Shah Faisal Colony and going towards KPT Interchange/Jam Sadiq Bridge

Exit from Malir Expressway

- Left turn for south bound traffic coming from M-9 and moving towards Korangi Industrial Area
- Right turn for south bound traffic coming from M-9 and moving towards Shah Faisal Colony
- Left turn for north bound traffic coming from KPT Interchange/Jam Sadiq Bridge and going towards Shaha Faisal Colony.

IV. Quaidabad (N-5) Interchange

(At this location Malir Expressway will be grade separated from the existing bridge of National Highway N-5 on Malir River)

Entry to Malir Expressway

- Left turn for north bound traffic coming from Airport to move towards M-9

- Left turn for south bound traffic coming from Thatta to move towards KPT Interchange.
- Right turn for traffic coming from Airport to move towards KPT Interchange via Malir Expressway
- Right turn for north bound traffic coming from Thatta to move towards M-9 via Malir Expressway

<u>Exit from Malir Expressway</u>

- Left turn for traffic coming from KPT Interchange (North Bound traffic) to move towards Airport
- Right turn north bound traffic coming from KPT Interchange and moving to Thatta
- Left turn for south bound traffic coming from M-9 and moving to Thatta
- Right turn for south bound traffic coming from M-9 and moving to Airport

V. Interchange near km 24+050 (Exact Location to be decided)

- Expressway will be At-Grade with two (2) left turning movements and grade separated trumpet interchange for two (2) right turning movements

VI. Interchange near km 28+750 (Exact Location to be decided)

- Expressway will be At-Grade with two (2) left turning movements and grade separated trumpet interchange for two (2) right turning movements

VII. Intersection at Km 37+300 for Education City

- At Km 37+300 Expressway will hit the existing link road between N5 & M9, the alignment of this link road is being realigned due to coming Education City at this location. The Designer is required to design and construct. At-grade intersection in coordination with plans of Education City Entry approach with the design provision of grade separated interchange in future

Note: All the entry and exit lanes shall be designed for smooth transition as per standard design requirements assuring no disturbance to existing traffic movements on connecting roads/bridges.

2.5 End Point

The end point of the proposed Malir Expressway is at M-9, about 14 km from the main gate of Bahria Town and about 25 km from the now demolished Toll Plaza on M-9. At the End Point a Trumpet type interchange is proposed.

2.6 Link to KPT

The proposed Malir Expressway will be linked to the Karachi Port via Korangi Road – Sunset Boulevard / Khayaban-e-Jami – Boat Basin - Mai Kolachi Bypass – Jinnah Bridge – M.A. Jinnah Road.

Similarly it will also be linked with the South Asia Pakistan Deep Water Container Terminal (SAPT) via Shahrah-e-Ghalib / Marine Prominade - Khayaban-e-Saadi – Balawal Chowrangi – Boat Basin – Mai Kolachi Bypass – Khayaban-e-Jami / Sunset Boulevard– Korangi Road.

A direct link to SAPT may also be improved in future by connecting it with the Creek Road through an alignment passing along the Marine Prominade – Sea view Road along DHA Phase VIII and onwards to the Creek Road.

2.7 Competitive Routes and Distance Savings Via Malir Expressway

The competitive routes and relative distance savings via Malir Expressway for the same origins and destinations i.e., for trips between the Southern parts of the city in the vicinity of Karachi Port, DHA and Clifton, etc. and the North Eastern parts i.e., DHA City, Bahria Town, the Karachi – Hyderabad Motorway, M9 for onwards journey up-country, are summarized hereunder:

Existing Route From Keamari Port to the End Point of Malir Expressway	Existing Route Length (Km)	Relative Distance Saving via Malir Expressay (KM)
Keamari – Northern Bypass – Motorway, M9	87	33
Keamari – SITE – Sharea Pakistan – Motroway, M9	60	06
Keamari – Mai Kolachi – Korangi Road – Link Road N5 to M9 – Motorway, M9	68	14
Keamari – Lyari Expressway – Motorway, M9	57	03

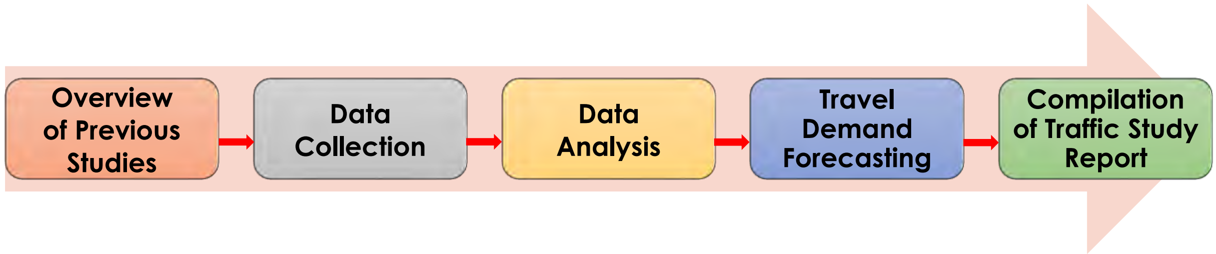
2.8 Alignment Data of Malir Expressway

PI No.	Radius (m)	PI Station	PI Easting (m)	PI Northing (m)
1	**Start Point**	**0+000**	**306656.772**	**2747414.414**
2	1000	0+978.67	306462.483	2748373.602
3	1000	2+010.42	306926.805	2749322.286
4	1200	3+923.62	307326.615	2751194.512
5	5000	6+974.14	310523.761	2751752.814
6	7000	8+110.78	311634.689	2751993.367
7	2000	10+123.12	313617.422	2752337.523
8	2500	13+888.05	317135.930	2750917.055
9	1000	16+142.43	319360.357	2751579.292
10	500	17+163.57	320383.779	2751559.869
11	5000	18+805.46	321422.048	2752877.628
12	2000	20+773.05	322434.212	2754565.915
13	1000	23+296.67	324621.361	2755865.804
14	800	24+706.17	325039.118	2757249.549
15	2500	26+403.09	326537.864	2758108.830
16	2000	27+750.85	327252.275	2759283.806
17	1000	28+963.68	328178.681	2760074.918
18	1000	29+895.76	329077.271	2760344.495
19	1000	30+861.61	329879.236	2760886.949
20	1000	31+730.19	330278.162	2761670.897
21	3000	35+330.53	332858.082	2764186.399
22	400	37+223.19	334634.285	2764885.065
23	1000	38+142.79	334650.991	2765867.997
25	**End Point**	**38+750.00**	**334271.080**	**2766373.597**

3 TRAFFIC DATA AND ANALYSIS

3.1 Approach & Methodology

The approach and methodology for traffic study is primarily focused on a systematic evaluation of travel demand forecast on the basis of available traffic and socio-economic data, study of the proposed alignment and the existing competitive routes, knowledge of the on-going projects of relevance to the Malir Expressway Project, and network-based comparative analysis using modern computer applications. Therefore the study involved the following main steps:



3.2 Overview of Previous Studies

The Karachi Master Plan 2020 has already recognized the ring road concepts in Karachi thereby creating an opportunity to bypass the congested radially oriented road system and from time to time many studies were undertaken and proposals were developed for construction of Malir Expressway Project including:

Dec 2010	Malir River Expressway concept initiated
Jul 2011	Project concept moves to CDGK to initiate on BOT
Aug 2012	Approval by the then CM for project on BOT basis
May 2014	New initiative by Military Authorities
July 2014	Principle approval given as part of Mega projects of Karachi
Aug 2014	Feasibility / PC-1 initiated to aid in fast tracking of Malir Expressway project
Nov 2014	Concept & PC-1 presented to NHA for review/approval
Feb 2015	Rationalized PC-1 prepared, presented & submitted to NHA
Mar 2015	Project announced by the then Prime Minister during the ground breaking Ceremony for the construction of Karachi – Hyderabad Motorway, M9
July 2016	Revised PC-I by the PPP Unit, Govt. of Sindh

In addition to the above, the Project was also considered it as the most viable option among the other competing routes in the Final Report on "Preparatory Survey on JICA Cooperation Program for Industry Development (Investment Climate Improvement in Karachi)" and was also recommended for future development in "The Study for Karachi Transport Improvement Plan" by JICA.

Besides the above studies, the following documents were also referred during the study:

- Traffic Study for Karachi – Hyderabad Motorway, M9, Final Report, July 2012
- Update of Feasibility Study - Karachi Harbor Crossing Project– Final Report, April 2011

The Final Report on JICA Study 2012 for "Karachi Transport Improvement Plan" provides a comprehensive analysis of the transport systems environment in the city and was therefore duly referred during this study. According to this Report (Table 4-3-3: Future Population by Town / Cantonment), Karachi's population is projected to grow from 18.9million in 2010 to around 31.6million in 2030 thereby making it the fastest growing city in the World.

Table 4-3-3 Future Population by Town / Cantonment

Town		2010	2020	2020/2010	2030	2030/2010
1	Keamari	762,000	1,914,000	2.51	2,290,000	3.01
2	S.I.T.E	854,000	895,000	1.05	895,000	1.05
3	BALDIA	864,000	1,110,000	1.28	1,110,000	1.28
4	ORANGI	1,338,000	1,429,000	1.07	1,523,000	1.14
5	LYARI	939,000	969,000	1.03	969,000	1.03
6	SADDAR	1,104,000	1,123,000	1.02	1,233,000	1.12
7	JAMSHED	1,397,000	1,560,000	1.12	1,713,000	1.23
8	GULSHAN-E-IQBAL	1,458,000	2,373,000	1.63	2,684,000	1.84
9	SHAH FAISAL	602,000	612,000	1.02	647,000	1.07
10	LANDHI	1,353,000	1,822,000	1.35	1,822,000	1.35
11	KORANGI	1,286,000	1,826,000	1.42	1,826,000	1.42
12	NORTH NAZIMABAD	917,000	979,000	1.07	1,044,000	1.14
13	NEW KARACHI	1,226,000	1,247,000	1.02	1,328,000	1.08
14	GULBERG	838,000	895,000	1.07	954,000	1.14
15	LIAQUATABAD	1,002,000	1,035,000	1.03	1,035,000	1.03
16	MALIR	781,000	907,000	1.16	937,000	1.20
17	BIN QASIM	518,000	2,032,000	3.92	2,697,000	5.21
18	GADAP West	263,000	1,058,000	4.02	1,715,000	6.52
	GADAP Central	146,000	1,512,000	10.36	2,522,000	17.27
	GADAP East	128,000	508,000	3.97	823,000	6.43
	GADAP Total	537,000	3,078,000	5.73	5,060,000	9.42
19	Karachi Cantonment	88,000	90,000	1.02	96,000	1.09
20	Clifton Cantonment	559,000	771,000	1.38	821,000	1.47
21	Faisal Cantonment	248,000	352,000	1.42	363,000	1.46
22	Malir Cantonment	206,000	400,000	1.94	414,000	2.01
23	Manora Cantonment	10,000	10,000	1.00	10,000	1.00
24	Korangi Cantonment	47,000	122,000	2.60	130,000	2.77
	Total	18,934,000	27,551,000	1.46	31,601,000	1.67

Source: Estimated in KTIP

This rapid increase in population has put a lot of pressure on the city's infrastructure especially the urban transport system (UTS) which is not yet organized in a modern manner, and therefore barely caters to the mobility needs of the mega city. With limited infrastructure and low level of public services coupled with other factors such as weak traffic management, lack of modern mass transit network, a rapid level of motorization of roads has been observed during the last two decades resulting in severe traffic congestion and unnecessary delays, noise and air pollution along the main corridors of travel in the city and impeding the economic efficiency and growth.

3.2.1 Main Problems Observed in the Transport System of Karachi

Based on the above studies, the main problems of the transport system in Karachi can be summarized as follows:

- Need for increasing the transport infrastructure with respect to capacity and quality in view of the increasing travel demand and expansion of the city in population and area.
- Failure of the public transport system to cater for increased travel demand especially for the lower and middle income groups.
- Poor condition of the road network and its unbalanced distribution and configuration due to non-implementation of development plans within their selected planning horizons.
- Increasing traffic congestion has become a serious problem within the city center (CBD area) and around Karachi Port.
- No defined and well-connected outer ring roads to bypass this city congestion.
- Demand – supply gap of parking spaces causes further reduction in road capacity due to roadside parking of vehicles especially near the main traffic generator areas, busy shopping centres, transport terminals and places of recreations.
- Lack of proper and effective traffic management system and enforcement of traffic rules and regulations in the city.
- Complex institutional and organizational structure to handle the various transport and traffic related matters. Administratively Karachi is divided into:
    - 18 Towns
    - 6 Cantonments
    - 178 Union Councils
- Land use anomalies and unplanned expansion of the city.
- Rapidly increasing car / motorcycle ownership

Year	No. of Cars / 1000 population	No. of Motorcycles / 1000 population
Vehicle ownership in 2010	50	48
Vehicle ownership in 2020*	60	73
Vehicle ownership in 2030*	84	115

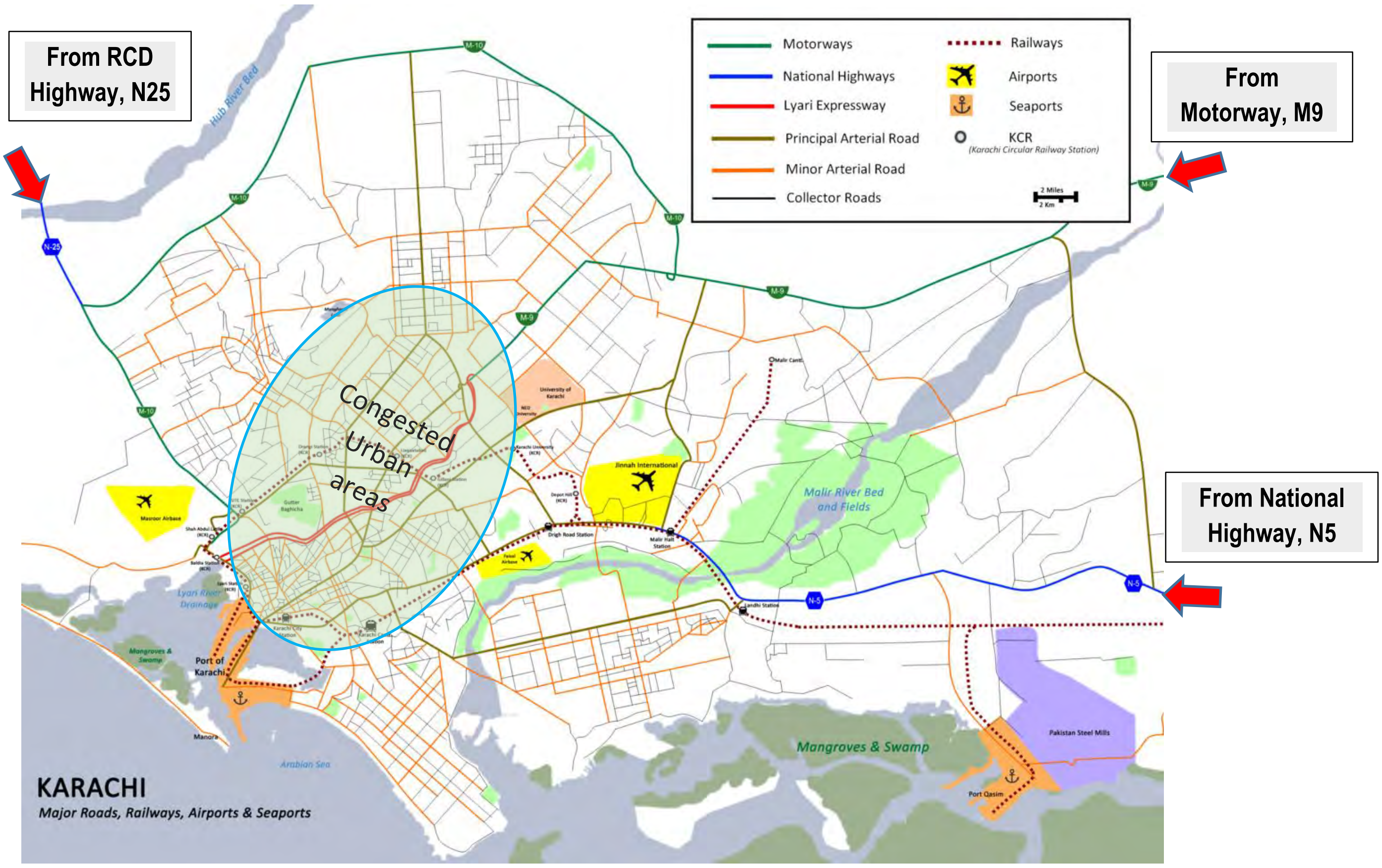
* Projected

- Increased urbanization in Karachi from 80,000 ha today projected to be 158,000 ha by 2030.

- Rapidly increasing population due to high rate of in-migration from up-country; from 18million to 31million by 2030.
- The KPT presently handles 19.2million tons of cargo per year; it is projected to increase to 112 million tons per year by 2030.

3.2.2 Main Access Routes for Karachi

At present Karachi has three main corridors linking it to rest of the country namely: the Karachi – Hyderabad Motorway, M9 (Superhighway) / Shahrah-e-Pakistan corridor, the National Highway N5 / Sharea Faisal corridor and the RCD Highway, N25 / Hub River Road corridor.



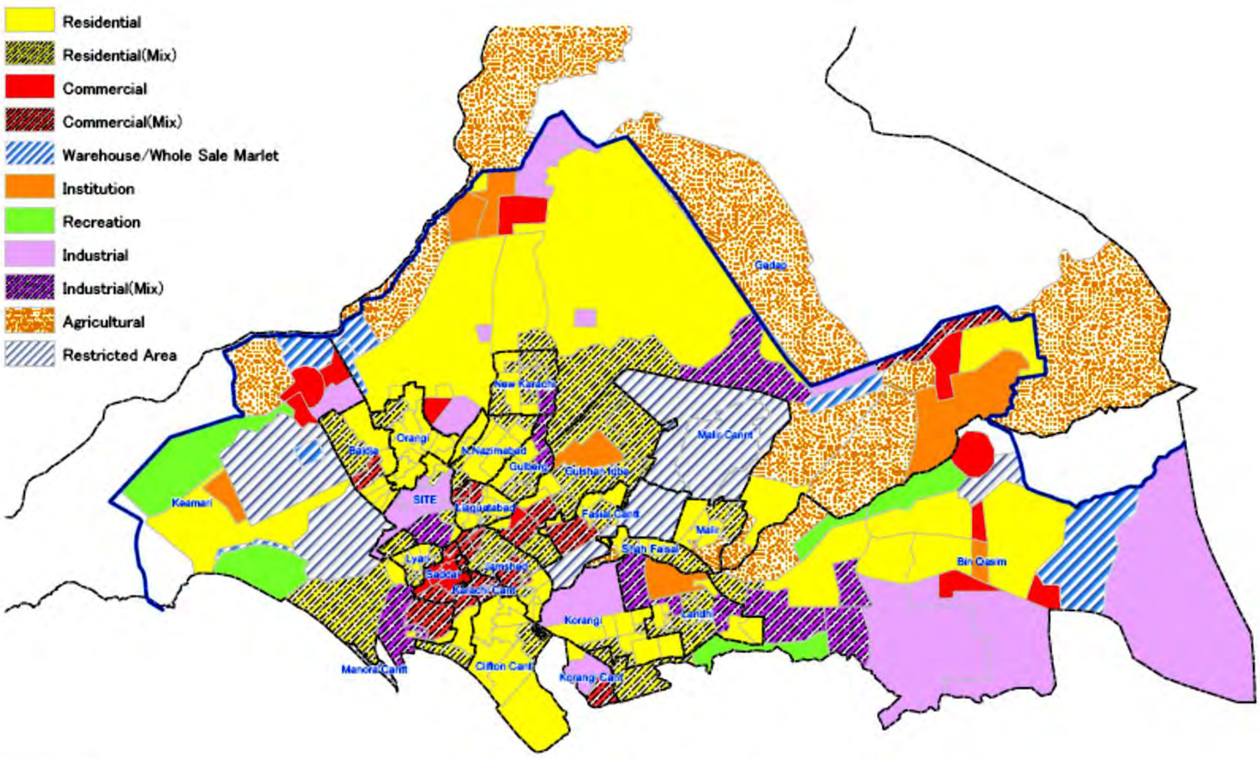
However, upon entering the urban limits these corridors become highly congested due to the increasing volume of internal traffic in the city with a substantial volume of light vehicles consisting of private cars, vans, rickshaws and motorcycles and public transport vehicles including buses, minibuses and coaches besides the frequent pedestrian movements across the roads conflicting with smooth & uninterrupted flow of traffic.

In addition to the above impeding factors, another serious issue is that during the day time movement of heavy vehicles is mostly restricted on them.

Therefore with the passage of time as the volume of external traffic between the upcountry destinations in Sindh, Punjab, KPK and beyond, and the Karachi Port, the CBD area, DHA / Clifton areas in the South and the industrial areas of Landhi and Korangi in the South Eastern part of the city increased, the need for a high speed expressway directly linking the entry point on the Karachi – Hyderabad Motorway, M9 (Superhighway) with these areas without mingling with the city traffic became evident and the concept of an exclusive high speed access controlled facility along the banks of Malir River (like the earlier constructed Lyari Expressway) was initiated.

3.2.3 Future Land Use Plan - 2030

The future Land Use Plan – 2030 presented in the JICA Study as Fig.4-3-5 is reproduced below:



Source: KTIP

Figure 4-3-5 Future Land Use Plan, 2030

3.3 Analytical Framework & Underlying Assumptions

A well-conceived analytical framework was developed on the basis of available knowledge-base of the existing development pattern along the corridor, the historic / existing traffic volumes, congestion and delays on the road network in Karachi and the growing demand for another exclusive route for the North – South connectivity, especially for the traffic between Karachi Port including SAPT, KCIT, PICT, Oil Terminal, Landhi / Korangi Industrial areas and the up-country and also for linking the new developments in the Northern suburb with the city center (CBD area), DHA and Clifton areas in the South of the city. Accordingly three mutually exclusive analysis scenarios were used for calculating the travel demand for the proposed Malir Expressway Project.

The three operational scenarios and the main assumptions underlying these scenarios are briefly presented below:

3.3.1 Analysis Scenario – 1:

The analysis scenario -1 presents an optimistic situation for the proposed Malir Expressway Project resulting in a higher traffic diversion to it under the following assumptions:

- The traffic conditions on the existing road network further deteriorate due to increased population and higher traffic volumes,
- There is no significant improvement of the network condition and capacity to handle further traffic especially on the other competing routes,
- The shuttle train service proposed by Pak Rail to transfer container cargo to upcountry via Pipri Marshalling Yard does not become operational
- The Elevated Expressway Project conceived by KPT still remains unexecuted.
- No significant improvement in the public transport system in the city resulting in an even higher level of private transport usage.
- The DHA City, Bahria Town and the Education City schemes develop at a faster pace resulting in additional daily trips between these facilities in the Northern suburbs and the Southern parts of the city especially the CBD and the DHA and Clifton areas. The interaction of traffic between these new developments will most likely result in increased traffic on Malir Expressway.

3.3.2 Analysis Scenario – 2:

The analysis scenario -2 presents a Pessimistic Situation for the proposed Malir Expressway Project resulting in a lower traffic diversion to it under the following assumptions:

- A significant improvement in the public transport system by implementation of the BRT System on the main transit corridors in the city especially the BRT Green, Blue, Red, Yellow and Orange Lines, resulting in a higher level of public transport usage and consequently decrease in private transport usage i.e., lesser volumes of private cars, motorcycles and paratransit vehicles; although so far this has only been in plans.
- The traffic conditions on the existing road network will undergo a remarkable improvement by better traffic management strategies based on the application of modern technology; however, such has not been the case.

- There is significant improvement in the network condition and capacity to handle further traffic especially on the existing competing routes,
- The shuttle train service proposed by Pak Rail to transfer container cargo to upcountry via Pipri Marshalling Yard becomes operational taking away about 40% of the containerized cargo traffic from the road network
- The Elevated Expressway Project conceived by KPT becomes operational and provides a direct connectivity from East Wharf, SAPT and Keamari Oil Terminal to West Wharf and onwards to Northern Bypass. This presumes that the KPT Expressway has proved to be feasible.

3.3.3 Analysis Scenario – 3:

As opposed to the above two extreme situations, the analysis scenario -3 presents a pragmatic situation for the proposed Malir Expressway Project resulting in a more realistic traffic diversion estimate for it under the following assumptions:

- There is some improvement in the public transport system by implementation of the BRT System on the transit corridors already under implementation phase especially the BRT Green and Orange Lines, resulting in a higher level of public transport usage and consequently decrease in private transport usage along these corridors.
- The traffic conditions on the existing road network slightly improved with no significant decrease in travel times and traffic congestion.
- There is also a little improvement in the network condition due to resurfacing of some major roads and construction of a few more flyover / underpass structures adding to their capacity to handle traffic but not necessarily on the existing competing routes,
- The shuttle train service proposed by Pak Rail to transfer container cargo to upcountry via Pipri Marshalling Yard still remains to be implemented.
- The Elevated Expressway Project conceived by KPT becomes operational and provides a direct connectivity from East Wharf, SAPT and Keamari Oil Terminal to West Wharf and onwards to Northern Bypass for traffic destinations towards North East.
- The development of DHA City, Bahria Town and the Education City schemes takes place at a moderate pace resulting in a minor volume of daily traffic between these facilities in the Northern suburbs at one end of the proposed Malir Expressway and the Southern parts of the city especially the CBD and the DHA and Clifton areas at the other end of the Expressway.
- It is a proven phenomenon that high speed facilities such as Malir Expressway function with increased volumes of traffic being the highest class of road and resultantly provide higher speeds and reduced travel time.

3.3.4 Special Traffic Generators for Malir Expressway Project

It is to be appreciated that the following constitute the special traffic generators in the area of influence of the proposed alignment of Malir Expressway:

- KPT (including the SAPT, KICT, PICT and the Oil Terminal at Shirin Jinnah Colony, Keamari)
- PQA and Steel Mills
- DHA City
- Bahria Town
- Education City
- Korangi Industrial Area
- Landhi Industrial Area
- Export Processing Zone (EPZ)
- Jinnah International Airport (JIAP), Karachi

3.3.5 Town areas to be served by Malir Expressway:

A study of the available road network, relative location of the various towns and the origins and destinations of the traffic shows that the following areas are likely to be served by the proposed Project:

S. No.	Name of Town / Cantonment	Remarks
1.	Bahria Town	Yes
2.	Bin Qasim Town	Yes
3.	Central Business District (CBD area / Saddar, II Chundirgar Road)	Yes
4.	Clifton Cantonment	Yes
5.	DHA Karachi (Phases 1 – 8)	Yes
	DHA City (Phase 9)	Yes
6.	Export Processing Zone (EPZA), Karachi	Yes
7.	Faisal Cantonment (Drigh Road CT)	Yes
8.	Gadap Town	Yes
9.	Gulshan-e-Maymar / Ahsanabad	Yes
10.	Ibrahim Hyderi Fishing Village / Fishing Jetty	Yes
11.	Jamshed Town	Yes
12.	Jinnah International Airport (JIAP), Karachi and adjoining areas	Yes
13.	Karachi Cantonment	Yes
14.	Keamari Town Including the entire Karachi Port Area, Container Terminals (SAPT, KICT, PICT) and the Oil Terminal at Shirin Jinnah Colony.	Yes
15.	Korangi Industrial Area	Yes
16.	Korangi Cantonment (Korangi Creek Cantt.)	Yes
17.	Landhi Industrial Area	Yes
18.	Malir Cantonment /Other areas of Malir	Yes
19.	Manora Cantonment	Yes
20.	Shah Faisal Colony	Yes

3.4 Data Collection

The data collection exercise comprised the following activities in connection with this study:

- Collection of historic traffic data
- Collection of other socio-economic data
- Fresh Traffic Surveys (based on Origins – Destinations served by MEW).

3.4.1 Historic Traffic Data

As stated above, Malir Expressway Project has been under active consideration for some time now and therefore, there are a number of Studies & Reports which give a focus on its traffic prospects with varying level of detail and reliability. The data was collected and carefully reviewed for its relevance and applicability for the present study. It was also very helpful in analyzing the growth in traffic over the years. The historic data were also used for validating and substantiating the O-D Survey results. Therefore, the historic traffic data provided valuable support in a rationalized analysis of the current data and drawing a representative picture of traffic conditions along the corridor. A summary of the various historic traffic data collected for the study is presented at Annexure “A”.

3.4.2 Fresh Traffic Surveys

Fresh traffic surveys included:

- Classified traffic counts at strategic locations for 24 hours for two days
- Origin-Destination Surveys at the above locations,
- Daily traffic movement data from truck stands, existing container terminals PICT, KICT, SAPT / Deep Water Container Port, Oil Terminal at Keamari and entry / exit gates of Karachi Port.
- Travel Time and Delay Study on the existing routes serving the traffic likely to use the proposed project.

The data were used for developing the travel pattern on the existing road network and the travel desire lines presented at Annexure “B”.

3.5 Data Analysis

A network based data analysis was carried out with the help of computers to compute the annual average daily traffic (AADT) on the existing network and the travel desire pattern, the traffic growth rates during the last 10 years, the present routes of travel for the external traffic likely to be served by the proposed Malir Expressway and the travel demand forecast for the Project, the projected traffic over the 25 years post-construction period and the capacity analysis including determination of number of lanes and operational level of service on the facility and also the impact of this traffic shift on the existing urban road network.

3.5.1 Traffic on the Existing Network

The desire line diagrams showing the travel pattern on Karachi's urban road network developed from the above traffic data are presented at Annexure "B".

3.5.2 Travel Demand Forecast for Malir Expressway

Based on the above data and analysis, the following travel demand volumes have been determined for the year 2019 under the three operational scenarios analyzed for the Project:

Analysis Scenario – 1				
Details	**Cars, Jeeps, SUVs, Vans**	**Buses & Minibuses**	**Truck and Trailer**	**Traffic Volume (Veh/ Day)**
Traffic Volume (Veh/ Day)	14,247	1,573	17,496	33,316
Travel Time Saved (Min/ Day)	403,865	14,557	107,073	525,495
Analysis Scenario – 2				
Details	**Cars, Jeeps, SUVs, Vans**	**Buses & Minibuses**	**Truck and Trailer**	**Traffic Volume (Veh/ Day)**
Traffic Volume (Veh/ Day)	3,166	977	4,860	9,003
Travel Time Saved (Min/ Day)	89,748	9,041	29,743	128,532
Analysis Scenario – 3				
Details	**Cars, Jeeps, SUVs, Vans**	**Buses & Minibuses**	**Truck and Trailer**	**Traffic Volume (Veh/ Day)**
Traffic Volume (Veh/ Day)	7,915	1,085	9,720	18,720
Travel Time Saved (Min/ Day)	224,370	10,041	59,485	293,895

3.5.3 Traffic Growth Rates Applied

After a detailed analysis of the previous trends of traffic growth in the city and the various factors likely to affect the growth of traffic on the proposed project, the following traffic growth rates were applied for traffic projections:

Applied Traffic Growth Rates (%)				
Years		**Cars, Jeeps, SUVs, Vans**	**Buses & Minibuses**	**Trucks and Trailers**
2019	**2020**	5.0%	5.0%	5.0%
2021	**2026**	10.0%	4.0%	4.0%
2027	**2036**	6.0%	4.0%	4.0%
2037	**2047**	3.5%	3.5%	3.5%

3.5.4 Projected Traffic

The projected traffic for Malir Expressway under the three analytical scenarios, as discussed in the foregoing sections, is presented below:

Analysis Scenario – 1

Year	Traffic Volume (Veh/ Day)			
	Cars, Jeeps, SUVs, Vans	Buses & Minibuses	Truck and Trailers	Total
2019	14,247	1,573	17,496	33,316
2020	14,959	1,652	18,371	34,982
2021	16,455	1,718	19,106	37,279
2022	18,101	1,787	19,870	39,758
2023	19,911	1,858	20,665	42,434
2024	21,902	1,932	21,492	45,326
2025	24,092	2,009	22,352	48,453
2026	26,501	2,089	23,246	51,836
2027	28,091	2,173	24,176	54,440
2028	29,776	2,260	25,143	57,179
2029	31,563	2,350	26,149	60,062
2030	33,457	2,444	27,195	63,096
2031	35,464	2,542	28,283	66,289
2032	37,592	2,644	29,414	69,650
2033	39,848	2,750	30,591	73,189
2034	42,239	2,860	31,815	76,914
2035	44,773	2,974	33,088	80,835
2036	47,459	3,093	34,412	84,964
2037	49,120	3,201	35,616	87,937
2038	50,839	3,313	36,863	91,015
2039	52,618	3,429	38,153	94,200
2040	54,460	3,549	39,488	97,497
2041	56,366	3,673	40,870	100,909
2042	58,339	3,802	42,300	104,441
2043	60,381	3,935	43,781	108,097
2044	62,494	4,073	45,313	111,880
2045	64,681	4,216	46,899	115,796
2046	66,945	4,364	48,540	119,849
2047	69,288	4,517	50,239	124,044

Analysis Scenario – 2

Year	Traffic Volume (Veh/ Day)			
	Cars, Jeeps, SUVs, Vans	Buses & Minibuses	Truck and Trailers	Total
2019	3,166	977	4,860	9,003
2020	3,324	1,026	5,103	9,453
2021	3,656	1,067	5,307	10,030
2022	4,022	1,110	5,519	10,651
2023	4,424	1,154	5,740	11,318
2024	4,866	1,200	5,970	12,036
2025	5,353	1,248	6,209	12,810
2026	5,888	1,298	6,457	13,643
2027	6,241	1,350	6,715	14,306
2028	6,615	1,404	6,984	15,003
2029	7,012	1,460	7,263	15,735
2030	7,433	1,518	7,554	16,505
2031	7,879	1,579	7,856	17,314
2032	8,352	1,642	8,170	18,164
2033	8,853	1,708	8,497	19,058
2034	9,384	1,776	8,837	19,997
2035	9,947	1,847	9,190	20,984
2036	10,544	1,921	9,558	22,023
2037	10,913	1,988	9,893	22,794
2038	11,295	2,058	10,239	23,592
2039	11,690	2,130	10,597	24,417
2040	12,099	2,205	10,968	25,272
2041	12,522	2,282	11,352	26,156
2042	12,960	2,362	11,749	27,071
2043	13,414	2,445	12,160	28,019
2044	13,883	2,531	12,586	29,000
2045	14,369	2,620	13,027	30,016
2046	14,872	2,712	13,483	31,067
2047	15,393	2,807	13,955	32,155

Analysis Scenario – 3				
Year	Traffic Volume (Veh/ Day)			
	Cars, Jeeps, SUVs, Vans	Buses & Minibuses	Truck and Trailers	Total
2019	7,915	1,085	9,720	18,720
2020	8,311	1,139	10,206	19,656
2021	9,142	1,185	10,614	20,941
2022	10,056	1,232	11,039	22,327
2023	11,062	1,281	11,481	23,824
2024	12,168	1,332	11,940	25,440
2025	13,385	1,385	12,418	27,188
2026	14,724	1,440	12,915	29,079
2027	15,607	1,498	13,432	30,537
2028	16,543	1,558	13,969	32,070
2029	17,536	1,620	14,528	33,684
2030	18,588	1,685	15,109	35,382
2031	19,703	1,752	15,713	37,168
2032	20,885	1,822	16,342	39,049
2033	22,138	1,895	16,996	41,029
2034	23,466	1,971	17,676	43,113
2035	24,874	2,050	18,383	45,307
2036	26,366	2,132	19,118	47,616
2037	27,289	2,207	19,787	49,283
2038	28,244	2,284	20,480	51,008
2039	29,233	2,364	21,197	52,794
2040	30,256	2,447	21,939	54,642
2041	31,315	2,533	22,707	56,555
2042	32,411	2,622	23,502	58,535
2043	33,545	2,714	24,325	60,584
2044	34,719	2,809	25,176	62,704
2045	35,934	2,907	26,057	64,898
2046	37,192	3,009	26,969	67,170
2047	38,494	3,114	27,913	69,521

3.5.5 Capacity Analysis

Capacity analysis was performed on the basis of procedures outlined in the Highway Capacity Manual, TRB, USA. It consisted in determination of the number of lanes required and the Level of service analysis for the three traffic scenarios for the 6-lane access controlled facility.

