Karachi Urban Transport Corporation
The Islamic Republic of Pakistan

PREPARATORY SURVEY (II)
ON
KARACHI CIRCULAR RAILWAY REVIVAL PROJECT
IN
ISLAMIC REPUBLIC OF PAKISTAN

FINAL REPORT

VOLUME 1/2
MAIN REPORT

FEBRUARY 2013

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.
YACHIYO ENGINEERING CO., LTD.
JAPAN ELECTRICAL CONSULTING CO., LTD.

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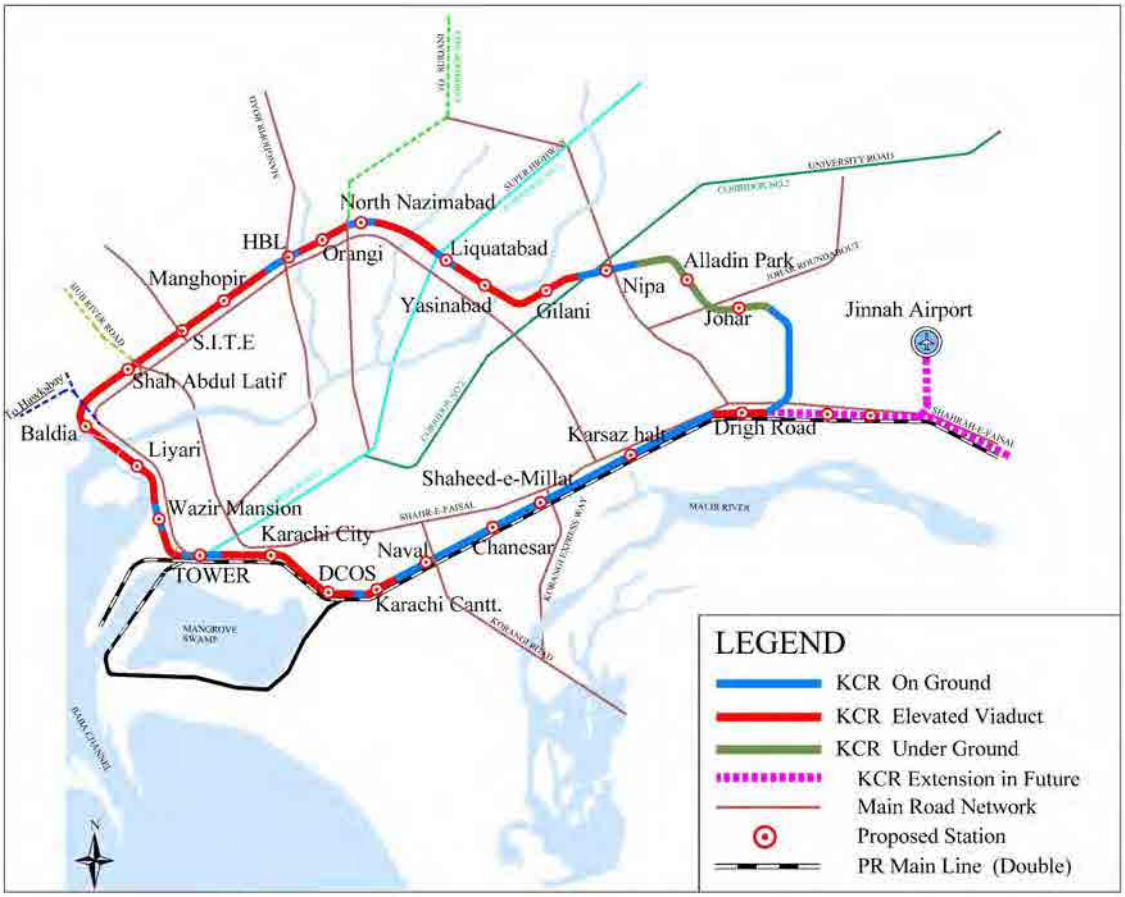
Exchange Rate

Description	Exchange Rate
JPY / USD	78.7
PRs / USD	94.5
JPY / PRs	0.83

LOCATION MAP



SALIENT FEATURES

Civil & Station structures	
Total Route Length	43.24 km
On-ground	15.68 km
Elevated	23.86 km
Trench	2.28 km
Bridge	1.42 km
Total Number of Stations	24
On-ground	10
Elevated	12
Trench	2
Gauge	Standard gauge, 1435 mm
Depot & Workshop	
Location	Wazir Mansion Depot-Hill
Track-work	
Rail	UIC 60 kg, 54 kg
Type of Track	Ballast, Solid-bed

Power supply system	
Grid Stations (GS)	2 GS at Mauipur & KDA
Traction Power Substation (TSS)	2 TSS at Alladin Park & Liyari
Electrification System	A/C-25kV x2 AT feeding system
Overhead Contact System	Simple catenary
Signal & Telecom System	
Signal System	ATO & CBTC
Telecom System	Dedicated fibre optic cable network with train radio etc
Rolling Stock	
Type	Electric multiple unit (EMU)
Train formation	4 cars (2M2T) with 20 m long car body
No. of Trains at Opening	25 train sets

Preparatory Survey (II) on Karachi Circular Railway Revival Project in Islamic Republic of Pakistan

FINAL REPORT

Executive Summary

JICA

NIPPON KOEI yec

Chapter 1 Introduction

- **Objectives and Scope of the Study**
  - ✓ To conduct topographic, hydrological, geological survey and KESC grids survey along the KCR entire route.
  - ✓ To review the KCR alignment plan, civil structures, track, depot plan and power supply system.
  - ✓ To provide advices and suggestions to strengthen the abilities of KUTC as the project implementation institution.
  - ✓ To conduct the O&M surveys of urban railways in the third countries and examine and propose a viable O&M plan.
  - ✓ To review the project costs and the results of economic and financial analysis.

Chapter 2 Survey on Site Conditions and Facilities

- **Survey Items**

i. Topographic Survey

- ✓ To develop the topographic map with a certain scale indicating boundary line designated by KUTC.
- ✓ To develop longitudinal profile and cross sections at 20-meter intervals along the center line of tentative route.

ii. Hydrological Survey

- ✓ Drainage plan and measures against domestic wastewater.
- ✓ Examination on dewatering stagnant water inside ROW.

iii. Geological Survey

- ✓ To determine subsoil geotechnical conditions and parameters along entire KCR route with borehole drilling and laboratory testing.
- ✓ Monitoring groundwater level.

iv. Survey on Power Supply Conditions

Chapter 3 Review of Demand Forecast

(1) Prerequisite Conditions for Demand Forecast

<table>
<tr><th colspan="2">Year</th><th>2022</th><th>2030</th><th>2040</th></tr>
<tr><td rowspan="2">KCR</td><td>A</td><td>Loop line</td><td>Loop line
+ Extension line</td><td>Loop line
+ Extension line</td></tr>
<tr><td>B</td><td>Shah-Abdul-Latif
~ Drigh Road</td><td colspan="2">Shah-Abdul-Latif ~ Drigh Road
+ Extension line</td></tr>
<tr><td rowspan="2">Bus</td><td>1</td><td colspan="3">Extension to suburban area of the existing bus route network
+ Establishment feeder routes from the station of loop line except BRT route</td></tr>
<tr><td>2</td><td colspan="3">Extension to suburban area of the existing bus route network</td></tr>
<tr><td colspan="2" rowspan="2">BRT and Velocity</td><td rowspan="2">Green and Red line
（Outside KCR）</td><td colspan="2">Green, Red, Brown, Aqua, Orange, Yellow and Purple line</td></tr>
<tr><td>25km/h outside KCR,
15km/h inside KCR</td><td>25km/h</td></tr>
<tr><td colspan="2">Road</td><td>Under construction</td><td colspan="2">Implementation based on Master Plan</td></tr>
</table>

(Source; JICA Study Team)

Chapter 3 Review of Demand Forecast

(2) KCR Demand

Item / Case	Project Demand		Maximum Number of Passengers loaded by section	
	2022	2030	2022	2030
N-A1	578,362	1,223,066	236,999	448,476
N-A2	526,738	1,174,107	219,548	426,870
N-B1	306,236	828,018	225,101	449,858
N-B2	283,543	798,716	207,820	427,397

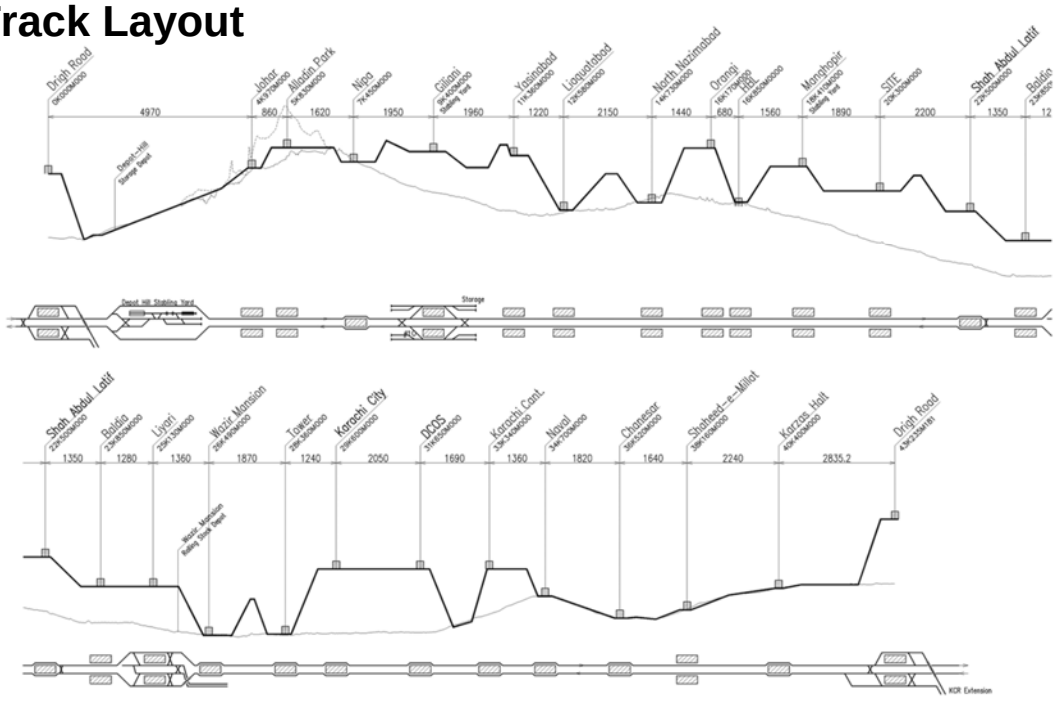
(Source; JICA Study Team)

Chapter 4 Review of Technical Standards and Railway Alignment

- **Review Items of Technical Standard**
  - ✓ Basic concept based on Japanese standard
  - ✓ Rolling stock gauge
  - ✓ Construction gauge
  - ✓ Distance between track centers
  - ✓ Formation width
  - ✓ Type of station and platform design (type and width)
  - ✓ Intermodal facility plan
- **Basic Concept of Route Alignment**
  - ✓ Based on results of topographic & boundary survey
  - ✓ On-ground track is applied to parallel section to PR line, between Tower and Drigh Road, on the assumption that PR tracks will be shifted.

Chapter 4 Review of Technical Standards and Railway Alignment

- **Track Layout**



(Source; JICA Study Team)

Chapter 5 Review of Preliminary Design

Scope of the Project (1/3)

Item		Option N-A1, A2	Option N-B1
Civil & Station	Route Length (total)	43.24 km	20.73 km
	On-ground	15.68 km	9.77 km
	Elevated	23.86 km	10.20 km
	Trench	2.28 km	-
	Bridge	1.42 km	0.76 km
	Number of Stations	24	13
	On-ground	*10*	*6*
	Elevated	*12*	*7*
	Trench	*2*	-
Depot & Workshop	Total Stabling Capacity	31 trains at opening (43 trains in future)	19 trains at opening (22 trains in future)
	Wazir Mansion Depot & Workshop	19 trains at opening (23 trains in future)	15 trains at opening (18 trains in future)
	Depot-Hill Depot	4 trains at opening (10 trains in future)	4 trains at opening (4 trains in future)
	Manghopir Stabling Yard	2 trains at opening (2 trains in future)	-
	Gilani Stabling Yard	6 trains at opening (8 trains in future)	-

(Source; JICA Study Team)

Chapter 5 Review of Preliminary Design

Scope of the Project (2/3)

Item		Option N-A1, A2	Option N-B1
Track	Gauge	Standard gauge, 1435 mm	
	Rail	UIC 60 kg for main line UIC 54 kg for sub line in depot	
	Type of Track	Ballasted track in on-ground sections Solid bed in elevated and trench sections	Ballasted track in on-ground sections Solid bed in elevated sections
Power Supply System	Grid Station (GS)	2 GS at Mauipur & KDA	1 GS at Mauipur
	Transmission Line	220 kV Mauripur-Liyari 132 kV, KDA-Alladin Prak	220 kV, Mauripur-Liyari
	Traction Power Substation (TSS)	2 TSS at Alladin Park & Liyari	1 TSS at Liyari
	Sectioning Post (SP)	2 SP at Orangi & Karsaz	1 SSP at Karachi Cantt
	Electrification System	A/C-25kVx2 AT feeding system	
	Overhead Contact System	Simple catenary	

(Source; JICA Study Team)

Chapter 5 Review of Preliminary Design

Scope of the Project (3/3)

Item		Option N-A1, A2	Option N-B1
Signal & Telecom System	Signaling System	Automatic train operation (ATO), CBTC system	
	Telecommunication System	Fibre optic cable network, Cab radio system, CCTV system, Public addressing system, Public information display system, etc.	
Rolling Stock	Type	Electric multiple unit (EMU)	
	Train Formation	4 cars (2M2T) with 20 m long car body at opening	
	Number of Train Set	25 sets at opening	16 sets at opening
Other Facility	Fare Collection System	Automatic fare collection system	
Train Operation	Time for Train Operation	6:00 – 23:30	
	Average Speed	43 km/h	
	Headway	6-8 min. at opening	5-8 min. at opening

(Source; JICA Study Team)

Chapter 6 Review of Project Schedule and Cost

- **Project Schedule**

Year	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Loan	▼		▼		▼		▼			
Resettlement site development	Design & Procurement			Construction						
House construction										
PR shifting, demolishing, walls										
KCR construction		Design & Procurement				Construction			Trial operation	
O&M preparation										

(Source; JICA Study Team)

Chapter 7 Review of O&M Plan

(1) Review Items

- **Review Items**

✓ Survey on Urban Railways in Asian Cities

✓ O&M Scheme and Organization of KCR

✓ Estimation of O&M Costs

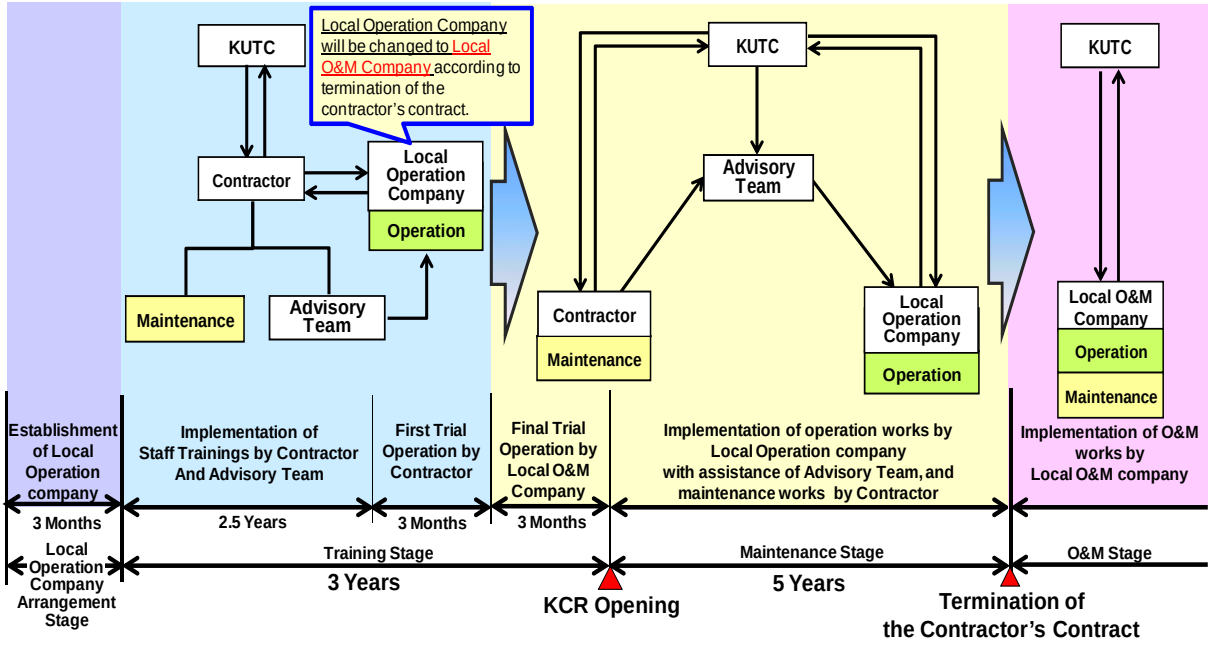
✓ Railway Fare Revenue

✓ Non-rail Business Revenues

✓ Revenue and Expenditure of KCR

Chapter 7 Review of O&M Plan

(2) Outline of the Proposed O&M Scheme



(Source; JICA Study Team)