The analysis for the earlier discussed three traffic scenarios is shown in Tables 3.5.5.1 – 3.5.5.3 respectively attached at the end of the Report. A summary of the Levels of Service (LoS) in various years after construction under the three operational scenarios is presented below:

Analysis Scenario	Years	Level of Service (LoS)	Reference
1	2023 – 2029	C	Table 3.5.5.1
	2030 – 2033	D	
	2034 onward	E	
2	2023 – 2029	B	Table 3.5.5.2
	2030 – 2037	C	
	2038 – 2043	D	
	2044 – 2047	E	
3	2023 – 2028	B	Table 3.5.5.3
	2029 – 2036	C	
	2037 – 2042	D	
	2043 – 2047	E	

3.5.6 Impact on Traffic Conditions on the Urban Road Network

The construction of Malir Expressway along the proposed alignment will have a positive impact on traffic conditions on the urban road network as:

- It will be more convenient and desirable for entry and exit from the central business area (CBD) for the external traffic (i.e., traffic to/from outside the city) as compared to the urban arterials which remain congested during the day and are not suitable for movement of heavy traffic.
- It will provide a direct linkage between Jinnah International Airport (Karachi airport) and the southern parts of the city including the DHA / Clifton areas.
- It will also help improve the traffic conditions on the existing urban road network and its capacity by providing an exclusive alternate diversion route for the external traffic and by serving an estimated 42% of the population in various areas lying along the corridor serving as a bypass for the Southern half of the city.

- It will also facilitate operation of public transport especially for the inter-city travel of people living in the Southern parts of the city like Landhi, Korangi, Shirin Jinnah Colony, Keamari, etc.

- With the reduction in traffic on urban roads network due to shift of external traffic to Malir Expressway, there is likely to be a reduction in traffic accidents especially those involving the heavy goods vehicles.

- There will be substantial improvement in the environmental conditions in the city due to reduction in air and noise pollution on the urban road network.

3.6 Conclusion

On the basis of the foregoing Traffic Study, it is concluded that:

1. Malir Expressway Project is amongst the important transport development projects for the city of Karachi as it would provide numerous benefits to the daily commuters especially between the southern parts of the city mainly Clifton and DHA to the Motorway M9 and beyond. It will essentially constitute the Southern Bypass for Karachi City.

2. It will be more convenient and desirable for entry and exit from the central business area (CBD) for the external traffic (i.e., traffic to/from outside the city) as compared to the urban arterials which remain congested during the day and are not suitable for movement of heavy traffic.

3. It will provide a direct linkage between Jinnah International Airport (Karachi airport) and the southern parts of the city including the DHA / Clifton areas.

4. It will also help improve the traffic conditions on the existing urban road network and its capacity by providing an exclusive alternate diversion route for the external traffic and by serving an estimated 42% of the population in various areas lying along the corridor serving as a bypass for the Southern half of the city.

5. No right-of-way acquisition / property compensation will be required as land is already available along the banks of Malir River without any encroachments along the proposed alignment.

6. Access / Exit ramps will be strategically placed with interchanges provided at the main arterials crossing the alignment.

7. It will also facilitate operation of public transport especially for the inter-city travel of people living in the Southern parts of the city like Landhi, Korangi, Shirin Jinnah Colony, Keamari, etc.

8. A substantial volume of heavy vehicles would be attracted by the Expressway besides the normal passenger traffic consisting of light vehicles consisting of cars, vans, jeeps, station wagons, and public transport vehicles including minibuses, coaches, coasters & large buses.

9. It is by necessity that no motorcycles and rickshaws should be allowed on the Expressway in view of the long distance, high speed movement of traffic and avoidance of unnecessary traffic hindrance and safety hazards.

10. The traffic level on the proposed Malir Expressway will vary depending upon the operational scenario, transport infrastructure development policies in effect and the overall socio-economic and geopolitical conditions prevailing at the time of its completion and opening.

11. According to the three operational scenarios envisaged for the proposed expressway, the total AADT will vary from 33,000vpd for the most optimistic scenario to 9,000vpd under the most pessimistic scenario. A more pragmatic estimate of travel demand along the proposed Expressway under the scenario-3 will be around 19,000vpd.

12. The capacity analysis based on the procedures outlined in the Highway Capacity Manual, TRB, USA, shows that during the 25 years post construction analysis period, the Expressway will offer an acceptable Level of Service most of the time. However, towards the last few years the Level of Service may drop down to LoS "E" as highlighted in section 3.5.5.

13. However, a number of feasibility studies for various transport projects are presently underway whose implementation is likely to influence travel demand on the Malir Expressway Project; these include:
    a. KPT Expressway dedicated for cargo movement in / out of the KPT area.
    b. Pak Rail to expand capacity by railway connectivity to evacuate Port Traffic by rail.
    c. Eight mass transit corridors still in various stages of planning; only Green and Orange Line BRT systems expected to go in service by the end of 2018.

14. There will be reduced vehicle operating costs and reduced travel time due to uninterrupted movement at higher speeds than experienced on the existing urban arterials network.

15. There will be substantial improvement in the environmental conditions in the city due to reduction in air and noise pollution on the urban road network.

16. There will be potential for increased economic activities along the corridor and the area of influence of the project.

17. There will also be a potential to use the ROW for the expressway (along the shoulders / embankment) for laying parallel pipe lines (for LNG, Gas, etc)

18. With the reduction in traffic on urban roads network due to shift of external traffic to Malir Expressway, there will also be a reduction in traffic accidents especially those involving the heavy goods vehicles.

4 Soil and Geotechnical Investigations

4.1 Program of Investigations

In order to evaluate subsoil conditions and to obtain soil parameters for the design of foundations, a program of sub-soil and geotechnical investigation was undertaken at the site. The task was awarded to 'Geotechnical Services', Karachi and the field work was accomplished in March, 2018.

The program of investigation consisted of executing 20 test pits carried to a depth of 1.50m below existing ground level. Bulk samples were extracted from tests pits for performing classification, compaction and CBR tests.

Table 4.1 - Detail of Test Pits

Boring No.	Chainage	Co-ordinates		Depth (m)
		Nothing	Easting	
TP-1	-0+827	24.8320597	67.0869323	1.50
TP-2	0+973	24.8474482	67.0892302	1.50
TP-3	2+773	24.8643030	67.0972750	1.50
TP-4	4+573	24.8666190	67.1139480	1.50
TP-5	6+373	24.8702107	67.1291040	1.50
TP-6	8+173	24.8735324	67.1466019	1.50
TP-7	9+973	24.8715480	67.1639903	1.50
TP-8	11+773	24.8656670	67.1805450	1.50
TP-9	13+573	24.8645819	67.1979968	1.50
TP-10	15+373	24.8702777	67.2146050	1.50
TP-11	17+173	24.8793240	67.2290128	1.50
TP-12	18+973	24.8918281	67.2408979	1.50
TP-13	20+773	24.9047140	67.2517523	1.50
TP-14	22+573	24.9175992	67.2626088	1.50
TP-15	24+373	24.9290755	67.2751492	1.50
TP-16	26+173	24.9398554	67.2848490	1.50
TP-17	27+973	24.9506342	67.3018229	1.50
TP-18	29+773	24.9609402	67.3100630	1.50
TP-19	31+573	24.9721886	67.3285060	1.50
TP-20	33+373	24.9828085	67.3419878	1.50

As the project involves the construction of a number of fly-over bridges that would span over the existing bridges across the Malir River, the program of investigation also consisted of drilling 4 boreholes each 30.0 m deep except BH-2 which was drilled upto 39.0 m below existing ground level.

The following Table shows the detail of Bore Holes while their location is also shown on layout plan appended to this report:

Detail of Boreholes

Boring No.	Chainage	Interchange	Co-ordinates		Depth (m)
			Nothing	Easting	
BH-1	-0+827	Korangi Causeway	24.8321459	67.0868994	30
BH-2	8+173	Korangi Shah Faisal Interchang	24.8748467	67.1447565	39
BH-3	14+173	Malir Quaidabad Interchange	24.8662000	67.2036863	30
BH-4	24+173	Open (near Memon Goth)	24.9248304	67.2713587	30

In order to ascertain the degree of compactness / consistency of substrata, standard penetration tests (SPTs) were performed wherever found feasible. Moreover, core samples were extracted using double tube core barrel.

A Laboratory testing program was developed and selected soil/rock samples were tested in the laboratory of Geotechnical Services, Karachi for the evaluation of geo-engineering characteristics.

The laboratory testing program for the samples for sub-grade soil included the following tests:

- Sieve Analysis — AASHTO T-80
- Liquid Limit, Plastic Limit — AASHTO T-90
- Moisture-Density Relationship (Modified AASHTO) — AASHTO T-180
- Three Point CBR (Soaked) — AASHTO T-193

4.2 Classification of Sub-grade Soil

The AASHTO classification of subgrade soil on the basis of particle size analysis and Atterberg limits, as reported in Table 3.1 of the Report on Soil Investigation Along Road Alignment (Volume II) is as under:

Pit No	Chainage	Description	AASHTO Classification	Rating as Subgrade
TP-1	-0+827	Sandy SILT	A-4	Fair
TP-2	0+973	Fine to medium SAND, little silt	A-2-4	Good
TP-3	2+773	Organic fill with garbage	-	-
TP-4	4+573	Fine to medium SAND, little silt	A-2-4	Good
TP-5	6+373	Clayey SAND / sandy CLAY	A-4	Fair to poor
TP-6	8+173	Fine to coarse SAND, little silt	A-2-4	Good
TP-7	9+973	Silty, fine to coarse SAND	A-2-4	Good
TP-8	11+773	Fine SAND, trace silt	A-3	Fair to good
TP-9	13+373	Coarse SAND, little gravel	A-1-b	Excellent
TP-10	15+373	Clayey SILT, some sand	A-4	Fair
TP-11	17+173	Fine to medium SAND, some silt	A-2-4	Good
TP-12	18+973	Fine to medium SAND, some silt	A-2-4	Good
TP-13	20+773	Sandy SILT	A-4	Fair
TP-14	22+573	Silty / clayey, fine to medium SAND	A-4	Fair
TP-15	24+373	Silty / clayey, fine to medium SAND	A-4	Fair
TP-16	26+173	Medium to coarse SAND, trace gravel	A-1-b	Excellent
TP-17	27+973	Medium to coarse SAND, little gravel	A-1-b	Excellent
TP-18	29+773	Medium to coarse SAND, little gravel	A-1-b	Excellent
TP-19	31+573	Silty SAND / sandy SILT	A-4	Fair
TP-20	33+373	Medium to coarse SAND, little gravel	A-1-b	Excellent

* In TP-5, top 1.4m comprise of organic fill. This is underlain by clayey SAND/sandy CLAY deposit.

The above classification shows that the material is fine to coarse grained throughout the alignment.

4.3 Compaction & California Bearing Ratio (CBR) of the Sub-grade Soil:

The details of compaction and Three point soaked CBR Test Results for the Sub-grade Soil Samples are reproduced below from Table 3.2 of the Report on Soil Investigation Along Road Alignment (Volume II):

COMPACTION / CBR TEST RESULTS FOR SUB-GRADE SOIL SAMPLES

Pit No	Chainage (km)	Classification	Max Dry Density (gm/cc)	Optimum Moisture Content (%)	CBR @ 95% MDD (%)	CBR @ 98% MDD (%)
TP-1	-0+827	A-4	1.952	8.15	9.40	9.40
TP-2	0+973	A-2-4	1.807	8.16	14.00	14.75
TP-4	4+573	A-2-4	1.924	7.91	16.92	17.78
TP-5	6+373	A-4	2.041	8.10	3.57	3.92
TP-7	9+973	A-2-4	2.112	6.25	19.70	21.40
TP-8	11+773	A-3	1.794	11.92	8.55	8.92
TP-10	15+373	A-4	1.884	10.46	4.55	4.90
TP-11	17+173	A-2-4	2.055	7.12	18.60	19.67
TP-13	20+773	A-4	1.918	8.25	10.10	10.78
TP-16	26+173	A-1-b	2.119	5.92	25.00	27.40
TP-17	27+973	A-1-b	2.158	5.76	32.00	34.48
TP-20	33+373	A-1-b	2.126	6.08	28.05	29.54

4.4 Conclusions For Sub-grade Soil Samples

Based on the above stated testing of the sub-grade soil samples taken along the Road alignment, the following important conclusions were drawn:

4.4.1 Grain Size Analysis:

The grain size analysis of soil samples along the alignment shows following ranges with regard to percent passing sieve Nos. 4, 10, 40 and 200:

Sieve No.	Percent Passing	Average
#4	70 to 100 %	89.35
#10	66 to 100 %	86.40
#40	19 to 100 %	54.80
#200	01 to 83 %	29.05

4.4.2 Atterberg Limits:

The Atterberg limits show following ranges with regard to liquid limit and plasticity index:

Test	Range	Average
Liquid Limit	17 to 22 %	18.80
Plasticity Index	05 to 07 %	5.40

A total of 15 samples have been found to be non-plastic.

4.4.3 Soil Classification:

It is evident that 07 soil samples along the alignment belong to A-4 group of AASHTO Soil Classification System. However 06 samples belong to A-2-4 group and 05 samples belong to A-1-b while one sample belongs to A-3 group of the AASHTO System.

4.4.4 Fine Aggregate:

The SAND present in test pits TP-9 & TP-16 belong to A-1-b group of AASHTO Soil Classification System. It is suggested that this SAND deposit can be used as construction sand in RCC works.

4.4.5 California Bearing Ratio:

The average results of CBR @ 95 & 98 % MDD are being presented for different AASHTO group categories:

A-1-b Group

- CBR @ 95% Compaction 28.35 %
- CBR @ 98% Compaction 30.58 %

A-2-4 Group

- CBR @ 95% Compaction 17.31 %
- CBR @ 98% Compaction 18.40 %

A-3 Group

- CBR @ 95% Compaction 8.55 %
- CBR @ 98% Compaction 8.92 %

A-4 Group

- CBR @ 95% Compaction 6.91 %
- CBR @ 98% Compaction 7.25 %

4.5 Suitability as Fill Material:

A study of Table 3.1 shows that 05 pit samples (TP-9, 16, 17, 18 & 20) belong to A-1-b group of AASHTO Classification System. These materials possess excellent compaction & CBR Characteristics. Hence they can be used both as embankment fill material as well as sub-base in the pavement construction.

Moreover, 06 soil samples (TP-2, 4, 6, 7, 8, 11 & 12) belong to A-2-4 group of AASHTO Classification System. Compaction characteristics and engineering properties of these material are suitable for use as select fill material in the Expressway Embankment.

It is important to note that in TP-3 & TP-5 (near DHA Karachi, Interchange-1) organic fill with garbage has been encountered upto 1.4-1.50 m depth. It is recommended that this organic material / garbage must be removed and replaced with well graded fine to coarse SAND belonging to A-1-b or A-2-4 groups of AASHTO Classification System.

It shall be placed in layers of 150-200mm thickness and compacted to minimum 90-95% of the maximum density obtained in accordance with ASTM Designation D-1557. The moisture content of fill material shall be controlled within ± 2% of optimum values. Field density tests (ASTM D-1556) shall be performed on each layer to control the degree of compaction.

4.6 Deep Soil / Geotechnical Investigations for Bridge Foundations

During the course of boring, standard penetration tests were performed wherever found feasible. This test was conducted in accordance with ASTM Designation D-1586. Disturbed samples were obtained through split spoon sampler used in the standard penetration tests. These samples were carefully examined to identify the soil types at various depths. Rock core drilling was carried out using double tube core barrel in conjunction with tungsten carbide bit. After each run of the core barrel, percent core recovery and rock quality designation (RQD) were determined.

4.7 Laboratory Testing:

In order to arrive at a rational evaluation of the geotechnical properties of substrata encountered at the site, a comprehensive program of laboratory testing was undertaken. The tests were performed to determine classification, strength and chemical characteristics. The testing was generally performed in accordance with relevant American Society for Testing and Material (ASTM) standards.

The following tests were performed on the representative samples in the laboratory:

- Grain size analysis
- Atterberg limits
- Unconfined compression
- Density & Moisture
- Total salts
- Sulphate content
- Chloride content
- pH value

The position of ground water table was also indicated on the borelogs.

4.8 Geological History & Formation:

The geological studies have revealed that the soil formations in this area are fresh and slightly weathered, recent and subrecent shoreline deposits. These deposits are derived from Gaj / Manchar formation of lower Moicene to Middle / Upper Miocene to Pliocene age. Quarternary deposits are represented by an extensive Conglomerate which unconformably overlies the Manchar rocks and slightly overlaps on to the Gaj series. Alluvial sands and gravels are of comparatively `Recent' origin.

The Gaj formation consists of mostly limestone with subordinate shale and sandstone. The limestone is friable to hard and at placed fossiliferious. This formation overlies Nari formation which consists of harder limestone beds and shale.

Overlying Gaj formation is Manchhar formation. This formation is composed of sandstone, clay beds, cemented sand and gravel (Conglomerate) and shell concrete. The clays are of various colors and consistency. Sandy layers are also found inter-bedded with clay and gravel.

4.9 Seismicity of the Region:

According to the Uniform Building Code (1997), Karachi and its adjoining areas fall in Seismic Zone-2B. Following are the seismic parameters for Karachi Region:

Seismic Parameters	Value
UBC Zone	2B
Max Peak Ground Acceleration	0.16 – 0.24g
Magnitude (Richter Scale)	6.0 – 7.0
Intensity (MM Scale)	VII – VIII

4.10 Subsurface Characteristics:

4.10.1 General Stratification:

The stratigraphy and the subsurface conditions have been evaluated on the basis of boring logs supported by field and laboratory test results.

Borehole BH-1:

In this borehole, subsoil investigation has revealed that top 10.50 m consist of fill and soft to firm organic clay. The organic matter has an odor. The soft nature of this deposit is manifested by SPT blow counts as well as the laboratory test results. The deposit has nearly 100% degree of saturation and the very high natural moisture content.

Beneath the clay deposit, substrata comprise of very dense, gravelly, coarse SAND. This deposit is underlain by friable to medium hard, SANDSTONE that continues upto the investigated depth of 30.0 m.

The substrata may be generally described as follows:

1. Blackish gray, soft to firm, silty CLAY / clayey SILT
2. Gray, very dense gravely, coarse SAND
3. Grayish brown, friable to medium hard, SANDSTONE

Borehole BH-2:

A study of bore log BH-2 shows that top 6.0 m consist of medium dense, silty SAND / sandy SILT. From 6.0-27.50 m substrata comprise of alternate layers of SAND and hard, clayey SILT. This is followed by very dense, sandy GRAVEL and medium hard to hard, SANDSTONE that continues upto the investigated depth of 39.0 m.

The principal subsurface deposits can be described as follows:

1. Brown, medium dense, silt SAND / sandy SILT
2. Gray, dense, fine to coarse SAND
3. Brown, hard, clayey SILT

4. Brown, cemented SAND with interlayers of clay
5. Brown, hard, clayey SILT with interlayer of sand
6. Gray, very dense, sandy GRAVEL
7. Yellowish brown, medium hard to hard, SANDSTONE

Borehole BH-3:
An assessment of bore log BH-3 has revealed that top 2.5 m consist of SAND and very stiff, clayey SILT. From 2.5-7.0 m, substrata comprise of dense, silty / clayey, fine to coarse SAND. Beneath the sand deposit, there occurs a thin layer of hard, silty CLAY / SHALE deposit. This is followed by very dense, SAND / sandy GRAVEL hard, clayey SILT. This is followed by soft CLAYSTONE that extends upto the explored depth of 30.0 m.
The principal lithological units can be classified as follows:

1. Brown, medium dense, fine to coarse SAND
2. Brown, very stiff, clayey SILT
3. Gray, dense, silty / clayey, fine to coarse SAND
4. Brown, hard, silty CLAY / SHALE
5. Brown, very dense, fine to coarse SAND, some silt

Borehole BH-4:
Subsoil investigation has revealed that top 2.50 m consist of medium dense, gravelly SAND. From 2.50-9.0 m substrata comprise of very dense, sandy GRAVEL. This is underlain by very dense, sandy SILT and soft, CLAYSTONE that continues upto the investigated depth of 30.0 m.

1. Brown, medium dense, gravely coarse SAND

2. Brown, very dense, fine to coarse SAND

3. Gray, very dense, sandy GRAVEL

4. Brown, soft, CLAYSTONE

The exact sequence of occurrence of these deposits is shown on bore logs appended to the report (Volume I).

4.10.2 Ground Water Table:

The following Table presents position of ground water table in the 4 boreholes

POSITION OF GROUND WATER TABLE

Boring No.	Chainage	Depth of Water Table (m)
BH-1	-0+827	2.50
BH-2	8+173	12.20

BH-3	14+173	2.50
BH-4	24+173	23.00

Source: Table3.1, Geotechnical Report (Volume1)

4.11 Foundation Recommendations:

4.11.1 General:

Foundations of structures are considered satisfactory if they satisfy the following requirements:

a) The foundation must be safe against the possibility of shear failure
b) The foundation must not undergo excessive settlements
c) It must be placed at sufficient depth below ground surface so as to be safe from erosion, scouring action of water and seasonal variations.

4.11.2 Foundation Type:

The selection of foundation type depends upon the type of structure, site conditions, structural loads and the subsoil conditions

It is recommended that the proposed flyover- bridge be supported on pile foundation.

4.11.3 Pile Foundations:

4.11.3.1 Pile Input Data:

Following pile data is provided by the consultants:
Pile diameter: 1000 mm
Load per Pile: 300 MT

4.11.4 Pile Length & Allowable Capacity:

As discussed earlier, there are significant variations in substrata present in all boreholes. Hence, following section presents allowable pile capacities for each borehole separately.

The following Table presents allowable pile capacities of 1000 mm diameter pile with total embedded lengths (based on Table 5.1, Geotechnical Investigations Report Volume2).

ALLOWABLE CAPACITY OF PILE FOUNDATION

Borehole	Interchange	Pile Dia (mm)	Total embedded Length (m)	Bearing Stratum	Allowable Pile Capacity (MT)
BH-1	DHA Karachi Interchang-1	1000	23	SANDSTONE	311
BH-2	Korangi Shah Faisal Interchang-2	1000	15	Very dense, SAND	314
BH-3	Malir Quaidabad Interchang-3	1000	16	-do-	304
BH-4	Open (near Memon Goth)	1000	12	Very dense, sandy GRAVEL	317

Source: Table 5.1, Geotechnical Report, Volume 1

4.12 General Considerations for Pile Foundations:-

1. The pile capacities are for vertical axial loads in compression only.

2. During piling, it is imperative that the bearing stratum is properly identified. Proper bore log must be maintained for each pile. In case recommended bearing stratum is not encountered within stipulated length, the matter must be referred to the geotechnical engineer.

3. Before commencing concreting, the bottom of borehole should be cleansed of loosened soil, mud or any other debris.

4. Concreting should be done using a tremie pipe. During concreting it should be ensured that the bottom of tremie pipe is always submerged in concrete. The precaution is necessary to prevent `necking' of soil.

5. The concrete should have a slump of about 150mm so that it may freely pass through the tremie pipe. If necessary, a plasticizer must be used in concrete to improve workability.

6. In borehole BH-1, due to presence of soft clay at top 10 m, it is recommended that permanent steel liner must be used at top 10 m length of pile. Minimum gauge of the steel liner must be 6 mm.

4.13 Allowable Bearing Capacity for Retaining Walls:

For Borehole BH-1:
As discussed earlier, top 10.50 m comprise of soft, organic clay. The soft nature of this deposit is manifested by SPT blow counts and high moisture content. This is underlain by very dense, gravelly, coarse SAND and friable to medium hard, SANDSTONE.

Due to presence of soft clay deposit upto 10.50 m depth, it is recommended that the retaining walls for approach ramps be supported on short piles.

Allowable pile capacity of 600 mm diameter pile with embedded length of 12.0 m should be adopted as 60 MT.

Allowable pile capacity of 760 mm diameter pile with embedded length of 12.0 m should be adopted as 100 MT.

For Borehole BH-2:
It is recommended that retaining walls for approach ramps will be supported on strip footing.
A study of borelog BH-2 shows that top 6.0 m consist of medium dense, silty SAND / sandy SILT. This is underlain by alternate layers of SAND and hard, clayey SILT.

Allowable bearing capacity for strip footing placed at 1.0 m depth should be taken as 1.00 tsf.

For Borehole BH-3:
In borehole BH-3,top 2.5 m consist of SAND and very stiff, clayey SILT. From 2.5-7.0m, substrata comprise of dense, silty / clayey, fine to coarse SAND.

Allowable bearing capacity for strip footing placed at 1.0 m depth should be taken as 1.50 tsf.

For Borehole BH-4:
Subsoil investigation has revealed that top 2.50 m consist of medium dense, gravelly SAND. From 2.50-9.0 m substrata comprise of very dense, sandy GRAVEL.

Allowable bearing capacity for strip footing placed at 1.0 m depth should be taken as 1.50 tsf.

4.14 Seismic Coefficients:

For Borehole BH-1:
According to the Uniform Building Code (1997), the soil profile type falls in "SD" category corresponding to 'stiff soil'. The following table gives seismic zone, seismic zone factor, soil profile type and seismic coefficients.

Seismic zone	Zone factor 'z'	Soil profile Type	Seismic Coefficient 'Ca'	Seismic Coefficient 'Cv'
2B	0.20	'SD'	0.28	0.40

For Boreholes BH-2, BH-3 & BH-4:
According to the Uniform Building Code (1997), the soil profile type falls in "SC" category corresponding to 'very dense, soil and soft rock'. Following table gives seismic zone, seismic zone factor, soil profile type and seismic coefficients.

Seismic zone	Zone factor 'z'	Soil profile Type	Seismic Coefficient 'Ca'	Seismic Coefficient 'Cv'
2B	**0.20**	**'SC'**	**0.24**	**0.32**

4.15 Cement Type:
American Concrete Institute (ACI) gives the requirements for concrete exposed to Sulphate (SO4) containing solutions. The ACI standards are given below:

Sulphate Exposure	Water Soluble Sulphate in Soil (%)	Sulphate in Water (mg/lit)	Cement Type
Negligible	0.00-0.10	0-150	OPC
Moderate	0.10-0.20	150-1500	Type II
Severe	0.20-2.00	1500-10000	Type V
Very Severe	Over 2.00	Over 10000	Type V plus Pozzolan

In addition to the above summary, detailed results of the Sub-soil and Geotechnical investigations are appended at the end of the Report.

5 Hydrology and Hydraulic Studies

5.1 Historic Flood

Previously, there have been four damaging floods in Karachi in the past 50 years; 1967, 1973, 1977, and 1978. The most devastating flood in the history occurred in June 1977. Following the rainfall of 29th June 1977 which had created a situation favorable for quick runoff. Intense rainfall occurred on 30th June 1977 in the catchment of Malir River which generated a flash flood on land resulting in damage of tremendous life and property loss.

It has been recorded that storm event of 29th June 1977 to 1st July 1977 comprised of two contagious spells and almost at all stations rainfall exceeded 7.00 inches. However, the intensity of spell increased at the confluence resulting in major rise in runoff.

The nature and extent of the rainfall conditions associated with the storm of June-July 1977 suggests that the peak discharge recorded at Super Highway Bridge might have increased substantially at the National Highway Bridge due to the inflow from Sukkan, Jarando, Turi and Thado Nullahs. The maximum flow in Malir River at this location had been estimated between 200,000 to 250,000 cusecs. During 1978 (on 18th August) 200,000 to 230,000 cusecs was estimated to be the peak discharge at this location.

Nevertheless, three main nullahs also enter into Malir River after National Highway Bridge namely; Green Town Nullah, Chakora Nullah, and Peer Bukhari Nullah. This also increases the flow at the outfall point into the sea. These Nullahs add up to give an approximated magnitude of the flow to be 100 cumecs (3500 cusecs) (KFCP report, 1990).

5.2 Estimated Peak Discharge

The Feasibility Study of Karachi Flood Control Plan (Nov, 1990) included the previous rainfall events and estimated the peak discharges for the Malir River at the outlet into the sea which is shown below,

Malir River		
Return Period	Runoff (Cusecs)	Runoff (Cumecs)
100 yr	409,000	11,580 ~ 11,600.
75 yr	372,000	10,532 ~ 10,600.
50 yr	240,000	6,795 ~ 7,000.
20 yr	193,000	5,464 ~ 5,500.

5.3 Existing Situation at Malir River Floodplain

Malir River is one of the primary rivers that has caused massive destruction to Karachi during the monsoon seasons. The flood of 1977 was reported as the highest flood ever experienced by Malir River. The loss of lives and property was enormous, posing the question on this river's potential strength, which joins the Korangi region to the main city. Due to low laying surrounding areas flood protection structures become necessary and thus embankment bunds were constructed at both left bank as well as right bank. Nevertheless, over time, the flood plain of Malir River has been transformed into a large-scale farming business, covering the land into divided agricultural fields. The notable irrigation methods that are being applied include border irrigation, flood irrigation and furrow irrigation, all of which require a milder slope of the farmland so that water can persist and percolate in the field as needed by the crops. This development of farming has reduced the width of river bed upto 5m at few locations which is potentially harmful during monsoon season and can result in higher water levels at these sections. Fortunately, the width of the plain is relatively larger at these locations which provides larger cross-sectional area for the discharge to flow.

Figure 1 Malir River Width Reduction Due To Agricultural Activities Near National Highway And Railway Crossing.

The hydraulic calculation is done for the section at National Highway and the sections downstream from it. Because the existing embankment bunds which were constructed for flood protection start approximately at 600m upstream from National Highway Bridge. While, the floodplain upstream of National Highway Bridge has not only agricultural land as well as residential area encroachments. These are already in the flow path of Malir River and it is the responsibility of the authorities to control such encroachments in the floodplain, to prevent any devastating situation in future floods like which were witnessed in the floods of 1977 and 1978.

5.4 River Hydraulics

River hydraulics is as dynamic as a river hydrology. This variable behavior of river is due to its meandering nature which is unpredictable at each season of the year. Such that the cross section changes at each location affect features like the sediment transport, longitudinal slope, flow path, centerline of the river, water level and so on. These hydraulic parameters are estimated to obtain a demeanor of the river in extreme runoff conditions.

1. Topographic Survey

The main parameter of hydraulic calculation on which every result is dependent is the terrain analysis. To study the nature of the land and to understand the land use of catchment area, topographic survey of Malir River was conducted. Hence, a team of surveyors was dispatched on-site for the purpose. Even though there have been some limitations in the survey data at different locations which includes accessibility problem caused by the locals for obtainment of bed levels, restricted area of Pakistan Naval Station Mehran at Peer Bukhari Nullah. Due to the mentioned limitations, some bed levels have been interpolated to project a realistic cross-sectional area of flow.

2. Longitudinal Slope

The depth of water or highest flood level (HFL) is majorly dependent on the longitudinal slope of the river bed. The most effective velocity of the flow in a channel is at the centroid of the cross-section, keeping in mind the variation in the cross-sections throughout the length of the river. Velocity is directly proportional to the steepness of slope and the higher the velocity the more flow a channel can accommodate. Therefore, it is mandatory to estimate the longitudinal slope of the river even though it is mostly difficult in larger rivers.

The longitudinal slope for Malir River is computed by using topographical level for the cross-sections which are accessible. Nevertheless, for cross-sections where bed level could not be obtained, statistical method of interpolation is applied between upstream and downstream levels to estimate a longitudinal slope.

Based on the levels as well computation from interpolation, following two longitudinal slopes are used, from National Highway Bridge to Shah Faisal bridge the approximated longitudinal slope is 0.002 and slope from Shah Faisal Bridge to Jam Sadiq Bridge is 0.0003. Hence, it is observed that the slope from upstream of Shah Faisal Bridge is steeper than the slope downstream.

3. Roughness Coefficient

Hydraulic roughness is the measure of the amount of frictional resistance water experiences when passing over land and channel features. One roughness coefficient is Manning's n-value. Manning's n is used extensively around the world to predict the degree of roughness in channels. Flow velocity is strongly dependent on the resistance to flow. An increase in this n value will cause a decrease in the velocity of water flowing across a surface

The value of Manning's n is affected by many variables. Factors like suspended load, sediment grain size, presence of bedrock or boulders in the stream channel, variations in channel width and depth, and overall sinuosity of the stream channel can all affect Manning's n value. Biological factors have the greatest overall effect on Manning's n; bank stabilization by vegetation, height of grass and brush across a floodplain, and stumps and logs creating natural dams are the main observable influences.

For the floodplain of Malir river (cultivated area, mature row crops) the Manning's roughness coefficient selected is 0.035. The reason for selecting a single Manning's coefficient for all cross-sections is the ease of hydraulic calculation because the soil of the bed of the river is variable in terms of the type plantation and crops cultivated.

4. Peak Flood Discharge

Peak flood discharge is the maximum flood that has passed through a river. In case of Malir River, there are two types of available information for peak flood discharge 1) the estimated flood from precipitation data and 2) the highest recorded floods of 1977 and 1978 at National Highway Bridge. Following are the maximum and minimum flood magnitude ranges considered for computation of Highest Flood Level at selective cross-sections,

Estimated 50 Year RP Flood @ Outlet Into Sea	=	**240,000 Cusecs ~ 7000 Cumecs**
Recorded Maximum Flood of 1977 @ Nation Highway Bridge	=	**250,000 Cusecs ~ 7100 Cumecs**
Recorded Minimum Flood of 1978 @ Nation Highway Bridge	=	**230,000 Cusecs ~ 6550 Cumecs**

Furthermore, the estimated 50 year return period flood is computed at the outlet into the sea while floods of 1977 and 1978 are recorded at National Highway Bridge, after which three main nullahs namely Green Town Nullah, Chakora Nullah and Peer Bukhari Nullah summate into the Malir River. Therefore, a total of 3500 cusecs ~ 100 Cumecs (KFCP report, 1990) flow added to the recorded flood to obtain the runoff at outlet into sea.

5.5 Hydraulic Calculations at Cross Sections

Numerous cross-sections are sliced over Malir River to understand the fluctuating nature of the river during flood after the Malir Expressway is constructed. The impact caused by the proposed alignment of Malir Expressway is studied and estimated for different cross-sections shown in the Figure 2.

Table 1 Labels of cross-sections with location

X-Sec. IDs.	Location Name
XS-1 ;	National Highway Bridge
XS-2 ;	Railway Crossing
XS-3 ;	Before Shah-Faisal Bridge
XS-4 ;	Shah-Faisal Bridge
XS-5 ;	After Shah-Faisal Bridge
XS-6 ;	After EBM Causeway
XS-7 ;	Jam Sadiq Bridge
XS-8 ;	After Jam Sadiq Bridge

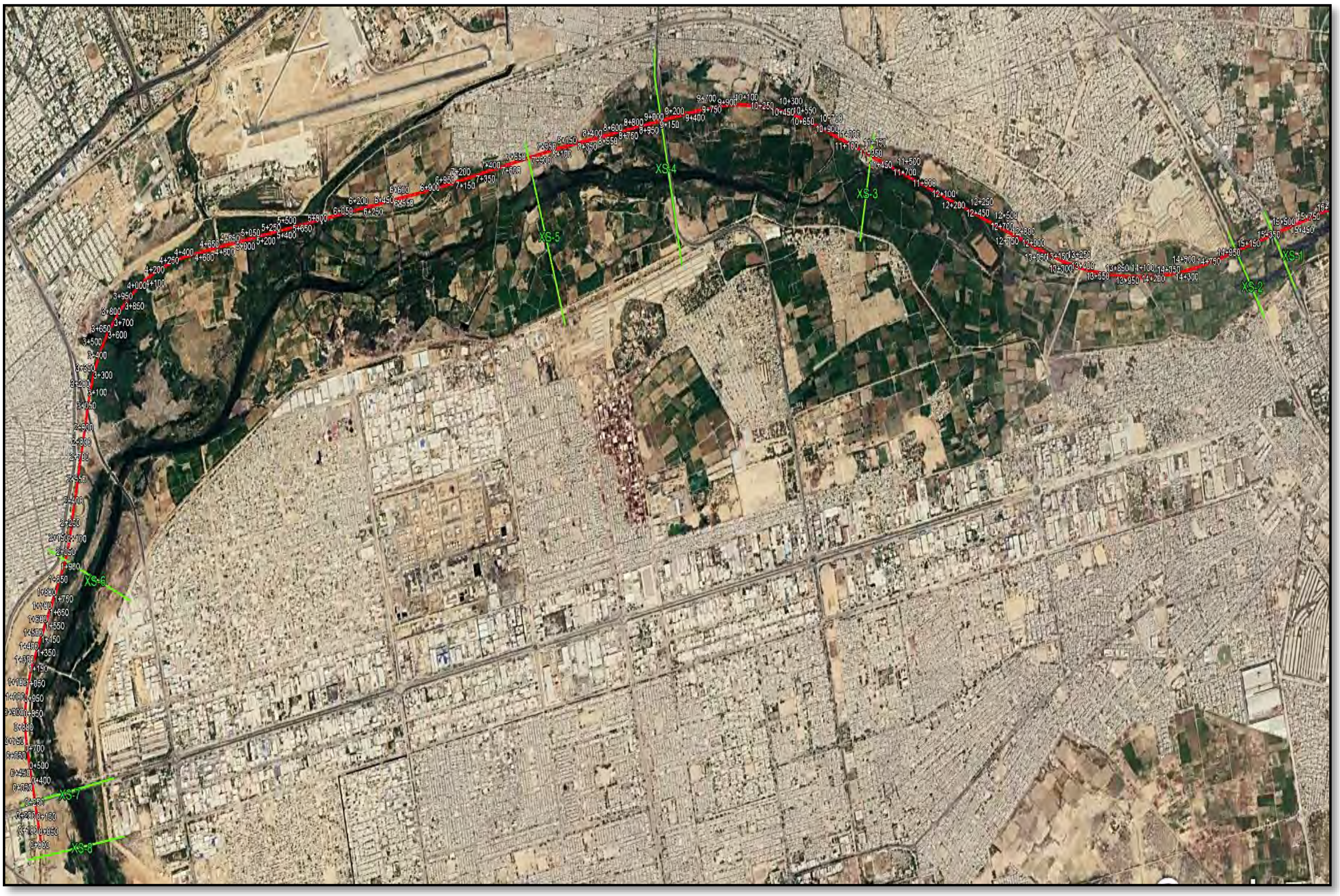


Figure-2 Figure showing location of Cross-Sections, Existing Banks/Bunds, and Proposed Malir Expressway Alignment at Malir River.

Hydraulic calculations are performed on the cross-sections listed above. Due to the decrease in river width and existing structures, these cross-sections are sliced at these locations centered on the effect induced by the Malir Expressway. There is a combination of hydraulic parameters to calculate the water level for three discrete discharge magnitudes initially outlined.

However, the computed results are shown in the Table 2 below,

Table 2 Computation of Post Project High Flood Level

Slope	X-Section ID	Bridge FRL (m)	Left Bank Level (m)	Width (m)	High Flood Level (m)		
					Runoff (7100 cms)	Runoff (7000 cms)	Runoff (6550 cms)
Long. Slope = 0.002	XS-1	27.70	25.20	285.00	24.80	24.70	24.45
	XS-2	27.77	25.60	330.00	24.10	24.00	23.90
	XS-3	-	18.70	470.00	18.10	18.07	17.90
	XS-4	18.67	16.77	800.00	14.14	14.10	14.00
	XS-5	-	15.82	1060.00	12.70	12.60	12.45
Long. Slope = 0.0003	Runoff from Nullahs added				Runoff (7100 cms)	Runoff (7000 cms)	Runoff (6650cms)
	XS-6	-	12.99	590.00	12.50	12.40	12.30
	XS-7	15.71	12.80	560.00	12.20	12.14	11.92
	XS-8	-	12.30	510.00	12.20	12.10	11.90

Note *: The runoff of 7100 cms is the recorded flood of 1977, the runoff of 7000 cms is the estimated 50 yr frequency flood while 6650 cms is the minimum flood encountered in 1978 at sea outlet.*

6 Design Standards And Criteria

6.1 Design Standards

The preliminary design is based on the following standards which shall also be followed for the detailed design of the project:

Geometric Design

A policy on Geometric Design for Highways and Streets (2011 Edition) published by American Association of State Highway and Transportation Officials (AASHTO).

Pavement Design

- AASHTO Guide for the Design of Pavement Structures – 1993, and
- The Overseas Road Note –31: A Guide to the Structural Design of Bitumen Surfaced Rods in Tropical and Sub-Tropical Countries" published by Transport Research Laboratory (TRL), UK.

Materials and Testing

- ASTM - American Society for Testing and Materials.
- AASHTO – American Association of State Highways & Streets Transportation Officials

Structure Design Standards

- AASHTO LRFD

Loading Criteria:

- West Pakistan Code of Practice
  for Highway Bridges 1967 and requirements of NHA.

Seismic Design:

- AASHTO analysis and design with latest Seismic zoning map for Pakistan as per revised current GoS seismic parameters.

Traffic Control Devices

- A Manual of Uniform Traffic Control Devices published by Highway Safety Wing, Ministry of Communications, Government of Pakistan.

6.2 Design Criteria

The Geometric Design Criteria proposed to be adopted for the project is based on the AASHTO Guide for the Design of Highways and Streets 2011 and include among others the following main elements:

Criteria	Expressway	Interchanges
Design Speed	100 km/h	40 km/h
Max. Super Elevation	4.00 %	4.00 %
Gradient (Max.)	3.00 %	4.00 %
Gradient (Min.)	0.20 %	0.20 %
Transverse Slope Carriageway Shoulders	2.0 % Outer Cross Slope 4.0 % Outer Cross Slope	2.0 % Outer Cross Slope 4.0 % Outer Cross Slope
Expressway Carriageway Width	10.95 m (7.30 m at Korangi End; One Lane to be reduced from Jam Sadiq Interchange to Korangi Road Interchange & Creek Avenue Connection)	7.0 m (Ramp / Loop / Slip Roads)
Outer Shoulder Width	3.0 m	0.50 m (Ramp / Loop / Slip Roads)
Inner Shoulder Width	1.20 m	0.50 m (Ramp / Loop / Slip Roads)
Bridge Carriageway Width Outer Shoulder Inner Shoulder	–	10.95 m 1.20 m 1.20 m
Shoulder Surfacing	Asphalt Concrete Wearing Course	Asphalt Concrete Wearing Course
Embankment Height	Min. 0.30 m above the HFL	Min. 0.30 m above the HFL
Embankment Side Slope	2H : 1V	2H : 1V

6.3 Design Life

The various structural components of Malir Expressway Project will have the following design life:

Design Life (Years)	
Bridges	80
Culverts	80
Flexible Pavement	10
First Overlay	10
Second Overlay	10
Rigid Pavement	40
Hydrology Study (return flood period)	50

6.4 Pavement Design

The pavement designs shall be carried out as per AASHTO Guide (1993 edition) with load factors from NTRC Report and the design shall be further verified with the mechanistic design methodology using the appropriate application software.

The pavement design shall be based on a minimum load of one hundred million (100,000,000) ESALS per Lane and its projection for a design life of ten (10) years. Traffic growth factors shall be established through the study of available traffic data.

Two Overlays are envisaged for this Project with design lives of both the overlays as 10 years. The first one will be provided after 10 years of operation and the 2^{nd} one, after another 10 years.

6.5 Embankment Design

The embankment design, its height, slopes and protection works, including apron on river side, shall be designed keeping in view the outcome of Hydrology Study Report which shall be carried out for not less than fifty (50) years Flood Return Period.

Due consideration shall be given to Road Side Barriers at high embankment locations as per design standards.

In areas of high water table, filter cut-off layer shall be provided to protect the pavement structure. This should include day-lighting of the pavement layers to outer side of the embankment. Surface drainage should also be designed properly.

For the outer lane of the Project Expressway, design of Rigid Pavement may also be considered.

6.6 Protection Works

Protection work and guide bank will be designed for high flood discharge for a return period of not less than fifty (50) years and flow pattern determined by design calculations and hydraulic study. Detail Drawings of the same will form part of Design report and construction package.

On both banks of Malir River, Sewerage and Storm Water outlets are discharging in Malir River. This drainage/discharge pattern shall be taken into account during the design and due diligence shall be given to the required protection works near each cross-drainage structure and underpasses.

7 Topographic Survey

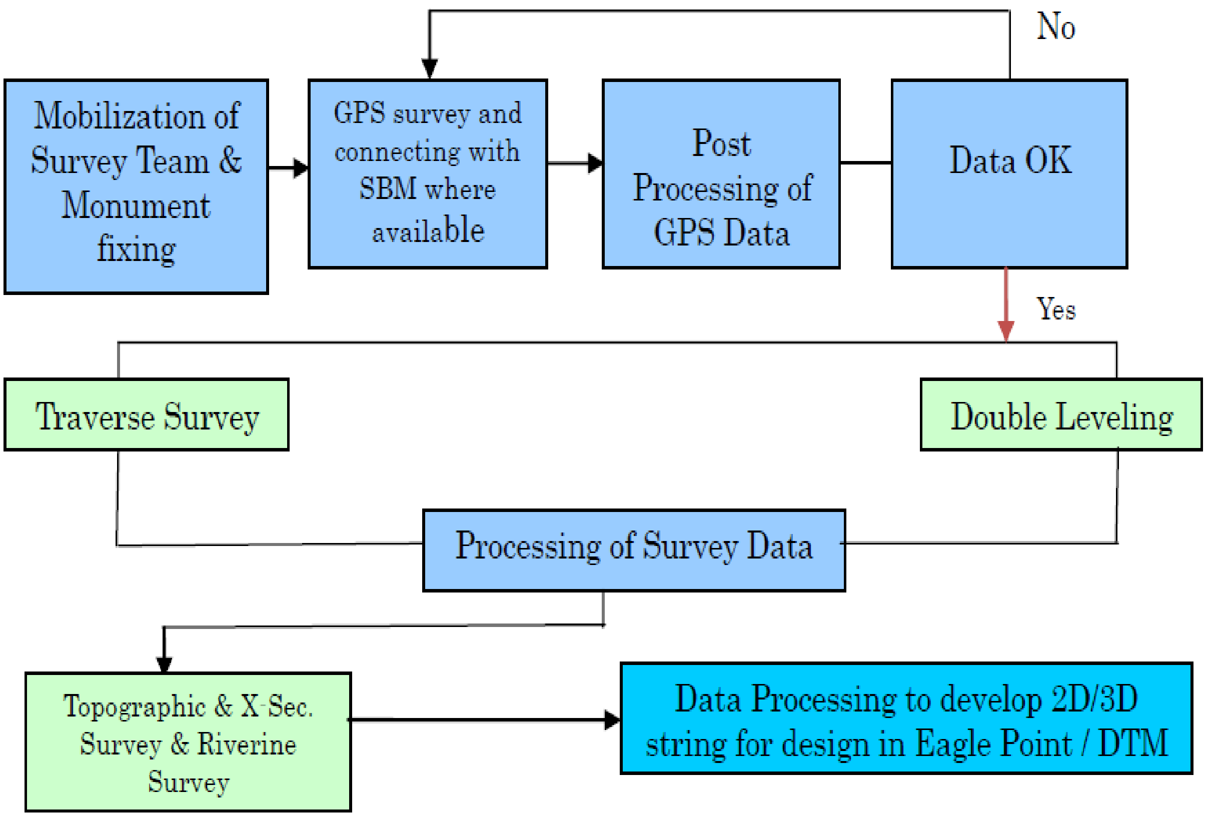
7.1 Mobilization of Survey Teams

After reviewing project requirements vis-à-vis topographic survey, following field teams were mobilized to the Project corridor along with their equipment:

- Monument Fixing Team
- GPS Survey Team
- Traverse Survey Team
- Control Leveling Team
- Topographic & X-Sec Survey Teams

7.2 Adopted Methodology

The following flow-chart briefly describes the procedures of different components of this topographic survey.



7.3 Pegging & Monument Fixing

Route Reccee and Pegging was completed by the Survey Team Leader himself, the senior most surveyor. The aim of this activity is to establish control points at suitable and safe places along the route by establishing primary and secondary control points along the approved alignment, and also for the riverine survey. Primary Control Points by GPS are generally established at an interval of less than 10 km to optimize the satellite signal reception, whereas Secondary Control Points are generally established at about 250m to 350m interval considering the visibility in the Project Area. This exercise was carried out both for alignment and riverine surveys.

Permanent Control Pillars using GPS Survey were installed at every five (05) kilometer. Every effort was made to select locations, which were safe from conservation point of view and free of any obstruction to facilitate uninterrupted GPS signals and observation.

7.4 Primary Control by GPS for X,Y,Z

The Primary control was established by GPS for XYZ coordinates. GPS observations were made using Trimble GPS 4000 SSI Dual Frequency Instrument using a pair of receivers, the "Base" and the "Rover". The Base was placed at the known point and the Rover was placed at the Station whose coordinates were to be determined. Static mode of survey was adopted with a small base line and longer observation time. All coordinates were observed in the UTM coordinate system.

During the post processing, the correct coordinates of the unknown points were obtained with reference to the correct coordinates of the known points. For this Project, the coordinates and levels of the Survey of Pakistan Bench Marks (SBM) were explored in the vicinity of the Project Roads. However, the same could not be found. Therefore, the coordinates / levels observed from GPS were used as reference coordinates for processing of GPS Survey data. At the end of each day, the post processing of GPS observations in UTM was carried out using the post processing of GPS observations in UTM were carried out using the post processing software to remove any possible errors. These coordinates were then used for generating the coordinates for Traverse Stations i.e., Secondary Control.

7.5 Secondary Horizontal Control by Traverse for X,Y

Secondary Horizontal Control was established by Traverse Method using the Primary GPS Survey Control Points. These traverse control points were used by topographic survey teams and cross-section survey teams both along the project alignment and for riverine survey. These points were established at suitable places along the route and on protection bunds (10 km upstream and 5 km downstream) by using small size pillars or by driving wooden pegs or by marking the station number by paint on road side permanent structures. The Coordinates of Secondary Control (Traverse) points were ultimately used for Topographic Survey, X-Section Survey and Riverine Survey.

The following precautions were taken in traverse observations to achieve the accuracy required for such work.

- Total Station with the least count of 1" (one second of arc) was used for all angular and linear measurements.

- Each traverse angle was observed on two zeroes taking measurements on both left and right faces. The agreement between the two values of the same traverse angle were not allowed to exceed 10". Observations were repeated where the discordance exceeded the given limit. The means of 2 sets (4 measures) of traverse angles were used for computing bearings.

- Total Station were used for all linear measurements. Having an accuracy of around 3mm plus 3 parts per million of distance which can yield high accuracy up to 1 in 25,000.

- Reciprocal linear measurements were made for each traverse leg, thus measuring each distance twice in fore and back directions. The agreement between the two measurements was ensured to be of the order of 1 in 10,000. The means of the two measurements was accepted for the computation of traverse line.

7.6 Secondary Vertical Control by Double Leveling Technique for "Z"

Vertical Control was established using Double Leveling method with precautionary measures as provided hereunder:

- Pentax Titling Leveling Instruments Model L-30 of magnifications 30X was used for control leveling.
- The longest permissible shot was limited to 100 meters provided the staff graduations could clearly be visible. The shots were further reduced to 50 meters and even shorter for accurate reading and to minimize the effect of shimmering created by high temperature.
- Two surveyors observed the leveling line in fore and back directions connecting all the traverse stations of the main traverse line en-route and establishing their own Temporary Bench Marks - TBMs on permanent structures or by marking the station number by paint on road side structures at suitable interval.
- The permissible discordance between "Fore" and "Back" leveling at any Benchmark was kept + 0.009 meter (9 mm)
- The accuracy of leveling line is kept 15mm √ K, where K is the length of line in kilometers.

7.7 Detailed Topographic Survey

The purpose of topographic survey is to collect all topographical (natural and man-made) features information of the area of interest to facilitate detailed design. It was carried out for the Project by Total Stations to depict all man-made and natural features existing inside the survey corridor. Sokkia Total Stations Power Set 2030-R with built-in electronic Data Collector and Trimble GPS were used for collecting topographic details.

In order to synchronize the work of each party a list of features codes was prepared in advance covering all the anticipated topographic features that could be encountered during the survey work. This final list of feature codes was fed into the Total Station Instrument prior to field work to facilitate the surveyors with the facility of on-line coding.

The method of surveying details through data collector is similar to conventional Plane Table Survey method but the major difference is its capacity of developing topo survey drawings on any desired scale with three dimensional output of every feature / point along with on-screen plotting of them, for minimizing error, which is not possible in the case of Plane Table Survey.

Topographic survey was conducted within the defined corridor and all features and ground details falling within the corridor were recorded. It was ensured that the following details were essentially picked up:

- Representative Ground Level
- Sudden Change of Ground Elevations
- Existing Road, including carriageway, shoulders, toe of embankment, etc
- Existing Drainage Structures
- Existing nullah boundaries, top width and ground features
- Boundaries of ditches, eroded banks, etc
- The outer limits of village boundaries, buildings, huts, hedges, walls, etc
- The location of isolated buildings / yards
- Roads intersecting the Project Road and their junction details
- Railway line passing through the corridor
- Boundaries of agricultural farms, orchards, dairy farms, poultry farms, graveyards, and other land uses within the corridor.

SDR Mapping and Design (Ver 6.5) and Civil – 3D software were used at the head office for the processing of raw survey data down loaded from the field work.

7.8 Riverine Survey by X-Section Method

The Riverine Survey was carried out to collect the X-section data covering the whole river width at suitable locations. In all 12 Nos. such cross sections were observed. This exercise was carried out for the purpose of Hydrological Study Report.

7.9 Post Processing of Field Data, Site Verification, Drafting and Plotting

The SDR Mapping and Design (Ver 6.5) and Civil – 3D software act as an interface to transform the Total Station / GPS Data and develop topographic feature Maps and Digital Terrain Model (DTM) using raw elevations. The processed data is converted to ASCII format which is then used to develop DXF format files which are imported in AutoCAD software to develop their Digital 3-Dimensional Survey Drawings. These AutoCAD drawings are further refined by draftsmen applying specific layer structure, line types and thicknesses, fonts, and other desirable features to enhance their drafting quality and output as per practice standards. A detailed line work and insertion of appropriate symbols is also carried out at this stage to make the survey drawings more legible and easy for use by the design engineers. Additional Software were also used to develop more refined DTM using the spot elevations and cross-sections data collected during the field survey. This DTM eventually produces contours at any desired contour intervals.

As soon as these survey drawings were printed on appropriate scale, they were sent back to survey teams for field verification. Any omissions, errors, or missing information were recorded either on drawing manually or, if required digitally, and this data was once again sent to the office for updating and finalizing the survey drawings.

Further detail of the Topographic Survey and the Horizontal and Vertical Control Point data is in the Topographic Survey Report attached as ***Annexure-E.***

8 Preliminary Design

8.1 Preliminary Alignment

Based on the Reconnaissance Survey and Alignment Study, a preliminary alignment was marked on the topographic survey drawings employing the design criteria presented above. This alignment helped establish the Project Start Point, End Point, tentative locations for the interchanges, underpasses, flyovers / bridges, toll plazas, and the location and length of the Project Expressway through the Malir River Corridor.

Moving in the direction of flow, this preliminary alignment lies along the right bank of Malir River and provides the basis for a fair estimation of preliminary cost of the Project presented in Section 11 of this Report.

8.2 Typical Cross Sections

Keeping in view the functional requirements, the design criteria and the alignment characteristics, typical cross sections were developed for the various elements of the Project including the main Expressway, the interchanges, bridges / flyover structures, underpasses and slip roads, etc. These cross sections are presented in the following sections of the Report and have been used for estimation of the preliminary cost of the Project.

8.3 Electrical Works

The Project Expressway, being an Urban Facility, will be provided with Road Lighting and the design of the lighting for the Expressway, interchanges, intersections, flyovers, toll plazas, toll buildings, control buildings and weigh bridges will be of approved illumination standards as per given technical specifications.

8.4 Tolling System And Electronic Toll And Ticketing System-ETTMS

The Project Expressway will be provided with toll plazas / gates, at all entry and exit locations. All Vehicles Entering Toll Gate will be issued a Machine-Readable Toll Ticket. At the Exit Toll Gates, the Vehicle will show the Ticket, and will be charged the applicable toll for the distance travelled.

There will be two main Toll Plazas along expressway, one at Start Point after Jam Sadiq Bridge and the other at End Point before M-9. For Toll Plaza, the 6-Lane Dual Carriage Expressway will have 16 Lanes at the Toll Gates, where middle four lanes shall be interchangeable for both ways traffic directions.

Between two Main Toll Plazas, there will be 3-Lanes Toll Gates at every entry and exit of each interchange.

Rigid Pavement of appropriate length and width will be used at Toll Gates.

8.5 Components Of ETTMS

The main components of the ETTMS including both hardware and software are:

a. Electronically Operated Toll Gate's Barrier;
b. Information Signs (Electrical) for "Stop" and "Go";
c. Vehicle Scanning, Type Identification and Number Plate Recording System;
d. Machine Readable Toll Ticket Generation System;
e. System of Video Filming, and achieving with time and date of all vehicles entering and exiting the toll gates, round the clock;
f. Reporting System of Toll Ticket Generation to Control Center;
g. Data Base and Data Back-up Center for this system;
h. Telecommunication System;
i. Proper Illumination / Lighting;
j. Stand-by power generation system for un-interrupted ETTMS Operation;
k. Classified Traffic Count / Reporting System with Toll Collection on Daily, Weekly and Monthly Basis on appropriate format.

8.6 Weigh Bridges And Control Buildings

8.6.1 Weigh Bridges

A total of 05 Nos. Weigh Bridges will be installed on the Project at the following tentative locations:

- 01 No. at North Bound of Main Toll Plaza after Jam Sadiq Bridge
- 01 No. at North Bound of Shah Faisal Colony Interchange
- 02 Nos. at Both Bounds of Quaidabad Interchange
- 01 No. at South Bound of Main Toll Plaza before M-9.

A U-turn facility shall be designed for return of overweight vehicles and provision for the additional land would be considered in land acquisition folder.

8.6.2 Toll Gates

Toll Gates shall be designed, constructed, equipped and operated as per following:

- Extra land will be acquired to accommodate the additional lanes.
- Proper transition shall be designed for approaches and exit of toll gates.
- Rigid Pavement of appropriate length and width, shall be designed as per design standards.

8.6.3 Control Buildings

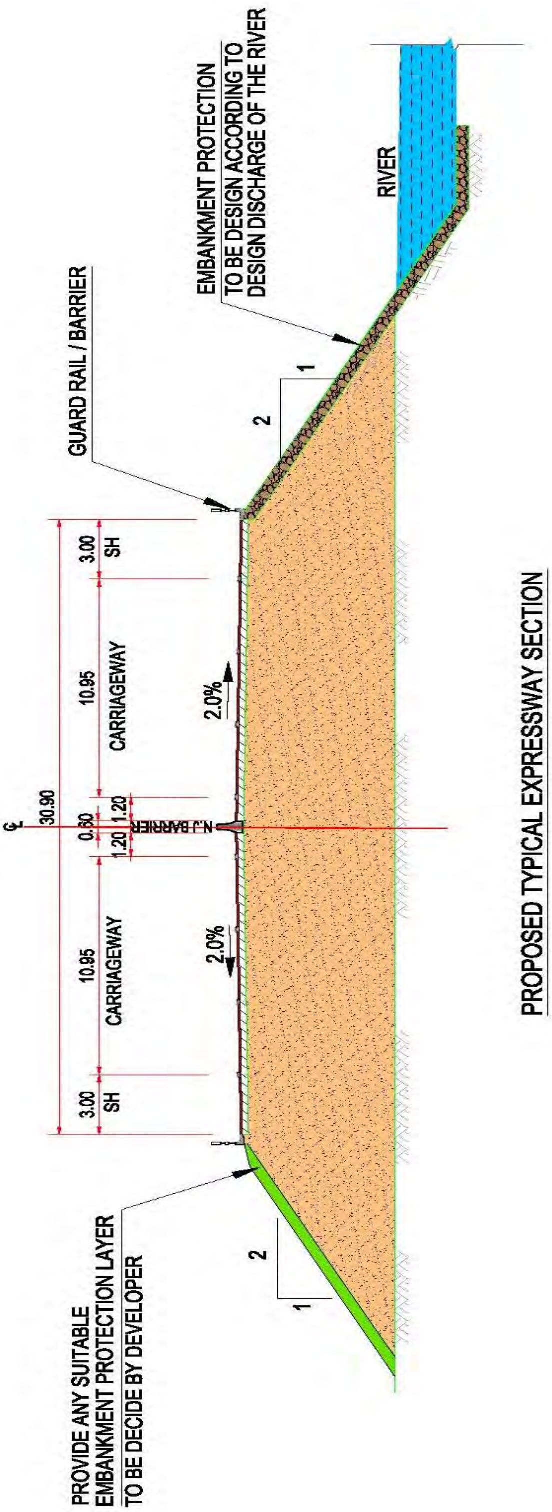
- One Toll Building of one hundred square meter (100 sq. m) area will be constructed at each Toll Gate Location with seventy percent (70%) covered area.
- One Toll Building at each Toll Gate Location at the start and end points the Expressway will be constructed with two hundred square meter (200 sq.m) area out of which seventy percent (70%) will be covered area.
- One (1) Main Control and Administration Building will also be constructed with one thousand square meter (1,000 sq. m) area out of which seventy percent (70%) will be covered area.

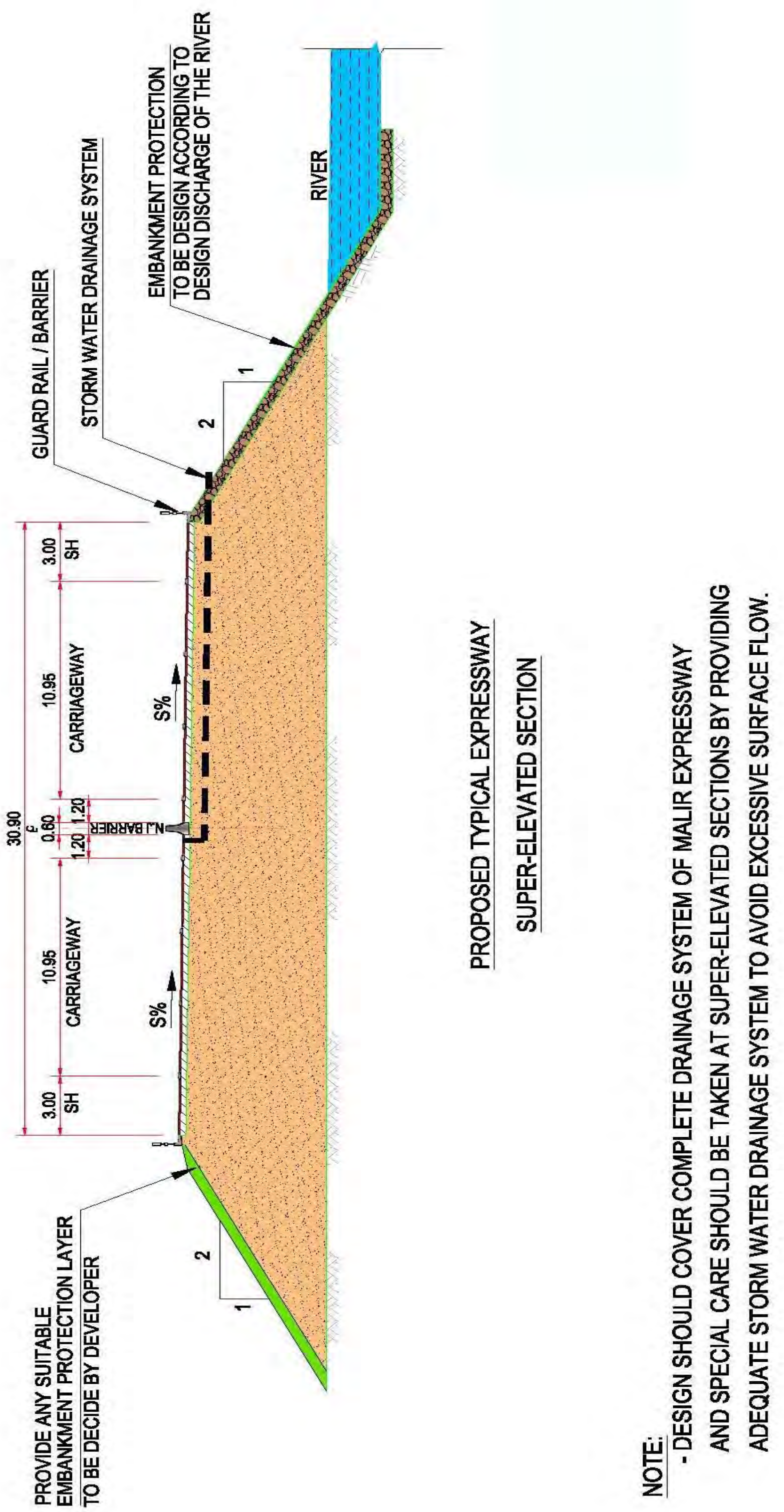
8.7 Identification of Land Strips

Based on the Preliminary Alignment Design, an assessment of the land strips required for the construction of Malir Expressway was made and it was observed that from the zero point unto Quaidabad the alignment lies within the protection bunds of the Malir River. Therefore, there are no significant land acquisition / property compensation issues in this 16km stretch.

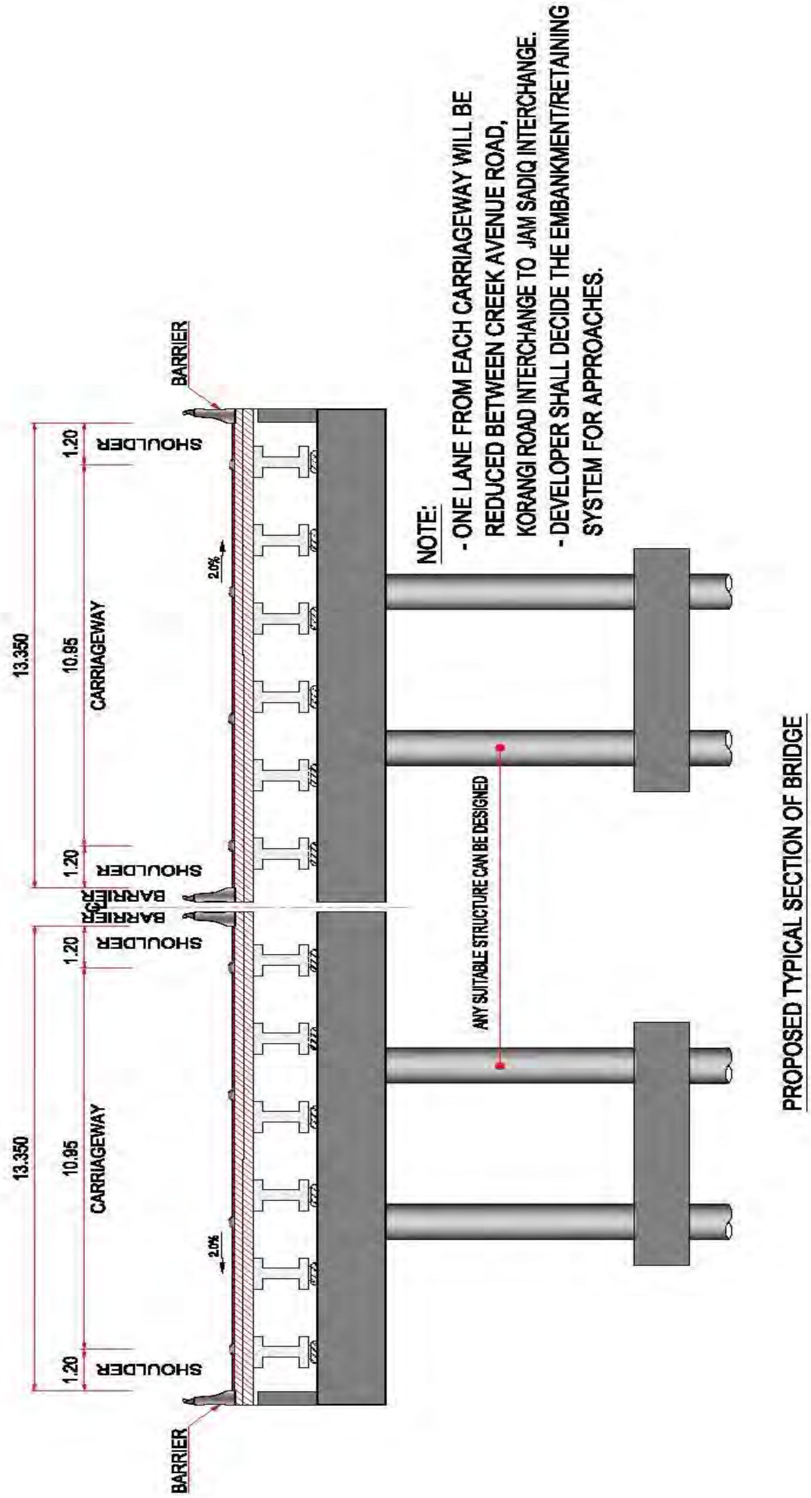
However, beyond Quaidabad the alignment passes through some inhabited areas / villages and agricultural land lying adjacent to the visible river bed. These areas include some dairy farms, poultry farms, agricultural land including fruit and vegetable farms and some cottage industries. Therefore, at this stage a wider corridor was selected and Land Acquisition folders were prepared and sent to the respective Deputy Commissioner's Offices, through the coordinating efforts of the PPP Unit, Govt. of Sindh, for land identification purpose in order to locate the alignment as much as possible through the open land owned by the Govt. and thereby minimize the land acquisition and property compensation needs by avoiding the built-up areas & farmland.