Chapter 7 Review of O&M Plan

(3) Implementation Schedule

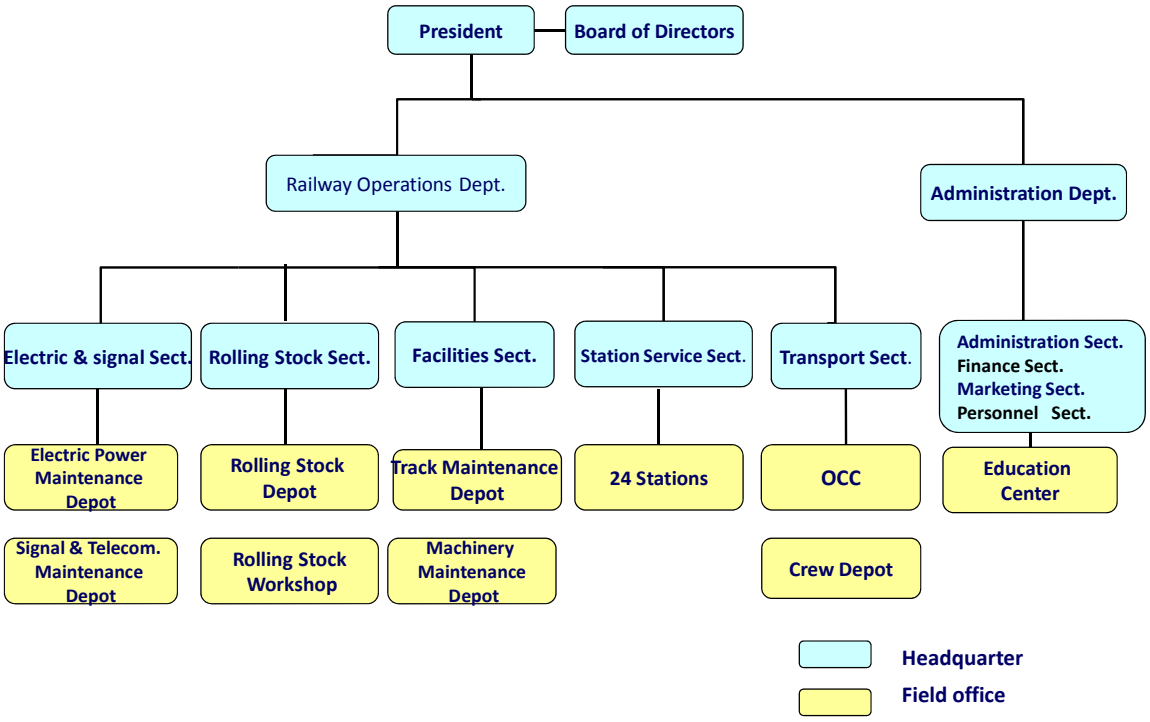
Implementation Schedule			Basic/Detail Design Phase				Construction Phase of KCR Project					O&M Phase of KCR Project (5 years)					After 5 years from the opening
			2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	
Project Schedule	Basic and Detail Design																
	Construction & Procurement																
	Operation and Maintenance																
Implementation Organization	Works																
KUTC	Establishment of O&M Company																
	Employment and Trainings in cooperation with Advisory Team	Driver															
		Operation Staff															
	Implementation of Operation Works in cooperation with Advisory Team																
	Supervision of O&M works																
Management Consultant or JICA Expert	Preparation for Establishment of O&M Company according to the law, tender documents for selection of O&M Company and so on.																
Advisary Team	Employment and Training	Driver															
		Operation Staff															
	Implementation of Operation Works with Operation Staff and KUTC																
Contractor	Construction & Procurement																
	Establishment of O&M Company																
	Organizing Advisory Team and Dispatching Advisory Team to KUTC																
	Employment and Training of Maintenance Staff																
	Implementation of Maintenance Works with Maintenance Staff																
O&M Company	Empolyment of Headquarter's Staff and preparation of management																
	Employment and Training in cooperation with Advisory Team	Driver															
		Operation Staff															
	Implementation of Operation Works																
	Implementation of Maintenance Works																
Consultant	Basic and Ditail Design (preparation of Establishment Plan for O&M Company)																
	Project Supervision																

Establishment of O&M Company 3 Months
2 Years 9 Implementation of Staff Trainings
Trial Operation by O&M Company 3
Trial Operation by Contractor 3
5 Years
Opening of KCR
Establishment of Operation Company by Contractor
Transfer of Operation Staff from Contractor to Operation Company
Opening of KCR
Transfer of Maintenance Staff from Contractor to O&M Company

(Source; JICA Study Team)

Chapter 7 Review of O&M Plan

(4) O&M Company Organizational Structure



(Source; JICA Study Team)

Chapter 8 Verification of Project Effects

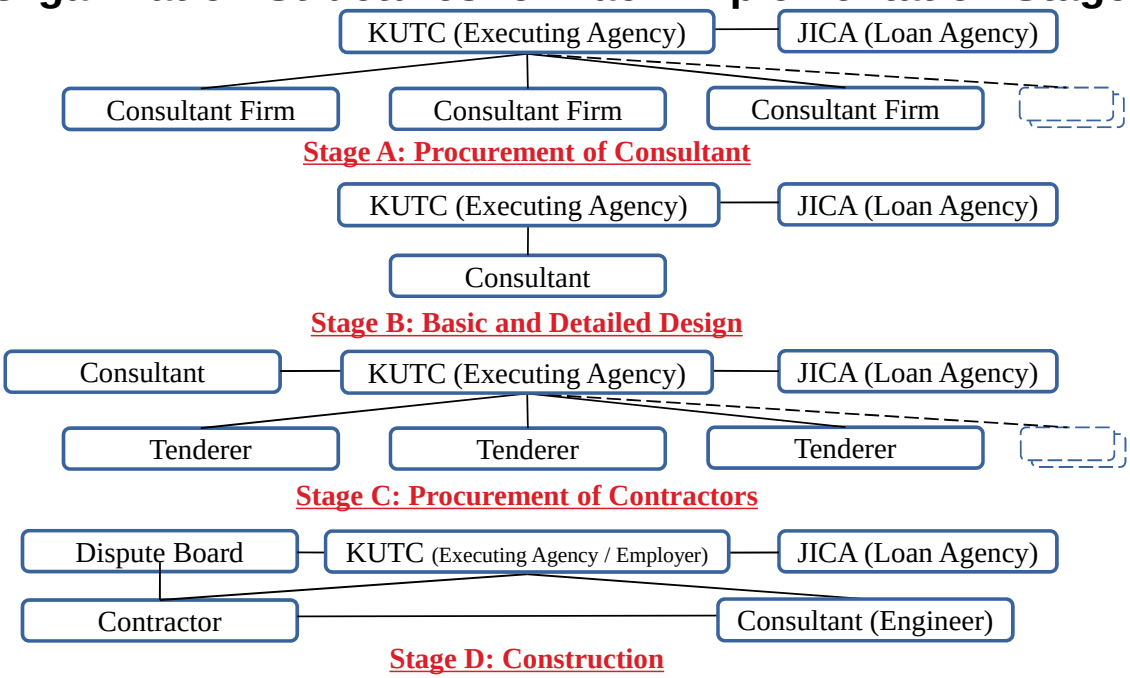
- **Climate Change Mitigation Effects**

  GHG emission reduction due to regenerative energy effect

  - ✓ Option N-A1: 128,306 [tCO2/10 years]
  - ✓ Option N-B1: 69,857 [tCO2/10 years]

Chapter 9 Advices for Project Implementation Organization

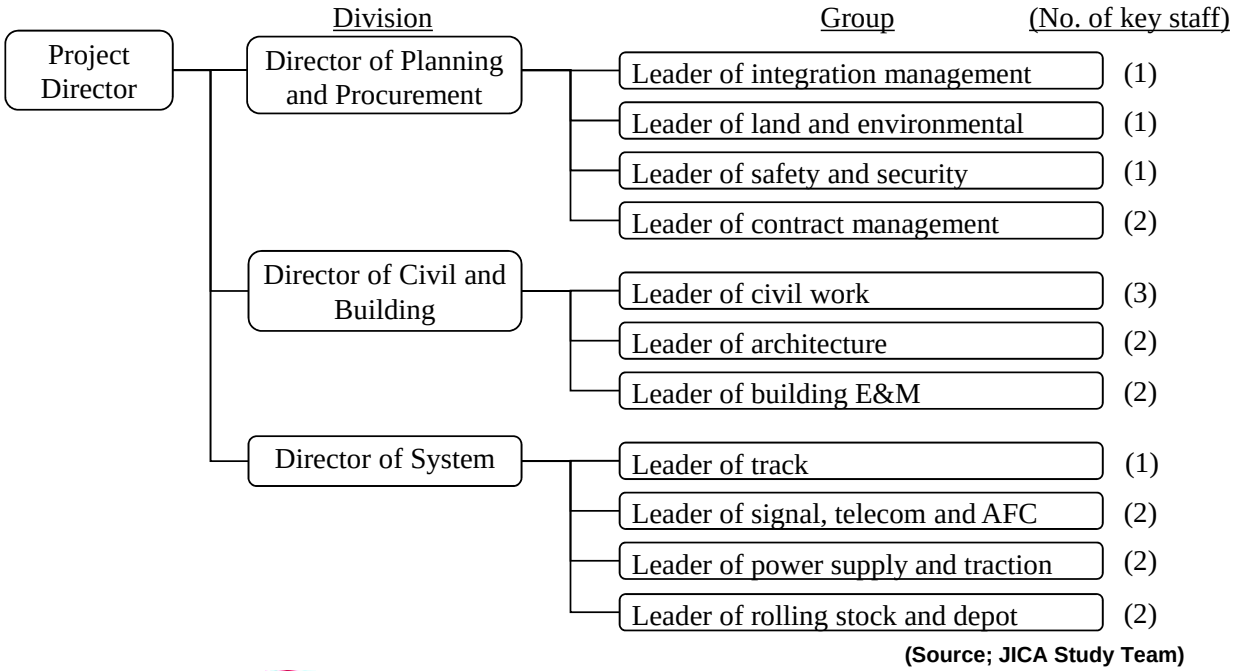
- **Organization Structures for Each Implementation Stage**



(Source; JICA Study Team)

Chapter 9 Advices for Project Implementation Organization

- **Proposed Organization of KUTC Engineering Units**



(Source; JICA Study Team)

Chapter 10 Environmental and Social Considerations

- **Environmental Consideration**
  - ✓ Review of IEE on Resettlement Site
  - ✓ Review of EIA for KCR Line
  - ✓ Environmental Management Plans
- **Social Consideration**
  - ✓ Review of Resettlement Action Plan
  - ✓ Rap Implementation Arrangement
  - ✓ O&M for Public Facilities at Resettlement Site

Chapter 11 Conclusions and Recommendations

(1) Comparison between options

- **Comparison between options**

Item	Option N-A1	Option N-B1	Remark
Demand	Fair	Slightly good	N-B1 is better in terms of passengers/km and fare revenue/km.
Headway	Good	Excellent	5 min. in peak time for N-B1.
Cost efficiency	Good	Slightly good	N-A1 is better in terms of unit cost per km.
Initial investment	Large	Compact	N-B1 requires 2/3 investment of N-A1.
EIRR	Fair	Marginal	N-A1 is better but both feasible.
FIRR	Insufficient	Insufficient	Marginal if taxes are exempted.
O&M easiness	Significantly tough	Easier than Option N-A1	N-B1 is rather simple due to less staff and shorter length.
Overall	Slightly good	Good	Option N-B1 as the Phase 1 implementation recommended .

(Source; JICA Study Team)

Chapter 11 Conclusions and Recommendations

(2) Recommendations -1

- ✓ Understanding of KUTC's roles for smooth implementation of KCR project.
- ✓ Completion of preparation works such as shifting of PR tracks and resettlement before commencement of KCR construction.
- ✓ Early implementation of KCR center line survey and setting of boundaries of KCR land.
- ✓ Establishment of high quality local O&M company.
- ✓ Proper setting of KCR fare level and adjustment during operation according to number of passengers.
- ✓ Management of railway land development and under-viaduct space development businesses with a non-rail business division in KUTC based on sound, careful and conservative policies.

Chapter 11 Conclusions and Recommendations

(3) Recommendations -2

- ✓ Consideration of rolling stock with performance of TX-2000 or higher taking into account the longer distance due to circular route.
- ✓ Suggestion of BRT operation for missing route in Case of N-B1 for the provision of better feeder transportation service and prevention of squatters.
- ✓ Special financial assistance and tax exemption support from GOP and GOS.
- ✓ Dispatch of a long-term JICA expert to MOR who owns rich experiences and know-how in urban railway projects and O&M.

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* To ensure fairness of procurement process as well as project implementation, information of the following sections should not be disclosed for a fixed period.

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6.5.2 Recommendable Items for STEP Component
7.4.4 Estimation of O&M Costs
8.1.2 Economic Analysis
8.1.3 Financial Analysis
10.6 Socio-Economic Survey on KCR Line
10.7 Stakeholder Meeting
10.8 Review of Resettlement Action Plan
10.12 Suggestion on Required Additional Survey
10.13.2 Resettlement Action Plan
10.13.3 Resettlement Site Development

** The information contains information of particular firms/institutions; information should not be disclosed for a fixed period.

(7.1 Survey on Urban Railways in Third Countries)
7.1.1 Singapore
7.1.2 India (Delhi)
7.1.3 TSUKUBA Express
7.4.1 Features of Revenue and Expenditure found through O&M Survey in Third World Countries
7.4.6 Non-rail Business Revenues
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7.7.3 Individual Cases of Risk Management in O&M taken by Singapore Metro, Delhi Metro, and TX

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ABBREVIATIONS

AAGR	Average Annual Growth Rate
AC	Alternating Current
ADB	Asian Development Bank
AFC	Automatic Fare Collection
APS	Affected Persons
ATC	Automatic Train Control
ATO	Automatic Train Operation
ATP	Automatic Train Protection
B/C	Benefit / Cost
BDT	Bangladesh Taka
BOD	Board of Directors
BOD	Biochemical Oxygen Demand
BOT	Build, Operate and Transfer
BRT	Bus Rapid Transit
BTS	Bangkok Transit System
CAA	Civil Aviation Authority
CAPEX	Capital Expenditure
CARE	City Airport Rail Enterprises
CBD	Central Business District
CBO	Community Based Organization
CBTC	Communications Based Train Control
CC	Control Center
CCP	Central Control Point
CCTV	Closed Circuit Television
CDGK	City District Government Karachi
CDM	Clean Development Mechanism
CDM EB	CDM Executive Board
CER	Certified Emission Reduction
CGL	City Green which Lewisham
CI	Converter- Inverter
CMS	Manganese Steel Cast Crossing
CO	Carbon monoxide
CO2	Carbon dioxide
COD	Chemical Oxygen Demand
COE	Certificate of Entitlement
CPT	Cone Penetration Test
CS-ATC	Cab Signal-Automatic Train Control
CSC	Centralised Substation Control
CTC	Centralised Traffic Control
DC	Direct Current

DID	Densely Inhabited Districts
DLR	Dockland Light Rail in London
DMRC	Delhi Metro Railway Corporation
DMU	Diesel Multiple Unit
DNA	Designated National Authority
DOE	Designated Operational Entity
E&M	Electrical & Mechanical
EC	Electric Car
EC	Entitlement Card
ECNEC	Executive Committee of National Economic Council
EIA	Environment Impact Assessment
EIRR	Economic Internal Rate of Return
EMC	External Monitoring Consultant
EMC	Environmental Management Consultant
EMI	Electromagnetic Interference
EMP	Environmental Management Plan
EMU	Electric Multiple Units
EP	Entitled Person
ERTMS	European Rail Traffic Management System
ESI	Electricity Supply Industry
ETCS	European Rail Traffic Management System
F/S	Feasibility Study
FIRR	Financial Internal Rate of Return
FTC	Finance and Trade Center
GAF	Grievance Application Form
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIG	Grievance Investigation Group
GNCTD	Government of National Capital Territory of Delhi
GOI	Government of India
GOJ	Government of Japan
GOP	Government of Pakistan
GOS	Government of Sindh
GPS	Global Positioning System
GRC	Grievance Redress Committee
GRDP	Gross Regional Domestic Product
GSM	Global System for Mobile communications
GSM-R	Global System for Mobile communications-Railways
GST	General Sales Tax
HHs	Households Heads
HS	Housing Society
HV	High Voltage

IEA	International Energy Agency
IEE	Initial Environmental Examination
IGDP	Insulated Gate Bipolar Transistor
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Producer
IRJ	Insulated Rail Joint
JEMP	Jurong East Modification Project
JETRO	Japan External Trade Organization
JICA	Japan International Cooperation Agency
JIS	Japanese Industrial Standards
JNR	Japanese National Railway
JR	Japan Railway
JV	Joint Venture
KBCA	Karachi Building Contract Authority
KCR	Karachi Circular Railway
KDA	Karachi Development Authority
KESC	Karachi Electric Supply Corporation
KMTC	Karachi Mass Transit Cell
KMTP	Karachi Mass Transit Priority (Corridors)
KPT	Karachi Port Trust
KSDP	Karachi Strategic Development Plan
KSDP	Karachi Strategic Development Plan
KTIP	Karachi Transportation Improvement Project
KUTC	Karachi Urban Transport Corporation
KW and SB	Karachi Water Supply and Sewerage Board
KWSB	Karachi Water & Sewerage Board
L/A	Loan Agreement
LAA	Land Acquisition Act
LOA	License and Operating Agreement
LRT	Light Rail Transit
LTA	Land Transport Authority
MD	Minutes of Discussion
MDA	Multan Development Authority
MLIT	Ministry of Land, Infrastructure, Transport and Tourism
MOR	Ministry of Railway
MRT	Mass Rapid Transit
MRTS	Mass Rapid Transit System
MW	Mega Watts
MWP	Ministry of Water and Power
NEQS	National Environmental Quality Standard
NGO	Non-Governmental Organization
NHA	National Highway Authority