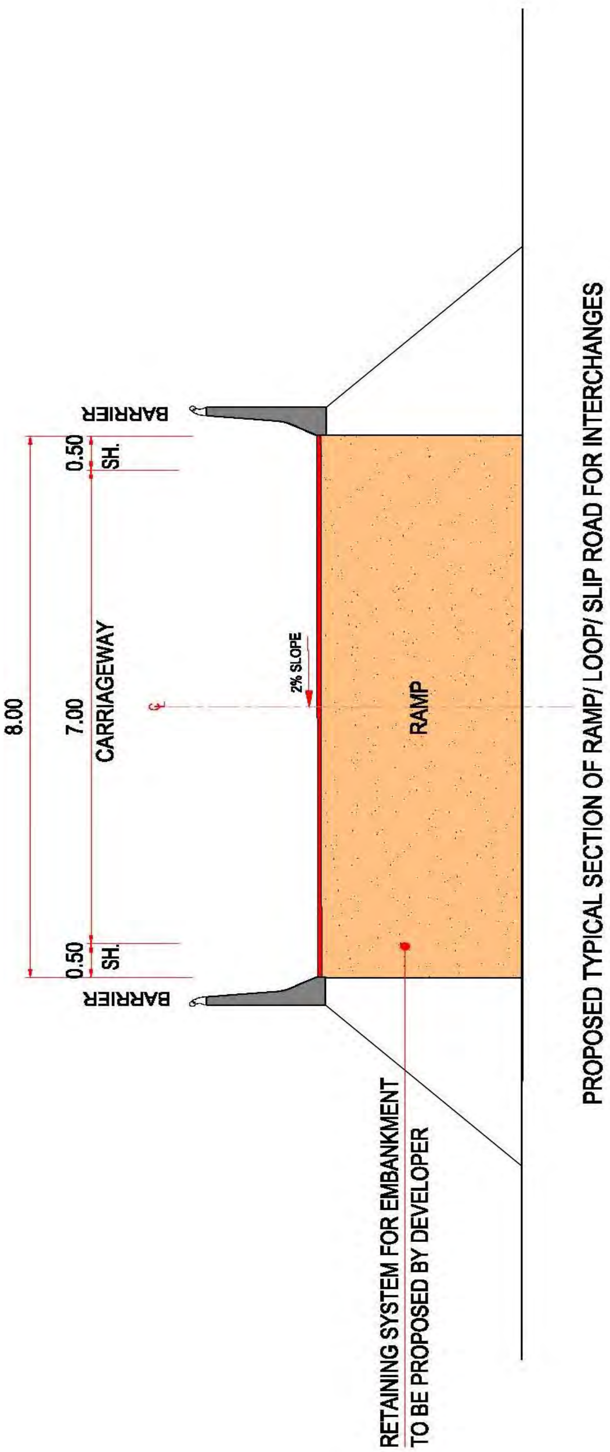
After final selection of alignment, survey, and design the concessionaire shall prepare the land acquisition folders accordingly. Details of property falling within required ROW, and additional area which may be required for interchanges shall be indicated thereupon. Details of land to be acquired for road construction shall also be updated. The Concessionaire shall prepare area estimation for ROW and additional land where required. ROW permanent markers shall also be set up by the Concessionaire. The Concessionaire shall also prepare area estimates for acquiring any additional land and removal of structures and utilities and prepare cost estimates for removal, if so required.

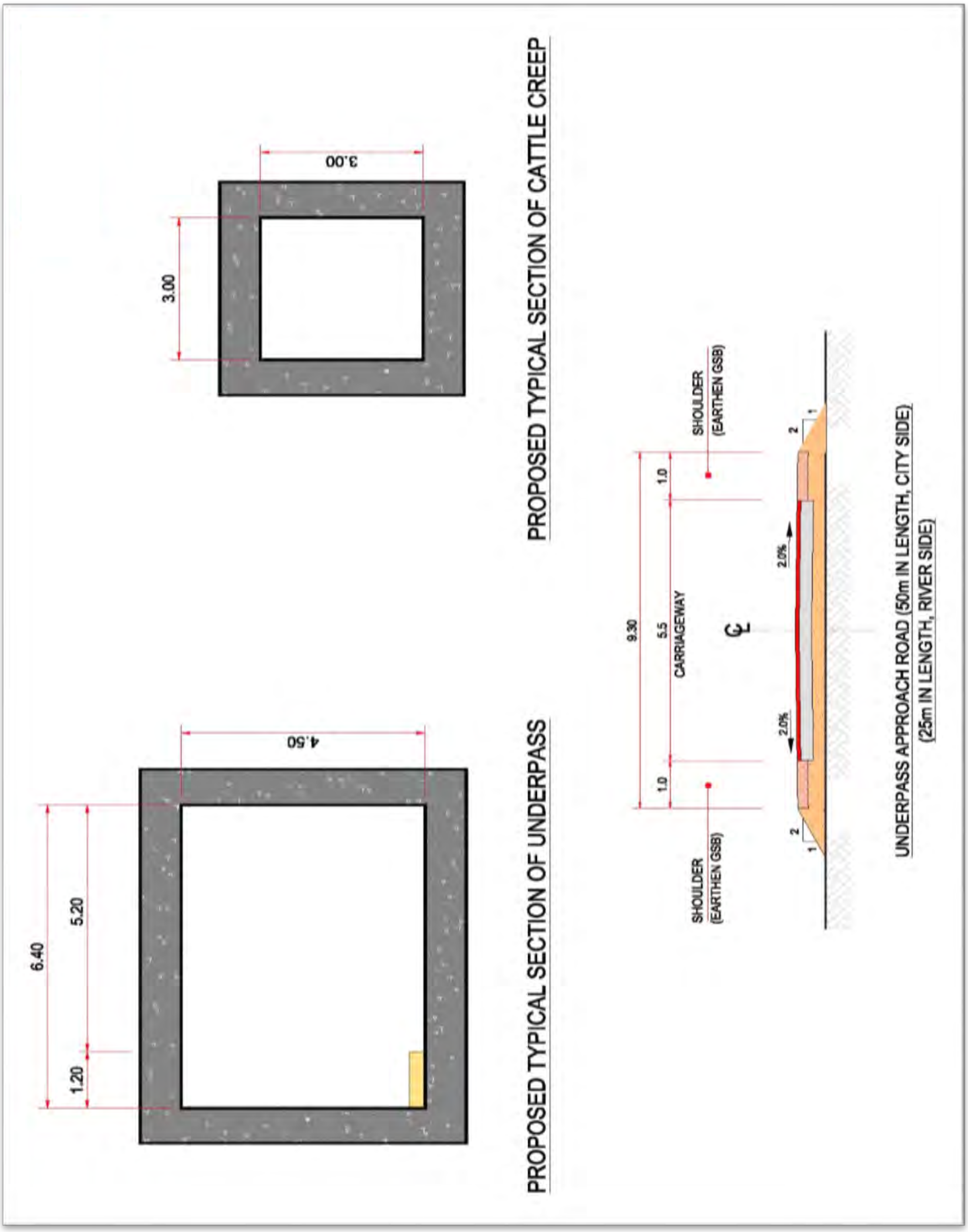

EMBANKMENT PROTECTION
TO BE DESIGN ACCORDING TO
DESIGN DISCHARGE OF THE RIVER
RIVER
GUARD RAIL / BARRIER
2
1
3.00
SH
10.95
CARRIAGEWAY
2.0%
30.90
0.50
1.20
1.20
N.J BARRIER
10.95
CARRIAGEWAY
2.0%
3.00
SH
PROVIDE ANY SUITABLE
EMBANKMENT PROTECTION LAYER
TO BE DECIDE BY DEVELOPER
2
1
PROPOSED TYPICAL EXPRESSWAY SECTION



EMBANKMENT PROTECTION TO BE DESIGN ACCORDING TO DESIGN DISCHARGE OF THE RIVER
RIVER
STORM WATER DRAINAGE SYSTEM
GUARD RAIL / BARRIER
2
1
30.90
3.00
SH
10.95
CARRIAGEWAY
1.20
0.60
1.20
NJ BARRIER
S%
PROVIDE ANY SUITABLE EMBANKMENT PROTECTION LAYER TO BE DECIDE BY DEVELOPER
PROPOSED TYPICAL EXPRESSWAY
SUPER-ELEVATED SECTION
NOTE:
- DESIGN SHOULD COVER COMPLETE DRAINAGE SYSTEM OF MALIR EXPRESSWAY AND SPECIAL CARE SHOULD BE TAKEN AT SUPER-ELEVATED SECTIONS BY PROVIDING ADEQUATE STORM WATER DRAINAGE SYSTEM TO AVOID EXCESSIVE SURFACE FLOW.


BARRIER
13.350
1.20
SHOULDER
10.95
CARRIAGEWAY
2.0%
ANY SUITABLE STRUCTURE CAN BE DESIGNED
NOTE:
- ONE LANE FROM EACH CARRIAGEWAY WILL BE REDUCED BETWEEN CREEK AVENUE ROAD, KORANGI ROAD INTERCHANGE TO JAM SADIQ INTERCHANGE.
- DEVELOPER SHALL DECIDE THE EMBANKMENT/RETAINING SYSTEM FOR APPROACHES.
PROPOSED TYPICAL SECTION OF BRIDGE


BARRIER
0.50
SH.
8.00
7.00
CARRIAGEWAY
2% SLOPE
RAMP
0.50
SH.
BARRIER
RETAINING SYSTEM FOR EMBANKMENT
TO BE PROPOSED BY DEVELOPER
PROPOSED TYPICAL SECTION OF RAMP/ LOOP/ SLIP ROAD FOR INTERCHANGES



PROPOSED TYPICAL SECTION OF CATTLE CREEP
3.00
3.00
PROPOSED TYPICAL SECTION OF UNDERPASS
4.50
6.40
5.20
1.20
SHOULDER
(EARTHEN GSB)
CARRIAGEWAY
9.30
5.5
1.0
1.0
2.0%
2.0%
UNDERPASS APPROACH ROAD (50m IN LENGTH, CITY SIDE)
(25m IN LENGTH, RIVER SIDE)

8.8 Coordination with Utility Agencies

Based on the topographic survey of the project corridor, the utility services falling within the proposed right-of-way of Malir Expressway were marked on topo maps and the Utility Folders were prepared and sent in November 2018 for further verification of the following utility agencies through the coordinating efforts of the Special Secretary (Tech) / Project Director, Malir Expressway Project, Local Govt. Department, Govt. of Sindh vide letter No. LG/DG/M&E/AD-II/301(204-Karachi)/2017/ dated: Nov 19, 2018:

- Karachi Water & Sewerage Board
- K-Electric
- PTCL / National Telecommunication Corporation (NTC)
- SSGC

The agencies provided information regarding their existing utility services and the need for any protection or relocation of the utilities likely to be affected by the Project by highlighting them on the above referred Utility

This coordination has helped identify the need for protection of the GKBWS, K-II, K-III and MS-36" dia main trunk line passing through the corridor between Km 33+473 to Km 33+673 as identified by the Chief Engineer (Bulk Transmission & Water Trunk Mains), Karachi Water & Sewerage Board, Karachi. The Executive Engineer (STP II), KWSB informed that no sewer main and pumping station of TP-II and PS-II Korangi is crossing / installed in the route of Malir Expressway Project.

Similarly, the Deputy General Manager (Technicl and Operational Coordination Distirbutions Operations) has also identified the KElectric assets falling within the corridor and the Divisional Engineer (Transmission), National Telecommunication Corporation (NTC), has also identified their infrastructure passing through the corridor which is likely to be affected.

The above information has been used to assess the amount of provisional sum allocated for relocation and protection of utilities. However, at the time of execution, further coordination with these agencies would be required on the basis of Detailed Design of the Project to work out the actual need for relocation and protection of any utility services and the costs to be incurred.

9 Preliminary Cost Estimate

9.1 Basis of Cost Estimation

This preliminary cost estimate is based on the preliminary alignment plan and typical cross sections appended with this Final Report.

The unit rates for various civil works items of construction have been mainly taken from the Composite Schedule of Rates of the National Highway Authority (NHA – CSR 2014 Edition) while the rates for specialized equipment and other items not available from the NHA – CSR have been estimated on the basis of recently undertaken projects of similar nature.

Where necessary, appropriate price adjustment factors have also been applied to reflect towards the latest applicable market rates.

9.2 Project Components Included in Cost Estimation

For the purpose of this preliminary estimation of the Project Cost, the following main components of the Malir Expressway Project have been taken into consideration:

Tentative length	38.750 km
Six lane dual carriageway with: Main carriageway Outer shoulder on either side Inner shoulder on either side New Jersey Median Barrier	 2x10.95m 3.00 m 1.200 m 0.600 m
No. of Interchanges (With Toll Collection Arrangement)	6
No. of Flyovers	2
No. of Cross-Drainage Bridges	4
No. of Toll Plazas (On Main Expressway)	2
No of Weigh Bridges	5
No. of Cross-Drainage Culverts	20/40
No. of Underpasses	14
No. of Cattle Creeps	10
* No. of Structures may vary later as per Detailed Design to be submitted by the Concessionaire.	

9.3 Summary of Preliminary Cost Estimate

A summary of the Preliminary Cost Estimate is presented hereunder:

NOT PROVIDED

10 Synopsis

10.1 Project Background

With its unique strategic location along the shores of Arabian Sea, Karachi has grown from a small fishermen's village into the largest metropolitan city of Pakistan, its main Sea port and center of business and commerce. According to the JICA Study 2012, Karachi Transport Improvement Plan, Final Report, its population is projected to grow from 18.9 Million in 2010 to 31.6 Million in 2030 and it would therefore be the fastest growing city in the World.

Over the years, the city has mainly expanded towards North as it is bound by the Arabian Sea on the South. However, due to a large industrial base at Landhi and Korangi and sea port at Keamari, employment, business and commercial activity is concentrated towards South and South East resulting in a major flow of commuter and cargo traffic in the North-South direction in the city. New developments like DHA Phase 9 and Education City in the North also attract traffic from DHA / Clifton. The existing arteries therefore remain choked resulting in unnecessary delays and congestion.

Malir Expressway Project was therefore conceived to provide a direct and more convenient alternate route along the Malir River corridor to serve this traffic from Karachi Port, Landhi / Korangi Industrial areas, DHA/Clifton to Northern suburbs and beyond / upcountry locations. It is estimated that the travel time for this traffic between Karachi – Hyderabad Motorway, M9 to KPT Interchange on the main Korangi Road will be only 30 minutes via Malir Expressway whereas along other alternate routes through congested urban areas it is around 1.5 hours on the average.

The Malir Expressway Project was:

- Already included for development in the Karachi Master Plan 2020.
- Considered as the most viable option among the other competing routes mentioned in the Final Report on "Preparatory Survey on JICA Cooperation Program for Industry Development (Investment Climate Improvement in Karachi)".
- Also recommended for future development in "The Study for Karachi Transport Improvement Project" by JICA.

Currently Karachi has 3 main access corridors namely:

1. Karachi – Hyderabad Motorway, M9,
2. National Highway, N-5 (Karachi – Thatta – Hyderabad Section) and
3. Hub River Road (Karachi – Quetta National Highway, N-25)

Therefore, Malir Expressway will be the 4th access corridor and will be the shortest connection from M-9 to Korangi Road, DHA, Clifton and both the seaports. Besides providing fast and uninterrupted access facility, development of the Expressway alongside Malir River will also ensure speedy development of:

- Karachi's not so developed Eastern part of Malir District
- Education city, DHA City (DHA Phase 9) & other upcoming new housing projects
- Fast connectivity with Jamshoro & Thatta districts from the Motorway, M9 and beyond

It will also ease overall traffic of Karachi with efficient connection to the interior & upcountry areas.

10.2 Preliminary Alignment

The Malir Expressway Project shall be an Access-Controlled facility, it will start before Jam Sadiq Bridge on Korangi Road which is on Right Bank of Malir River and travelling along the Malir River up to the existing Link Road between N-5 and M-9 (2.4 km short of M-9) and it will take left turn from this point to meet M-9 (Kathor), the end point of the Project, as shown in the Location Plan. The tentative measured length of the expressway is 38.750 km. The exiting section of Link Road between N-5 and M-9 will need modification to meet the requirements of the Expressway according to given cross-sections. Similarly, the existing Trumpet Interchange on M-9 will also be modified to meet the design requirements of the Expressway.

Initially a 4-lane divided cross section was being considered for the Expressway but later it was decided by the Govt. of Sindh in the Policy Board Meeting that there will be a 6-lane divided cross section for the Malir Expressway keeping in view the road safety aspects / movement of light traffic alongside heavy traffic and future traffic requirements along the corridor.

10.3 Project Components

The Malir Expressway Project shall include the following major components as detailed on the attached drawings and in the previous sections:

1. Roadwork including embankment construction
2. Bridge Structures
3. Flyover Structures
4. Culverts
5. Underpasses
6. Cattle Creeps
7. Embankment Protection Works /Erosion and Drainage Protection Works
8. Traffic Control Devices
9. Toll Plazas
10. Rigid Pavement at Toll Plazas
11. Control Building for Toll Plazas
12. Weigh Bridges
13. Electronic Toll & Ticketing Management System
14. Office Building for ETTMS
15. Electrification & Lighting Works
16. Administration Building
17. ITS Applications

10.4 Project Implementation Schedule

Main features of the Project Implementation Schedule are:

Financial Close	Within 180 Days of Signing of Concession Agreement
Surveys, Planning & Design Work	Within 120 Days of Signing of Concession Agreement
Anticipated start of construction (the **Commencement Date**)	180 Days from the Signing Date
Anticipated end of construction	30 months from the Commencement Date[TAK1]
Anticipated expiry of Concession Agreement & handover of facilities	25 years from the Substantial Completion Date

CONSULTANCY / TRANSACTION ADVISROY SERVICES FOR DEVELOPMENT OF MALIR EXPRESSWAY

(From Motorway, M9 to KPT Interchange)

FINAL REPORT

ANNEXURES

Annexure A: Summary of Historic Traffic Data

Annexure B: Travel Desire Lines on Karachi's Road Network

Annexure C: Road Infrastructure in Karachi & Relative Speeds

Annexure D: Feasibility Study of Karachi Flood Control Plan (1990) by WAPDA.

Annexure E: Horizontal and Vertical Control Point Data

Annexure F: Interchanges

Annexure G: List of Structures

Annexure H: Project Route Map

CONSULTANCY / TRANSACTION ADVISROY SERVICES
FOR DEVELOPMENT OF MALIR EXPRESSWAY
(From Motorway, M9 to KPT Interchange)
FINAL REPORT

ANNEXURE ***A***

Summary of Historic Traffic Data

National Highway Authority
Traffic Data Summary Form (24 Hours)
SUMMARY (3 Days Daily Average)

Direction: Karachi-Kathor (Both Directions) Location Karachi - Toll Plaza
Date: 26-01-2009 to 29-01-2009 Day Monday/Thursday
Time: From: 0600 hrs To 0600 hrs

Time	Cars/Jeeps	Wagons/ Pick ups	Coasters/ Mini Trucks	Buses	Trucks (Rigid)		Articulated			Total
					2-Axles	3-Axles	4-Axles	5-Axles	6-Axles	
0600-0700	79	58	18	38	67	98	78	11	38	**485**
0700-0800	155	82	31	56	121	164	95	19	36	**759**
0800-0900	200	113	15	56	102	134	100	31	39	**790**
0900-1000	234	124	24	63	98	139	101	28	33	**843**
1000-1100	277	120	31	63	112	110	92	18	33	**857**
1100-1200	346	83	35	59	99	111	92	16	27	**868**
1200-1300	344	71	25	53	87	87	58	12	42	**778**
1300-1400	341	102	28	62	104	113	80	21	29	**880**
1400-1500	322	102	26	59	144	129	91	14	16	**903**
1500-1600	357	140	23	82	147	130	57	15	17	**968**
1600-1700	384	123	54	78	173	155	81	28	29	**1106**
1700-1800	469	121	39	79	133	149	114	25	20	**1149**
1800-1900	467	113	41	74	127	74	80	13	25	**1014**
1900-2000	384	81	33	58	165	201	94	24	31	**1070**
2000-2100	341	109	31	48	170	226	131	19	52	**1127**
2100-2200	311	66	35	35	176	259	79	10	25	**996**
2200-2300	257	71	65	43	189	264	136	22	30	**1077**
2300-2400	196	40	44	44	182	283	153	25	37	**1003**
0000-0100	161	44	47	31	223	263	206	27	43	**1045**
0100-0200	127	40	30	12	171	216	173	23	48	**841**
0200-0300	76	31	47	6	151	271	150	27	45	**804**
0300-0400	55	71	4	5	137	211	140	16	48	**686**
0400-0500	47	51	11	17	129	182	114	9	18	**579**
0500-0600	68	54	13	42	126	144	120	12	27	**606**
Total	**6001**	**2010**	**750**	**1162**	**3331**	**4110**	**2615**	**465**	**791**	**21235**
%age	**28.26**	**9.47**	**3.53**		**40.51**			**18.23**		**100**

Source:

Commercial Feasibility Report for Conversion of 4-Lane to 6-Lanes, Karachi – Hyderabad Motorway, M9 Project – Presented along with RFP Nov 2013

SUMMARY OF TRAFFIC DATA - YEAR 2017

LOCATION	DIRECTION FROM	DIRECTION TO	CARS, JEEPS, TAXIS, VANS	MINI BUSES	LARGE / INTER CITY BUSES	TRUCKS 2-3 AXLES	TRUCKS WITH TRAILERS >4AXLES	TOTAL
RCD HIGHWAY, N-25	Hub	Karachi	5304	577	313	2995	752	9941
	Karachi	Hub	3886	397	370	3189	718	8560
	Both		9190	974	683	6184	1470	18501
	Composition		50%	5%	4%	33%	8%	
NATIONAL HIGHWAY, N-5	Thatt	Karachi	4461	377	141	1770	452	7201
	Karachi	Thatta	4471	429	134	1649	348	7031
	Both		8932	806	275	3419	800	14232
	Composition		63%	6%	2%	24%	6%	
KARACHI - HYDERABAD MOTORWAY, M9	Karachi	Hyderabad	5942	21	827	4219	3570	14579
	Hyderabad	Karachi	8290	24	1184	5206	3359	18063
	Both		14232	45	2011	9425	6929	32642
	Composition		44%	0.14%	6%	29%	21%	

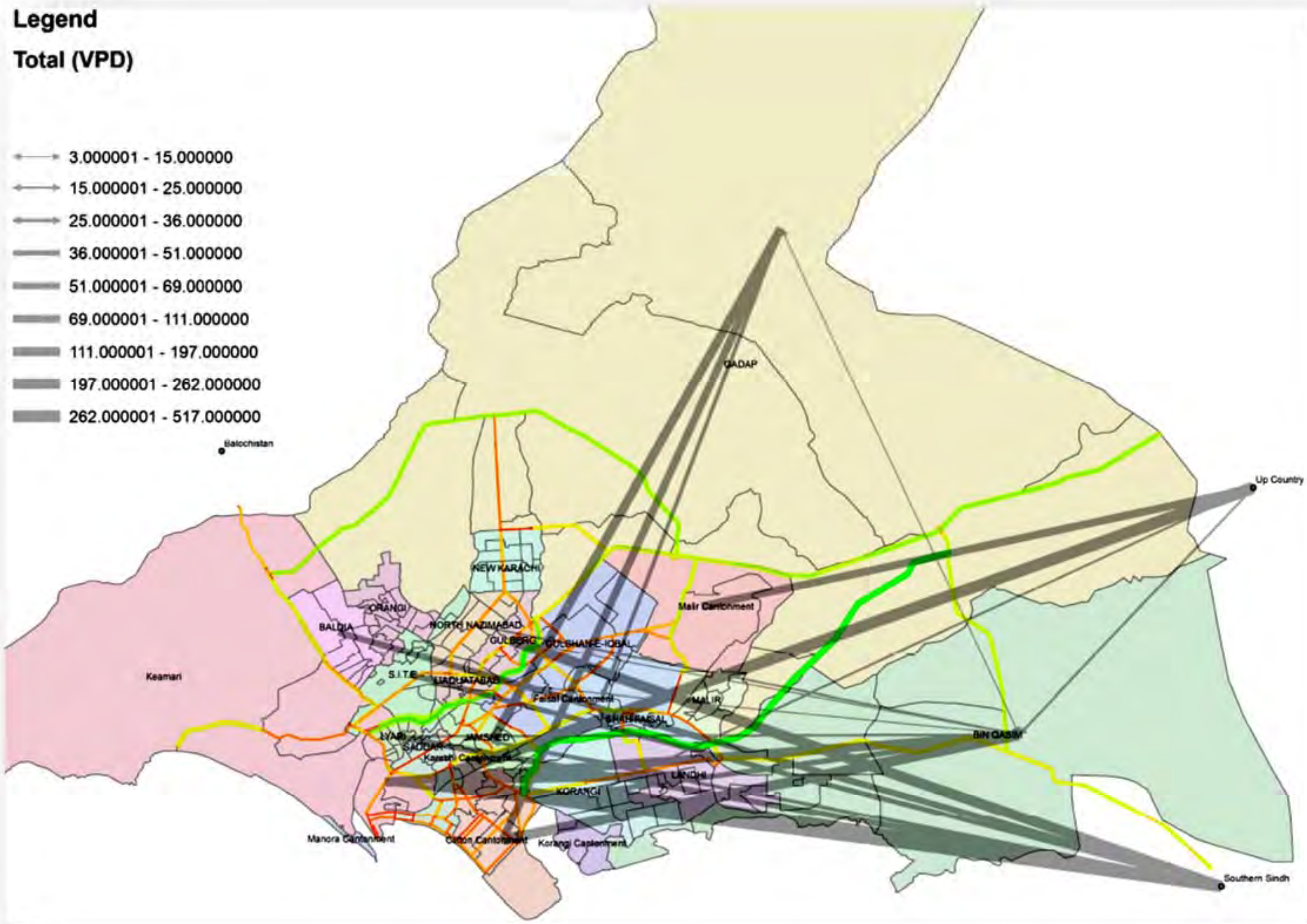
CONSULTANCY / TRANSACTION ADVISROY SERVICES
FOR DEVELOPMENT OF MALIR EXPRESSWAY
(From Motorway, M9 to KPT Interchange)
FINAL REPORT

ANNEXURE B

Travel Desire Lines on Karachi Road Network

ANNEXURE B

TRAVEL DESIRE LINES



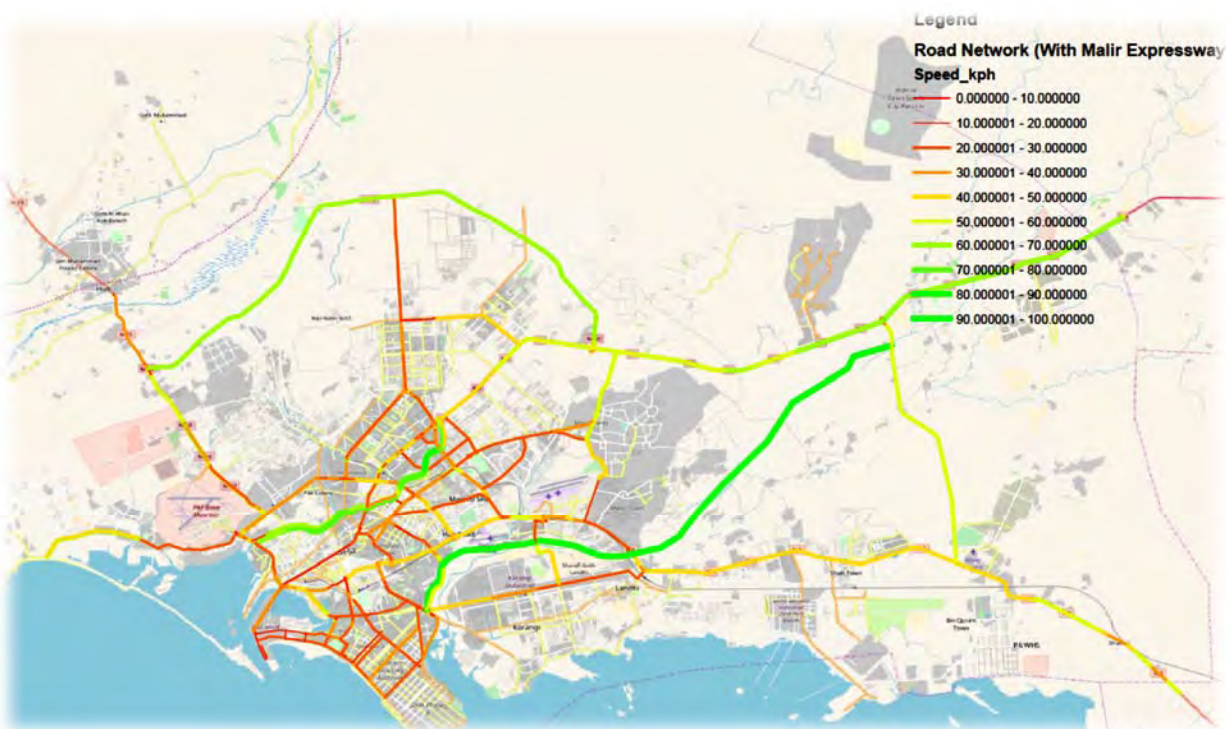
CONSULTANCY / TRANSACTION ADVISROY SERVICES
FOR DEVELOPMENT OF MALIR EXPRESSWAY
(From Motorway, M9 to KPT Interchange)
FINAL REPORT

ANNEXURE C

Road Infrastructure in Karachi & Relative Speeds

ANNEXURE C

ROAD INFRASTRUCTURE IN KARACHI & RELATIVE SPEEDS.


Legend
Road Network (With Malir Expressway
Speed_kph
0.000000 - 10.000000
10.000001 - 20.000000
20.000001 - 30.000000
30.000001 - 40.000000
40.000001 - 50.000000
50.000001 - 60.000000
60.000001 - 70.000000
70.000001 - 80.000000
80.000001 - 90.000000
90.000001 - 100.000000

CONSTRUCTION OF MALIR EXPRESSWAY
FROM MOTORWAY M9 TO KPT INTERCHANGE
KARACHI

C A P A C I T Y   A N A L Y S I S
(UNDER IMPROVED UNINTERRUPTED FLOW CONDITION ON ACCESS CONTROLLED FACILITY)

Table 3.5.5.1

DESIGN CRITERIA :

HIGHWAY CLASSIFICATION 6-Lane Freeway	LATERAL CLEARANCE	TERRAIN TYPE: LEVEL	DRIVER POPULAT COMMUTERS
DESIGN SPEED: 100km/hr (60 mph)	ROAD SIDE 2M	DIRECTION :	ANALSYSIS SCENARIO: 1
FREE FLOW SPEED: 80.45 km / hr (50 mph)	MEDIAN VARIES		

NO. LANES ON THE PROPOSED FACILITY (N)	=	3
ADJUSTMENT FACTOR FOR DRIVER POPULATION (fp)	=	1.00
LANE ADJUSTMENT FACTOR (fw)	=	1.00
PC EQUIVALENT BUSES (E_B)	=	1.60
PC EQUIVALENT TRUCKS AND TRAILERS (ET)	=	1.70

V/C RATIO -------------------- LOS A	=	-
V/C RATIO -------------------- LOS B	=	0.490
V/C RATIO -------------------- LOS C	=	0.690
V/C RATIO -------------------- LOS D	=	0.840
V/C RATIO -------------------- LOS E	=	1.000

(v/c from Table 3-1, for 60 mph Design Speed)

Note : *This analysis is based on the procedures outlined in the Highway Capacity Manual - 1994 Edition (Special Report 209), published by the Transportation Research Board, National Research Council, U.S.A. Necessary Adjustments, as already mentioned, have been made to reflect the actual project conditions.*

YEAR	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047
					1st Year of Operation	Uninterrupted Traffic Flow Condition								10th Year of Operation										20th Year of Operation					25th Year of Operation
Total Volume of Traffic Mix VPD	33316	34982	37279	39758	42434	45326	48453	51836	54440	57179	60062	63096	66289	69650	73189	76914	80835	84964	87937	91015	94200	97497	100909	104441	108097	111880	115796	119849	124044
Total Volume of Traffic Mix PCU'S	46287	48602	51444	54489	57754	61260	65024	69069	72363	75819	79448	83257	87257	91456	95868	100501	105365	110475	114341	118343	122485	126771	131208	135800	140554	145473	150565	155835	161290
PERCENT BUSES	0.065	0.065	0.064	0.063	0.061	0.060	0.058	0.057	0.057	0.056	0.056	0.055	0.055	0.054	0.054	0.053	0.053	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052
PERCENT TRUCKS	0.540	0.540	0.529	0.518	0.507	0.496	0.485	0.473	0.469	0.466	0.462	0.458	0.454	0.450	0.446	0.442	0.438	0.434	0.434	0.434	0.434	0.434	0.434	0.434	0.434	0.434	0.434	0.434	0.434
FACTOR FOR HEAVY VEHICLE (f_{HV})	0.71	0.71	0.71	0.71	0.72	0.72	0.73	0.73	0.73	0.74	0.74	0.74	0.74	0.74	0.74	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
ALLOWABLE FLOW RATES*																													
SERVICE FLOW RATE - LOS A																													
SERVICE FLOW RATE - LOS B	2075	2075	2087	2100	2113	2126	2139	2153	2158	2163	2167	2172	2177	2182	2187	2192	2197	2202	2202	2202	2202	2202	2202	2202	2202	2202	2202	2202	2202
SERVICE FLOW RATE - LOS C	2922	2922	2939	2957	2975	2993	3012	3032	3038	3045	3052	3059	3066	3073	3080	3087	3094	3101	3101	3101	3101	3101	3101	3101	3101	3101	3101	3101	3101
SERVICE FLOW RATE - LOS D	3557	3557	3578	3599	3621	3644	3667	3691	3699	3707	3715	3724	3732	3741	3749	3758	3766	3775	3775	3775	3775	3775	3775	3775	3775	3775	3775	3775	3775
SERVICE FLOW RATE - LOS E	4235	4235	4259	4285	4311	4338	4366	4394	4404	4413	4423	4433	4443	4453	4463	4473	4483	4494	4494	4494	4494	4494	4494	4494	4494	4494	4494	4494	4494
Peak hour percentage factor "K" 0.070																													
Directional distribution factor "D" 0.500																													
Hourly Volume at the freeway (In one direction)	1620	1701	1801	1907	2021	2144	2276	2417	2533	2654	2781	2914	3054	3201	3355	3518	3688	3867	4002	4142	4287	4437	4592	4753	4919	5092	5270	5454	5645
Peak Hour Factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Actual Flow rate at the highway (in one direction)	1761	1849	1957	2073	2197	2331	2474	2628	2753	2884	3022	3167	3320	3479	3647	3823	4008	4203	4350	4502	4660	4823	4992	5166	5347	5534	5728	5929	6136
* Cj=2000																													
LEVEL OF SERVICE	B				C							D				E													

CONSTRUCTION OF MALIR EXPRESSWAY
FROM MOTORWAY M9 TO KPT INTERCHANGE
KARACHI

C A P A C I T Y   A N A L Y S I S
(UNDER IMPROVED UNINTERRUPTED FLOW CONDITION ON ACCESS CONTROLLED FACILITY)

Table 3.5.5.2

DESIGN CRITERIA :

HIGHWAY CLASSIFICATION 6-Lane Freeway	LATERAL CLEARANCE	TERRAIN TYPE: LEVEL	DRIVER POPULAT COMMUTERS
DESIGN SPEED: 100km/hr (60 mph)	ROAD SIDE 2M	DIRECTION :	ANALSYSIS SCENARIO: 2
FREE FLOW SPEED: 80.45 km / hr (50 mph)	MEDIAN VARIES		

NO. LANES ON THE PROPOSED FACILITY (N)	=	3	V/C RATIO -------------------- LOS A	=	-
ADJUSTMENT FACTOR FOR DRIVER POPULATION (fp)	=	1.00	V/C RATIO -------------------- LOS B	=	0.490
LANE ADJUSTMENT FACTOR (fw)	=	1.00	V/C RATIO -------------------- LOS C	=	0.690
PC EQUIVALENT BUSES (E_B)	=	1.60	V/C RATIO -------------------- LOS D	=	0.840
PC EQUIVALENT TRUCKS AND TRAILERS (ET)	=	1.70	V/C RATIO -------------------- LOS E	=	1.000

(v/c from Table 3-1, for 60 mph Design Speed)

Note : *This analysis is based on the procedures outlined in the Highway Capacity Manual - 1994 Edition (Special Report 209), published by the Transportation Research Board, National Research Council, U.S.A. Necessary Adjustments, as already mentioned, have been made to reflect the actual project conditions.*

YEAR		2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
						1st Year of Operation	Uninterrupted Traffic Flow Condition								10th Year of Operation	
Total Volume of Traffic Mix	**VPD**	9003	9453	10030	10651	11318	12036	12810	13643	14306	15003	15735	16505	17314	18164	19058
	PCU'S	12855	13497	14236	15025	15867	16767	17731	18760	19628	20538	21491	22491	23540	24639	25792
PERCENT BUSES		0.0651	0.0651	0.0638	0.0625	0.0611	0.0598	0.0584	0.057	0.0566	0.0561	0.0557	0.0551	0.0547	0.0542	0.0537
PERCENT TRUCKS		0.5398	0.5398	0.5291	0.5182	0.5072	0.496	0.4847	0.4733	0.4694	0.4655	0.4616	0.4577	0.4537	0.4498	0.4458
FACTOR FOR HEAVY VEHICLE (f_{HV})		0.71	0.71	0.71	0.71	0.72	0.72	0.73	0.73	0.73	0.74	0.74	0.74	0.74	0.74	0.74
ALLOWABLE FLOW RATES*																
SERVICE FLOW RATE - LOS A																
SERVICE FLOW RATE - LOS B		1971	1971	1983	1995	2007	2019	2032	2045	2050	2054	2059	2064	2068	2073	2078
SERVICE FLOW RATE - LOS C		2776	2776	2792	2809	2826	2844	2862	2880	2887	2893	2899	2906	2912	2919	2926
SERVICE FLOW RATE - LOS D		3379	3379	3399	3419	3440	3462	3484	3506	3514	3522	3530	3538	3546	3554	3562
SERVICE FLOW RATE - LOS E		4023	4023	4046	4071	4096	4121	4147	4174	4183	4193	4202	4211	4221	4230	4240
Peak hour percentage factor "K"	0.150															
Directional distribution factor "D"	0.560															
Hourly Volume at the freeway (In one direction)		1080	1134	1196	1262	1333	1408	1489	1576	1649	1725	1805	1889	1977	2070	2167
Peak Hour Factor, PHF		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	0.9	0.9
Actual Flow rate at the highway (in one direction)		1200	1260	1329	1402	1481	1565	1655	1751	1832	1917	2006	2099	2197	2300	2407
LEVEL OF SERVICE		**B**											**C**			

YEAR		2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047
										20th Year of Operation					25th Year of Operation
Total Volume of Traffic Mix	**VPD**	19997	20984	22023	22794	23592	24417	25272	26156	27071	28019	29000	30016	31067	32155
	PCU'S	27000	28267	29598	30634	31706	32815	33964	35153	36382	37656	38975	40341	41753	43215
PERCENT BUSES		0.0533	0.0528	0.0523	0.0523	0.0523	0.0523	0.0524	0.0523	0.0523	0.0524	0.0523	0.0524	0.0524	0.0524
PERCENT TRUCKS		0.4419	0.438	0.434	0.434	0.434	0.434	0.434	0.434	0.434	0.434	0.434	0.434	0.434	0.434
FACTOR FOR HEAVY VEHICLE (f_{HV})		0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
ALLOWABLE FLOW RATES*															
SERVICE FLOW RATE - LOS A															
SERVICE FLOW RATE - LOS B		2082	2087	2092	2092	2092	2092	2092	2092	2092	2092	2092	2092	2092	2092
SERVICE FLOW RATE - LOS C		2932	2939	2946	2946	2946	2946	2946	2946	2946	2946	2946	2946	2946	2946
SERVICE FLOW RATE - LOS D		3570	3578	3586	3586	3586	3586	3586	3586	3586	3586	3586	3586	3586	3586
SERVICE FLOW RATE - LOS E		4250	4259	4269	4269	4269	4269	4269	4269	4269	4269	4269	4269	4269	4269
Peak hour percentage factor "K"	0.150														
Directional distribution factor "D"	0.560														
Hourly Volume at the freeway (In one direction)		2268	2374	2486	2573	2663	2756	2853	2953	3056	3163	3274	3389	3507	3630
Peak Hour Factor, PHF		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	0.9
Actual Flow rate at the highway (in one direction)		2520	2638	2762	2859	2959	3063	3170	3281	3396	3515	3638	3765	3897	4033
LEVEL OF SERVICE		**C**				**D**						**E**			

* Cj=1900

FROM MOTORWAY M9 TO KPT INTERCHANGE
KARACHI
C A P A C I T Y   A N A L Y S I S
(UNDER IMPROVED UNINTERRUPTED FLOW CONDITION ON ACCESS CONTROLLED FACILITY)

Table 3.5.5.3

DESIGN CRITERIA :

HIGHWAY CLASSIFICATION 6-Lane Freeway	LATERAL CLEARANCE	TERRAIN TYPE: LEVEL	DRIVER POPULAT COMMUTERS
DESIGN SPEED: 100km/hr (60 mph)	ROAD SIDE 2M	DIRECTION :	ANALSYSIS SCENARIO: 3
FREE FLOW SPEED: 80.45 km / hr (50 mph)	MEDIAN VARIES		

NO. LANES ON THE PROPOSED FACILITY (N)	=	3	V/C RATIO -------------------- LOS A	=	-
ADJUSTMENT FACTOR FOR DRIVER POPULATION (fp)	=	1.00	V/C RATIO -------------------- LOS B	=	0.490
LANE ADJUSTMENT FACTOR (fw)	=	1.00	V/C RATIO -------------------- LOS C	=	0.690
PC EQUIVALENT BUSES (E_B)	=	1.60	V/C RATIO -------------------- LOS D	=	0.840
PC EQUIVALENT TRUCKS AND TRAILERS (ET)	=	1.70	V/C RATIO -------------------- LOS E	=	1.000

(v/c from Table 3-1, for 60 mph Design Speed)

Note : *This analysis is based on the procedures outlined in the Highway Capacity Manual - 1994 Edition (Special Report 209), published by the Transportation Research Board, National Research Council, U.S.A. Necessary Adjustments, as already mentioned, have been made to reflect the actual project conditions.*

YEAR	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
					1st Year of Operation	Uninterrupted Traffic Flow Condition								10th Year of Operation	
Total Volume of Traffic Mix – **VPD**	18720	19656	20941	22327	23824	25440	27188	29079	30537	32070	33684	35382	37168	39049	41029
Total Volume of Traffic Mix – **PCU'S**	26024	27324	28916	30621	32450	34411	36518	38782	40629	42565	44599	46734	48973	51327	53798
PERCENT BUSES	0.035	0.035	0.034	0.033	0.032	0.031	0.031	0.030	0.029	0.029	0.029	0.029	0.028	0.028	0.028
PERCENT TRUCKS	0.519	0.519	0.507	0.494	0.482	0.469	0.457	0.444	0.440	0.436	0.431	0.427	0.423	0.418	0.414
FACTOR FOR HEAVY VEHICLE (f_{HV})	0.72	0.72	0.73	0.73	0.74	0.74	0.75	0.75	0.75	0.76	0.76	0.76	0.76	0.76	0.77
ALLOWABLE FLOW RATES*															
SERVICE FLOW RATE - LOS A															
SERVICE FLOW RATE - LOS B	2018	2018	2031	2045	2059	2073	2087	2102	2107	2112	2117	2122	2127	2132	2138
SERVICE FLOW RATE - LOS C	2841	2841	2860	2879	2899	2919	2939	2960	2967	2974	2981	2988	2996	3003	3010
SERVICE FLOW RATE - LOS D	3459	3459	3482	3505	3529	3554	3578	3603	3612	3621	3629	3638	3647	3656	3664
SERVICE FLOW RATE - LOS E	4118	4118	4145	4173	4201	4230	4260	4290	4300	4310	4321	4331	4342	4352	4362
Peak hour percentage factor "K" 0.085															
Directional distribution factor "D" 0.520															
Hourly Volume at the freeway (In one direct	1150	1208	1278	1353	1434	1521	1614	1714	1796	1881	1971	2066	2165	2269	2378
Peak Hour Factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Actual Flow rate at the highway (in one dire	1250	1313	1389	1471	1559	1653	1754	1863	1952	2045	2143	2245	2353	2466	2585
* Cj=1900															
LEVEL OF SERVICE	**B**										**C**				

YEAR	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047
									20th Year of Operation					25th Year of Operation
Total Volume of Traffic Mix – **VPD**	43113	45307	47616	49283	51008	52794	54642	56555	58535	60584	62704	64898	67170	69521
Total Volume of Traffic Mix – **PCU'S**	56393	59119	61980	64150	66395	68720	71125	73615	76193	78860	81620	84476	87433	90493
PERCENT BUSES	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027
PERCENT TRUCKS	0.410	0.406	0.402	0.401	0.402	0.402	0.402	0.402	0.402	0.402	0.402	0.402	0.402	0.402
FACTOR FOR HEAVY VEHICLE (f_{HV})	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77
ALLOWABLE FLOW RATES*														
SERVICE FLOW RATE - LOS A														
SERVICE FLOW RATE - LOS B	2143	2148	2153	2153	2153	2153	2153	2153	2153	2153	2153	2153	2153	2153
SERVICE FLOW RATE - LOS C	3017	3025	3032	3032	3032	3032	3032	3032	3032	3032	3032	3032	3032	3032
SERVICE FLOW RATE - LOS D	3673	3682	3691	3691	3691	3691	3691	3691	3691	3691	3691	3691	3691	3691
SERVICE FLOW RATE - LOS E	4373	4384	4394	4394	4394	4394	4394	4394	4394	4394	4394	4394	4394	4394
Peak hour percentage factor "K" 0.085														
Directional distribution factor "D" 0.520														
Hourly Volume at the freeway (In one direct	2493	2613	2740	2835	2935	3037	3144	3254	3368	3486	3608	3734	3865	4000
Peak Hour Factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Actual Flow rate at the highway (in one dire	2709	2840	2978	3082	3190	3302	3417	3537	3661	3789	3921	4059	4201	4348
* Cj=1900														
LEVEL OF SERVICE	**C**			**D**						**E**				

CONSULTANCY / TRANSACTION ADVISROY SERVICES
FOR DEVELOPMENT OF MALIR EXPRESSWAY
(From Motorway, M9 to KPT Interchange)
FINAL REPORT

ANNEXURE D

Feasibility Study of Karachi Flood Control Plan (1990) by WAPDA

CHAPTER - 2

HYDROLOGY

2.1 LOCATION

Karachi, the Provincial Capital of Sind is located at the extreme west end of the Indus delta between north latitude 24° - 51' and east longitude 67° - 4' (Refer Dwg. 2-1 for location).

2.2 CLIMATE

On the whole the weather of Karachi is pleasant though occasionally sultry. The average annual rainfall does not exceed 9 Inches. The mean daily maximum temperature during the summer months ranges between 89°F and 94°F. Relative humidity varies from 40% (December) to 84% and even more (August). Average wind speed varies from 3.2 to 10.7 knots per hour.

Karachi Airport is the nearest meteorological station for which climatological data is available over a considerable period (over 50 years). A net-work of climatological stations consisting of 2 automatic type rain gauges at Sari Sing and Thano Shah Ahmed Beg in the catchment of Khadeji and Mol tributaries of Malir river and one A-Class observatory at Super Highway Bridge across Malir river were set up by WAPDA during 1975 in connection with feasibility studies for Water Resources Development in Malir Basin. In addition three rain gauging stations at Goth Haji Shah Mohammad (Sukhan Nullah catchment), Roop Kani (Lyari catchment) and Goth Habitat (Makh catchment) were set up during 1978. Besides five additional stream gauging stations at National Highway Bririge (Malir river) Super Highway crossings of Jarando Nai, Turi Nai and Kandar Nai (all tributaries of Malir river) and Super Highway Bridge (Lyari river) were established by WAPDA during 1978.

2.2.1 Rainfall

Mean yearly precipitation averages about 8.33 inches. During the summer season (June-October) the rainfall is predominantly contributed by the south-west monsoon while the comparatively less significant winter rains are due to the secondary low pressure waves Induced by the main western disturbances passing across Russian Turjistan In the north. As the summer season advances, a low pressure area (the seasonal low) is formed over central India by excessive heating of the land, which extends in July to the Quetta, Kalat and Hyderabad Divisions of Pakistan, thereby causing the inflow of moist air from the Arabian Sea and the Bay of Bengal.

Generally the storms (depressions) originating In the Bay of Bengal move in a north westerly direction across the Indian Peninsula. After being fed by the moist air currents from the Bay and the Arabian Sea, they regain their activity and occasionally move westwards, giving heavy showers over parts of Sind and Baluchistan. Storms formed in the Arabian Sea usually take a northerly direction and affect Karachi and Hyderabad Divisions. The eastward passage of a western disturbance moving over Russian Turkistan also accentuates the season low, thus giving rise to thunder showers over the area. The average rainfall of Karachi Airport with monthly distribution based on 51 years record, and those for Sari Sing, Thano Shah Beg and Malir Super Highway Bridge based on 1976-78 records are respectively exhibited In Table 2-1, 2-2, 2-3, 2-3A and 2-3B.

2.2.2 Temperatures

The temperatures are moderate but the relative humidity is in excess In some months, so that while the temperature is actually not high, warm air feels warmer and the cold air cooler than It really Is. During the hottest months of May and June the mean daily maximum

TABLE 2-1

AVERAGE MONTHLY & PERCENTAGE DISTRIBUTION OF RAINFALL* BY MONTHS (AT KARACHI AIRPORT)

Months	Average Rainfall (Inches)	Percentage Distribution	Seasonal Index
January	0.289	3.4	40.6
February	0.355	4.2	49.9
March	0.337	3.9	47.4
April	0.094	1.1	13.2
May	0.014	0.2	2.0
June	0.300	3.5	42.2
July	3.699	43.3	520.3
August	1.968	23.1	276.8
September	0.980	11.5	137.8
October	0.103	1.2	14.5
November	0.119	1.4	16.7
December	0.274	3.2	38.5
Total Yearly	8.532		
Monthly Average	0.711	100.0	

*Based upon data of 51 years (1928 through 1978)

TABLE 2-2

TOTAL AVERAGE MONTHLY RAINFALL*
AT
SARI SING AND THANA SHAH BEG

Months	Average Rainfall (Inches)	
	Sari Sing	Thana Shah Beg
January	0.46	0.45
February	0.15	0.61
March	0.35	0.72
April	0.00	0.00
May	0.00	0.00
June	0.94	1.65
July	6.21	5.57
August	3.20	4.00
September	1.99	2.04
October	0.00	0.00
November	0.00	0.00
December	0.00	0.00

* Average of data 1976 through 1978.

TABLE 2-3

TOTAL MONTHLY RAINFALL, EVAPORATION AND HUMIDITY AT MALIR SUPER HIGHWAY BRIDGE

Months	Total Rainfall (Inches)	Evaporation (Inches)	Humidity %
January	1.25	7.10	70
February	0.05	5.98	67
March	0.27	10.09	70
April	0.02	11.65	72
May	0.00	12.92	70
June	0.97	12.61	71
July	4.62	8.92	84
August	2.91	5.80	84
September	2.43	8.43	83
October	0.00	11.33	87
November	0.03	10.71	40
December	0.00	9.03	63

Mean for three years data of 1976 through 1978

TABLE 2-3A

KARACHI FLOOD CONTROL PLAN
1977 FLOODS
RAINFALL DATA IN INCHES

Section	Date	Time Hours 01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Total
Karachi Airport	29.6.77	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.02	.07	-	-	-	-	.02	.03
	30.6.77	.02	-	.15	.14	.09	.07	.09	.24	.14	-	.15	-	.02	.13	1.31	1.44	1.49	.31	.63	.04	-	.02	.21	.38	6.90
Thana Shah Beg	29.6.77	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.25	1.50	.65	-	-	-	.10	.20	-	2.70
	30.6.77	.55	.10	.45	.20	.10	.20	.05	.05	-	-	-	-	-	.35	.50	.90	-	.40	.25	.25	.25	.30	-	-	4.90
Sari Sang	29.6.77	-	-	-	-	-	-	-	-	.05	.05	.05	.20	-	.10	.95	.02	-	-	-	-	.13	-	.45	.10	2.10
	30.6.77	.15	.20	.30	.15	.05	.05	-	-	-	-	.10	1.15	1.25	1.75	-	.02	.10	-	-	.45	-	-	.18	-	6.08
Super Highway Bridge	29.6.77	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.25	-	.05	.05	-	-	-	-	.05	-	.40
	30.6.77	-	-	.40	.05	.05	.20	.20	.10	-	-	-	-	-		Recorder removed										

TABLE 2-3B
KARACHI FLOOD CONTROL PLAN
1978 FLOODS
RAINFALL DATA IN INCH

Station	Date	Time Hours 01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Total
Karachi Airport	17.8.78		0.04			0.44			0.02			0.01			0.44			0.57			1.13			1.91		4.56
	18.8.78		0.95			0.22			Trace			0.02			0.15			0.05			0.22			0.29		1.90
	19.8.78		Trace			0.13			0.01			-			0.01			-			-			Trace		0.15
	20.8.78		0.08			-			-			-			-			-			-			-		0.08
Thano Shah Beg	17.8.78	-	-	0.02	0.02	0.06	0.20	0.70	0.50	-	-	-	-	-	-	0.40	0.05	0.02	0.63	0.25	0.25	0.10	0.75	0.75	0.30	5.00
	18.8.78	2.50	1.00	0.65	0.30	0.01	0.01	0.02	0.01	0.05	-	-	-	-	-	0.02	-	-	-	-	0.01	-	0.01	0.08	-	4.67
	19.8.78	-	-	0.03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03
	22.8.78	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.30	0.70	0.05	-	-	-	-	-	1.05
Malir Super Highway	17.8.78	-	-	0.03	0.05	0.07	0.15	0.15	0.15	-	-	-	-	-	-	0.10	0.73	0.05	0.12	0.45	0.03	0.02	0.30	0.25	0.70	3.35
	18.8.78	0.55	0.55	0.15	0.02	0.05	0.06	0.17	0.05	0.01	0.04	0.03	0.02	0.01	0.04	-	-	0.16	-	0.05	-	-	0.13	0.01	-	2.10
	19.8.78	-	0.07	-	-	-	-	0.05	0.03	0.04	-	-	0.01	-	-	-	-	-	-	-	-	-	-	-	-	0.20
	21.8.78	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.30	-	-	-	-	-	-	-	0.30
Sari Sing	16.8.78	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.09	0.02	0.11
	17.8.78	0.03	-	-	-	0.31	0.02	0.03	0.35	0.50	-	-	0.65	0.45	0.30	2.00	1.35	0.40	0.14	0.01	-	0.01	0.04	0.05	-	6.64
	18.8.78	-	-	-	-	-	-	-	-	-	-	0.01	-	0.05	-	-	-	0.09	-	-	-	-	-	-	-	0.15

TABLE 2-4
MAXIMUM - TEMPERATURE KARACHI AIRPORT STATION
(1943 THROUGH 1976)

F°

Month	Mean Daily	Mean Monthly Highest	Mean Monthly Lowest	Extreme Highest Recorded Value	Extreme Highest Recorded Date/Year	Extreme Lowest Recorded Value	Extreme Lowest Recorded Date/Year
KHARIF							
April	93.1	103	85	112	16/47	76	12/65
May	92.0	103	87	114	19/55	85	4/45
June	94.0	103	90	116	23/53	85	10/48
July	91.0	99	86	108	3/58	80	31/71
August	89.0	95	84	107	9/64	81	14/55
September	89.0	99	85	109	50/51	80	29/57
Season	91.6	100	86	116	23 June 1953	76	12 April 1965
No. of Years	34	34	34	34	-	34	-
RABI							
October	93.4	102	87	110	1/51	82	2/56
November	88.7	95	82	98	7/65	76	25/63
December	80.8	87	73	93	8/63	61	26/67
January	77.5	84	69	90	31/52	61	10/50
February	79.0	86	71	95	29/60	61	10/49
March	88.5	95	80	103	29/52	72	4/45
Season	84.7	92	77	110	1 Oct.1951	61	26 Dec.1967
No. of Years	33	33	33	33	-	33	-

TABLE 2-5
MINIMUM - TEMPERATURE KARACHI AIRPORT STATION
(1943 THROUGH 1976)

F°

Month	Mean Daily	Mean Monthly Highest	Mean Monthly Lowest	Extreme Highest Recorded Value	Extreme Highest Recorded Date/Year	Extreme Lowest Recorded Value	Extreme Lowest Recorded Date/Year
KHARIF							
April	71.8	78	62	81	13/73	46	22/48
May	76.1	80	71	81	29/68	64	9/60
June	82.1	85	77	87	12/46	49	13/48
July	81.2	84	76	88	24/65	72	15/58
August	79.0	82	76	85	[illegible]/64	71	24/68
September	77.6	80	73	87	11/62	65	30/50
Season	78.0	82	73	88	24 Jul. 1965	46	22 April 1948
No. of Years	34	34	34	34	-	34	-
RABI							
October	70.0	78	62	81	3/75	50	30/49
November	60.6	69	55	76	7/63	48	30/60
December	53.3	62	45	81	4/69	40	19/50
January	49.6	58	42	71	23/44	35	4/49
February	53.5	63	45	71	14/54	38	11/50
March	64.2	73	55	79	18/48	52	12/75
Season	58.5	67	51	81	3 Oct. 1975	35	4 Jan. 1949
No. of Years	33	33	33	33	-	33	-

TABLE 2-6
TOTAL RAINFALL, EVAPORATION, HUMIDITY
AIR AND DRY, WET BULB TEMPERATURES
(MALIR SUPER HIGHWAY)

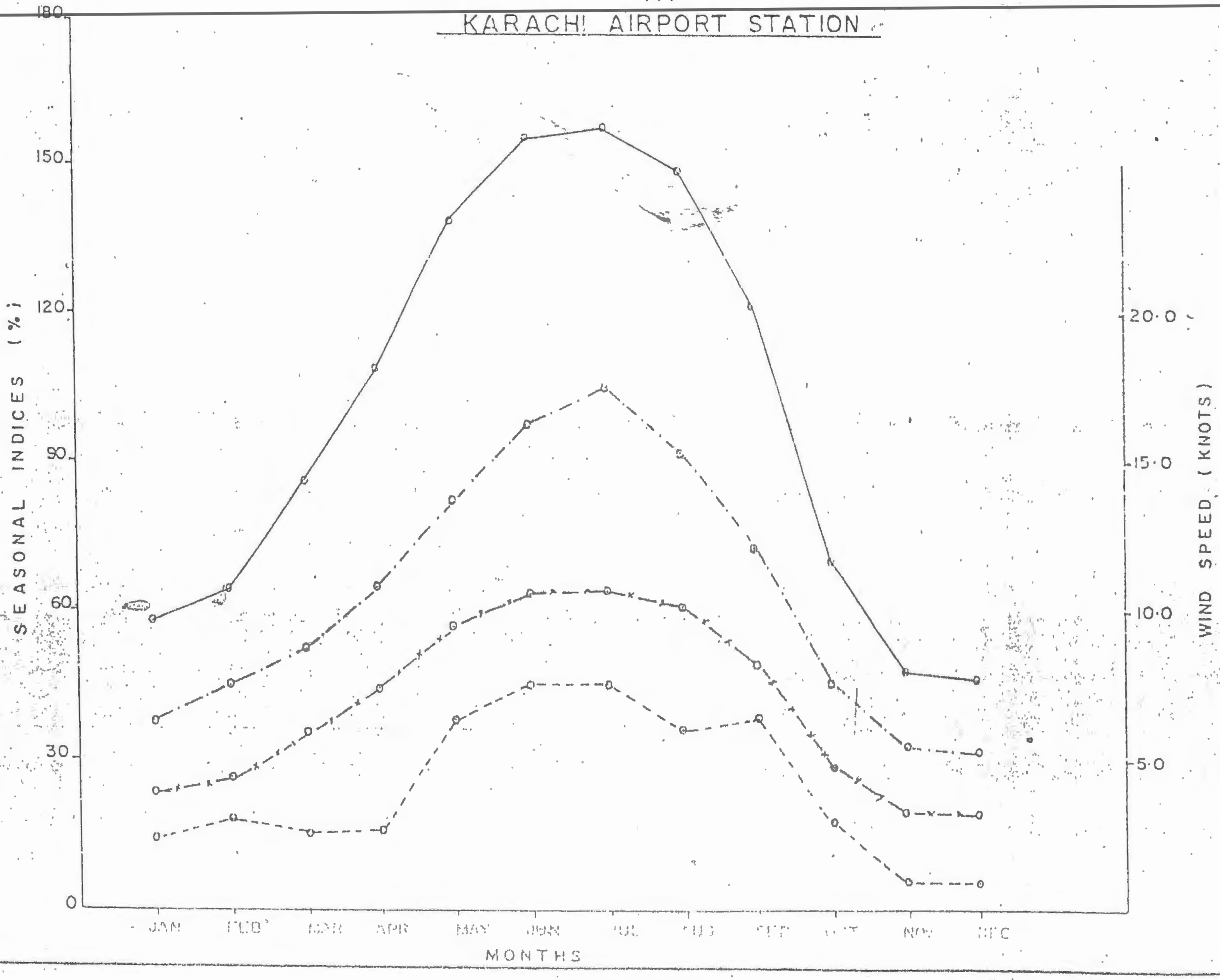
Months	Rainfall (inches)	Evaporation (Inches)	Humidity (%)	Air Temp(F) Max.	Air Temp(F) Min.	Bulb Temp (F) Dry	Bulb Temp (F) Wet
January	1.25	7.1	70	78	64	65	59
February	0.05	8.9	68	81	57	70	63
March	0.24	11.7	74.4	90	64	77	71
April	0.00	13.1	75.6	95	72	83	77
May	0.00	14.1	70.4	98	83	87	79
June	0.41	13.4	73.8	97	81	88	81
July	4.62	8.3	80	90	80	85	80
August	2.58	6.8	79.6	89	79	93	78
September	2.42	7.5	75.6	89	78	83	77
October	0.00	11.1	55.6	94	72	84	72
November	0.03	10.7	49.3	89	65	78	65
December	0:00	9.0	63.4	80	57	69	61

Note: Average of 3 years 1975 through 1977 for Sept. through Dec. and 1976 through 1978 for Jan. through August.

MAXIMUM, MINIMUM, AVERAGE & SEASONAL INDICES OF WIND SPEED AT KARACHI AIRPORT STATION

LEGEND

Seasonal Indices	————
Maximum.	—·—·—
Average.	—x—x—
Minimum	- - - - -



PAKISTAN WAPDA
PLANNING AND INVESTIGATION DIVISION

MAXIMUM MINIMUM AVERAGE & SEASONAL INDICES OF WIND SPEED AT KARACHI AIRPORT STATION

Drawn.	Submitted
Traced. M. K. Mahmood	Recommended
Checked.	Approved
LAHORE	Date Nov: 90 · Fig. No. 2 - 1

2.2.3 Relative Humidity

Relative humidity varies from 40 percent in December which is the driest month to 84 percent and even more in August which is the most worst of all the months. Evaporation from free surface varies from high to moderate and with seasons. Studies have shown that theoretical mean monthly evaporation may range from 3.17 inches to 7.13 inches. The cumulative yearly evaporation comes out to be 57.80 inches (Ref.Table 2-7).

2.2.4 Wind Movement

Wind in Karachi blows practically from all directions throughout the year. However during the summer months south westerly direction predominantes. Velocity of wind during the hot and monsoon season is high but reduces as it travels inland and as the winter season approaches.

The wind movement data as recorded at Karachi Airport station for the past 34 years from 1943 through 1976 have been analysed on monthly basis. The average wind speed during the year varies from 3.2 to 10.7 knot per hour. Average monthly wind speed has been expressed as a percentage of the overall 12 monthly average of 6.8 knots and given in Table 2-8. These seasonal indices have been plotted as a graph alongwith the minimum, maximum and average wind speeds during each month as shown in Fig. 2-1.

2.3 WATERSHED

The physical characteristics of the neighborhood of Karachi are marked by three anticilines and three synclines known as Malir, Lyari and Hub. Malir flows in the east; the Lyari flows through the heart of the city and Hub lies 19 miles to the west and flows along Karachi Lasbela boundary (Ref.Dwg. 2-2).

2.3.1 Malir River

Malir river is formed by the confluence of Mol and Khadeji tributaries, the catchment area of which are 236 and 219 Sq. miles respectively. After the confluence the Malir drains the adjoining areas of Malir, Deh, Drigh and Landhi in the NE-SW direction for a distance of about 30 miles before debauching into the Arabian Sea near Karachi. There are other tributaries also such as Jarando, Turi, Thaddo and Sukhan Nai joining the main river below the Mol-Khadeji confluence.

Of the two principal tributaries, the Mol rises from the Kohistan hills and draining the Mol-plateau with its subsequent streams, flows for 50 miles from a height of 2000 ft. The Khadeji though rising from 1000 ft. height drains a greater catchment area than the former, and flows for about 30 miles. The catchment of the Malir river upto Sea adds upto about 792 Sq. miles.

The catchment of Mol and Khadeji tributaries are generally mountaineous and mostly comprise of barren hills of low to medium height consisting of pale coloured limestone with some calcareous sand stones. The area is almost devoid of vegetation as the soil formation contains alluvial deposits, boulders, gravel and sandy clays. The downstream reach of the river flows through urban areas. Karachi city area forming part of the catchment of Malir river is approximately 70 Sq. miles.

TABLE 2-7
TOTAL AND AVERAGE MONTHLY EVAPORATION* AT KARACHI AIRPORT (1960 THROUGH 1966)***

YEARS Months	1960	1961	1962	1963	1964	1966	Average
January	3.84	3.47	1.54	4.18	3.17	7.74	3.99
February	3.77	2.26	2.35	4.66	3.39	2.57	3.17
March	3.47	3.86	4.24	6.05	5.02	3.94	4.43
April	6.28	4.34	3.63	6.17	5.01	5.72	5.19
May	6.13	7.14	8.40	7.87	6.12	5.93	6.93
June	7.69	9.47	5.25	7.79	7.44	5.11	7.13
July	8.21	4.31	3.51	6.40	9.33	7.67	6.57
August	5.15	2.63	2.37	6.01	5.55	5.08	4.47
September	3.76	2.38	3.61	5.53	6.33	3.78	4.23
October	3.05	4.23	5.68	5.10	6.43	5.04	4.92
November	2.20	2.37	5.39	2.63	4.51	4.12	3.54
December	3.37	2.24	3.05	2.71	4.22	3.73	3.22
Total	56.92	48.70	49.02	65.10	66.52	60.43	57.80

Note: Based upon 24 hours total evaporation values
Data for 1965 being incomplete has been discarded

TABLE 2-8
AVERAGE MONTHLY WIND SPEED

Months	Minimum	Wind Speed (Knots) Maximum	Average	Seasonal Index
January	2.3	6.4	3.9	57.4
February	3.0	7.6	4.4	64.7
March	2.5	8.7	5.9	86.8
April	5.2	10.8	7.4	108.8
May	6.9	13.7	9.5	139.7
June	7.6	16.3	10.6	155.9
July	7.5	17.6	10.7	157.4
August	6.0	15.3	10.1	148.5
September	6.4	12.2	8.3	122.1
October	2.9	7.7	4.8	70.6
November	1.9	5.5	3.3	48.7
December	1.9	5.3	3.2	47.1
Overall	1.9	17.6	6.8	-

2.3.2 Lyari River

The Lyari river with its tributaries Makh, Songal, Korangi and Gujro nullahs has a total catchment area of about 242 sq. miles out of which approximately 58 sq. miles lies in the city area. It flows towards south-west and traversing the city, debauches finally into the Arabian Sea. Lyari river has a very mild slope in the outfall touching almost zero level downstream of Mauripur Road Bridge. The flow in the river is thus very much influenced by the diurnal rise and fall of the tides. The slope of the bed gradually increases upstream of the estuary upto the end of city limits. In the hilly areas the bed slope is very steep.