NOx	Nitrogen Oxides
O&M	Operation & Maintenance
OCC	Operations Control Center
OCS	Overhead Contact System
OD	Origin and Destination
ODA	Official Development Assistance
OECD	Organization for Economic Cooperation and Development
OPEX	Operating Expenditure
P&R	Park & Ride
PA	Public Address
PABX	Private Automatic Branch Exchange
PAHs	Project Affected Households
Pak-EPA	Pakistan Environmental Protection Agency
PAPs	Project Affected persons
PBC	Pakistan Building Code
PC	Pre-stressed Concrete
PCM	Public Consultation Meeting
PDD	Project Design Document
PDMA	Provincial Disaster Management Authority
PDMA	Provincial Disaster Management Authority
PDWP	Provincial Development Working Party
PEPA	Pakistan Environmental Protection Act
PEPO	Pakistan Environmental Protection Ordinance
PH	Public Hearing
PLDP	Power Line Drop Platform
PM	Particulate Matter
PM10	Particulate Matter less than 10 micrometer of particulate size
PMD	Pakistan Meteorological Department
PPK	Post Processed Kinematic
PPP	Public Private Partnership
PR	Pakistan Railways
PRACS	Pakistan Railways Advisory & Consultancy Services Ltd
PSD	Platform Screen Door
RAP	Resettlement Action Plan
RL	Rail Level
ROB	Road-Over Bridge
ROW	Right of Way
RPMU	Resettlement Project Management Unit
RPO	Resettlement Project Officer
Rs.	Pakistan Rupees
RTA	Roads and Transport Authority
RTK	Real Time Kinematic

RUB	Road-Under Bridge
S&C	Switches & Crossings
SAPROF	Special Assistance for Project Formulation
SCADA	Supervisory Control and Data Acquisition
SDF	Special Development Fund
SEBS	Socio-Economic Baseline Survey
SECP	Securities Exchange Commission of Pakistan
SITE	Sindh Industrial Trading Estates
SMRT	Singapore Mass Rapid Transit
SP	Stated Preference
SPT	Standard Penetration Test
SSGC	Sui Southern Gas Company
SSP	Sub Sectioning Post
ST	STation
STEP	Japanese Special Term for Economic Partnership
STRASYA	STandard urban RAilway SYstem for Asia
SUPARCO	Space & Upper Atmosphere Research Commission
SWR	Scott Wilson Railways
TAZ	Traffic Analysis Zone
TETRA	Terrestrial Trunked Radio
TMAs	Town Municipal Authorities
TPH	Trains Per Hour
TSP	Total Suspended Particulate matter
TSS	Traction Sub Station
TTC	Travel Time Cost
TX	Tsukuba Express
UBC	Unified Building Code
UC	Union Council
UHF	Ultra High Frequency
UIC	International Union of Railway
UMA	Umar Munshi Associates
UNFCCC	United Nations Framework Convention on Climate Change
VOC	Vehicle Operating Cost
VVVF	Variable Voltage Variable Frequency
WAPDA	Water and Power Development Authority
WARE	Woolwich Arsenal Rail Enterprises

1. INTRODUCTION

1.1 Background of the Study

Karachi City is the largest city in Pakistan, which has a population of 18 million, and the capital of Sindh Province. Karachi continues to be the national center of finance, industry, and overseas trade as well as an international center of southwest Asian countries. However, its urban transport infrastructure has been insufficiently developed. About 99% of trips generated in Karachi are by means of cars and buses, while the registered number of automobiles has increased exponentially. This has worsened traffic jams and air pollution to such a degree of average vehicle speed of about 15 km/h and particulate matter (PM10) of twice the WHO guideline. Therefore, to resolve the traffic problems in Karachi and enhance economic growth with better living environment, urban mass transit systems that facilitate modal shift from road transportation are indispensable.

In 1964, the Karachi Circular Railway (KCR) opened in the 26.56-km section between Drigh Road and Wazir Mansion as an unelectrified at-grade single track railway and was extended from Wazir Mansion to Karachi City in 1970. As a result, it had a total route length of 29.32 km with 16 stations. However, the operational efficiency of KCR was marginalized and its ridership dwindled with every passing day beyond the year 1985 and was eventually closed to traffic in 1999, due to longer running time, low frequency of trains, lack of punctuality, and lack of adequate integration with other transportation modes. In 2005, KCR reopened partially using the Pakistan Railway (PR) main line, but the daily number of passengers was only about 3,000 persons. The remaining closed KCR sections have been increasingly occupied by squatters and the right of way (ROW) has not been well-defined due to surrounding housing development.

Under such situation, the Medium Term Development Framework 2005-2010 recognizes that urban public transportation development in the mega cities such as Karachi and Lahore will play a key role in Pakistan's economic development in the decades ahead. The Karachi Strategic Development Plan 2020 prepared in 2007 also emphasizes the need for mass rapid transits in Karachi. The Government of Pakistan (GOP), the Government of Sindh (GOS) and the City District Government of Karachi (CDGK) prioritize the KCR revival project.

In 2006, the Japan External Trade Organization (JETRO) carried out a feasibility study for the revival of KCR, which was reviewed by Scott Wilson Railways and local consultants Umar Munshi Associates through the Ministry of Railways (MOR). To implement the project, The Karachi Urban Transport Corporation (KUTC) was established with the capitals provided by MOR, GOS and CDGK in May 2008.

The Government of Japan (GOJ) places importance on well-balanced development of regional society and economy as well as strengthening Karachi as a regional economic center in his Official Development Assistance Policy for Pakistan established in 2005. GOJ also has been assisting developing countries who are implementing climate change countermeasures for low carbon society in financing projects for reducing greenhouse gas including low-carbon transport infrastructures.

In order to resolve the traffic problems in Karachi by the development of mass rapid transits and to mitigate air pollution and climate change, GOP has requested for an ODA loan from GOJ for the KCR revival project. In response, Japan International Cooperation Agency (JICA) has shown willingness to arrange the funding of the project under the Special Term for Economic Partnership (STEP) Loan. JICA conducted the study of Special Assistance for Project Formulation (SAPROF-I) on the project from October 2008 to May 2009, scopes of which included transport demand forecast, policies and measures for the shift of travelers towards KCR, preliminary designs and technical specifications, project cost estimate, O&M arrangements and project effect evaluations. From April 2009 to May 2010, JICA intermittently dispatched project formation advisors on railway planning, traction power supply planning and social environmental considerations to assist KUTC in the preliminary design, cost estimate, organization and resettlement plan of the project.

JICA further decided to carry out the second preparatory survey (expressed as SAPROF-II in this

report) including more studies on technical issues and operational and management plans for smooth project implementation and operation.

1.2 Objectives and Scope of the Study

The objectives of the SAPROF-II study are as follows:

a) To conduct topographic survey, hydrological survey, geological survey and KESC grids survey concerned with the KCR entire route.

b) To review the KCR alignment plan, civil structures, track, depot plan and power supply system of the SAPROF study based on the results of the above mentioned site surveys.

c) To provide advices and suggestions to strengthen the abilities of KUTC as the project implementation institution relating to the design review, provisions of approvals, tender evaluations and construction supervisions.

d) To conduct the O&M surveys of urban railways in the third countries about revenues, expenses, organizations and funding plans, and to examine and propose a viable O&M plan taking into account the results of the survey.

e) To review the project costs and the results of economic and financial analysis of the SAPROF study and to submit the interim reports to make reference for Yen loan appraisal by JICA.

The Terms of Reference (TOR) of the study are summarized as follows:

TOR 1 Review of existing reports
TOR 2 Survey on conditions of site and facilities
- [2-1] Survey on site conditions - topographic survey
- [2-2] Survey on site conditions - hydrological survey
- [2-3] Survey on site conditions - geological survey
- [2-4] Survey of power supply facilities

TOR 3 Review of KCR O&M plan
- [3-1] O&M survey in other countries
- [3-2] Review on O&M cost and revenue
- [3-3] Prepare proposed O&M organization
- [3-4] Prepare proposed O&M financial plan

TOR 4 Verification of demand forecast, project costs and project effects
- [4-1] Review of demand forecast
- [4-2] Estimate of project costs
- [4-3] Economic and financial analysis
- [4-4] Effect indicators
- [4-5] Effects on climate change

TOR 5 Review of preliminary designs
- [5-1] Railway alignment
- [5-2] Civil and track works
- [5-3] Train operation and depot
- [5-4] Electrical facilities

TOR 6 Suggestions for project implementation organization
TOR 7 Review of environmental and social considerations and preparation of plans
TOR 8 Preparation of project implementation schedule
TOR 9 Preparation and submission of reports
Inception Report (IC/R)

Interim Report (1)	(IT/R-1)
Interim Report (2)	(IT/R-2)
Draft Final Report	(DF/R)
Final Report	(F/R)

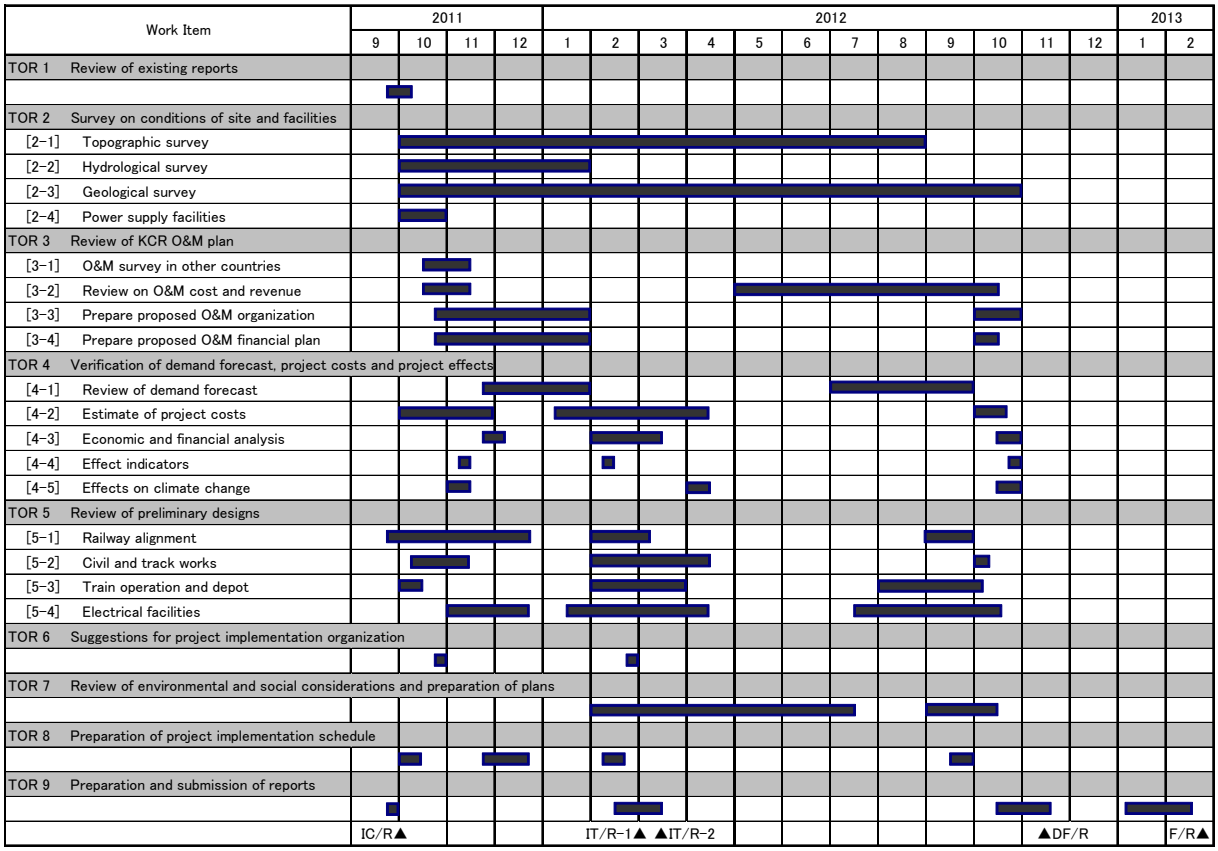
1.3 Schedule of the Study

The SAPROF-II study was commenced at the end of September 2011, the IT/R-1 and IT/R-2 were submitted in March 2012, and the study was completed in February 2013 when submitting the F/R.

The study was originally planned to be completed in June 2012 where the IT/R-1 was to be prepared in November 2011. However, due to the addition of the following works instructed by JICA, the program was rescheduled:

a) Study on an option with partial KCR operation as well as entire route operation
b) Review of transport demand forecast based on the OD matrix and planned highway and mass transit networks prepared in Karachi Transport Improvement Project (KTIP)
c) Review of resettlement plans, schedules and organizations, livelihood restoration programs and arrangement of stakeholder meetings
d) Review of environmental management and monitoring plans for the resettlement area development project, consulting services and costs
e) Preparation of overall project implementation schedule
f) Additional topographic survey and geological survey

Figure 1.3.1 shows the overall work schedule of the study.



Source: JICA Study Team

Figure 1.3.1 Work Schedule of the Study

1.4 Contents of the Final Report

This final report presents all the results of the SAPROF-II study including survey on site conditions and facilities, review of demand forecast, review of technical standards and railway alignment, review of preliminary design, review of project schedule and cost, review of O&M plan, verification of project effects, advices for project implementation organization, environmental and social considerations, and conclusions and recommendations.

2. SURVEY ON SITE CONDITIONS AND FACILITIES

To identify the project site conditions, surveys on topography, hydrology, geotechnical conditions and power supply were conducted in the study.

2.1 Topographic Survey

2.1.1 Methodology

(1) Survey standard

Following standards were adopted for control point survey:

Coordinate System	: Universal Transverse Mercator (Zone42N)
Horizontal Datum	: World Geodetic System 1984 (WGS84)
Vertical Datum	: Mean Sea Level at Karachi Port.

(2) Reconnaissance Survey and installation of primary control points

Site reconnaissance survey was conducted using Handheld GPS for the entire route and proper primary control points were selected at about 1km intervals. All the selected primary control points were established solidly with concrete monuments.

(3) GPS Survey for primary control points

The selected primary control points were surveyed using more than 4 static-GPS L1 and L2 wave equipments. Reference Benchmark was the one that has been authorized by the Pakistan Government. The standard observation time of each session was minimum 1-hour, but in case the distance between static-GPS equipments (base line) was over 5km, the surveying was conducted up to 5-hour. Observation data interval was done in 15 second with elevation mask of 15 degree. The required accuracy of Loop Closure was 3ppm or less after processing.

(4) Leveling Survey for primary control points

Level network was based on the Bench Mark that is recognized to be the standard mean sea level for all survey works around Karachi. The leveling work was performed with digital automatic level instruments connected with or built-in data logging systems. Digital recording of the logged data ensured high reliability by excluding human error in writing down of observations and manual calculations. Primary controls leveling was conducted by double leveling using two separate level instruments working together from one Control Point to the next and closing their data. If the difference between the two readings were found to be more than the specified tolerance, the level circuit is repeated with double leveling again till the required accuracy is achieved.

(5) Photo control point survey

Photo control points were surveyed with high precision GPS equipment. Complete network was developed covering the entire Karachi city in and around the KCR route. Network GPS observations ensured the high accuracy of the Photo Controls data that was used to ortho-rectify the stereo satellite imagery for accurate mapping of the terrain and ground features.

Photo Control points locations were selected in such a fashion that the points are suitable for high accuracy GPS observations without multi-path errors.

(6) Installation of center line posts

Centerline posts had been installed all along the KCR route at every 20 meter distance. These posts are in the form of wooden pegs for soft ground and railway ballast and steel nails on hard surfaces like

wooden sleepers, roads etc. Chain-ages are marked with paint on the side rail whereas the centerline posts themselves are placed in the center of the KCR survey track wherever it is visible and its centerline can be demarked.

Along the stagnated water reach from NIPA to COD where the tracks are not visible, the survey markers are placed at offsets from which to survey the cross sections so that the survey references are available for future referencing.

(7) Center line survey for the entire route

The centerline posts established along the proposed KCR route are surveyed to high precision using RTK/PPK GPS or Total Station for establishing their X, Y coordinates. Elevations of each centerline post are established using high precision automatic, self recording digital levels. Both positional and elevation values are referenced to the nearest Control Points already established as defined under section (3) and (4) above.

Spreading the survey controls to centerline posts distribute the survey control to a very high extent so that if any Primary Control Point is disturbed for any reason, it can be reestablished again easily from its nearby centerline posts which are setup at every 20 meters interval. Annexure-5 contains the X, Y, Z data information for the centerline posts surveyed.

(8) Land boundary confirmation and survey

Land boundary confirmation and survey was carried out to delineate KUTC boundary for the design of KCR. The boundary was identified physically by the KUTC staff/engineers in the field and its survey was carried out by JST through the survey contractor.

The KUTC boundary survey was carried out using the same coordinate system as of Primary Controls already setup earlier. The boundary survey was done using total stations or RTK/PPK setup.