The upper catchment is covered with sandy limestone, sandstone and mud stone and further down it is a saucer shaped plain surrounded by low hill range. In its lower part the formation largely comprises of consolidated or semi consolidated soil of recent deposits. The basin is covered with bushes and shrub trees spread too far apart. Area under cultivation is limited to about 700 acres only.

2.4 PROBABLE MAXIMUM PRECIPITATION (PMP) AND PROBABLE MAXIMUM FLOOD (PMF)

2.4.1 Data Used

For determining the PMF studies of two sub-basins of Malir the PMP studies have been based on the data available in the records of Pakistan Meteorological Department and that collected by the Surface Water Hydrology Project (SWHP), WAPDA.

2.4.2 Mechanism of Precipitation

Monsoon season is the chief rainy season as 70% of the annual rainfall occurs from July through September. With the advent of the summer season the seasonal heat low develops over Baluchistan-Sind and adjoining areas. The monsoon trough extends over Gangetic Basin from Bay of Bengal to the Punjab. Both develop as a normal feature. The orientation of this trough and the activity of the monsoon depressions determine the amount of rainfall.

Normally, these monsoon depressions develop in the Bay of Bengal and move west/northwest. After crossing the coast, these continue to move in a westerly/north-westerly direction through the Central India. While over Central India, these are fed by the moist air from the bay of Bengal and the Arabian Sea. They, however, regain their activity and sometimes take W/NW/N/NE course and merge in the seasonal low or dissipate mainly in the Kumaon and Simla hills. On occasions they move westwards and give heavy showers over parts of Sind and Baluchistan. The storms formed in the Arabian Sea, usually take a northerly direction and often cause heavy rainfall in Karachi and Hyderabad Divisions.

Further, normally the passage of a western disturbance/wave with or without frontal system move across Russian Turkistan, north of the country, throughout the year. However, during summer season their tracks shift further north but their occasional movement at a lower latitude accentuates the seasonal low and causes incursion of moist air from the Arabian monsoon pulses or with the activity of monsoon depression, then widespread heavy rainfall occurs.

Examination of basic data and isohyetal maps revealed six major storms. The storm of 1913 July 19-22 turned out to be the heaviest for the project basins. This storm after transposition and maximization was taken as the PMP for the basin.

PMF Hydrographs for the basin was determined by developing unit hydrograph with the dimensionless unit hydrograph method. Topography of the basin i.e. area, slope, length were the basis for the hypothetical approach. PMP was converted into PMF with the help of this unit hydrograph. The reasonability of the unitgraph values was ascertained by other checks as well. PMF unitgraph determined with PMP based on the observed transposed Depth-Area-Duration (D-A-D) values may reflect 100 years storm conditions and that based on PMP of maximized D-A-D values may reflect 1000 years storm conditions.

2.4.3 Techniques Used And Confidence Level

The probable maximum precipitation estimates were made by following the generally used procedures of storm transposition and moisture maximization. The salient points are indicated below:

a) The selection of the most significant storm for the basin is done with the help of the weather charts of significant storm-periods, their isohyetal patterns and mass curves. The main purpose is to select a storm which reflects all the adverse conditions of heavy rainfall. On occasions maximum adverse conditions are not reflected in one significant case and under these circumstances transposition and maximization of the storm is undertaken.

b) The transposition of the most significant storm is considered when the center of the maximum precipitation lies outside the project basin and its selection is meteorologically justified. The isohyetal is then adjusted by moving the center of storm isohyetal to place within the basin in a manner that maximum possible portion of the high-grade isohyetal is accommodated in the basin. The D-A-D Values of the transposed storm reflect the condition when the storm would be over the basin.

c) Maximization accounts for the adjustment to be made by considering the situation when this storm may occur with the most favorable atmospheric conditions in the basin exist. The adjustment factor is worked out by determining the ratio between the amount of perceptible water with the maximum dew point value reduced to 1000 mb level and the perceptible water with the observed storm of the transposed storm are then multiplied with the adjustment factor that give the D-A-D values of the transposed and maximized storm.

d) The enveloping curves for the plotted points of the transposed maximized D-A-D values for different areas and location reflect the D-A-D values of the PMP.

The reliability of the PMP estimates is shown by the quantity of meteorological data that are available and the quantity of the standard techniques used.

The probable maximum flood estimates were made using the synthetic method of Snyder & Dimensionless Hydrograph techniques. Application of these methods involved determination of a host of parameters and coefficient i.e.

a) Area of the basin (A)
b) Total & Effective lengths of the channel (L&L_o)
c) Slopes (S)
d) Time of peak of the unitgraph (t_p)
e) Peak discharge of the unithydrograph (q_p)
f) Time of concentration (t_c)
g) C_t, a coefficient used by Snyder.

The diverse approaches provided material for comparison and reasonable assessments for the project basin. The dimensionless technique was considered to be comparatively convenient and reasonable.

The salient stages of the technique are described below:

a) Time of concentration (t_c) was determined by the various formulae. The data of the neighboring catchment was indicative of the most probable value for smaller catchment of the type under question. t_p is a function of t_c and is considered almost equal to t_c for smaller catchments.

b) The determination of the peak rate of flow (q_p) of the unit hydrograph in cfs is then the next major step. The equation generally used for the peak rate of unit hydrographs.

$$q_p = \frac{KA}{t_p}$$

Where K is constant dependent on the shape of a hydrograph.

c) The ordinates of the dimensionless unit hydrograph are given in the ratio

$$\frac{t}{t_p} \quad \& \quad \frac{q}{q_p}$$

Where t/t_p = 0.5/1.0/1.5/2.0/2.5/3.0/3.5/4.0
q/q_p = Ratio is read from the dimensionless hydrograph

Time ordinates of the unit hydrograph are determined by multiplying the ratio t/t_p with t_p and discharge ordinates by multiplying q/q_p with known value of q_p.

d) The unit hydrograph thus determined is used for converting the 6-hourly increments of PMP runoff into 6-hour increment hydrographs.

e) The proper addition of the 6 hourly increment hydrographs would give the desired Probable Maximum Flood Hydrographs.

2.4.4 Probable Maximum Precipitation

Storm Transposition

Preliminary analysis of the basic data for the period 1892-1976 showed 85 storm periods 36 storms were considered as significant storms. Detailed analysis of these significant storms showed that the following cases reflected major storm activity i.e.

a) 1910 July 3-8
b) 1913 July 19-22
c) 1929 July 26-29
d) 1933 July 16-23
e) 1944 August 2-4
f) 1959 July 1-4

All the above storms were associated with the movement and activity of the monsoon depressions in the project area. The isohyetal pattern of all these storms had a cell of maximum precipitation over the southern and south-eastern slopes of the Kirthar/Kohistan Range. The rainfall with storm of 1913 July 19-21 was associated with the isohyetal pattern that had a maximum cell of about 18 inches over the southeastern section of the project basin comprising of Khadeji Nadi (Fig.2-2). This rainfall had occurred in 36 hours, with major rainfall occurring in three consecutive six hour bursts. The rainfall storm of 1933 July 15-33 had also been a significant storm for the basin, especially the Mol Nadi. It could not be a PMP storm, because of the lesser intensities. It also had occurred in two spells with a 3 to 4 days interval. In order to visualize the most critical condition, the isohyetal pattern developed for the 1913-July 19-22 storm was transposed to the project basins, the pattern of transposed storm is shown in Fig. 2.3. The isohyetal pattern of the transposed storm provided the Depth-Area values and the mass curves of Karachi (Manora), Hyderabad and Thatta (see Fig. 2-4) determined the time section of the Depth-Duration. It was observed that the Depth-Area values of Khadeji and Mol Nadis were almost the same and, therefore, a single set of D-A-D values would represent both the catchments. The D-A-D curves and the D-A-D values of the transposed storm are given in Fig. 2-5 and Table 2-9.

Storm Maximization

The 12-hour highest persisting dew point of Karachi being 84°F and the corresponding value for the storm being 79°F at Karachi gave a maximizing factor of 1.25. The D-A-D values of the transposed 1913 July 19-21 storm was maximized accordingly. The maximized D-A-D values for Mol and Khadeji are given in Table 2-10.

Seasonal Variation

The seasonal normal isohyetal maps, highest 12-hour persisting dew points and frequency of the intense weather system all show that the PMP for the project basin would occur during monsoon months with July and August as the most probable months.

Re-Occurrence Interval

The minimum re-occurrence interval for a rainfall storm other than that caused by a monsoon depression is 3 days. It has been observed that minimum interval between the development of two major monsoon depressions in the Bay of Bengal may be five to six days. These two depressions may follow each other to the project basin in a minimum interval of 3 to 4 days.

Probable Maximum Flood

It has already been described that in a dimensionless hydrograph the discharge is expressed by the ratio of discharge to peak discharge i.e. q/q_p and the time by the ratio of time from the rise of the hydrograph to time to peak i.e. t/t_p. Peak discharge (q_p) and time to peak (t_p) are determined by empirical relationships. The dimensionless hydrograph then gives the discharge (q) at the desired time intervals. t_p and c_p the basic inputs for the dimensionless hydrograph were determined by

TABLE 2-9

MAXIMUM OBSERVED DEPTH AT MOL AND KHADEJI

Area(Square Miles)	Duration(Hours)					
	6	12	18	24	30	36
10	10.40	14.60	17.50	18.43	19.57	20.45
50	10.25	14.25	17.10	18.04	19.20	20.10
100	10.15	14.10	16.90	17.84	18.99	19.80
150	10.02	13.92	16.72	17.65	18.78	19.60
200	9.90	13.77	16.55	17.45	18.60	19.40
216	9.86	13.75	16.51	17.42	18.53	19.35
235	9.80	13.68	16.44	17.36	28.48	19.27

TABLE 2-10

MAXIMIZED TRANSPOSED DEPTHS - AT MOL AND KHADEJI NADI

Area(Square Miles)	Duration(Hours) 6	12	18	24	30	36
10	13.00	18.25	21.86	23.04	24.46	25.55
50	12.81	17.81	21.38	22.55	24.00	25.10
100	12.69	17.63	21.13	22.30	23.74	24.75
150	12.53	17.40	20.90	22.06	23.48	24.5[illegible]
200	12.38	17.21	20.69	21.81	23.25	24.28
216	12.33	17.19	20.64	21.78	23.16	24.19
235	12.25	17.10	20.55	21.70	23.10	24.0[illegible]

the empirical relation as described in the standard reference books. These parameters and co-efficients used in the present study are summarized below:

	Mol		Khadeji	
Length of the basin (l)	48	Miles	24	Miles
Distance from the outlet to the central (L_c) of Gravity	24	Miles	12	Miles
Inlet elevation	440	feet	440	feet
Highest point	2102	feet	1090	feet
Slope (S)	.0066		.0051	
u_p	11.44	hours	7.95	hours
t_c	13.05	hours	8.41	hours
c_t Linsley, Kohler and Paulhus	0.302		0.359	

The time ordinates of the unit hydrograph of Mol and Khadeji were determined by multiplying their values of lag time t_p (i.e. 12 hrs. and 8 hrs. respectively) with the time ordinates of the dimensionless unit hydrograph (t/t_p). The discharge values are given below:

Mol	Khadeji
1st 6 hours 4,284	1st 4 hours 5,963
2nd 6 hours 9,520	2nd 4 hours 13,250
3rd 6 hours 5,902	3rd 4 hours 8,215
4th 6 hours 2,951	4th 4 hours 4,108
5th 6 hours 1,333	5th 4 hours 1,855
6th 6 hours 666	6th 4 hours 928
7th 6 hours 287	7th 4 hours 398
8th 6 hours 95	8th 4 hours 133

PMP could only be the basis for a PMF because it is based on the maximized D-A-D values of all durations. In distributing the PMP sequentially the following considerations were made:

a) The PMP rainfall, as observed, was considered to have occurred in an 18 hour continuous spell.

b) Keeping in view the gradual slope and the area of the two sub-basins, the three six-hourly increments.

c) The magnitude of each increment and their sequential arrangement was made to resemble with the rainfall pattern of the storm with the consideration that it should also give critical value.

d) Each increment was considered to have given uniform areal distribution of rainfall.

e) The retention rate of 0.1" per hour was applied to each increment. This value was enhanced to 0.30" per hour for the first increment, keeping in view the increased retention and infiltration rates in the beginning. This corrected value was then used for the determination of hydrograph ordinates of Mol and Khadeji Nadis for 100 years and 1000 years return periods. Increments of direct PMP runoff are given below:

Period Hour	100 Years Return Period PMP-Inch	100 Years Return Period R.O.Inch.	1000 Years Return Period PMP-Inch	1000 Years Return Period R.O.Inch.
0-06	9.90	8.00	12.30	11.00
6-12	4.30	3.50	5.20	4.80
12-18	2.30	1.70	3.10	2.50
18-24	1.40	0.80	1.60	1.00
24-30	0.90	0.30	1.10	0.50
30-36	0.50	0.00	0.90	0.30

2.4.5 Development of Probable Maximum Flood Hydrograph

The Probable Maximum Flood Hydrographs for the Mol and Khadeji sub-basins of Malir have been determined with the help of their unit hydrographs. The PMP of each sub-basin is divided into six hours increments (see Table 2-9 & 2-10). The six-hourly increment hydrographs are then determined by these values in a chronological order, and added up to give the storm hydrograph. (Ref. Table 2- 11 & Fig. 2-6 & 2-7).

TABLE 2-11

ORDINATES OF PROBABLE MAXIMUM FLOOD OF 100 YEARS FREQUENCY AND 1000 YEARS FREQUENCY FOR KHADEJI SUB-BASIN OF MALIR

4-hour Ordinates of PMF	100 Years Frequency	1000 Years Frequency
4	47,704	65,593
8	1,26,871	1,74,372
12	1,22,232	1,68,873
16	88,912	1,23,708
20	55,573	76,893
24	31,448	46,011
28	15,337	25,661
32	6,751	12,067
36	2,424	4,721
40	822	1,752
44	225	610
48	40	186
52	-	40

ORDINATES OF PROBABLE MAXIMUM FLOOD OF 100 YEARS FREQUENCY AND 1000 YEAR FREQUENCY FOR MOL SUB-BASIN OF MALIR

6-hour Ordinates of PMF	100 Years Frequency	1000 Years Frequency
6	34,272	47,124
12	91,154	1,25,283
18	7,819	1,21,328
24	63,876	88,875
30	39,927	55,245
36	22,589	33,049
42	11,016	18,434
48	4,844	6,662
54	1,752	3,389
60	591	1,257
66	162	428
72	29	134
78	-	29

The observed PMP values are considered to reflect the 100 year PMF and that of maximized PMP values that of 1000 years PMF.

For the planning of flood protection embankment, the flood hydrographs on 20 years 50 years frequency interval for, khadeji and Mol have also been computed and these are exhibited in Fig. 2-8, 2-9 and 2-10. The ordinates of these floods are given in Table 2-1[illegible].

2.4.6 Conclusions

The PMF estimates of Mol and Khadeji sub-basin of Malir have been determined with the help of PMP estimates and related parameters and are as under:

Return Period		Peak Discharge (Cusecs)	
20 Years	Khadeji	64000	111,000
	Mil	47000	
50 Years	Khadeji	80000	132,000
	Mol	52000	
75 Years	Khadeji	128000	214,000
	Mol	86000	
100 Years	Khadeji	134000	235,000
	Mol	101000	
1000 Years	Khadeji	184000	322,000
	Mol	138000	

The estimates have been based on the worst possible conditions that could ever coincide. The 1913 July 19-21 storm for the area lying to the southeast of the project basin has been suitably transposed and then maximized for determination of the D-A-D values of the PMP storm.

The PMF have been determined by arranging the rainfall occurring in three six- hourly consecutive bursts in a manner that highest discharge values could be obtained.

TABLE 2-12

4-hours intervals	20 Years	50 [illegible]	75 Years
4	5000	23,852	[illegible]
8	24500	[illegible]	[illegible]
12	52750	70,491	112,970
16	62200	45,955	35,000
20	38100	33,205	62,449
24	19800	20,000	40,655
28	9900	12,000	26,095
32	4200	7,146	12,766
36	1800	2,997	5,423
40	500	1,180	2,201
44	200	438	266
48	0	133	266
52	0	27	53
56	0	00	00

MOL

6-hours intervals	20 Years	50 Years	75Years
6	3850	17,136	29,131
12	14750	47,933	79,730
18	36700	50,645	81,165
24	44600	39,801	63,001
30	27800	27,579	46,000
36	14000	18,067	30,918
42	6800	10,606	18,746
48	3200	5,131	9,167
54	1600	2,151	3,893
60	600	847	1,580
66	250	314	609
72	00	95	190
78	00	19	38
84	00	00	00

Moreover, in the absence of observed hydrological data, the dimensionless unitgraph have been determined on the basis of the latest techniques and related parameters elicited from survey sheets etc.

The estimates described above are on the latest procedures of synthetic Probable Maximum Flood Analysis. This hypothetical approach eliminates to a considerable degree the subjectivity introduced by the non-availability of the basic data.

On the above basis the PMF estimates of Malir river near its outfall into Sea at different return period of occurrence have been computed as follows:

Malir River

Return Period	Runoff (Cusecs)
100 Years	4,09,000
75 Years	3,72,000
50 Years	2,40,000
20 Years	1,93,000

Lyari river basin is an adjacent basin of Malir river and is a similar basin as far as the climate and watershed characteristics are concerned. Therefore the same PMP and PMF as computed for the Malir river has been adopted for the Lyari river for calculating the flood runoffs at its outfall at various return periods.

Lyari River

Return Period	Runoff (Cusecs)
100 Years	1,04,146
75 Years	88,883
50 Years	53,620
20 Years	48,482

CHAPTER - 6

CHANNELIZATION

PART - A MALIR RIVER

6.1 GENERAL

After the horrible experience of 1977 floods, it was decided that some protective works must be built in the most sensitive of area i.e. National Highway Bridge to Karachi-Korangi Causeway to meet the immediate needs while awaiting the implementation of a long range multipurpose plan. After detailed discussion in various meetings, it has been decided to provide flood protection in this reach against historical floods to meet the immediate needs.

However, in view of the importance and sensitivity of Karachi area between National Highway Bridge and the estuary through which Malir river passes, it is being proposed to provide ultimate protection against floods of 100 years return period.

In the planning of spillway structures for the two dams at Khadeji and Moi also, 100-year frequency floods are proposed to be spilled over whereas routing floods over and above this frequency upto 1000 years into the reservoirs.

The channelization of Malir river between National Highway Bridge and the estuary has already been planned and is presently under execution for protection against the historic flood. During this time the floods will be closely monitored and in the light of the experience gained, subsequently these embankments can be raised to provide ultimate protection against 100 year frequency flood.

6.2 HISTORIC FLOODS

There have been four damaging floods in Karachi during the past 12 years in 1967, 1970, 1977 and 1978. But the most severe flood in recent history occurred in June 1977. Following the rainfall on 29th June 1977 which had created a situation favourable for quick run-off, intense rainfall occurred on 30th June 1977 in the catchment of Malir river which generated a flash flood. The rainfall records on stations Karachi Airport, Thano Shah Beg, Sari Sing and Super Highway Bridge are shown in Tables 2-1 to 2-3. Damaging floods occurred in Karachi again on 18 August 1978. The rainfall records on aforementioned stations are shown in Tables 2-3A & 2-3B.

6.2.1 Storm Characteristics

Storm of 29th June - 1st July 1977

The storm appears to have commenced at about 2 PM of 29th June and ended at about 2 AM of 1st July after remaining active for 42 hours.

The storm rainfall comprised of two contagious spells and practically at all stations. The rainfall exceeded 7.00 inches.

The maximum rainfall increment with the first spell was of about 2 to 3 inches in the afternoon of 24th June while the intensive increment with the second spell was more than 4 inches in the afternoon of 30th.

Both the sub-basins received the intensive rainfall increment simultaneously that made the resulting run-off to add up at the confluence.

The isohyetal pattern shows that rainfall with the 1977 storm was extensive widespread and concentrated primarily in the southern sections of the two catchments. A maximum spell of 11 - 12 inches is suggested over these areas.

The Mole sub-basin appears to have received about 9 inches of mean rainfall while for Khadeji sub-basin this value may be of the order of 10 inches.

Storm of 17th - 19th August 1978

The spell appears to have commenced at about early hours of 17th and ended at 11 AM of 19th after remaining active for about 60 hours. At Sari Sing (Khadeji) it rained 7 inches and at Thano Shah Beg (Mol) about 9.74 inches.

The effective rainfall had in fact occurred in a single spell of not more than 36 hours.

In this case the intensive rainfall increment had not occurred in the two sub- basins simultaneously. Khadeji was first to recover an increment of about 5.10 inches rainfall at 5 PM of 17th.

Mol received rainfall recovered about 12 hours later in the morning of 18th and the rainfall increment was 7.49 inches.

The isohyetal pattern suggests that the rainfall with 1978 storm was less widespread and concentrated primarily over the middle upper section of the Mol Sub-basin.

The mean rainfall values determined with this pattern suggest about 7.5 inches for Mol and about 6.96 inches for Khadeji Sub-basin.

6.2.2 Flood Hydrographs

Flood of 29th June - 1st July 1977

It is based on the rainfall increments of the storm rainfall as adjusted to the mean rainfall of the sub basins.

The flood hydrograph shows multiple peaks in both sub-basins. The highest peak indicates that Khadeji could contribute a flow increment of about 5000 cusecs at the confluence by 6 PM of 30th. The contribution from the Mol sub-basin could be about 30,000 cusecs. This would raise the peak to about 120,000 cusecs at Super Highway Bridge.

Flood of 17 - 19th August 1978

The flood hydrograph is based on the rainfall increment adjusted to the mean rainfall of the sub-basin. Each sub-basin has a single peak. Peak runoff contribution for Khadeji could be about 75000 cusecs at 7 PM of 17th and from Mol could be about 60,000 cusecs at 8 AM of 18th. Adding simultaneous contributions from the sister sub-basin the peak flow could be [illegible],000 on 17th and 70,000 on 18th.

6.2.3 Comments

It appears that the storm of 1978 though has been of lesser duration than that of 1977 and was mostly confined to the Malir Basin yet had the potentialities of giving higher peak discharge at the confluence. Had the intensive rainfall increment been simultaneous in both the sub-basin the peak discharge would have easily reached 150,000 cusecs.

As regards the peak of 120,000 cusecs generated by the 1977 storm at Khadeji - Mol confluence it may be added that the peak would have received further increment below the confluence because of extensive and widespread rainfall conditions that prevailed over Malir and the neighbouring catchments. This situation was not associated with 1978 storm.

The observed data of 30.6.1977 at Super Highway Bridge was incomplete as the station was closed on that day by the Surface Water Hydrology Project. There was also no gauging station at National Highway Bridge which was only set up w.e.f. 1.6.1978 when the present study was taken up.

The nature and extent of the rainfall conditions associated with the storm of June - July 1977 suggests that the peak discharge recorded at Super Highwy Bridge might have increased substantially at the National Highway Bridge due to the inflow from Sukkan, Jarando, Turi and Thado nullahs. The maximum flow in Malir river at this location had been estimated between 200,000 to 250,000 cusecs. During 1978 (on 18 August) 200,000 to 230,000 cusecs was estimated to be the peak discharge at this location.

6.2.4 Flood Profile

The flood marks observed after the 1978 floods in Malir river between Karachi- Korangi Road Causeway and National Highway Bridge which are considered more reliable and are available at number of locations have been plotted on the L- Section (Dwg.6-1). It has been observed that;

i. The flood profile runs essentially in parallel to the 50 years return period flood profile as marked in the Interim Report with minor variation from National Highway Bridge upto RD 41 ± (Bund).

ii. From RD 41± to RD 30 ± the flood profile is higher than the 50 years flood profile. In this reach spillage has also occured on the left side. There is extensive shrub growth in this reach.

iii. Between RD 29 and 30 there is an abrupt fall in the flood profile which can be attributed to the major spillage on the upstream side.

iv. From RD 24 ± to RD 0 there is extensive spillage which is the cause for appreciable fall in the flood profile. No meaningful appraisal in this section can possibly be made

High flood level marks observed during the 1978 floods are considered more reliable as compared to the marks of 1977 floods and these are also available at a number of locations.

The high flood marks of 1978 floods in the head reach may be considered as representative H.F.L. as the hydraulic profile is consistant. All the remaining high flood marks downstream upto Karachi-Korangi Road Causeway cannot be considered as such because spillage was extensive throughout the reach.

During 1978 a peak flood in the range of 220,000 cusecs (estimated) passed at Naional Highway Bridge which lies between flood estimated for 20 to 50 years return period. However the flood profile as marked on the L-Section (Ref Dwg.6- 1) runs in close proximity of the 50 years return period profile in the head reach which may be primarily due to the reason that the computed flood profiles indicated for various frequencies are based on the minimum river bed levels for channelization. The average bed levels in this reach are higher than he minimum bed level. If the present section of the river is left undisturbed then the proposed flood profile and re-run the same and report results. Their report was received by

WAPDA during June 1982 with the following recommendations:

i. The Alternative "A" is the best from the hydraulics and fiscal consideration and is recommended for adoption. The Alternative "D" is not feasible as one of the two arms can over develop at the cost of the other and pose problems over the course of time.

ii. The left guide bank of Shaheed-I-Millat Korangi Road Bridge can be extended upstreamward to join the flood embankment as shown in Fig.1 and chunk of land in its wake can be reclaimed but the cost of extension of left guide bank be weighed against the cost of reclaimed land.

iii. The right guide bank of Shaheed-I-Millat Korangi Road can be extended downstream (with a gap) to fully protect the Manzoor Colony flood embankment and the flood embankment closing the right arm at in its head reach against direct attack of the river.

The Model Study Report was re-submitted to the Govt. of Sind and a decision was solicited as to the Alternative Course to be followed in this critical reach of Malir river. In a special meeting of the RFC&D Commission held on July 21, 1982 Alternative "A" which envisages closing of the right hand channel and developing the left hand channel to full capacity was approved with the following suggestions:

i. Varying levels of the river beds to determine the shorter length of the discharge route to the sea.

ii. The most efficient method of channelization and river training should be adopted. Initial investments in proper structures will reduce the cost of maintenance.

iii. Adequate arrangements should be made for drainage of the areas al along the right embankment.

iv. Proper arrangements for maintenance of the infrastructures should be made. This may necessitate creation of a separate organization in KDA and training of maintenance crews under actual flood conditions in for 50 years return period as proposed in Interim Report will represent the historic flood profile with the existing bed configuration.

The embankment elevations are maintained in conformity with historical High Flood Levels with 4 ft of free board in pursuance to decision of the Govt. of Sind.

6.3 WATERWAY

The design width of waterway has been determined using Lacey's Formula for the wetted perimeter for the ultimate discharge i.e. 100 years frequency flood. This works out to be 1770 ft. However a minimum waterway of 2000 ft has been catered for in the construction of embankment.

6.4 BUND SECTIONS

The controlling factor for the saturation gradient in bund section is the duration of high flood. Malir river Is an hill torrent which carries flash flood discharge. Under such hydraulic conditions of flow, a saturation gradient of one in six has been assumed. This has been checked by using Swedish Slip Circle Analysis and the factor of safety found to be more than 1:25 which is safe.

Stone apron is needed as protection against scour and should be used only in those bund reaches where there is danger of scour. Stone pitching is not to be done on general principle. It should be done only in places where stabilisation of the bund profile is required. The extent for the provision of stone pitching and apron etc. has been recommended/identified by the LRL in their model testing report of Malir river. Although stone pitcing has been provided by KDA at along the embankment as protection against high wind, however it is recommended that the training works evolved as a result of model studies of Malir river for its proper channelization through its adopted course should be constructed. For typical section refer Dwg 6-2.

6.5 ALIGNMENT OF EMBANKMENTS

For channelization of Malir river from National Highway Bridge to the estuary refer Dwgs. 6-3, 6-4 for L-Section of right and left side of bunds, Dwg. 6-5 designed L-Section of Malir river and Dwg 6-6 alignment for channelization of Malir river.

For the purpose of description, Malir river downstream of National Highway Bridge has been split into three reaches as follows:

Reach No.1

From the outfall point sea to the under construction bridge on Shaheed-I-Millat Road.

Reach No.2

From under construction bridge to 224,7500 North Grid Line (passing through Salim Farm on the right and Gabool Farm on the left).

Reach No.3

From 224,7500 North Grid Line to National Highway Bridge.

6.5.1 Reach No.1

i. Downstream of Karachi Korangi Causeway

In this reach which in fact is the estuary, the Defence Housing Society Flood Protection Bund is protruding in the main river course on the right and Qayumabad colony has been constructed on the left side which cause an obstruction to the flow in the event of flood.

The two components of river discharge are the velocity of flow and the area through which it passes. If the flood situation downstream of the causeway on the Karachi-Korangi Road is to be eased out, then such action is needed which would enable positive adjustment either in the velocity of flow or the area of discharge. Due to proximity of the sea, the gradient of the river cannot be made steeper for increasing velocity of flow. Further the width of the river channel is also constricted due to the Irrigation Department.

In this connection following may be informed:

i. According to model testing report Alternative 'A' has been found best from the hydraulic consideration. In Alternative 'A' the discharge route downstream of Shaheed-e-Millat road bridge to the sea is 18,900 feet ± long. Compared to this, passage under Alternative 'D' is 20,850 feet ± which is longer by about 950 feet, thus showing improvement in the river bed slope.

ii. As a result of model test studies of various alternatives, Alternative 'A' has been found best from the hydraulic and fiscal considerations. Model testing report indicates various river training works required for the most efficient and economical way to channelise floods.

A pilot cut downstream of Shaheed-i-Millat road bridge has been proposed in Alternative 'A' which involve about 2.25 mcyds which would be used in the construction of embankments in this area. However a total of over 3.5 mcyds can be available upto the designed bed level in this reach which can be utilized for the construction of embankments and other training works.

Substitution of the training works as evolved through model testing by other proper structures would involve extensive studies and more time. If deemed necessary this aspect may be looked into in detail at the time of detailed designing. Apparently initial investment cost would be more if masonary wall/sheet pilling is done in lieu of earthen embankment.

iii. Necessary provision, in consultation with KDA for drainage of the areas along enabnkments has been made in the proposed plan. A cunnettee section for a capacity of 1000 cusecs has been provided in the middle reach of Malir river downstream of Shaheed-i-Millat road bridge from RD 44± to the estuary to cater for normal domestic effluent which at present is passing through the existing Karachi-Korangi Causeway.

iv. Proper arrangements for maintenance of the infrastructure should be made by concerned authorities as outlined under recommendations.

6.5.2 Reach No.2

i. Technical Area of PNS Mehran

The repeated overflow of water from Malir river affecting the Technical Area of PNS Mehran could be contributed to following reasons:

a. due to continuous silting and unchecked growth of bushes/shrubs, the level of the river bed has risen.

b. broken causeway of unused road linked Shahrah-e-Faisal Base with Korangi Creek, north of PNS Mehran, obstructing Natural flow of water.

The proposal for closing of Malir channel which bifurcates towards the south of eastern end of Technical area was discussed with the concerned authorities in detail. It was conveyed that the proposed alignment of flood protection embankment for the right bank of Malir river includes the technical area. Together with the channelization of Chakora nullah which passes through this area, the danger of flooding would be eliminated. The plugging of Malir channel in this context is an interim measure and would not fit in within the overall plan.

Presently the protection to the base from the Malir river floods is provided by a concrete wall about 7'-0" high constructed along the base on the river side which is inadequate for protection against historic floods.

It is not possible to extend concrete wall to the required elevation. To construct an earthen embankment at this location is also not possible because of the constriction of space i.e. on right side there is the periphery road plus buildings and on the river side there is a drain running in close vicinity of it. Furthermore there are number of drainage crossings. It is therefore being proposed to align the bund in this reach farther on the river side on the high ground. The present drainage of the base will continue to be done through the existing drain in its close vicinity. However a sluice gate will be provided at its exit to the main river course through the bund.

On the left side also it follows the high ground as far as possible. However it has been kept in view that at least 200 ft clear distance is kept between the toe of the bund and the edge of the river.

ii. Drigh Colony

In this section waterway is restricted/limited. KDA has already constructed an embankment in this reach on the left bank during 1978 which was just sufficient to hold 1978 floods. The embankment interjects into the waterway at two locations which are vulnerable points. In this reach there is also an existing embankment of about 3000 ft. To relieve pressure and safeguard against any breach in future, it is recommended to move the proposed KDA alignment towards the left as far as possible. Since the ground is low in the close vicinity of the presently constructed embankment, it is necessary to move to the left hitting high ground as far as possible.

On the right side of Malir river the alignment is proposed along the existing embankment on economic reasons.

6.5.3 Reach No.3

i. Drigh Colony to National Highway Bridge

In this reach the alignment generally follows high ground and the railway embankment as closely as possible.

In the reach upstream of National Highway Bridge it is also recommended to channelize the river and Thado nullah for safe passage of the computed/designed floods.

Defence Society Bund on one side and Qayumabad on the other side. Consequently when flood protection bunds on the upstream of the causeway are completed, higher flood heights will be experienced on the downstream, thus making the Defence Society area more vulnerable to inundation by the flood water.

For channelization of the Malir river a minimum waterway of about 2000 ft has been provided in the proposals for the left and right bund alignment in the reach from National Highway Bridge to Karachi-Korangi Road Causeway. Beyond it is in fact the estuary area. The slope of ground in this reach is very flat. In case same water depth as upstream of Karach-Korangi Causeway is maintained then about 3000 ft of waterway is required to safely pass this magnitude of flood. Presently the available waterway is 500 ft ± which is too small.

To cater for 3000 ft of waterway will require abandoning of part of Phase 4 and Phase 7 of Defence Housing Society located in the estuary. Since this is a very critical issue as the services in the area have already been developed involving lot of expenditure, therefore it was discussed in detail at various levels with the Govt. of Sind. The Society agreed to allow expansion in the waterway upto the road side running parallel to the existing protection bund which means a total waterway of about 1000 ft.

ii. Manzoor Colony And Mehran Town

In this reach Manzoor Colony, which is quite sizeable in area, has been constructed on the right side, in the river bed just on the downstream side of the under construction Shaheed-i-Millat Road Bridge. On the left side of the river Mehran Town has been laid out. In view of the high cost of development of services and the sale of plots to the Pakistanis living abroad, KDA insisted that it should not be encroached upon for bund construction.