Boundary pillars were installed at the request of the MD KUTC at selected positions. Total number of boundary survey points was approximately 200. The design of the boundary pillars include a 3 inches diameter concrete pipe 3 feet long inserted into the ground about 2’-6”. Boundary survey was referenced to the Control Points already established and/or the sub-controls spread in the form of Centerline Posts along the entire KCR route.

(9) Cross section survey

Cross sections along the entire KCR route were observed at every centerline post, approximately 20m apart. Cross section corridor was observed 50 meters on either side of the survey centerline or up to the property line whichever is encountered first. At station areas the corridor width is 125 meters.

Cross sections were observed using total stations, RTK/PPK GPS systems for precise measurements and direct data plotting for quick results. Cross sections were referenced to the already surveyed Centerline Posts along the entire KCR route.

(10) Longitudinal profile survey

Longitudinal profile was generated from the cross sections data but it is supplemented with additional profile information that lies in between two centerline posts. These include the culverts, pipes, bridge piers, columns and river beds etc.

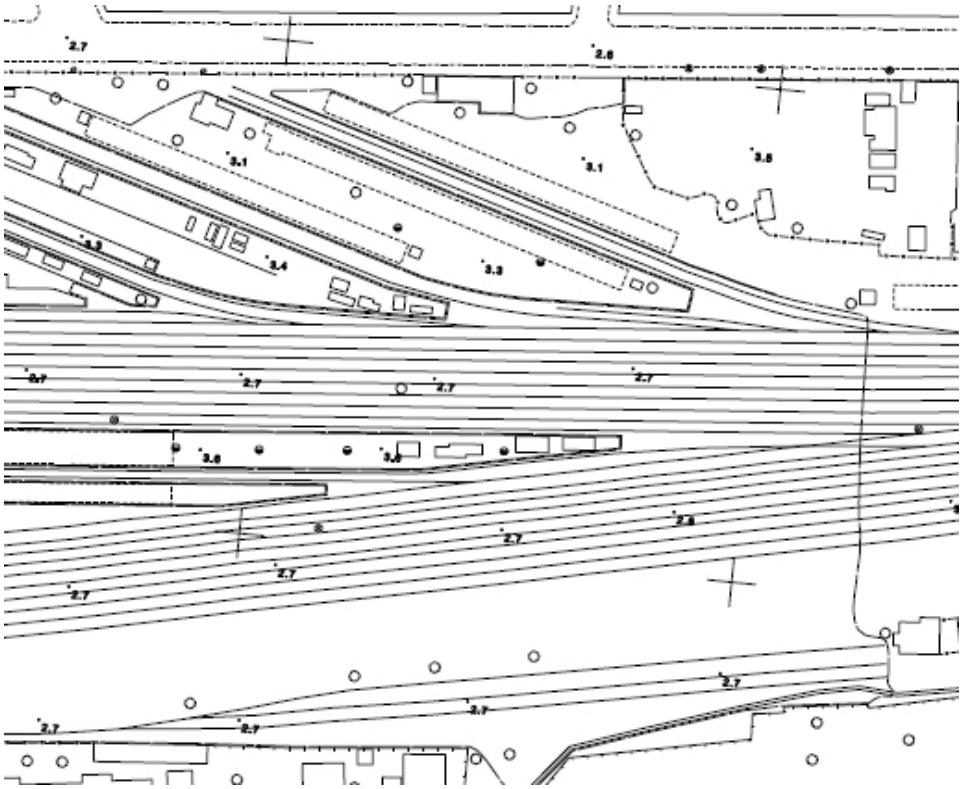
(11) 1/2000 scale topographic map creation

1/2000 scale topographic map was created using the satellite image.

The specification of the purchased satellite image is as follows:

- Satellite name : WorldView-1
- Image type : Stereo pair

- Product type : Pan-chromatic
- Image resolution : 0.5 m
- Purchase number of sheets : 2 stereo pair (four scenes)



Source: JICA Study Team

Figure 2.1.1 1/2000 Scale Topographic Map

(12) 1/1000 scale complementary topographic maps at proposed stations

Complementary survey at 1/1000 scale are performed for selected 21 sites for stations or yards along the proposed KCR route. Location of these stations and yards are:

1 Depot Hill
2 Gulistan-e-Johar
3 Alladin Park
4 NIPA
5 Gilani
6 Yasinabad
7 Liaquatabad
8 North Nazimabad
9 Orangi
10 HBL
11 Manghopir
12 SITE
13 Shah Abdul Latif
14 Baladiya
15 Liyari
16 Wazir Mansion
17 DCOS
18 Naval
19 Chanesar
20 Shaheed-e-Millat
21 Karsaz

Complementary survey was performed to fill up the finer details of topography that are not visible on the satellite imagery. Complementary survey was referenced to the Control Points already established along the entire KCR route.

Complementary survey was conducted using total station or tape measurements from known positions to achieve the required accuracy of 1/1000 scale mapping.

(13) 1/500 scale detailed topographic maps at 4 proposed stations

Four Main Line stations are selected for detailed topographic survey at 1/500 scale. These include:

1 Tower Station	3 Cantt Station
2 City Station	4 Drigh Road Station

These maps are developed in digital form through a complete resurvey at 1/500 scale covering details that are not visible from the satellite imagery. Survey was performed using total stations or RTK GPS depending upon the equipment suitability for that area. Annexure–10 shows the resultant survey maps of the 4 stations. Primary references were taken from the already established Control Points at every kilometer approximately.

2.1.2 Control Points

(1) Established control point

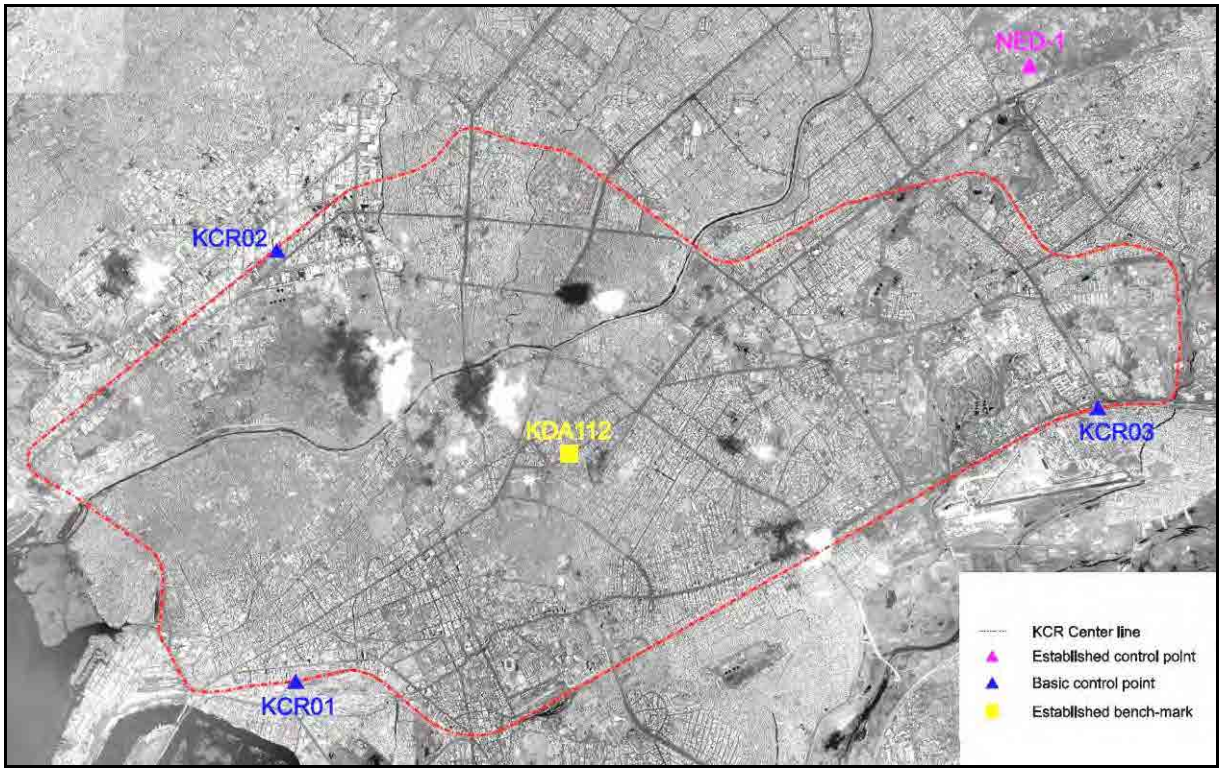
NED-1 (NED University) and KDA-112 are used as the horizontal datum of control point (XY) and the vertical datum of bench-mark (Z) respectively in this project.

(2) Basic control points

The basic control point was installed in the following three places.

- Drigh Road Station
- Mangohpir Station
- Karachi city Station

The location of Established and Basic control points are shown in Figure 2.1.2.



Source: JICA Study Team

Figure 2.1.2 Index Map of Established Control Point and Bench-mark

(3) Primary control points

40 primary control points was installed at about 1km intervals.

Figure 2.1.3 shows the description of project control point at near Drigh Road Station. All the points of it are shown in Appendix-2.1

DESCRIPTION OF PROJECT CONTROL POINT

Point No.	City	Operated by	Faheem
KCR - 03	Drigh Road Station, Shah Faisal Town, Karachi	Checked by	Shamoon Saeed
		Date	24-10-2011

Coordinates

UTM (Zone 42N)		Geographic (WGS84)	
Northing	2753607.24	Latitude	24°53'08.86552"N
Easting	310553.87	Longitude	67°07'28.43515"E
Elevation	15.390	Ellipsoid Height	-28.6918

Sketch-Map of Point and Neighborhood

Description of exact location

Photograph of Point

Close-up	Long Shot
	

Source: JICA Study Team

Figure 2.1.3 Description of Control Points

2.1.3 List of Topographic Survey Data

The list of the Topographic survey data is as shown in the following:

(1) GPS Survey for primary control points

- GPS observation Raw Data
- GPS observation log sheet
- Description of Primary Control Point
- Coordinate List

(2) Leveling Survey for primary control points

- Observation Raw Data or Field note book
- One set of digital files and hard copies of Coordinate List

(3) Photo control point survey

- GPS observation Raw Data
- GPS observation log sheet
- Description of Primary Control Point
- Coordinate List

(4) Center line survey for the entire route

- Observation Raw Data or Field note book
- Coordinate List of all center line post

(5) Land boundary confirmation and survey

- Observation Raw Data or Field note book
- Coordinate List of all boundary survey point
- Land boundary map

(6) Cross section survey

- Observation Raw Data or Field note book
- Coordinate list of all observation point with section name
- Cross sections sheets

(7) Longitudinal profile survey

- Observation Raw Data or Field note book
- Coordinate list of all observation point
- Longitudinal profile sheets

(8) 1/2000 scale topographic map creation

- 1/2000 scale topographic map data
- 1/2000 scale topographic map sheets

(9) 1/1000 scale complementary topographic maps at proposed stations

- 1/1000 scale topographic map data
- 1/1000 scale topographic map sheets

(10) 1/500 scale detailed topographic maps at 4 proposed stations

- 1/500 scale topographic map data
- 1/500 scale topographic map sheets

2.2 Hydrological Survey

2.2.1 Overview of the Hydrological Survey

(1) Purpose of the Hydrological Survey

Currently, some portion in the Right of Way (ROW) of Karachi circular railway (Target Area "P" as defined afterward) has been affected by the inflow of the domestic wastewater and probably by seepage through ground. For the revival design of Karachi circular railway for the future, any kind of inflow has to be stopped and the stagnant water and the inflow into the existing circular railway need to be drained. For this purpose it is important to know, the quantity of the stagnant water and inflow of domestic wastewater as well as the status-quo of the existing sewer system into which domestic wastewater might be discharged. Their surveys are essential for an examination of the drain system required for ridding the circular railway of the flood water.

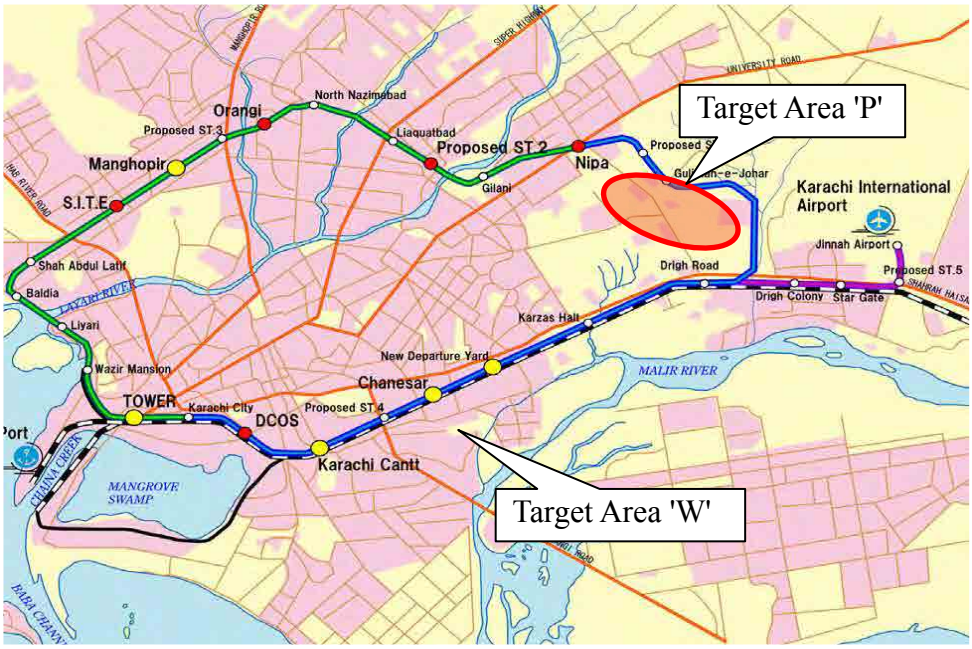
To study protection from inundation in the ROW of the KCR due to an inflow of rain and wastewater, hydrological data, flood disaster data and information on status-quo of the existing sewer system have been collected through hydrological survey. The objectives of the survey are to:

- Clarify the cause of the inundation are as along Karachi Circular Railway
- Study to dewater stagnant water in the ROW
- Study to protect the ROW from inflow such as domestic wastewater
- Propose drainage plan

(2) Target Area

The hydrological survey is done in the area that is along Karachi circular railway. The survey area is divided into the Target Area 'W' and 'P' (see Figure 2.2.1). Respective target area is defined as follows:

- Target Area 'W':
  It is the entire area along Karachi Circular Railway ROW excluding the Target Area 'P'.
- Target Area 'P':
  It is the area in the KCR ROW where domestic wastewater and rain water are remarkably stagnant.



Source: JICA Study Team

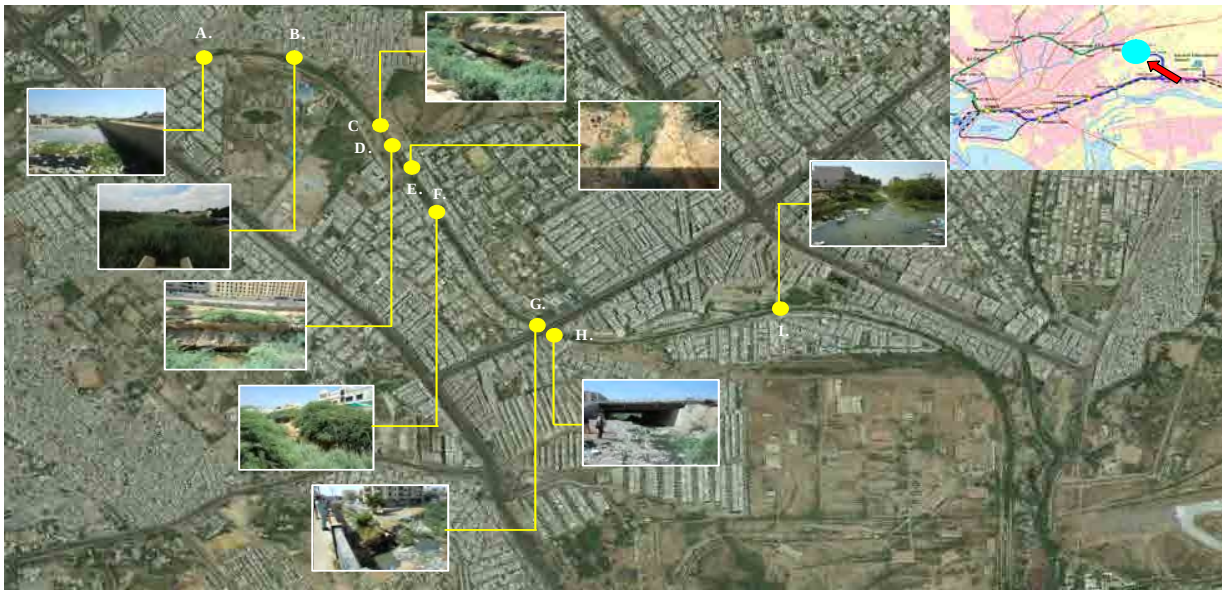
Figure 2.2.1 Target Area of the Hydrological Survey

(3) Condition of Stagnant Water and Inflow in the Right of Way

It was recognized that domestic and industrial wastewater was found to be flowing and/or stagnant in the ROW of the Karachi circular railway.

In the Target Area 'W', domestic and industrial wastewaters have been flowing in the parts of the ROW. Domestic wastewater has leaked from the damaged sewer pipes and flowed in the small trench in the ROW. In addition, it is likely that the small trench was intentionally made by dwellers such as informal settlers living surrounding the circular railway to flush and spill domestic wastewater downstream, such as to creek 'Nala'. An industrial wastewater has been discharged into the existing rainstorm drainage and small trench without any treatment.

There is no industrial wastewater in the Target Area 'P', but domestic wastewater has been discharged into the ROW and stagnated due to the feature of topographical condition (See Figure 2.2.2). Most of the domestic wastewater has leaked from the existing sewer pipes which were damaged as mentioned above and over-flowed from the sewer manholes, which were blocked up with waste, sludge, etc at point 'G' as shown in Figure 2.2.2.



-Note: A to I denotes the sampling points of water quality analysis as described in '2.2.2'
Source: JICA Study Team

Figure 2.2.2 Overview of Target Area 'P'

2.2.2 Result of Survey Work

To effectively learn topographical, environmental, infrastructural and meteorological condition, JICA Study Team farmed out the field works to the contractor of the name of "ENVIRONMENTAL MANAGEMENT CONSULTANTS" hereinafter referred to as EMC) as shown in Table 2.2.1.

The contract work was carried out from the beginning of October 2011 to the end of January 2012.

Table 2.2.1 Contents of Survey Work and Time Schedule

Survey Categories	2011			2012
	Oct.	Nov	Dec	Jan
(1) Survey on the Stagnant Water in Target Area 'P'				
(2) Survey on Inflow of Domestic Wastewater in Target Area 'P'				
(3) Survey on the Discharge Point to be proposed				
(4) Collection of Rainfall Data, Water Level Data and Flow Regime Data for the Target Area 'W'				
(5) Survey/ Collection on Flood Disaster Records				
(6) Water Quality Analysis				
(7) Effluent Standards into Public Water Body and Treatment Plant in Pakistan				
(8) Existing Water Supply, Drainage and Sewerage Survey				

Source: JICA Study Team

(1) Survey on the Stagnant Water in Target Area 'P'

To grasp the Stagnated Water in Target Area 'P', Field Survey shown in Table 2.2.2 was carried out by EMC.

Table 2.2.2 Field Survey in Target Area 'P'

Item	Quantity
Cross-Section and Water-Depth Survey	13 points
Longitudinal Section and Water-Depth Survey	12 points

Source: JICA Study Team

Target Area 'P' is further divided into two (2) areas judging according to the topographical situation, P1 and P2 as shown in Figure 2.2.4. Furthermore, P2 is sub-divided into two (2) areas, Stagnant-Water area and Flowing-area.

Cross-Section and Water-Depth Survey and Longitudinal-Section Water-Depth Survey were carried out at 13 points and 12 points respectively as shown in Figure 2.2.4.

The quantity of the stagnated water is estimated about 14,510 m^3 (10,860 m^3 at 'P1' and 3,650 m^3 at 'P2') by the way as shown below.

The results of Cross-Section and Water-Depth Survey and Longitudinal-Section and Water-Depth Survey are shown in Table 2.2.3. Figure 2.2.5 shows the view of Cross-Section and Water-Depth Survey.

1) Cross-Section and Water-Depth Survey

The depth for water pool (measure depth D_1, D_2 and D_3) as shown in Figure 2.2.3 to specify approximate water volume of stagnation in Target Area 'P' shall be conducted. Interval of the cross section shall be 500 m toward the flow direction. Cross section area should be calculated as follows:

$$A = \frac{D_1}{2} \times \frac{L_1}{4} \times \frac{(D_1 + D_2)}{2} \times \frac{L_1}{4} + \frac{(D_2 + D_3)}{2} \times \frac{L_1}{4} + \frac{D_3}{2} \times \frac{L_1}{4}$$

$$= \frac{L_1}{4} \times (D_1 + D_2 + D_3)$$

$$V = \frac{A_1}{2} \times DL_0 + \frac{(A_1 + A_2)}{2} \times DL_1 + \ldots + \frac{(A_{n-1} + A_n)}{2} \times DL_n$$

Hereby,

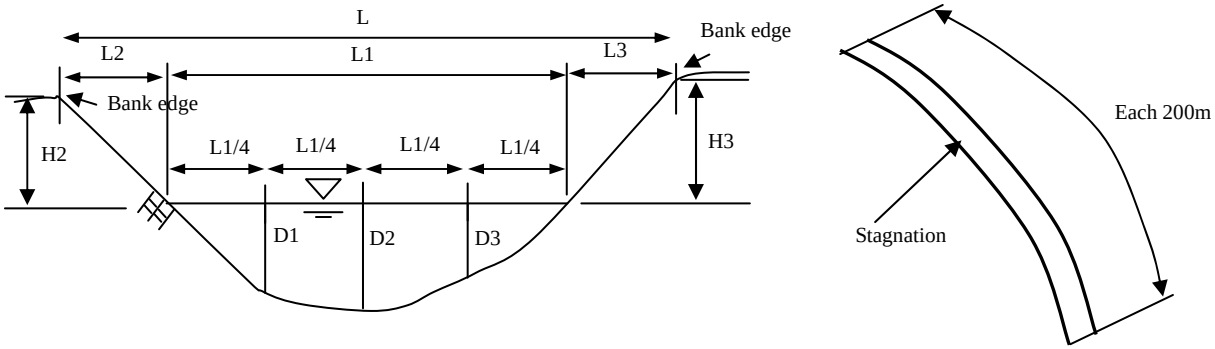
A_n : Section area of the stagnated (m^2) (see below)

V : Approximate quantity of the stagnated water (m^3)

DL_n : Interval between section area (m)

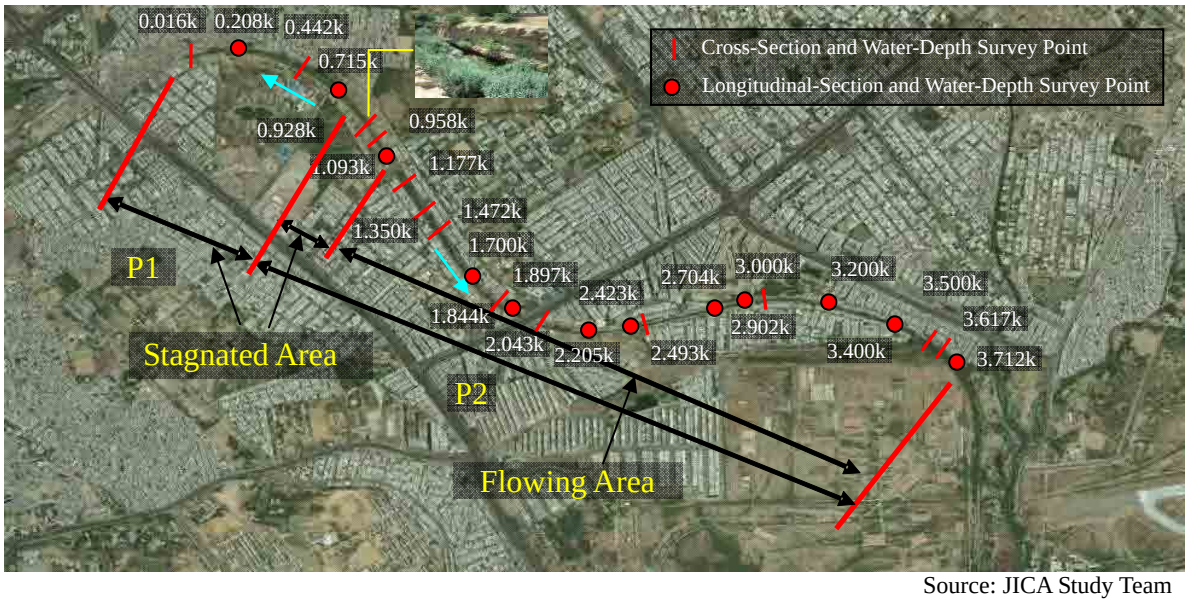
2) Longitudinal-Section and Water-depth Survey

The depth for water pool at center line in target area has been measured. Interval of the longitudinal section was 200 m.



Source: JICA Study Team

Figure 2.2.3 Cross-Section, Longitudinal-Section and Water-Depth Survey



Source: JICA Study Team

Figure 2.2.4 Cross-Section and Water-Depth Survey Points in Target Area 'P'

Table 2.2.3 Quantity of Stagnated Water in Target Area 'P'

No.	P1orP2	Cross Section	L	L1	L1/4	L2	L3	H2	H3	D1	D2	D3	An		DLn		V	Remarks
			m	m	m	m	m	m	m	m	m	m	m^2		m		m^3	
1	P1	0.016k	17.20	17.20	4.30	0.00	0.00	0.00	0.00	1.11	1.14	1.42	A1	15.78	DL0	16	126	Stagnated Area
2'		0.208K		24.00	6.00					1.01	1.04	1.30	A1'	20.09	DL0'	192	3,305	
2		0.442k	30.90	24.30	6.08	4.20	2.40	1.09	1.37	0.61	0.76	0.99	A2	14.34	DL1	234	1,677	
2''		0.715K		26.00	6.50					1.48	1.85	2.41	A2'	37.34	DL1'	273	5,097	
2'''															DL1''	35	653	
															S.Total		10,859	
3	P2	0.928k	16.00	10.70	2.68	3.00	2.30	6.60	7.31	1.93	2.00	1.57	A3	14.71	DL3	178	1,309	Stagnated Area
4		0.958k	20.60	10.66	2.67	7.30	2.64	8.33	7.30	1.93	2.26	1.68	A4	15.64	DL4	30	455	
4'		1.093k		9.75	2.44					1.58	1.85	1.38	A4'	11.71	DL4'	135	1,847	
4''																7	41	
															S.Total		3,652	
5		1.177k	17.10	8.00	2.00	6.65	2.45	0.00	12.02	0.07	0.61	0.48	A5	2.32	DL5	77	89	Flowing Area
6		1.350k	17.70	6.00	1.50	8.70	3.00	8.45	5.50	0.50	0.30	0.30	A6	1.65	DL6	173	343	
7		1.472k	19.10	3.00	0.75	6.21	9.92	7.00	4.40	0.18	0.78	0.45	A7	1.06	DL7	122	165	
7'		1.700k		8.40	2.10					0.07	0.30	0.17	A7'	1.14	DL7'	228	250	
8		1.844k	16.76	8.80	2.20	4.72	3.20	8.91	8.10	0.53	0.51	0.41	A8	3.19	DL8	144	312	
8'		1.897k		8.70	2.18					0.77	0.74	0.59	A8'	4.58	DL8'	53	206	
9		2.043k	4.87	4.30	1.08	0.00	0.61	1.00	0.61	0.61	0.48	0.48	A9	1.69	DL9	146	457	
9'		2.205k		6.70	1.68					0.19	0.15	0.15	A9'	0.82	DL9'	162	203	
10'		2423k		8.00	2.00					0.28	0.22	0.22	A10'	1.44	DL10'	218	246	
10		2.493k	13.65	6.00	1.50	4.40	3.25	0.61	0.74	0.10	0.00	0.15	A10	0.38	DL10	70	63	
11'		2.704k		7.60	1.90					0.33	0.33	0.44	A11'	2.10	DL11'	211	261	
11''		2.902k		9.00	2.25					0.45	0.45	0.60	A11''	3.38	DL11''	198	542	
11		3.000k	11.20	7.35	1.84	1.75	2.10	0.69	0.61	0.38	0.38	0.51	A11	2.33	DL11	98	280	
12'		3.200k		5.60	1.40					0.17	0.20	0.37	A12'	1.05	DL12'	200	338	
12''		3.400k		7.80	1.95					0.33	0.38	0.71	A12''	2.77	DL12''	200	382	
12		3.500k	11.80	7.20	1.80	1.80	2.80	0.81	1.20	0.20	0.23	0.43	A12	1.55	DL12	100	216	
13		3.617k	13.25	5.30	1.33	5.60	2.35	0.46	1.00	0.10	0.18	0.18	A13	0.61	DL13	117	126	
13'		3.712k		3.00	0.75					0.42	0.76	0.76	A13'	1.46	DL13'	95	98	
															S.Total		4,580	
															Stagnated Area		14,511	
															Flowing Area		4,580	
															Total		19,091	

Note; n' or n'': Longitudinal-Section and Water-Depth Survey Point
Source: JICA Study Team

Source: JICA Study Team

Figure 2.2.5 View of Cross-Section and Water-Depth Survey

(2) Survey on inflow of domestic wastewater in the Target Area 'P'

The following surveys were carried out by EMC to specify the points where household wastewater is flushed into Target Area 'P'.

a) The Number of flush points connected to Target Area 'P' from surroundings.
   : N (locations)
b) The survey of the quantity of wastewater inflow through household interview

The quantity of wastewater was to be estimated initially in accordance with the way shown below.

After flow measurement at 3 locations, the survey of the quantity of wastewater inflow through household interview was adopted instead of flow measurement because of inaccesibility.

Selecting 10 representative locations out of the flush points (N locations) of above a), the number ('m') of households located in hinterland for 10 locations, and rate 'q' (litter/day/household) of wastewater from sampling points are surveyed. Quantity of wastewater Q (litter/day) per location is estimated by following formula.

Q (litter/day/ location) = q (litter/day・household) × m (households)

Note: 'q' and 'm': average for 10 locations

Total quantity of wastewater (TQ) was estimated as follows:

TQ (litter/day) = Q (litter/day/location) × N (locations)

1) The Number of flush points connected to Target Area 'P' from surroundings

A total of 64 flush points were identified through field investigation.

Some of 64 flush points are shown in Figure 2.2.6.

Source: JICA Study Team

Figure 2.2.6 View of Some Flush Points

2) The survey of the quantity of wastewater inflow through household interview

The quantity of wastewater inflow through household interview is summarized in Table 2.2.4. As seen in Table 2.2.4, the total quantity of wastewater inflow is about 13,200 L/day. The wastewater inflow per one flush point is estimated about 206 L/day/point and this quantity seems to be wastewater inflow per singlehousehold because of each households having their own flush points. Table 2.2.5 shows flow measurement data at P-22, P-34 and P-40. After the flow measurement at these points, the interview survey was adopted instead of flow measurement owing to inaccessibility as mentioned above. Average flow measurement data are calculated as 1.3 L/10M, 3.1 L/10M and 1.4 L/10M at P-22, P-34 and P-40 respectively. Daily wastewater from one household is estimated about 76 L/day – 186 L/day on the assumption that the average flow measurement data run on for 10 hours on average. This value based on the flow measurement might be rather underestimated in comparison with the

quantity of the wastewater inflow through household interview.

Figure 2.2.7 shows view of the interview to householders.

Source: JICA Study Team

Figure 2.2.7 View of Interview to Householder

Table 2.2.4 Quantity of the Wastewater Inflow Through Household Interview

Point	Latitude	Longitude	Daily Usage (Ltr/day)	Remarks
P-01	24.91741	67.1036	40	Single Household
P-02	24.9174	67.10365	40	Single Household
P-03	24.91742	67.10365	80	2 Households
P-04	24.91737	67.10371	40	Single Household
P-05	24.91744	67.10387	1226	6 Households
P-06	24.91744	67.10385	1000	2 Households
P-07	24.91748	67.10406	120	Single Household
P-08	24.91747	67.10404	120	Single Household
P-09	24.91769	67.10483	290	Single Household
P-10	24.91776	67.105	160	Single Household
P-11	24.91784	67.10503	180	Single Household
P-12	24.91772	67.10511	140	Single Household
P-13	24.91778	67.10513	80	Single Household
P-14	24.91777	67.10529	80	Single Household Assumed (Based on household size)
P-15	24.91773	67.10539	200	Single Household
P-16	24.9177	67.10548	200	Single Household
P-17+18+19	24.91777	67.10571	100	Single Household
P-20	24.91776	67.10574	80	Single Household
P-21	24.91775	67.10587	100	Single Household
P-22	24.91775	67.10588	100	Single Household
P-23+24	24.91775	67.10588	240	Single Household
P-25+26	24.91771	67.10595	240	Single Household
P-27+28+29	24.91772	67.10603	250	Single Household Assumed (Based on household size)
P-30	24.91772	67.10622	100	Single Household
P-31	24.91775	67.10626	40	Single Household
P-32	24.91775	67.10628	40	Single Household

Point	Latitude	Longitude	Daily Usage (Ltr/day)	Remarks
P-33	24.91775	67.10628	320	Single Household
P-34	24.91772	67.10635	300	Single Household
P-35	24.9177	67.10638	170	Single Household
P-36+37+38	24.91771	67.1064	100	Single Household
P-39	24.91772	67.10654	20	Single Household
P-40	24.91771	67.10659	280	Single Household
P-41+42	24.91765	67.10667	140	Single Household
P-43	24.91766	67.1067	80	Single Household
P-44	24.91766	67.10704	150	Single Household
P-45	24.91766	67.10712	200	Single Household
P-46	24.91755	67.10755	750	4 Households
P-47	24.91748	67.10771	160	Single Household Assumed (Based on household size)
P-48	24.91746	67.10783	980	2 Households
P-49	24.91735	67.10802	554	2 Households
P-50	24.91736	67.10802	170	Single Household
P-51	24.91735	67.10804	120	Single Household
P-52	24.91733	67.10806	72	Single Household
P-53	24.91731	67.10809	200	Single Household
P-54	24.91726	67.10822	240	Single Household
P-55	24.91724	67.10831	884	Single Household
P-56	24.91689	67.10911	350	2 Households
P-57	24.91675	67.10929	440	Single Household
P-58	24.91666	67.10941	100	Single Household Assumed (Based on household size)
P-59	24.91661	67.10948	95	Single Household
P-60	24.91637	67.1097	240	Single Household
P-61	24.91675	67.10929	40	Single Household Assumed (Based on household size)
P-62	24.91666	67.10941	750	Single Household
P-63 + 64	24.91661	67.10948	10	Single Household
Total Quantity			**13,201 Ltrs/Day (Approx.) from 67 households**	

Source: JICA Study Team

Table 2.2.5 Flow Measurement Data at P-22, P-34 and P-40

Point No.	Latitude	Longitude	Time			Quantity
22	24.91775	67.10588		From	To	(Ltrs)
			Morning	8:00	8:10	1.5
			After Noon	12:00	12:10	1.2
			Evening	16:00	16:10	1.1
Point No.	**Latitude**	**Longitude**	**Time**			**Quantity**
34	24.91772	67.10635		From	To	(Ltrs)
			Morning	8:25	8:35	2.2
			After Noon	12:25	12:35	No Flow
			Evening	16:25	16:35	4.0
Point No.	**Latitude**	**Longitude**	**Time**			**Quantity**
40	24.91771	67.10659		From	To	(Ltrs)
			Morning	8:50	9:00	1.8
			After Noon	12:50	13:00	1.0
			Evening	16:50	17:10	No Flow

Source: JICA Study Team

Table 2.2.6 Wastewater from Single Household Based on Flow Measurement

Flush Point	Average Inflow (L/10M)	Daily Wastewater (L)	Remarks
P-22	1.3	76	10-hour duration
P-34	3.1	186	
P-40	1.4	84	

Source: JICA Study Team

(3) Survey on the Discharge Point to be proposed

To deal with wastewater being flushed illegally, practical use of the existing sewer system was proposed. Based on the existing sewer drawings, site reconnaissance was carried out to identify manholes and verify the flow direction. In addition, the invert depth of manholes was measured so as to verify a possibility of the proper sewer connection with the existing sewer pipes.