For safe passage of flood runoffs in this reach i.e., downstream of Shaheed-i- Millat Road Bridge 4 (A,B,C & D) alternative channelized courses have been model tested at Nandipur Hydraulic Research Station. These alternative proposals have been made by WAPDA in consultations with KDA, D.H.S. and I&P Deptt. and are described below.

Alternative-A

The existing right hand channel opposite Defence Society area is assumed choked by plugging it upstream of the existing causeway on Karachi-Korangi Road and the left hand channel (breach) is developed to the full capacity of the river. Road Bridge with appropriate guide banks has been provided for the Karachi-Korangi Road. (See plan for Alternative-A) Fig.6-1.

Alternative-B

In this alternative the right hand channel is developed by setting back the left bank of the river through Qayumabad and providing flood embankment in the receeded position. In this alternative the existing causeway on Karachi-Korangi Road is replaced by a proper bridge with guide banks. (See Plan for Alternative- B) Fig.6-2.

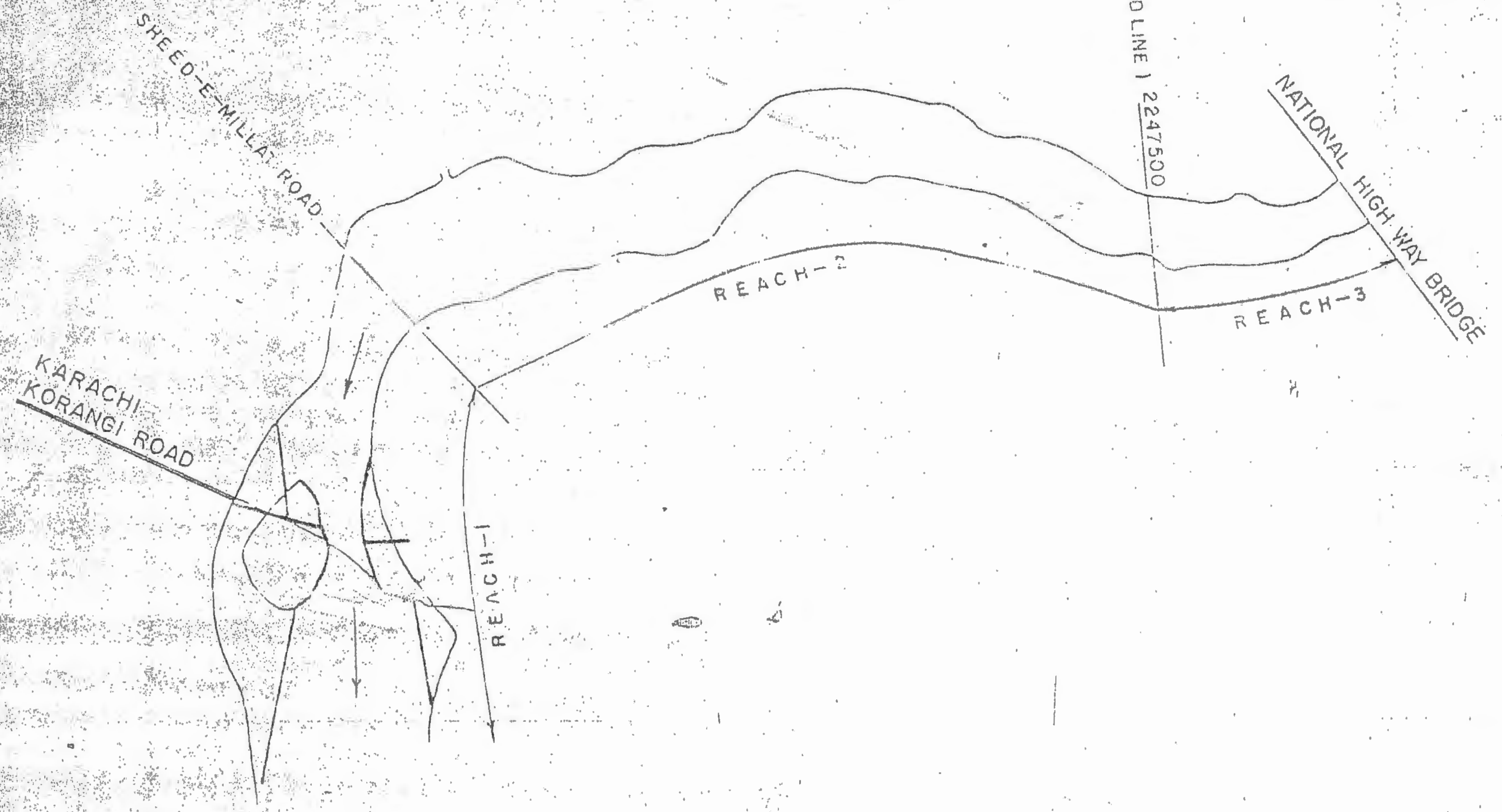
Alternative-C

In this alternative the right hand channel is developed setting back the right bank of the river and providing embankment along the receeded positon of the river. The existing left bank of the right hand channel is kept intact and protected with flood embankment. In this alternative quite a big chunk of Defence Housing Society area is encroached by the river. Similarly quite a number of houses in Akhtar Colony need to be dismantled to widen the right channel. The causeway on Karachi-Korangi Road is to be replaced with bridge and proper guide banks. (See Plan for Alternative-C) Fig. 6-3.

Alternative-D

In this alternative both the channels are kept open, the alignment of embankment of the left hand channel is almost identical to Alternative "A" except the difference in certain reaches. In the right hand channel the alignment of the left bank was the same as existing at site whereas the alignment of the right bank was the same as in Alternative "B". (See plan for Alternative-D). Fig. 6-4.

The merits and demerits of Alternative A, B, C & D are detailed below:

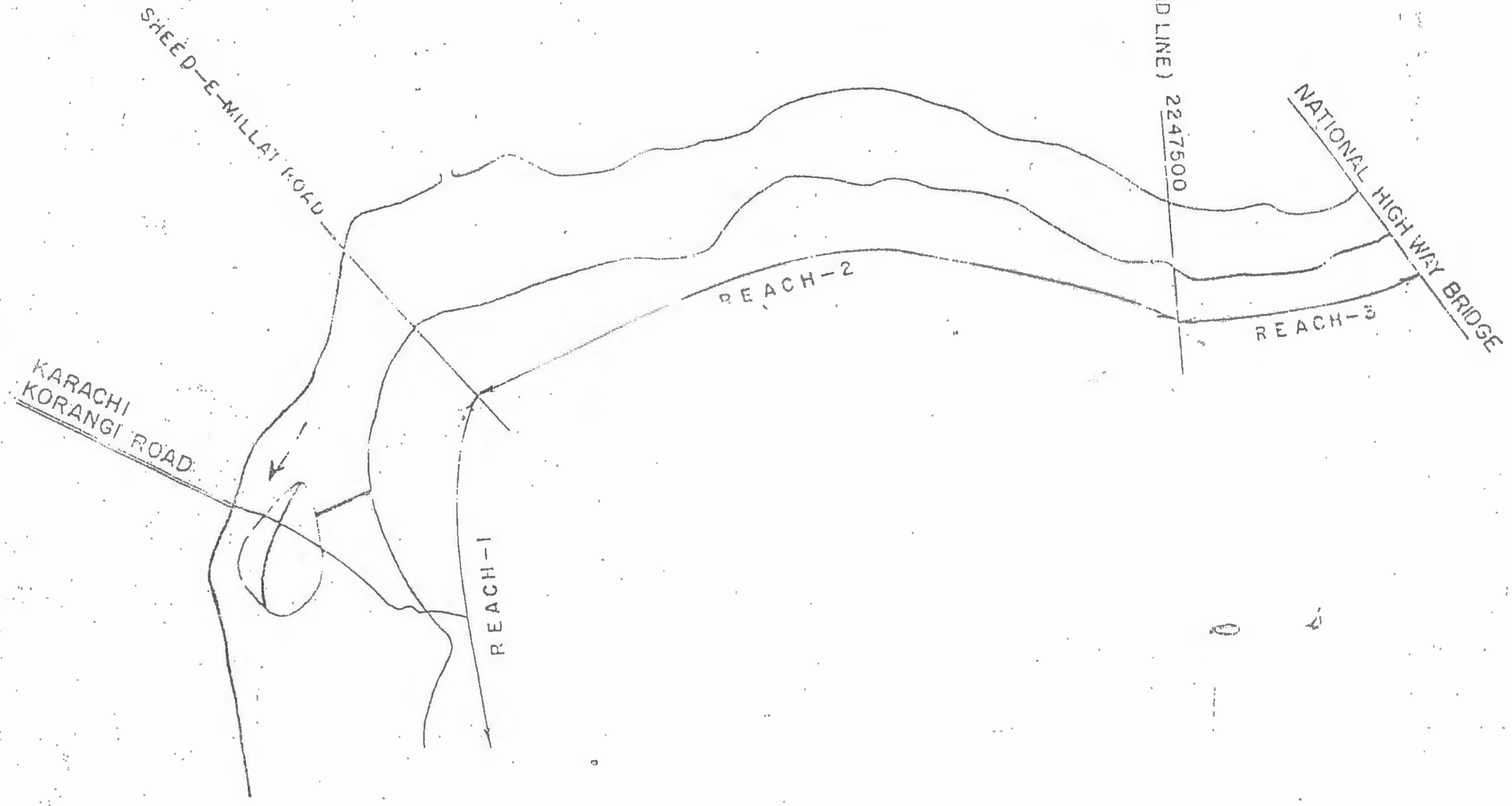


KEY MAP

KARACHI FLOOD CONTROL PLAN

ALTERNATIVE — A

FIG. 6-1

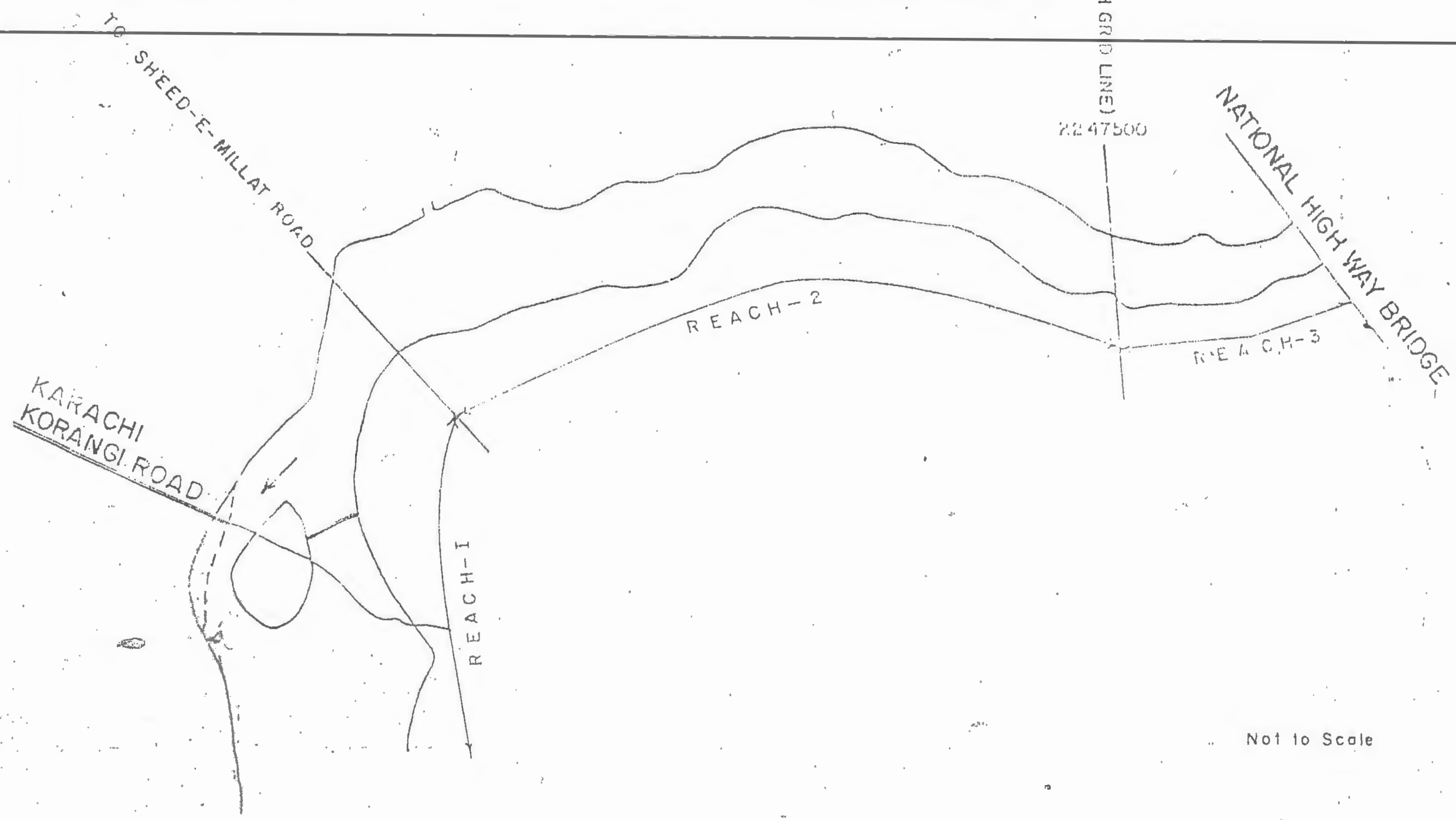


KEY MAP

KARACHI FLOOD CONTROL PLAN

ALTERNATIVE—B

FIG.6-2

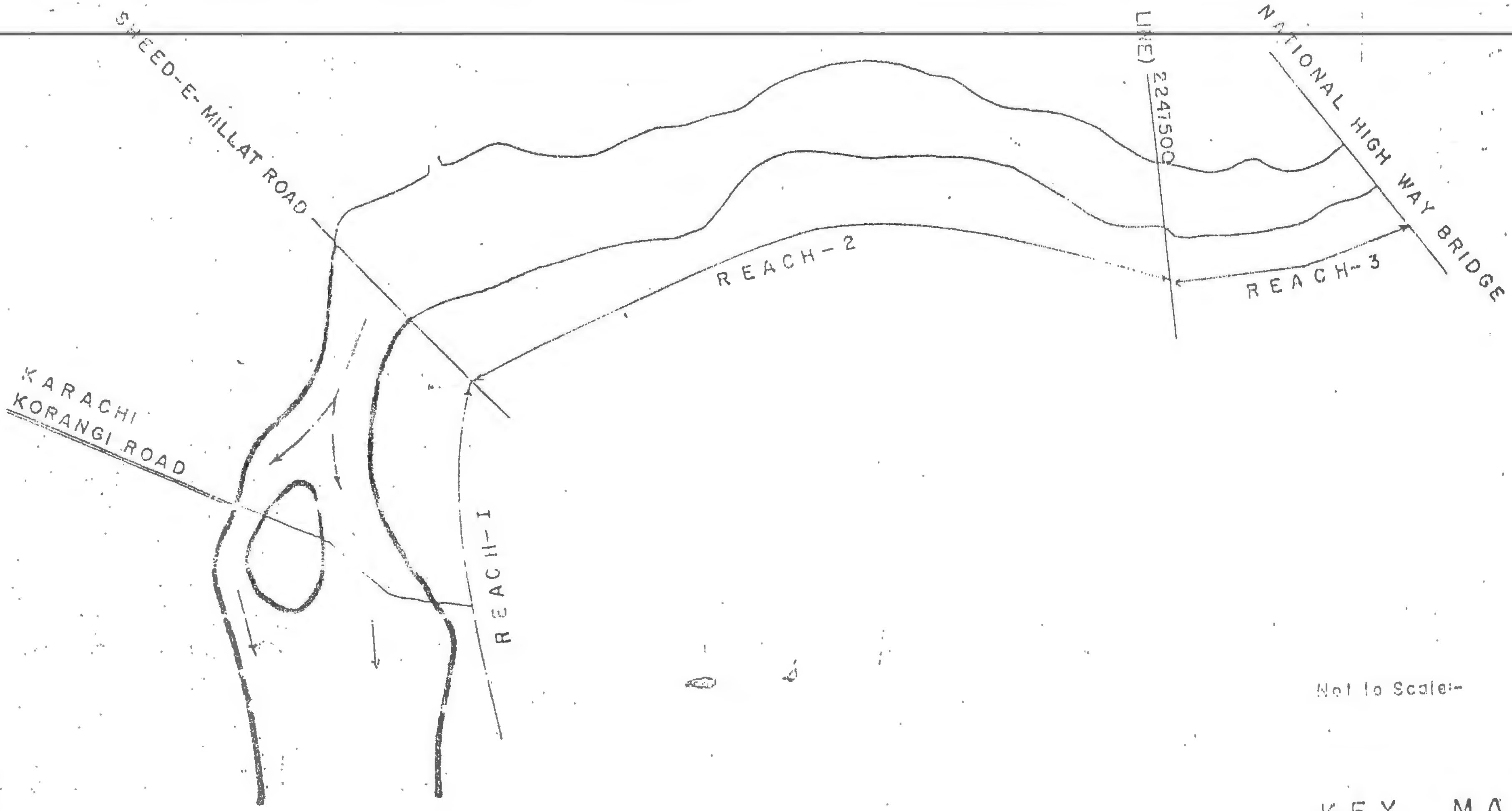


KEY MAP

KARACHI FLOOD CONTROL PLAN.

ALTERNATIVE —C

FIG. 6-3



KEY MAP

KARACHI FLOOD CONTROL PLAN.

ALTERNATIVE—D

FIG: 5-4

i. Alternatives "A" & "D" do not require any dislodgement of the existing population whereas in alternatives "B" & "C" the dislodgement of population is involved.

ii. The guide banks of the bridge on Karachi-Korangi Road will be shortest for alternative "A".

iii. With alternative "A" no slope protection is required upto 325000 cusecs for the two embankments excepting in some reach opposite Manzoor Colony whereas in alternative "D" the slope protection all along the right bank of right hand channel and in the vicinity of corner of Qayumabad Island is required.

iv. The bridge on right hand channel on Karachi-Korangi Road will involve additional expenditure in alternative "D".

v. The alternative "A" is the best from the hydraulic and fiscal consideration whereas alternative "D" is the 2nd best.

The comparative cost estimates of the 4 alternatives have been prepared. The comparative cost of Alternative-A is Rs 104.5 million, Alternative-B is Rs 244.1 million, Alternative-C is Rs 139.2 million and Alternative-D is Rs 134.4 million.

The above comparison shows that Alternative - A is cheaper than Alternative-B, C & D by Rs 139.6 million, 34.7 million and 29.9 million respectively.

A meeting was held with the Govt. of Sind to discuss the above Model Study Report on Oct. 25, 1981 and it was decided:

1. The proposed bridge on the Shaheed-i Millat Korangi Road should be re-located in such a manner that it provides the best approach to the river.

2. The proposed flood embankments along the left bank of the Malir river in the vicinity of Mehran Town should be re-aligned so as to provide protection to the major part of area of the town.

3. A leading channel for guiding the entire flood flows through the left arm of the river upstream of the Causeway on the Karachi-Korangi road should be provided.

4. After these changes in the model, it would be run for Alternative-A and the results compiled.

5. After carrying out the modification at Serial Nos.1 and 2 above, the model will also be test run for Alternative D.

6. The cost estimates of Alternative-A will be re-worked out with the changes mentioned at Sr.Nos. 1, 2 and 3.

7. While re-working out the cost estimates of Alternative-A, below mentioned requirements will be kept in view.

    i. Stone pitching will be provided all along the flood embankment on the right bank of the Malir river downstream of the proposed sloping spur up to its junction with Qayumabad.

ii. The flood embankment across the right arm of the Malir river will be designed as a low height dam, minus the drainage arrangement

iii. The cost of earth work Involved In providing the leading channel will be Included In the cost estimates.

8. After receipt of this Information from WAPDA the case will be referred to the Karachi Flood Control and Drainage Commission incorporating the views of the WAPDA and I & P Deptt. Sind for decision by the Commission.

The Irrigation Research Insitute, Nandipur was requested to incorporate the above changes in the Model of Malir river.

6.6 TRIBUTARIES

Chakora, Peer Bukhari and Green Town nullahs are the three major tributaries of Malir river downstream of the National Highway Bridge.

6.6.1 Chakora Nullah

Chakora nullah is a tributary of Malir river situated on its right bank and outfalls into main stream downstream of Drigh Colony. Its catchment area is about 17 sq. miles. Maximum discharge of 100 years frequency works out to be about 9000 cusecs.

Present nullah section is insufficient to cater for the maximum design discharge as computed above. Even during recent floods it inundated adjoining areas of PNS Mehran Base and other areas along its course. It is therefore necessary to channelize Chakora nullah by Widening and by raising its banks to the required elevation from railway crossing to its outfall into Malir river. In the first Instant banks will be raised to provide protection against historic floods as is done in the case of Malir river which can later be raised for ultimate protection against 100 years flood after due monitoring. Back water effect of Malir river into Chakora nullah is a critical element for design of embankment elevation. Refer Dwg. 6-7 for longitudinal section and Dwg. 6-8 for typical retaining wall section for Chakora nullah.

6.6.2 Peer Bukhari Nullah

Peer Bukhari nullah outfalls into Malir river just downstream of PNS Mehran. Its catchment area is about 4.2 sq. miles which can generate a flood of 2169 Cs. on 100 years recurrence interval

Similar to the channelization of Chakora nullah, the bank of this nullah are also proposed to be made safe for the passage of historic floods in Malir river in the first instant and ultimately for 100 years floods. Refer Dwg. 6-9 for L- Section & Dwg. 6-10 for typical retaining wall section at outfall of Peer Bukhari nullah.

6.6.3 Green Town Nullah

Historic discharge of this nullah is estimated to be 1192 cusecs. It is proposed to channelize this nullah downstream of the existing road bridge 1050 ± from the right embankment of Malir river to safeguard the afflux from the Malir river against historic flood elevation of 45' ±. However for proper crossing over the Malir river embankment a drainage inlet-cum-bridge consisting of 15 boxes of size 6'x4' has been provided for this nullah. For extra safety gates have been catered for. Refer Dwg.6-11 for L-Section of Green Town nullah.

6.7 LOCAL DRAINAGE

Present plan is only confined to the control and channelization of Malir river and its major tributaries downstream of National Highway Bridge. Various nullahs and drains already in operation and under planning would be planned for their inlets into the Malir river in accordance with the flood hydrograph contained in this report. Exact locations of these inlets with sluices will be decided by the KDA. The sizes determined in accordance with the design flows are given under Project Cost.

A cunnettee for a capacity of 1000 cusecs has been provided in the middle reach of Malir river downstream of Shaheed-e-Millat road bridge from RD 44± to the estuary to cater for normal domestic effluent which at present is passing through the existing Karachi-Korangi Causeway.

6.7.1 Tannery Area

In the tannery area along left bank of Malir river it is suggested to provide an inlet consisting of 3 No. boxes of size 6'x4' for local drainage into Malir river.

6.7.2 National Refinery

The local drainage in this area will run in vicinity along the left embankment of Malir river and drain independently into the sea.

6.7.3 Mehran Town

Presently the local drainage in this area is not definite and remains under the planning of the K.D.A. It is recommended that the drainage through this area be taken along the side of Malir embankment directly into the Sea without inletting into the Malir river.

6.7.4 PNS Mehran and Adjoining Area

The local drainage from Shah Faisal Base and PNS Mehran technical area would continue to be channeled through Chakora and Peer Bukhari nullahs. Proper inlets into the nullahs would be provided in the proposed bunds. A drainage culvert 6 feet wide has been proposed under approach road to Shaheed-i-Millat road bridge for the drainage of Dada Bhoy Town into the existing channel which would ultimately outfall into the estuary near RD 63±.

6.7.5 Area Downstream of Peer Bukhari Nullah Includes Manzoor Colony, Kashmir Colony and Defence Housing Society

The local drainage will continue to flow through the existing drainage line on the right side of the proposed bund along Malir river. It will join the existing Malir river channel passing through Karachi-Korangi Causeway which will continue to be maintained as a storm channel for the adjoining city areas. Historic flood discharge of this area has been estimated as 1375

6.6.3 Green Town Nullah

Historic discharge of this nullah is estimated to be 1192 cusecs. It is proposed to channelize this nullah downstream of the existing road bridge 1050 ± from the right embankment of Malir river to safeguard the afflux from the Malir river against historic flood elevation of 45' ±. However for proper crossing over the Malir river embankment a drainage inlet-cum-bridge consisting of 15 boxes of size 6'x4' has been provided for this nullah. For extra safety gates have been catered for. Refer Dwg.6-11 for L-Section of Green Town nullah.

6.7 LOCAL DRAINAGE

Present plan is only confined to the control and channelization of Malir river and its major tributaries downstream of National Highway Bridge. Various nullahs and drains already in operation and under planning would be planned for their inlets into the Malir river in accordance with the flood hydrograph contained in this report. Exact locations of these inlets with sluices will be decided by the KDA. The sizes determined in accordance with the design flows are given under Project Cost.

A cunnettee for a capacity of 1000 cusecs has been provided in the middle reach of Malir river downstream of Shaheed-e-Millat road bridge from RD 44± to the estuary to cater for normal domestic effluent which at present is passing through the existing Karachi-Korangi Causeway.

6.7.1 Tannery Area

In the tannery area along left bank of Malir river it is suggested to provide an inlet consisting of 3 No. boxes of size 6'x4' for local drainage into Malir river.

6.7.2 National Refinery

The local drainage in this area will run in vicinity along the left embankment of Malir river and drain independently into the sea.

6.7.3 Mehran Town

Presently the local drainage in this area is not definite and remains under the planning of the K.D.A. It is recommended that the drainage through this area be taken along the side of Malir embankment directly into the Sea without inletting into the Malir river.

6.7.4 PNS Mehran and Adjoining Area

The local drainage from Shah Faisal Base and PNS Mehran technical area would continue to be channeled through Chakora and Peer Bukhari nullahs. Proper inlets into the nullahs would be provided in the proposed bunds. A drainage culvert 6 feet wide has been proposed under approach road to Shaheed-I-Millat road bridge for the drainage of Dada Bhoy Town into the existing channel which would ultimately outfall into the estuary near RD 63±.

6.7.5 Area Downstream of Peer Bukhari Nullah Includes Manzoor Colony, Kashmir Colony and Defence Housing Society

The local drainage will continue to flow through the existing drainage line on the right side of the proposed bund along Malir river. It will join the existing Malir river channel passing through Karachi-Korangi Causeway which will continue to be maintained as a storm channel for the adjoining city areas. Historic flood discharge of this area has been estimated as 1375 cusecs and for its disposal a drainage consisting of 18 boxes of size 6'x4' has been proposed in the right embankment at RD 63± into the estuary.

There is no need of converting the existing low level causeway into high level or bridge for the following reasons:

a. There are 88 No, 18" dia pipes in the low level causeway whose discharging capacity is sufficient to pass the historic discharge under free fall condition.

b. In case water level rises, in the downstream side, the discharging capacity through the above pipe would be reduced. However in the close vicinity of these pipes there is a box culvert consisting 5 boxes of size 2.5'x3.5' in addition to the main bridge of 36 spans of about 12.5' each with large discharging capacity.

In case of high floods in Malir river pumping from the local drainage outfalling into Malir river/estuary is carried out by the concerned agencies of Karachi Metropolitan to safeguard flooding of the adjoining areas. It is recommended that an adequate pumping provision at 75% of the design historic discharge at the following locations be catered for.

(i)	Area downstream of Peer Bukhari Nullah including defence Housing Society	1178 Cusecs
(ii)	Area around Green Town nullah	894 Cusecs
(iii)	Area along left embankment near tanneries	176 Cusecs

CONSULTANCY / TRANSACTION ADVISROY SERVICES
FOR DEVELOPMENT OF MALIR EXPRESSWAY
(From Motorway, M9 to KPT Interchange)
FINAL REPORT

ANNEXURE E

Horizontal And Vertical Control Points Data

(Based on the Annexure D of Topographic Survey Report)

Survey Control Data

LOOP-1

Station No.	Easting (m)	Northing (m)	Elevation (m)
ME90	327299.286	2757563.554	-
ME89	327233.986	2757431.199	54.948
EX1	326795.518	2758558.889	-
EX2	326594.646	2758714.682	-
KQ27	326617.509	2758737.463	56.123
KQ26	326854.205	2758988.544	57.088
KQ25	327112.255	2759288.259	68.361
KQ24	327529.931	2759789.687	60.543
KQ23	327800.241	2760142.099	62.064
KQ22	327929.813	2760288.500	62.529
KQ21	328242.706	2760686.914	63.810
KQ20	328619.799	2761180.816	66.403
KQ19	328745.079	2761288.085	67.062
KQ18	328977.287	2761382.484	66.239
KQ17	329095.900	2761421.978	67.504
KQ16	329374.640	2761716.690	68.856
KQ15	329554.414	2761863.956	69.501
KQ14	330029.633	2762267.266	71.966
KQ13A	330476.757	2762505.077	-
KQ13	330712.180	2762636.989	75.251
KQ12	330931.769	2762746.254	76.033
KQ11	331260.083	2762929.646	77.129
KQ10	331458.952	2763047.095	85.051
KQ9	331834.913	2763253.426	-
KQ8	331921.537	2763420.639	79.733
KQ7	332020.119	2763585.414	80.569
BM4	332046.704	2763632.565	-
BM3	332146.841	2763797.711	-
KQ6	332446.526	2763966.033	79.097
KQ5	332826.005	2764145.922	80.431
KQ4	333243.689	2764238.350	84.013
KQ3	333786.446	2764497.517	85.896
KQ2	334250.526	2764631.242	85.365
BM2	334360.721	2764654.095	-
EABM1	334537.563	2764631.311	-
KQ1	334630.413	2764623.387	96.798
ME130	334958.516	2764492.687	100.171
ME131	335369.095	2764786.792	-
ME132	335457.972	2765006.038	-

LOOP-2

Station No.	Easting (m)	Northing (m)	Elevation (m)
KQ27	326617.509	2758737.463	56.123
KQ26	326854.157	2758988.596	-
KQ28	326461.014	2758602.757	55.483
KQ29	326264.510	2758429.589	54.32
KQ30	326181.889	2758306.008	53.922
KQ31	326152.256	2758180.879	55.244
KQ32	325957.884	2758094.639	52.603
KQ33	325841.682	2758100.785	52.232
KQ34	325752.958	2757636.322	51.403
KQ35	325474.713	2757542.249	51.072
KQ36	325147.218	2757472.750	49.871
KQ37	324995.055	2757249.756	49.824
KQ38	324899.214	2757085.581	47.480
KQ39	324873.269	2756877.074	47.024
KQ40	324840.652	2756599.281	46.896
BM5(LSIDE)	324854.032	2756587.608	46.620
BM6(LSIDE)	325069.824	2756535.891	46.761
ME82	325493.042	2756325.032	46.836
KQ41	324840.255	2756285.673	36.225
KQ42	324753.446	2756058.279	35.526
KQ43	324692.454	2755964.058	38.430
KQ44	324447.180	2755689.955	43.790
KQ45	324361.279	2755578.389	43.284
KQ46	324048.645	2755490.685	43.96
KQ47	323890.270	2755438.351	42.973
KQ48	323762.493	2755348.883	41.470
KQ49	323543.630	2755155.442	40.093
KQ50	323480.822	2754960.499	38.836
KQ51	323046.635	2754630.417	36.877
KQ52	322892.344	2754495.734	36.808
KQ53	322672.113	2754325.578	36.423
KQ54	322521.447	2754145.315	37.054
KQ55	322279.592	2753816.920	34.852
KQ56	322110.851	2753610.925	34.555
KQ57	321758.967	2753248.262	35.914
KQ58	321488.460	2752597.035	24.896
KQ59	321123.129	2752477.362	25.384
KQ60	320875.701	2752203.556	27.527
KQ61	320761.194	2751871.186	25.767
KQ62	320603.272	2751737.142	22.076
KQ63	320121.231	2751327.123	23.955
KQ64	319933.693	2751593.958	24.164
KQ65	319522.121	2751386.107	21.278
KQ66	319491.395	2751271.696	22.174
KQ67	319399.633	2751302.629	21.246
KQ68	319155.089	2751249.705	20.353
ME53	318949.308	2751196.294	-
ME54	319084.859	2751203.303	20.371
BM8(LSIDE)	319070.411	2751150.212	25.439

LOOP-3

Station No.	Easting (m)	Northing (m)	Elevation (m)
ME54	319084.906	2751203.277	-
BM8 R(SIDE)	319070.460	2751150.176	25.439
KQ69	318962.773	2751231.613	19.732
KQ70	318546.870	2751300.859	28.314
KQ71	318186.849	2751140.942	17.239
KQ72	318007.713	2751160.312	17.527
KQ73	317658.510	2751072.726	17.016
KQ74	317494.669	2751069.306	17.234
KQ75	317167.253	2751055.121	16.001
KQ76	316630.758	2751015.745	16.479
BM7	316604.952	2750993.009	16.436
BM-8(L)SIDE	316449.540	2751167.468	21.327
ME42OLD	316373.604	2750595.264	-
KQ77	316290.636	2751253.506	20.653
KQ78	316009.765	2751398.098	19.747
KQ79	315777.448	2751448.303	15.584
KQ80	315664.209	2751716.345	19.078
KQ80A	315187.824	2751740.832	15.013
KQ81	314763.490	2751850.754	19.873
KQ82	314637.367	2751906.811	20.183
KQ83	314382.900	2751991.091	13.544
KQ84	314342.310	2752101.514	18.986
KQ85	314029.248	2752342.418	-
KQ86	313573.263	2752330.863	18.18
KQ87	313324.966	2752278.692	12.352
KQ88	312686.451	2752205.694	18.616
KQ89	312154.469	2752350.773	16.302
KQ90	311903.269	2752024.668	16.122
BM9(L SIDE)	311526.263	2751954.272	15.521
BM10(L SIDE)	311223.080	2751914.150	15.381
KQ91	310961.086	2751919.944	15.193
KQ92	310693.613	2751901.170	14.973
KQ93	310592.562	2751657.498	15.007
EX1	309846.870	2750596.414	-
ME12	309680.866	2750552.416	14.613
ME11	309092.689	2750406.423	-