Domestic wastewater, total quantity of which is approximately 13.2 m^3/day, has being discharged form 64 points (about 67 households) to the ROW in Area 'P'. The quantity per household can be assumed to be 200 liter/day/household. In case household size of 5 persons, wastewater per capita per day is accounted for 40 liter/capita/day, which is nearly equal to 70%[1] of water consumption per capita per day (55-60 liter/capita/day) for poverty in urban area, which was reported in The Study on Water Supply and Sewerage System in Karachi in the Islamic Republic of Pakistan, July 2008: JICA Study Report.

(4) Collection of Rainfall Data, Water Level Data and Flow Regime Data for the Target Area 'W'

Rainfall data, temperature data and evaporation data were collected through Pakistan Meteorological Department. Actual water level data or flow regime data in the Lyari River and the Malir River were not collected. Despite all enquiries to every organizations concerned were done, any data could not be recognized at all.

(5) Survey/Collection on Flood Disaster Record

Flood disaster records in the Target Area 'W' including vicinity areas could not be obtained in spite of spending great effort to get desired records through concerned agencies, like Provincial Disaster

[1] Daily per capita domestic wastewater is defined as 70% of daily per capita consumption in Pakistan.

Management Authority (PDMA), City District Government Karachi (CGDK) and Town Municipal Authorities (TMAs). Consequently, the interview survey was carried out to gather useful information related to floods in the ROW of the KCR.

(6) Sewage Quality Analysis

Twelve points of the stagnant wastewater in Target Area 'P', raw sewage water and sewage-treated water and Nala were sampled and analyzed in nine parameters. Sampling points were directed by the JICA Study Team in the field as shown in Figure 2.2.8 as well as Figure 2.2.2.

As shown in Figure 2.2.8, sewage-treated water at the Sewage Treatment Plant (T.P-3) complies with National Environmental Quality Standards (NEQS) for wastewater discharge in Pakistan. However, treated water at T.P-1 does not comply with NEQS. Judging from analysis data, stagnant and the flowing wastewater in target area 'P' are typical domestic wastewater. It is not so different quality between stagnant and the flowing wastewater. Regarding Point 'B', since BOD and COD of first analysis are extremely high to be 428 mg/L and 1,270 mg/L respectively, water quality was rechecked by local contractor. Consequently, second analysis result was an ordinal quality level of domestic wastewater. It is envisaged that the result of first sampling might be caused by sampling wastewater unexpectedly at the place where dwellers had dumped the domestic wastewater concentrated through garbage.

Meanwhile, the flowing water in the storm water drain (turned into *Nala*) contains industrial wastewater which results in a remarkable deterioration of water quality around S.I.T.E.

Source: JICA Study Team

Figure 2.2.8 Sampling Points for Waste Quality Analysis

Table 2.2.7 Result of Sewage Water Quality Analysis

S.No	Parameters	Units	National Environment Quality Standard Limits			T.P.-1 (Raw Sewage)	T.P-1 (Treated Sewage)	T.P-3 (Raw Sewage)	T.P-3 (Treated Sewage)	Point A	Point B
			For Sewage Treatment Plant	For Inland Water	For Sea	Treatment	Treatment	Treatment	Treatment	Stangant	Stangant
1	Temperature	Deg.	3 or less difference againt water body	3 or less difference againt water body	3 or less difference againt water body	30.6	31	30.9	29.9	28.1	25.5 (23.4)
2	pH	SU	6-9	6-9	6-9	6.75	7.22	6.91	9.22	7.87	7.28 (7.41)
3	5 Days (BOD)	mg/L	250	80	80	284	132	251	39	193	428 (41)
4	COD	mg/L	400	150	400	518	229	432	85	369	1,270 (68)
5	TSS	mg/L	400	200	200	179	54	148	102	214	381 (90.6)
6	TDS	mg/L	3,500	3,500	3,500	969	932	748	2,667	3,237	1,318 (1,160.5)
7	Total Nirogen (as N)	mg/L	N/A	N/A	N/A	6.82	5.38	12.98	2.17	5.68	4.37 (16.84)
8	Total Phophate (PO_4)	mg/L	N/A	N/A	N/A	17.29	13.27	9.19	0.76	10.64	3.06 (4.35)
9	Total Sulfate (SO_4)	mg/L	1000	600	Below concentration at sea	124	86	280	220	180	160 (128)

S.No	Parameters	Units	National Environment Quality Standard Limits			Point C	Point E	Point F	Point H	Point I	Storm Water Drain
			For Sewage Treatment Plant	For Inland Water	For Sea	Stangant	Flowing	Flowing	Flowing	Flowing	Flowing
1	Temperature	Deg.	3 or less difference againt water body	3 or less difference againt water body	3 or less difference againt water body	28.4	26.72	27.3	29.3	28.6	35.7
2	pH	SU	6-9	6-9	6-9	6.96	6.89	7.71	7.22	7.62	7.4
3	5 Days (BOD)	mg/L	250	80	80	141	83	81	134	157	826
4	COD	mg/L	400	150	400	263	154	143	287	311	1386
5	TSS	mg/L	400	200	200	393	127	328	193	204	1,174
6	TDS	mg/L	3,500	3,500	3,500	2,890	6,575	6241	4,975	5,670	6,334
7	Total Nirogen (as N)	mg/L	N/A	N/A	N/A	2.68	5.46	2.14	3.84	11.94	7.19
8	Total Phophate (PO_4)	mg/L	N/A	N/A	N/A	6.72	1.54	1.93	13.28	10.68	4.79
9	Total Sulfate (SO_4)	mg/L	1000	600	Below concentration at sea	91	680	128	120	210	310

Source: Water Quality Survey in the JICA Study
Note: In regard to Point 'B', Upper: First sampling, Lower: Second sampling

(7) Effluent Standards into Public Water Body and Treatment Plant in Pakistan

The Gazette of Pakistan which included 'National Environmental Quality Standards for Municipal and Liquid Industrial Effluents' was obtained. Effluent standards are described for detail in '2.2.4'.

(8) Existing Water Supply, Drainage and Sewerage Survey

Drawings on the existing water supply, drainage and sewerage were obtained from KW and SB and Pakistan Railway Housing Authority in the study. However, their information lacks and includes only trunk main lines.

Meanwhile, information on sewer pipes along Target area 'P' was utilized so as to deal with wastewater being flushed illegally from houses into the ROW.

2.2.3 Hydrology

The following data were collected through the organizations concerned.

(1) Rainfall

Rainfall data was collected through Pakistan Meteorological Department (hereinafter referred to as PMD). Table 2.2.8 and Figure 2.2.9 show the rainfall data from 2001 through 2011 in Karachi.

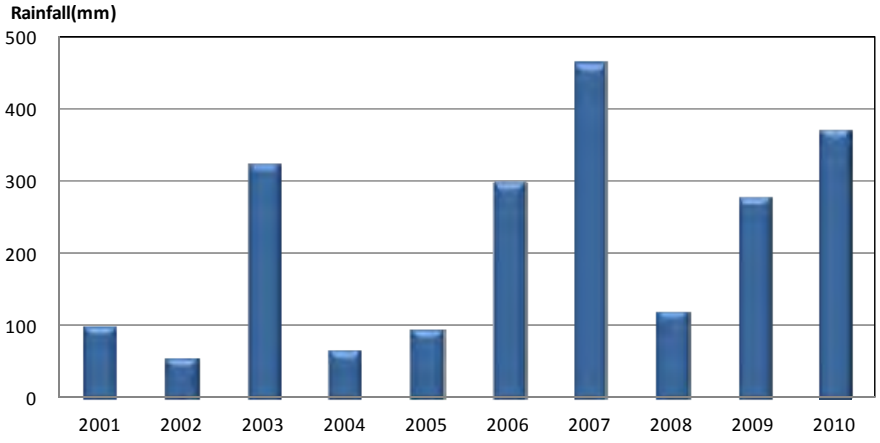
Rainfall in Karachi is limited from June to September, and the annual rainfall is no more than 500 mm at most.

Table 2.2.8 Rainfall in Karachi

Rainfall Station:Karachi(Airport) (mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
2001	0.0	0.0	0.0	0.0	0.0	10.6	73.6	16.2	0.0	0.0	0.0	0.0	100.4
2002	0.0	2.4	0.0	0.0	0.0	0.0	0.3	52.2	0.0	0.0	0.5	0.4	55.8
2003	6.4	21.8	0.0	0.0	0.0	16.3	270.4	9.8	0.0	0.0	0.2	0.0	324.9
2004	13.7	0.0	0.0	0.0	0.0	0.0	3.0	5.6	0.0	39.3	0.0	4.3	65.9
2005	10.8	12.8	0.0	0.0	0.0	0.0	1.3	0.3	54.9	0.0	0.0	17.1	97.2
2006	0.0	0.0	0.0	0.0	0.0	0.0	66.2	148.6	21.9	0.0	3.1	61.3	301.1
2007	0.0	13.2	33.4	0.0	0.0	110.2	41.0	250.4	0.0	0.0	0.0	17.4	465.6
2008	8.0	0.0	1.1	0.0	0.0	0.0	54.0	37.5	0.0	0.0	0.0	21.0	121.6
2009	3.0	0.0	0.0	0.0	0.0	2.6	159.9	44.0	68.9	0.0	0.0	1.5	279.9
2010	0.0	0.5	0.0	0.0	0.0	97.4	120.4	111.5	42.7	0.4	0.0	0.0	372.9
2011	8.5	1.6	0.0	0.0	0.0	0.0	7.2	61.1	212.9				291.3
Average	4.6	4.8	3.1	0.0	0.0	21.6	72.5	67.0	36.5	4.0	0.4	12.3	225.1
Max.	13.7	21.8	33.4	0.0	0.0	110.2	270.4	250.4	212.9	39.3	3.1	61.3	465.6
Min.	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.0	0.0	0.0	0.0	55.8

Source: PMD



Source: Pakistan Metrorilogical Department

Figure 2.2.9 Annual Rainfall in Karachi

(2) Temperature

Temperature data was also collected through PMD. Table 2.2.9, Table 2.2.10 and Figure 2.2.10 show the mean monthly maximum and minimum temperature data from 2001 through 2011 in Karachi.

The mean monthly maximum temperature in Karachi is about 36 degrees from April to June and October at maximum, and about 27 degrees in January at minimum. The mean monthly minimum temperature is about 29 degrees in June at maximum, and about 12 degrees in January at minimum.

Table 2.2.9 Mean Monthly Maximum Temperature in Karachi (1)

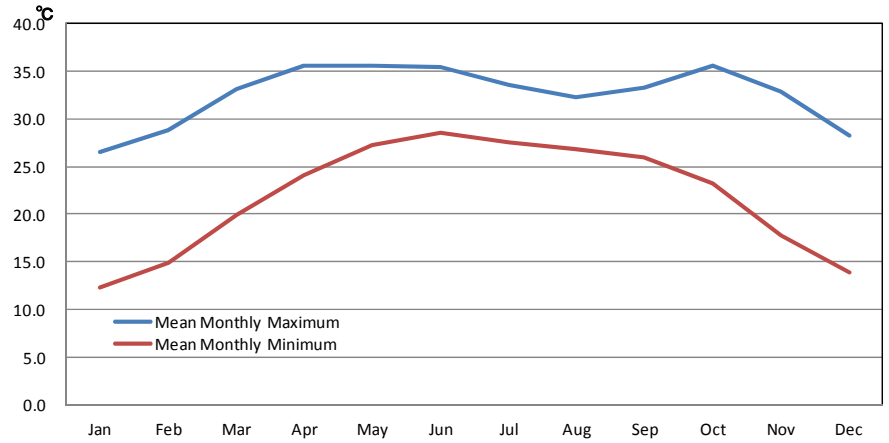
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2001	27.2	29.6	33.1	34.6	35.1	34.9	32.2	32.3	33.1	36	33.5	30.4	32.7
2002	27	28.2	33.3	35.4	35.6	35.1	32.2	31.6	31.4	36.5	32.7	28.1	32.3
2003	27.6	28.5	32.4	36.6	35.7	34.9	34.1	32.6	32.5	37	32.2	28.3	32.7
2004	26.6	29.9	36.2	35.4	36.8	35.6	33.8	32.7	32.8	33.7	33.1	29.4	33
2005	24.9	26.3	31.5	35.3	35.4	36	33.2	32.2	34.2	35.2	33.1	28.4	32.1
2006	26	31.3	31.8	34	34.6	35.3	33.8	31	34.2	35	33.4	26.3	32.2
2007	26.9	29.4	31.4	37.7	36	36.4	N/A	N/A	N/A	N/A	N/A	N/A	33
2008	24.4	26.9	34.3	34.4	33.9	35.1	33.5	31.9	34.7	35.5	32.5	27.2	32
2009	26.2	29.8	33	36	36.8	35.7	34.5	33	32.8	35.9	33	28.6	32.9
2010	27.5	29.2	34	35.7	36.5	34.7	34.6	33.2	34.5	35.9	32.7	28	33.0
2011	26.9	28.5	33.2	35.8	35.3	35.3	34.2	32.8	32.9				
Average	26.5	28.9	33.1	35.5	35.6	35.4	33.6	32.3	33.3	35.6	32.9	28.3	32.6
Max.	27.6	31.3	36.2	37.7	36.8	36.4	34.6	33.2	34.7	37.0	33.5	30.4	33.0
Min.	24.4	26.3	31.4	34.0	33.9	34.7	32.2	31.0	31.4	33.7	32.2	26.3	32.0

Source: Pakistan Metrorilogical Department

Table 2.2.10 Mean Monthly Minimum Temperature in Karachi (2)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2001	11.5	14.9	19.6	23.8	28.1	29	27.1	26.5	25.9	24.4	18.6	15.8	22.1
2002	12.8	13.8	19.5	23.9	27	28.2	29.6	25.6	24.8	22.5	17.7	14.9	21.7
2003	12.7	16.9	19.8	24.2	26.5	28.2	23.6	27	25.3	20.9	15.2	12	21
2004	12.9	14.5	19.1	24.8	27.3	28.8	27.5	26.3	25.3	22.4	18	15.4	21.9
2005	12.3	11.3	20.3	23	26.4	28.3	27.2	26.6	26.6	22.9	18.9	13	21.4
2006	11.7	18.1	19.6	24.5	27.5	28.5	28.3	26.3	26.8	25.7	19.4	14	22.5
2007	13	17.3	19.7	24.7	27.6	28.6	N/A	N/A	N/A	N/A	N/A	N/A	21.8
2008	10.1	11.1	19.6	24	27.3	29.1	27.9	26.8	26.6	23.8	17.6	14.9	21.6
2009	14.7	16.5	20.8	23.8	27.6	28.7	28.1	27.5	26.5	22.6	17	13.9	22.3
2010	12.2	14.7	21.3	25.1	28	28.2	28.3	27.2	25.8	23.9	17.4	11.1	21.9
2011	11	14.5	19.7	23.1	27.1	28.8	27.8	28.6	26.5				
Average	12.3	14.9	19.9	24.1	27.3	28.6	27.5	26.8	26.0	23.2	17.8	13.9	21.8
Max.	14.7	18.1	21.3	25.1	28.1	29.1	29.6	28.6	26.8	25.7	19.4	15.8	22.5
Min.	10.1	11.1	19.1	23.0	26.4	28.2	23.6	25.6	24.8	20.9	15.2	11.1	21.0

Source: Pakistan Metrorilogical Department



Source: Pakistan Metrorilogical Department

Figure 2.2.10 Mean Monthly Maximum and Minimum Temperature in Karachi

(3) Evaporation

Evaporation data at UTHAL Station was also collected through PMD. The specification of UTHAL Station is shown in Table 2.2.11. Table 2.2.12 and Figure 2.2.11 show the mean monthly pan evaporation data from 2001 through 2011 at UTHAL Station.