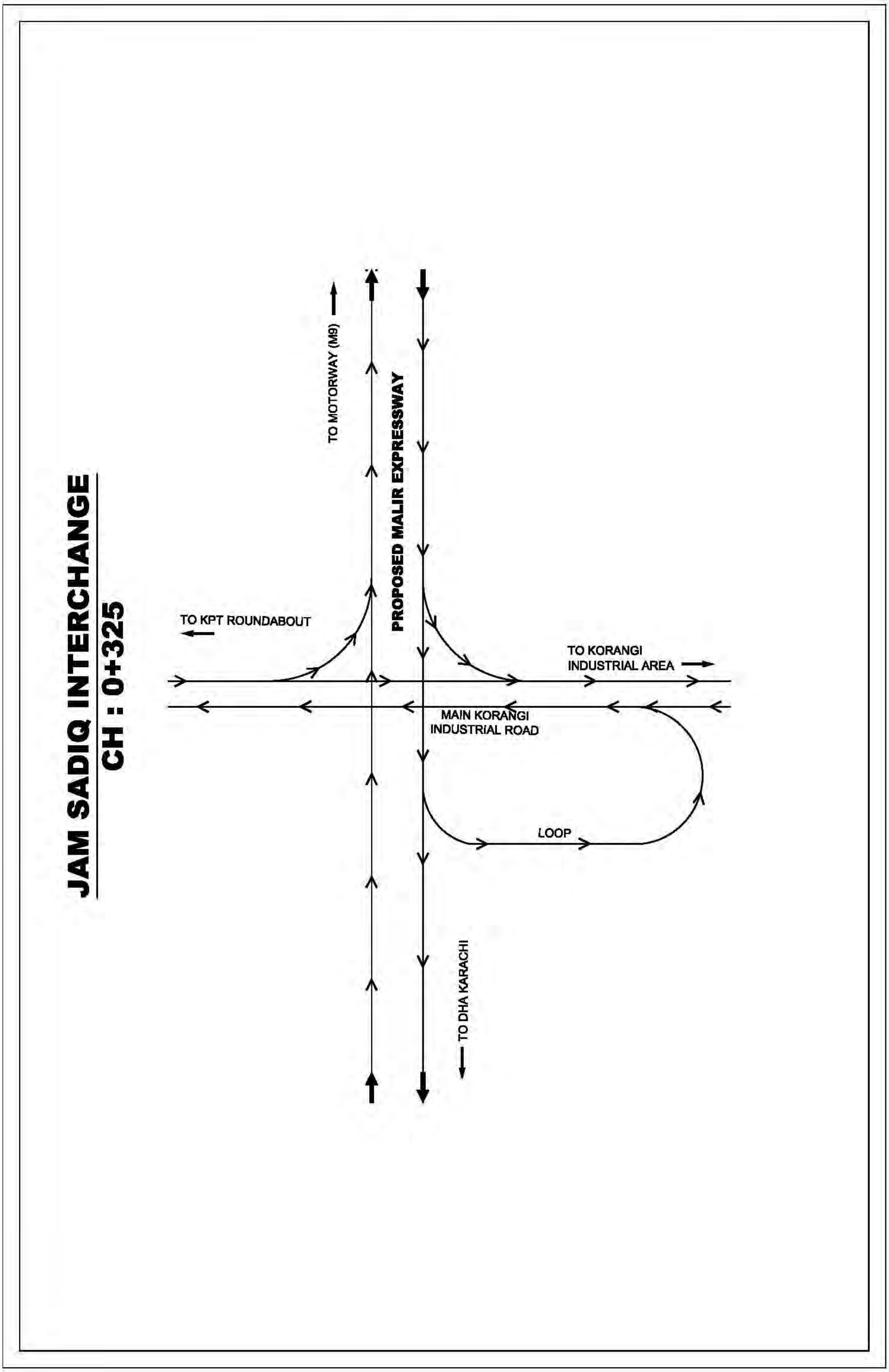
LOOP-4

Station No.	Easting (m)	Northing (m)	Elevation (m)
ME1	307234.930	2747860.776	12.117
BM2	307290.498	2747875.654	5.403
QK5	306593.926	2747742.144	12.421
QK6	306531.772	2748155.920	10.796
QK7	306568.940	2748560.555	8.821
QK8	306706.196	2748931.519	10.731
QK9	306869.161	2749295.231	12.211
QK10	306979.063	2749583.899	12.423
QK11	307147.308	2750140.752	8.343
QK12	307126.594	2750331.916	8.889
QK13	307019.883	2750676.788	12.900
QK14	307328.243	2751110.100	13.078
QK15	307778.421	2751317.112	9.872
QK16	308388.022	2751501.804	13.791
QK17	309389.587	2751583.613	14.219
QK18	309579.051	2751584.203	14.335
QK19	309930.368	2751566.840	14.444
QK20	310304.268	2751616.019	14.797
QK21	310351.059	2751630.820	14.908
QK22	310509.175	2751624.922	14.959
KQ92	310693.688	2751901.173	14.973
KQ91	310961.077	2751919.941	15.193

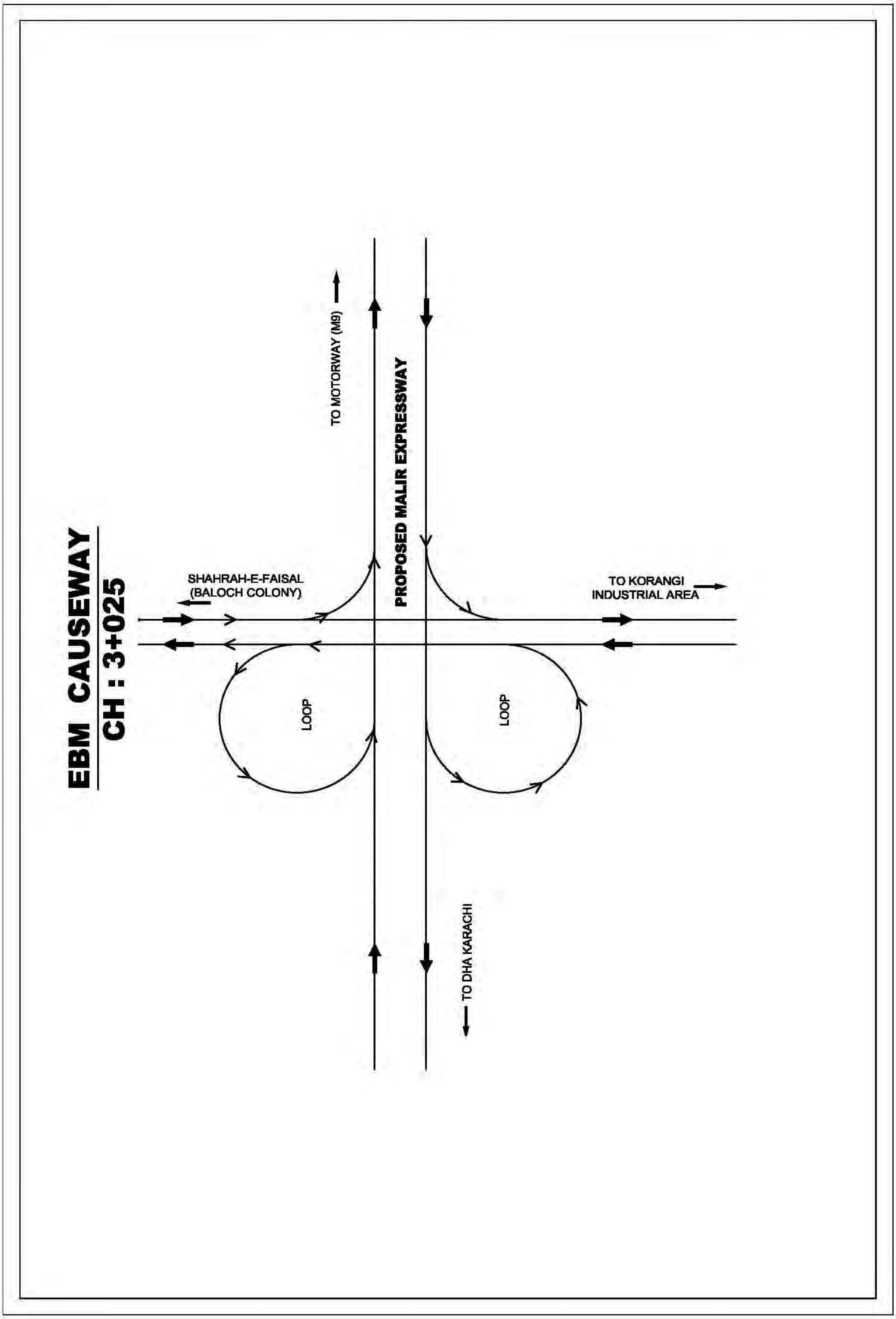
ANNEXURE F

INTERCHANGE

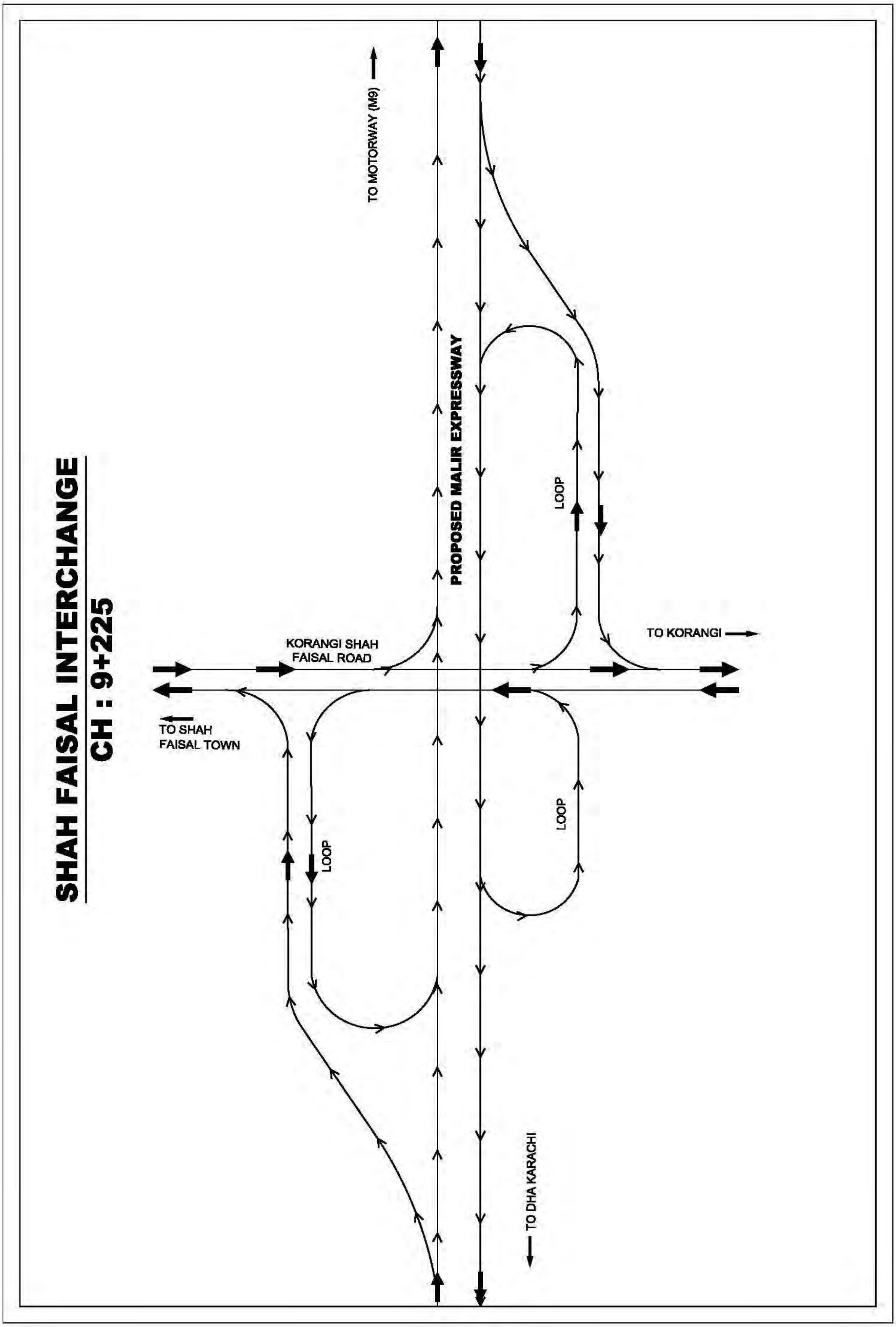
1. JAM SADIQ INTERCHANGE



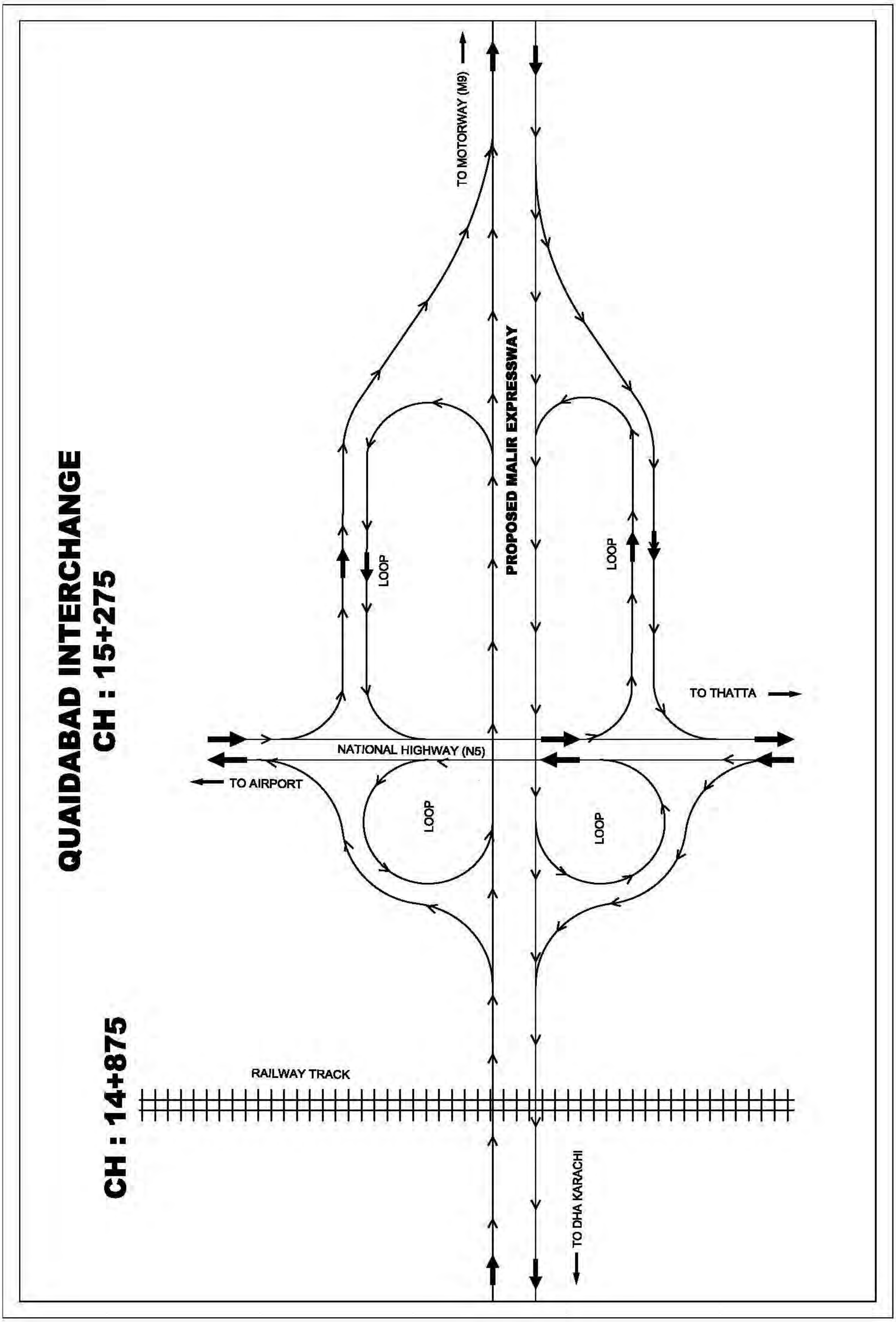
2. EBM INTERCHANGE



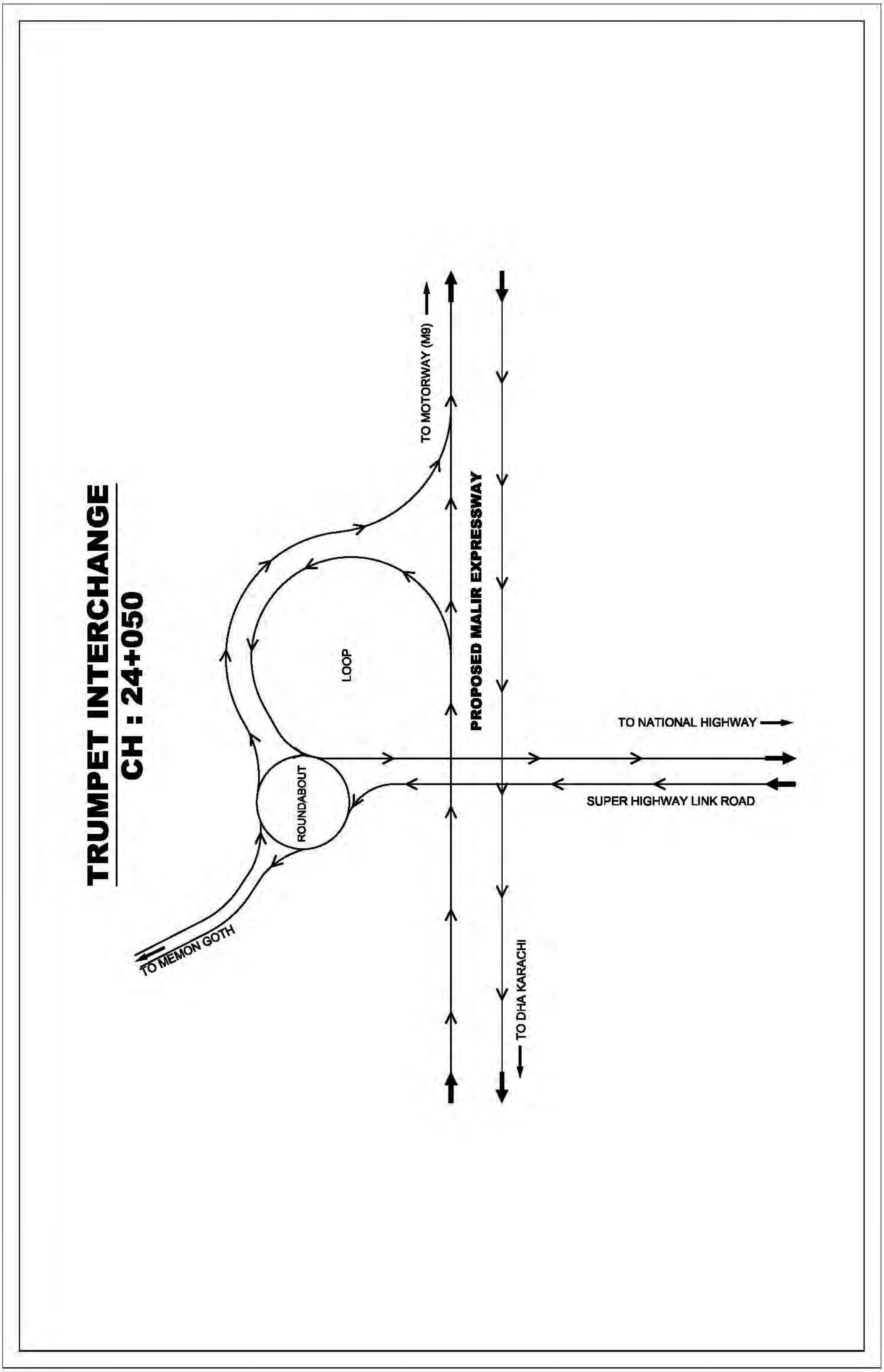
3. SHAH FAISAL INTERCHANGE



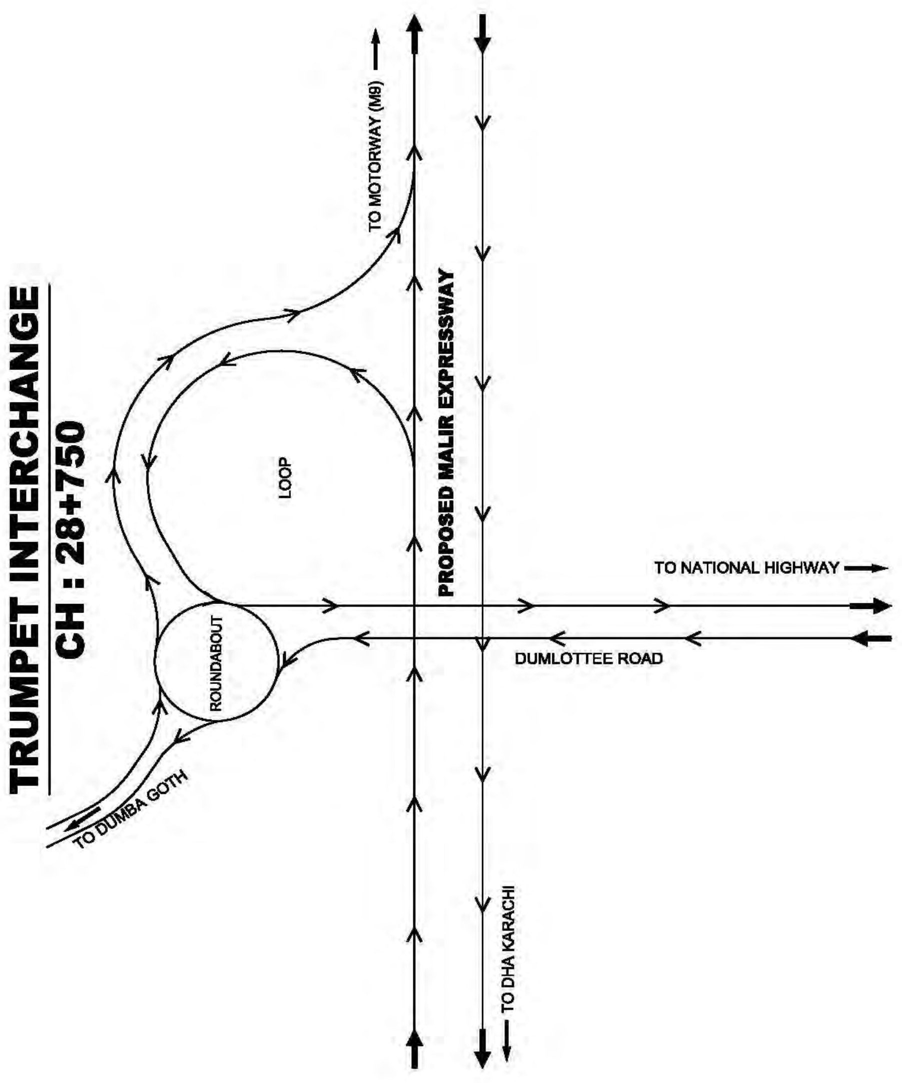
4. QUAIDABAD INTERCHANGE



5. TRUMPET-1


TRUMPET INTERCHANGE
CH : 24+050
TO MOTORWAY (M9)
PROPOSED MALIR EXPRESSWAY
LOOP
ROUNDABOUT
TO NATIONAL HIGHWAY
SUPER HIGHWAY LINK ROAD
TO MEMON GOTH
TO DHA KARACHI

6. TRUMPET-2



TRUMPET INTERCHANGE
CH : 28+750
TO MOTORWAY (M9)
PROPOSED MALIR EXPRESSWAY
LOOP
ROUNDABOUT
TO NATIONAL HIGHWAY
DUMLOTTEE ROAD
TO DUMBA GOTH
TO DHA KARACHI

CONSULTANCY / TRANSACTION ADVISROY SERVICES
FOR DEVELOPMENT OF MALIR EXPRESSWAY
(From Motorway, M9 to KPT Interchange)
FINAL REPORT

ANNEXURE G

LIST OF STRUCTURES

1. BOX AND PIPE CULVERTS

SR.No.	STATION	DESCRIPTION	SR.No.	STATION	DESCRIPTION
1	3+418	BC / PC	34	20+473	BC / PC
2	3+503	BC / PC	35	20+573	BC / PC
3	3+713	BC / PC	36	20+793	BC / PC
4	3+793	BC / PC	37	20+833	BC / PC
5	3+873	BC / PC	38	20+883	BC / PC
6	4+433	BC / PC	39	25+443	BC / PC
7	4+583	BC / PC	40	25+673	BC / PC
8	4+663	BC / PC	41	26+373	BC / PC
9	5+373	BC / PC	42	26+933	BC / PC
10	5+458	BC / PC	43	26+993	BC / PC
11	5+543	BC / PC	44	27+213	BC / PC
12	5+703	BC / PC	45	27+438	BC / PC
13	7+463	BC / PC	46	27+563	BC / PC
14	8+408	BC / PC	47	27+863	BC / PC
15	8+873	BC / PC	48	28+043	BC / PC
16	9+673	BC / PC	49	29+183	BC / PC
17	10+273	BC / PC	50	30+033	BC / PC
18	10+393	BC / PC	51	30+233	BC / PC
19	10+623	BC / PC	52	31+263	BC / PC
20	10+733	BC / PC	53	32+773	BC / PC
21	11+973	BC / PC	54	32+883	BC / PC
22	12+403	BC / PC	55	33+173	BC / PC
23	13+783	BC / PC	56	33+643	BC / PC
24	13+993	BC / PC	57	34+053	BC / PC
25	14+273	BC / PC	58	34+203	BC / PC
26	14+753	BC / PC	59	34+283	BC / PC
27	14+813	BC / PC	60	34+373	BC / PC
28	15+873	BC / PC	61	34+493	BC / PC
29	16+833	BC / PC	62	34+673	BC / PC
30	17+083	BC / PC	63	34+933	BC / PC
31	20+103	BC / PC	64	35+023	BC / PC
32	20+133	BC / PC	65	35+353	BC / PC
33	20+453	BC / PC	66	35+853	BC / PC
TOTAL No. OF BOX CULVERT / PIPE CULVERT					**20 / 40**

2. UNDERPASS

SR.No.	STATION	UNDERPASS	SIZE (m)
1	2+863	Underpass	6.4 x 4.5 x 40
2	4+173	Underpass (Road/Track)	6.4 x 4.5 x 40
3	10+373	Underpass (Cultivation Field & Nala)	6.4 x 4.5 x 40
4	10+473	Underpass (Nala)	6.4 x 4.5 x 40
5	10+923	Underpass (Link Road)	6.4 x 4.5 x 40
6	13+423	Underpass x 2 (Link Road)	6.4 x 4.5 x 40
7	16+673	Underpass (Habitance Area)	6.4 x 4.5 x 40
8	18+633	Underpass (Link Road, Malir Shah Latif)	6.4 x 4.5 x 40
9	25+273	Underpass x2 (Link Road), Malir Dam X-ing	6.4 x 4.5 x 40
10	26+623	Underpass (Link Road)	6.4 x 4.5 x 40
11	32+173	Underpass (Link Road)	6.4 x 4.5 x 40
12	33+623	Underpass (Link Road)	6.4 x 4.5 x 40
Total No. of Underpass =14 Nos.			

3. CATTLE CREEP

SR.No.	STATION	CATTLE CREEP	SIZE (m)
1	1+273	Cattle Creep Kacha track (Pipe)	3.0 x 3.0 x 40
2	6+573	Cattle Creep (Bike Track)	3.0 x 3.0 x 40
3	7+623	Cattle Creep (Bike Track)	3.0 x 3.0 x 40
4	12+673	Cattle Creep (Cultivation Field)	3.0 x 3.0 x 40
5	13+923	Cattle Creep (Cultivation Field)	3.0 x 3.0 x 40
6	14+248	Cattle Creep (Cultivation Field)	3.0 x 3.0 x 40
7	19+473	Cattle Creep (Link Road)	3.0 x 3.0 x 40
8	21+373	Cattle Creep (Link Road)	3.0 x 3.0 x 40
9	22+643	Cattle Creep (Cultivation Field)	3.0 x 3.0 x 40
10	30+673	Cattle Creep (Cultivation Field)	3.0 x 3.0 x 40
Total No. of Cattle Creep = 10 Nos.			

4. INTERCHANGE

SR.No.	STATION	INTERCHANGE
1	0+325	Jam Sadiq; One Loop, One Grade Separated Left Turn and One at-grade left turns
2	3+025	EBM: Two Loops and Two at-grade left turns
3	9+225	Shah Faisal; Three Loops and Three at-grade left turns
4	15+275	Quaidabad; Four Loops and Four at-grade left turns
5	24+050	Already Proposed Trumpet should be Semi Clover Leaf (N-Hwy-Super Hwy Link Road)
6	28+750	Already Proposed Trumpet should be Semi Clover Leaf (Dumlottee Road)
Total No. of Interchange =6		

5. NALA BRIDGE

SR.No.	STATION	NALA BRIDGE	LENGTH (m)
1	4+823	Malir Right Bank, Behind PAF Museum; (Nala, also requires Channelizing)	80
2	5+773	Chakora Nala Crossing; (Nala, also requires Channelizing)	200
3	15+973	Thaddo Nala Crossing; (Nala, also requires Channelizing)	150
4	29+623	Malir River Tributary (Koncar Nadi) Crossing; (Nala, also requires Channelizing)	150
Total No. of Bridge = 4 Nos			**580**

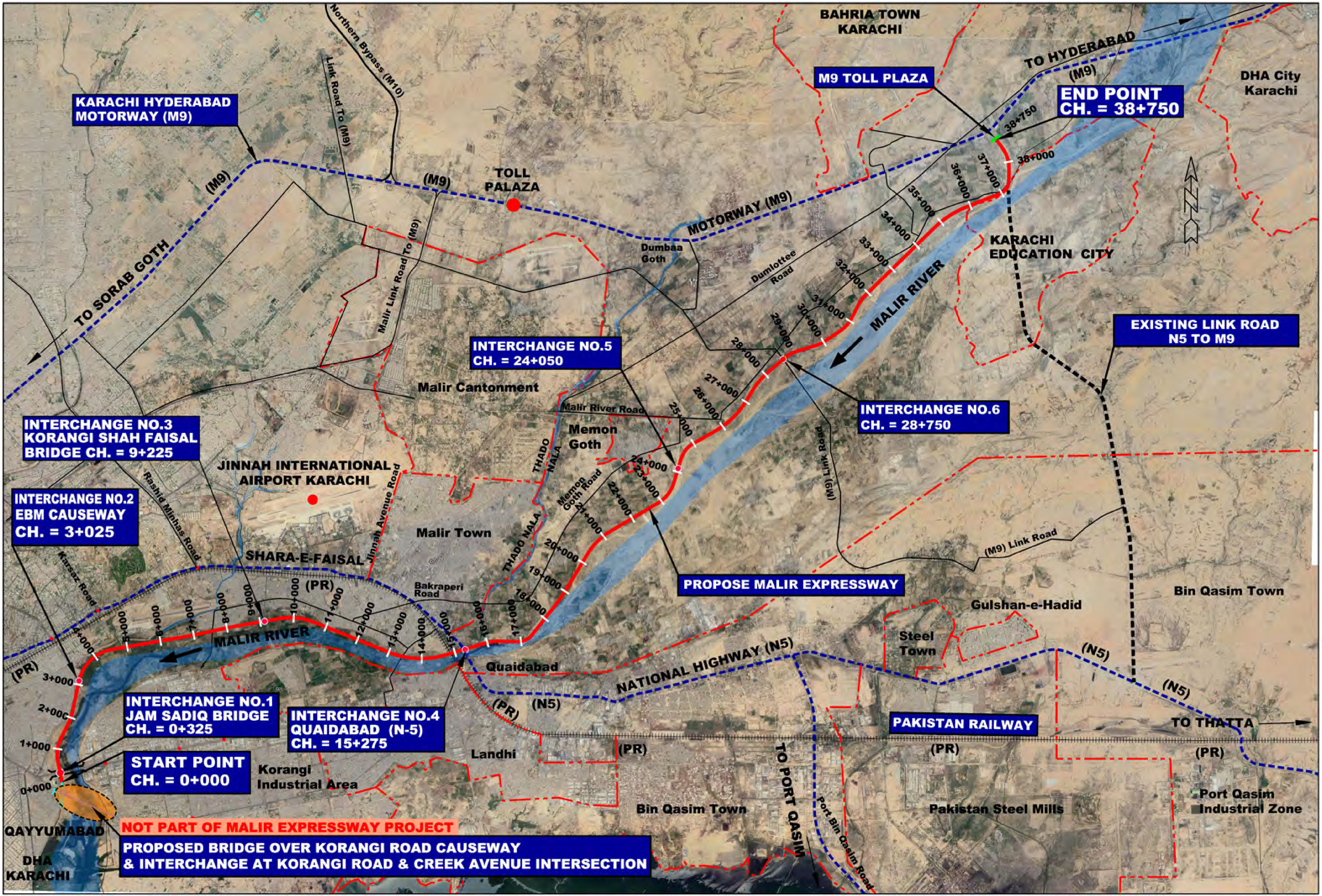
6. FLYOVER

SR.No.	STATION	FLYOVER	LENGTH (m)
1	14+875	Flyover at Railway Main Line(Double Track)	30
Total No. of Flyover =1			

CONSULTANCY / TRANSACTION ADVISROY SERVICES
FOR DEVELOPMENT OF MALIR EXPRESSWAY
(From Motorway, M9 to KPT Interchange)
FINAL REPORT

ANNEXURE ***H***

Project Route Map



KARACHI HYDERABAD MOTORWAY (M9)
BAHRIA TOWN KARACHI
TO HYDERABAD
M9 TOLL PLAZA
END POINT CH. = 38+750
DHA City Karachi
TOLL PALAZA
MOTORWAY (M9)
TO SORAB GOTH
Dumbaa Goth
Dumlottee Road
KARACHI EDUCATION CITY
MALIR RIVER
INTERCHANGE NO.5 CH. = 24+050
EXISTING LINK ROAD N5 TO M9
Malir Cantonment
Malir River Road
INTERCHANGE NO.6 CH. = 28+750
INTERCHANGE NO.3 KORANGI SHAH FAISAL BRIDGE CH. = 9+225
Memon Goth
JINNAH INTERNATIONAL AIRPORT KARACHI
INTERCHANGE NO.2 EBM CAUSEWAY CH. = 3+025
Malir Town
SHARA-E-FAISAL
(M9) Link Road
PROPOSE MALIR EXPRESSWAY
Bakraperi Road
Gulshan-e-Hadid
Bin Qasim Town
Steel Town
Quaidabad
NATIONAL HIGHWAY (N5)
INTERCHANGE NO.1 JAM SADIQ BRIDGE CH. = 0+325
INTERCHANGE NO.4 QUAIDABAD (N-5) CH. = 15+275
PAKISTAN RAILWAY
TO THATTA
Landhi
START POINT CH. = 0+000
Korangi Industrial Area
TO PORT QASIM
Port Bin Qasim Road
Bin Qasim Town
Pakistan Steel Mills
Port Qasim Industrial Zone
QAYYUMABAD
DHA KARACHI
NOT PART OF MALIR EXPRESSWAY PROJECT
PROPOSED BRIDGE OVER KORANGI ROAD CAUSEWAY & INTERCHANGE AT KORANGI ROAD & CREEK AVENUE INTERSECTION