The mean monthly pan evaporation at UTHAL Station is about 260 mm in May at maximum, and about 175 mm in December at minimum. The annual pan evaporation is about 2,600 mm.

Table 2.2.11 Specification of UTHAL Station

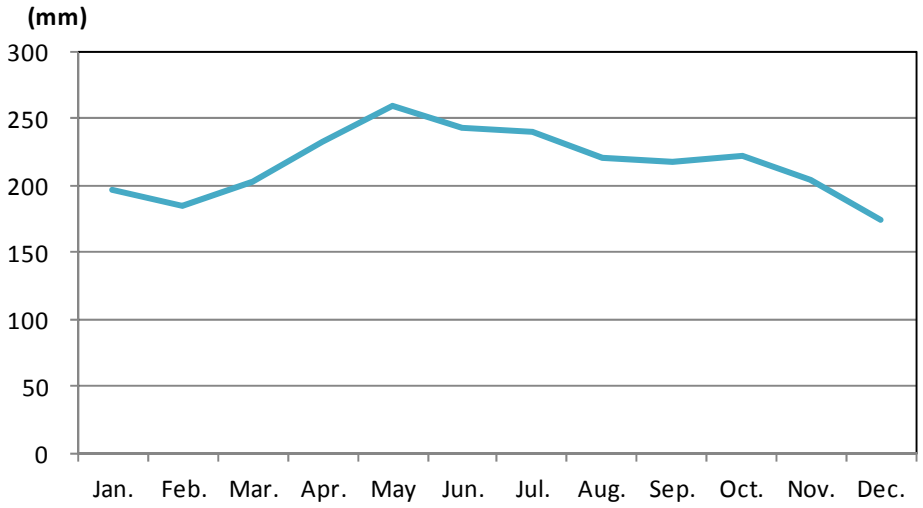
Station Name	Latitude	Longitude	Elevation
UTHAL	25° 48´N	66° 37´E	41.67 m

Source: Pakistan Metrorilogical Department

Table 2.2.12 Mean Monthly Pan Evaporation at UTHAL Station

year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
2003	-	-	-	-	-	-	-	-	232.5	258.9	-	214.4	-
2004	236.8	217.2	234.3	-	284.0	269.2	314.6	207.5	259.0	201.8	226.0	254.3	-
2005	-	219.6	220.2	224.5	-	224.2	237.9	274.1	206.9	265.1	218.6	240.2	-
2006	252.5	173.8	129.2	225.7	230.5	252.7	237.1	247.8	216.8	216.0	220.4	292.0	2,694.5
2007	194.7	190.4	238.9	237.2	231.7	236.3	268.6	219.2	238.9	248.6	259.7	157.6	2,721.8
2008	302.6	225.9	211.6	239.4	256.8	228.0	196.4	174.0	190.3	177.6	133.6	81.8	2,417.8
2009	90.0	132.8	188.4	250.8	312.5	276.4	231.5	232.4	215.6	215.7	149.7	38.2	2,334.0
2010	106.9	134.9	200.0	220.1	246.8	216.0	190.5	192.4	186.6	197.2	227.5	123.5	2,242.3
Mean	197.2	185.0	203.2	233.0	260.4	243.3	239.5	221.0	218.3	222.6	205.1	175.2	2,603.8

Source: Pakistan Metrorilogical Department



Source: Pakistan Metrorilogical Department

Figure 2.2.11 Mean Monthly Pan Evaporation at UTHAL Station

(4) Floods

Flood disaster records in the Target Area 'W' including vicinity areas could not be obtained in spite of spending great effort to get desired records through concerned agencies, like Provincial Disaster Management Authority (PDMA), City District Government Karachi (CGDK) and Town Municipal Authorities (TMAs). It was also found that none of the authorities have been assigned the responsibility of maintaining records of such type of data. During emergency scenarios TMAs and other CDGK departmetns carry out relief measures based on complaints and on required basis. Consequently, the interview survey was carried out to gather useful information related to floods in the ROW of the KCR.

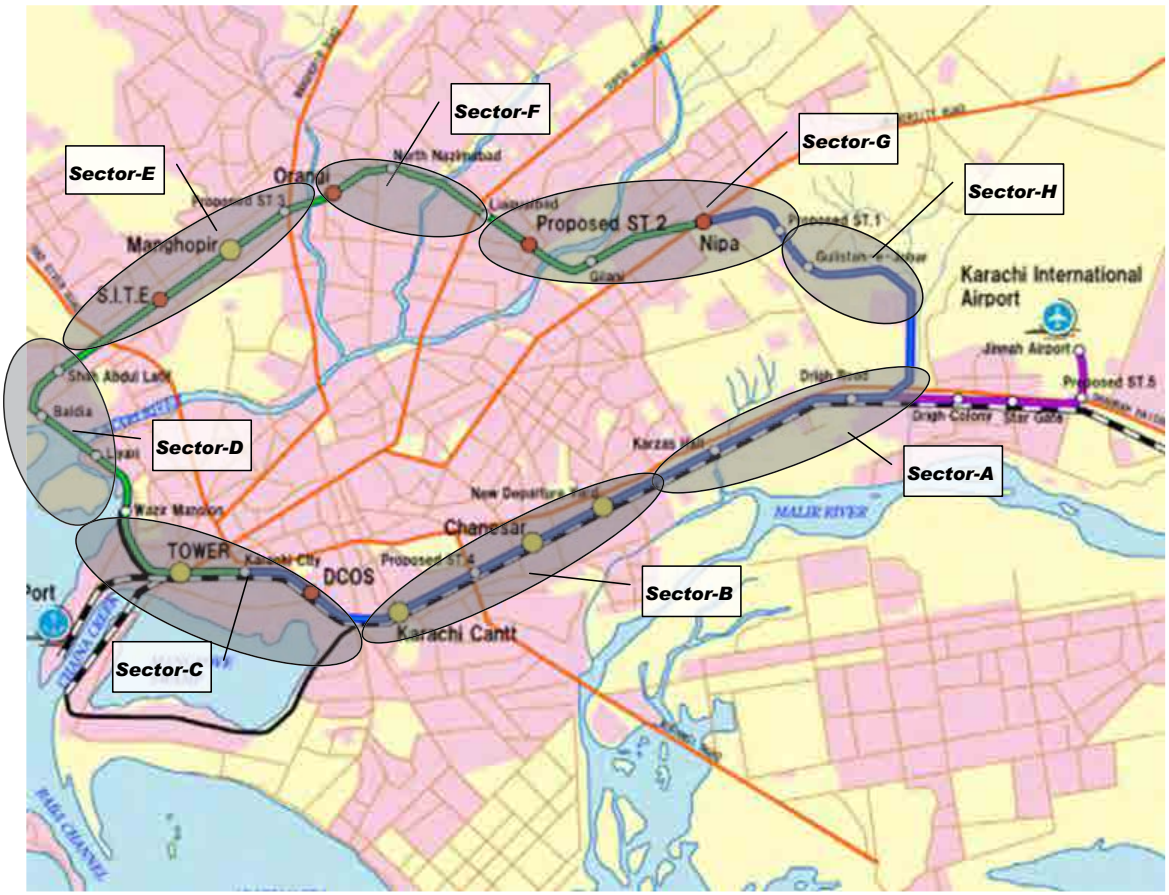
The interview survey was done in every sectors shown in Table 2.2.13 and Figure 2.2.12.

Figure 2.2.24 shows view of the interview survey.

Table 2.2.13 Details of Survey Sectors

Sector	EXTENT		Mileage
	From	To	
A	Drigh Road	Shaheed-e-Millat Flyover	5.5 Km
B	Shaheed-e-Millat Flyover	Clifton Bridge	5.9 Km
C	Clifton Bridge	Machhar Colony	5.5 Km
D	Machhar Colony	Sher Shah bridge	4.75 Km
E	Sher Shah bridge	Bara maidan	5.0 Km
F	Bara maidan	Gharibabad Furniture market	5.05 Km
G	Gharibabad Furniture market	Lal Flat/Railway Societ Bridge	5.5 Km
H	Lal Flat/Railway Society Bridge	Rabia City	2.6 Km

Note: The area from Rabia City to Drigh Road is generally devoid of population.
Source: JICA Study Team



Source: JICA Study Team

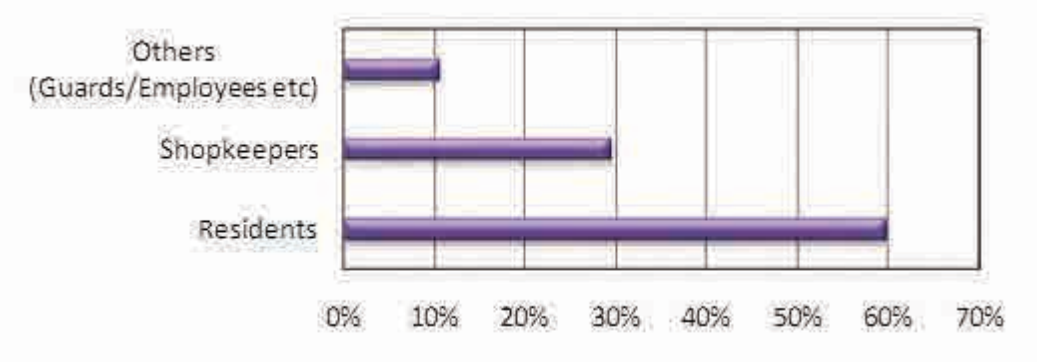
Figure 2.2.12 Survey Sectors

1) Result of Interview Survey

(a) Number of Interviewee

A total number of 281 persons were interviewed all along the KCR route which included residents, shopkeepers and others.

The percentage of residents of the total sample size was 59.8% whereas, shopkeepers constituted 29.5% and others (Guards, Cattle farmers, Flat Union representatives) 10.7% as shown in Figure 2.2.13.

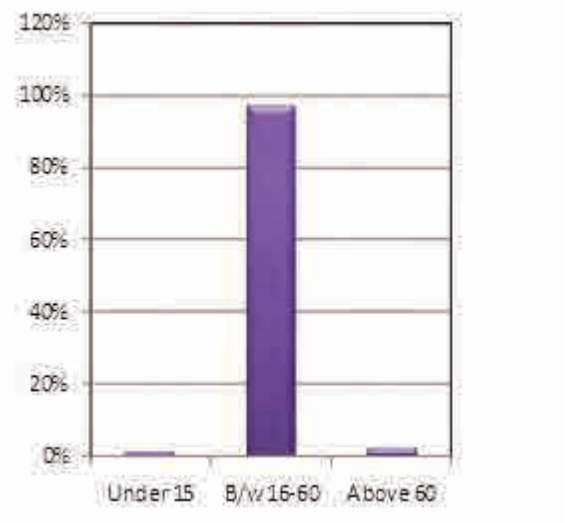


Source: JICA Study Team

Figure 2.2.13 Classification of Interviewee

(b) Age of Interviewee

Age group of interviewee was mostly between 16 years to 60 years with 96.8%.

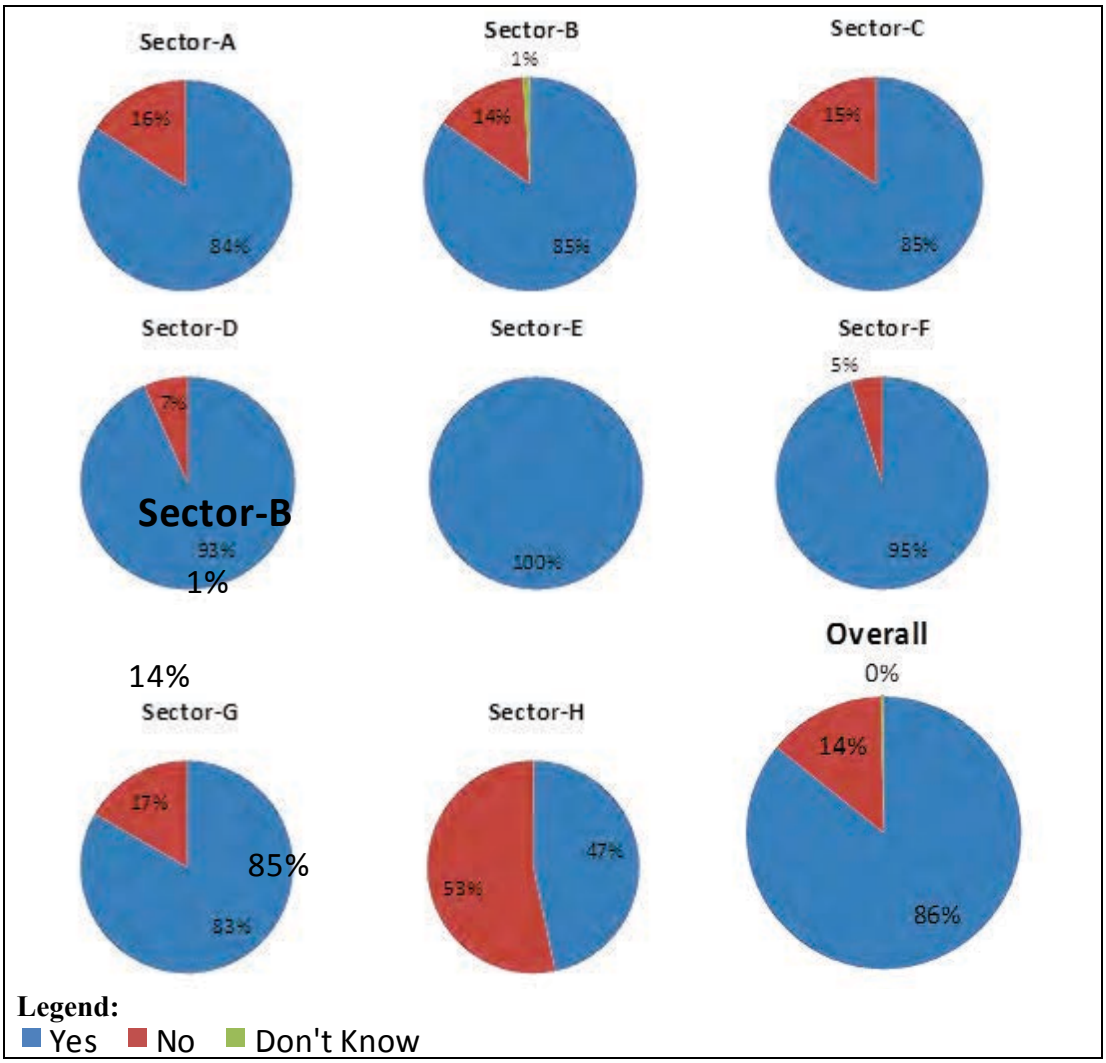


Source: JICA Study Team

Figure 2.2.14 Classification of Age of Interviewee

(c) Experience of Flooding

Overall 86% of the interviewee experienced flooding around their premises while 14% denied. Sector-wise distribution is shown in Figure 2.2.15.

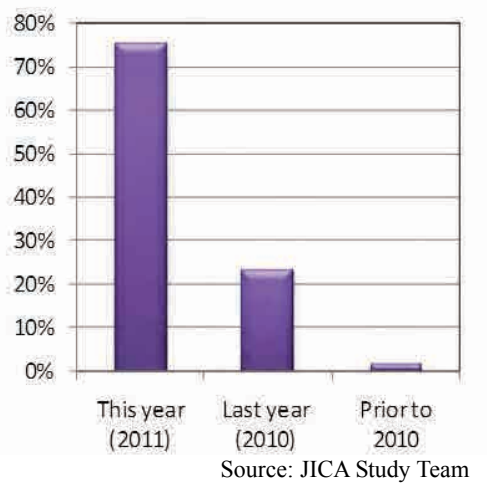


Source: JICA Study Team

Figure 2.2.15 Classification of Flooding Experience

(d) Time of the year

According to the opinion of the interviewee, 75.1% of them experienced last rainwater flooding in 2011, while 23.2% in 2010 and 1.7% prior to 2010.

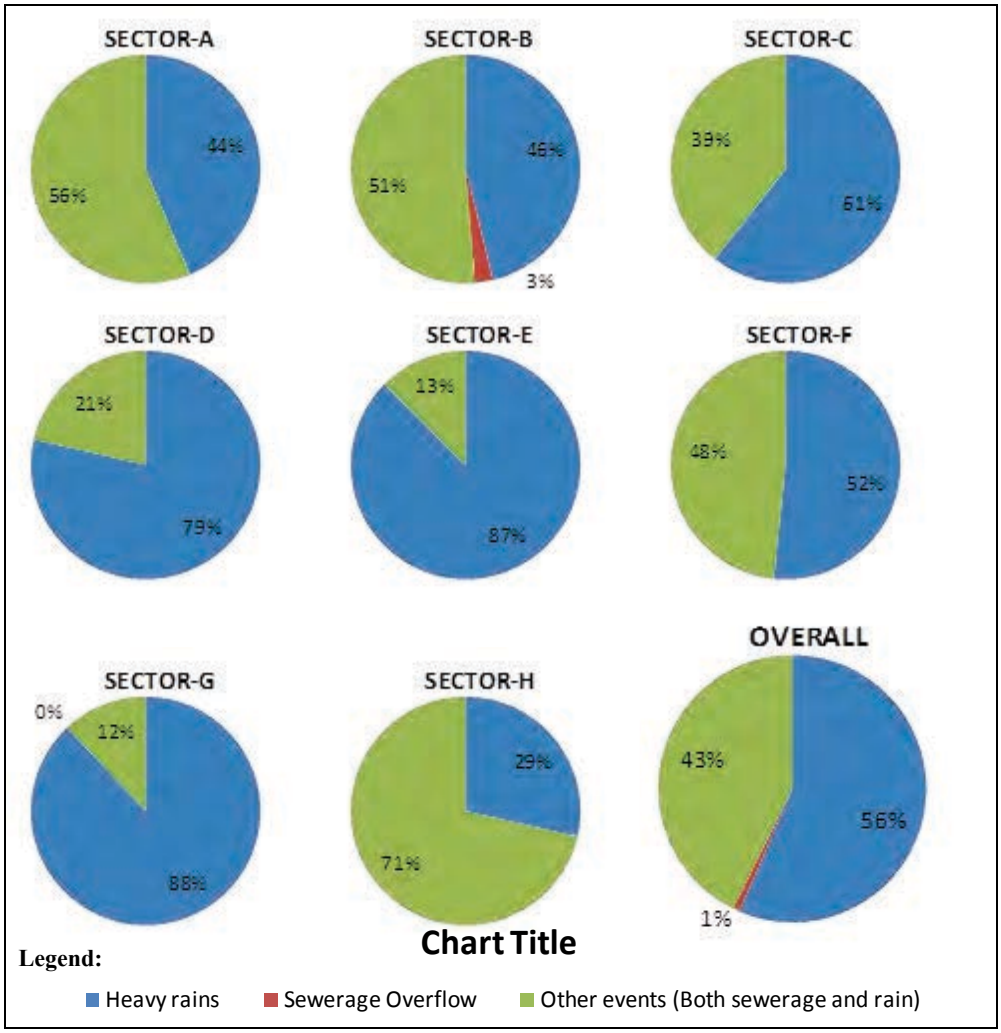


Source: JICA Study Team

Figure 2.2.16 Time of the year of Flooding Experience

(e) Cause of Flood

56% of the interviewee answered that water inundated due to rain, 1% due to Sewerage overflow and 43% due to both reasons.

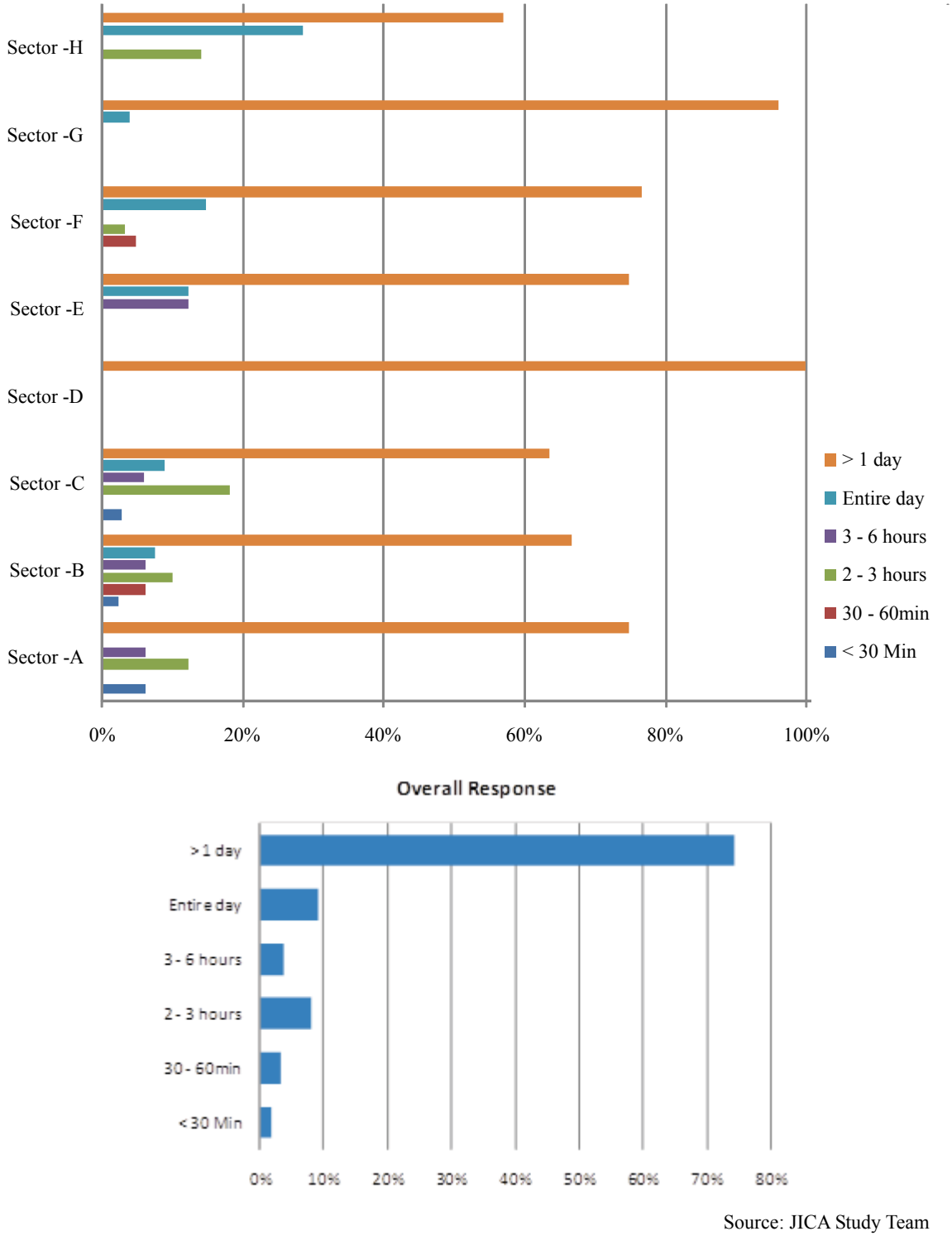


Source: JICA Study Team

Figure 2.2.17 Classification of Cause of Flood

(f) Duration of Flood

The flood lasted for more than a day according to 74% of interviewee. Sector-wise details are shown in Figure 2.2.18.

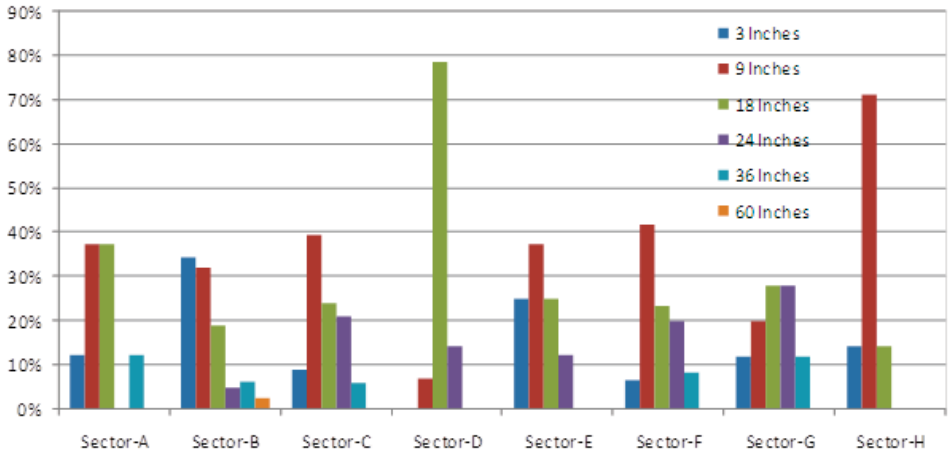


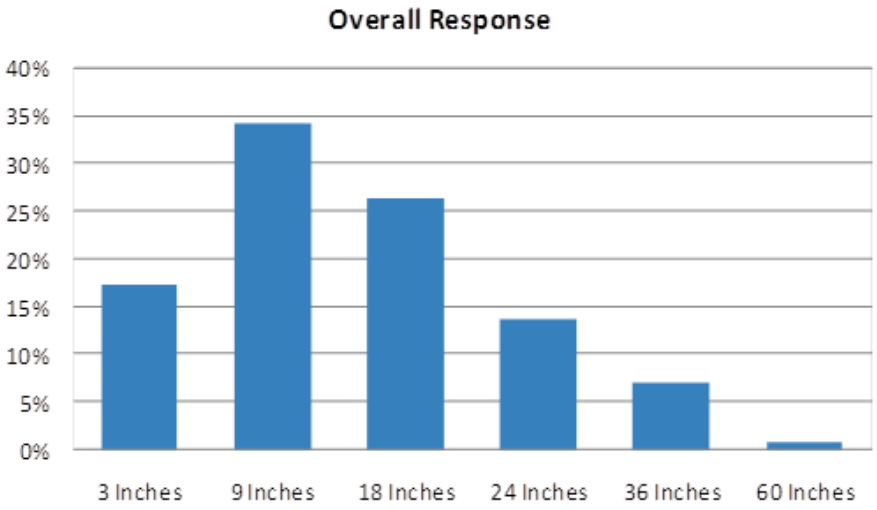
Source: JICA Study Team

Figure 2.2.18 Classification of Flooding Duration

(g) Depth of Flood

According to 61% of the interviewee, the flood depth was noted between 9 to 18 inches. Sector-wise details are shown in Figure 2.2.19. The flood depth in Sector-D seemed to be the heaviest among all Sectors.



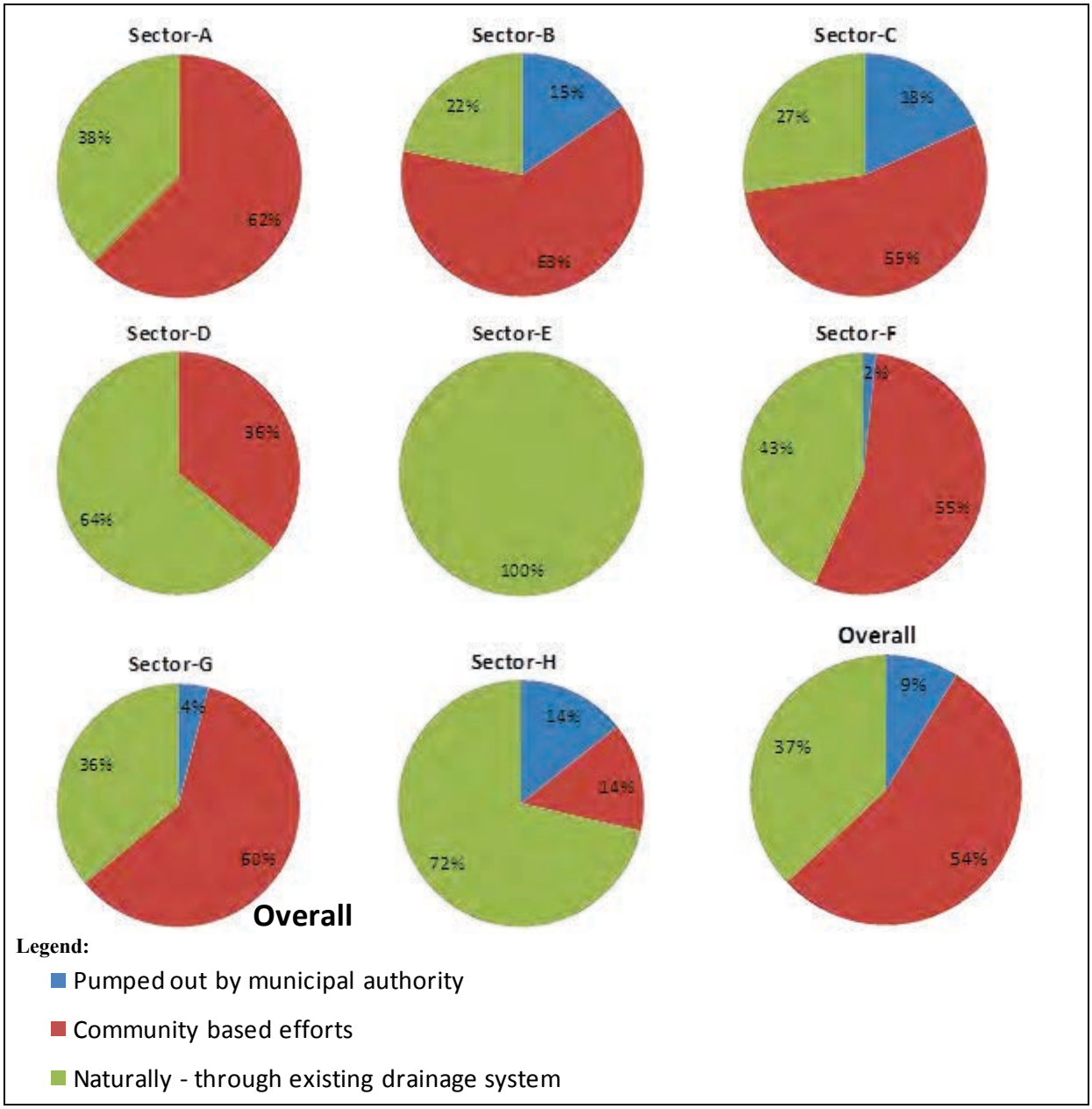


Source: JICA Study Team

Figure 2.2.19 Classification of Flooding Depth

(h) Method of Disposal of Standing Water

According to 54% of the interviewee, standing water was removed through community efforts, 37% stated that water receded naturally through existing drains or by evaporation while 9% said that it was pumped by municipal authorities.

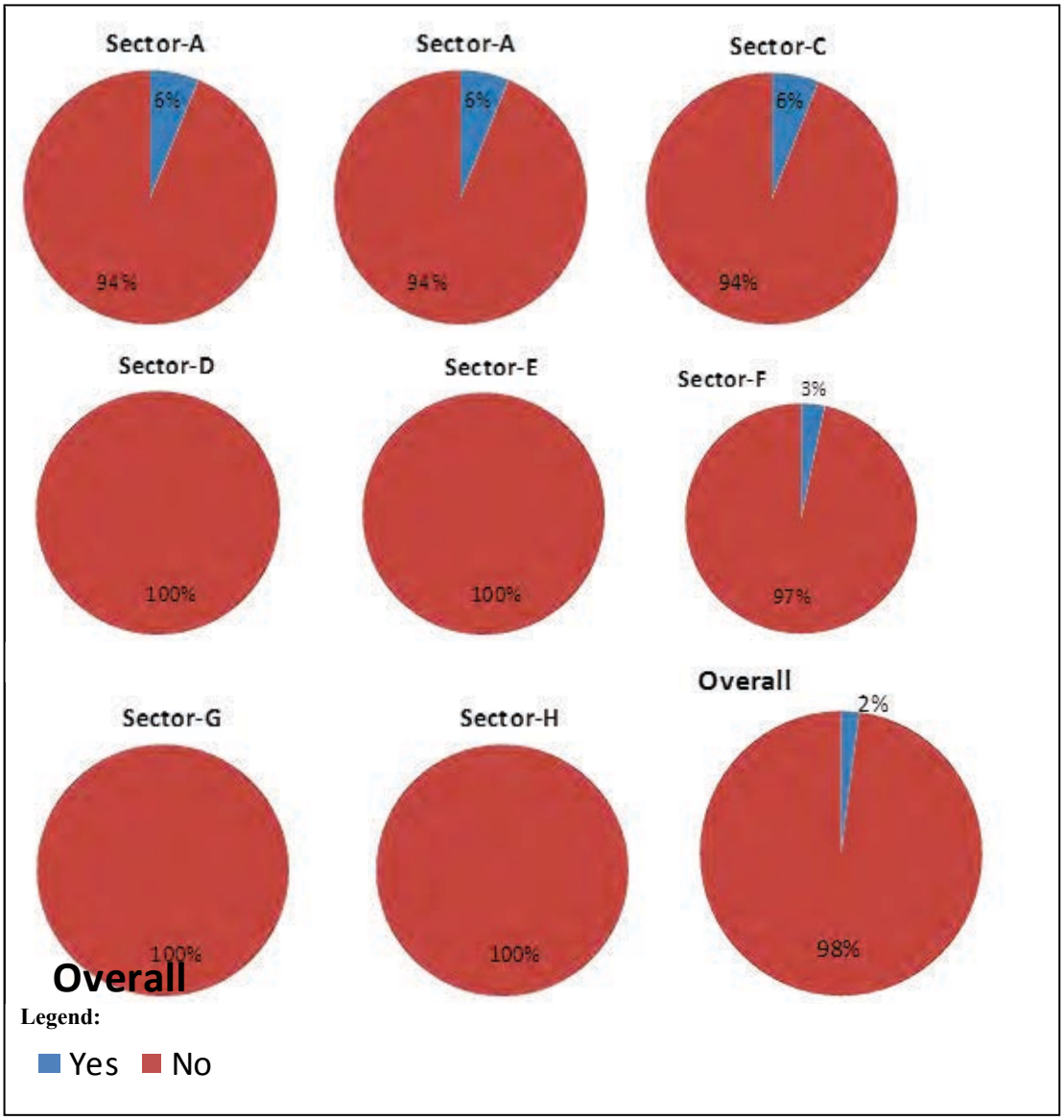


Source: JICA Study Team

Figure 2.2.20 Classification of Method of Disposal

(i) Existence of Drainage System

98% of the interviewee denied about the storm water drainage system in the area.

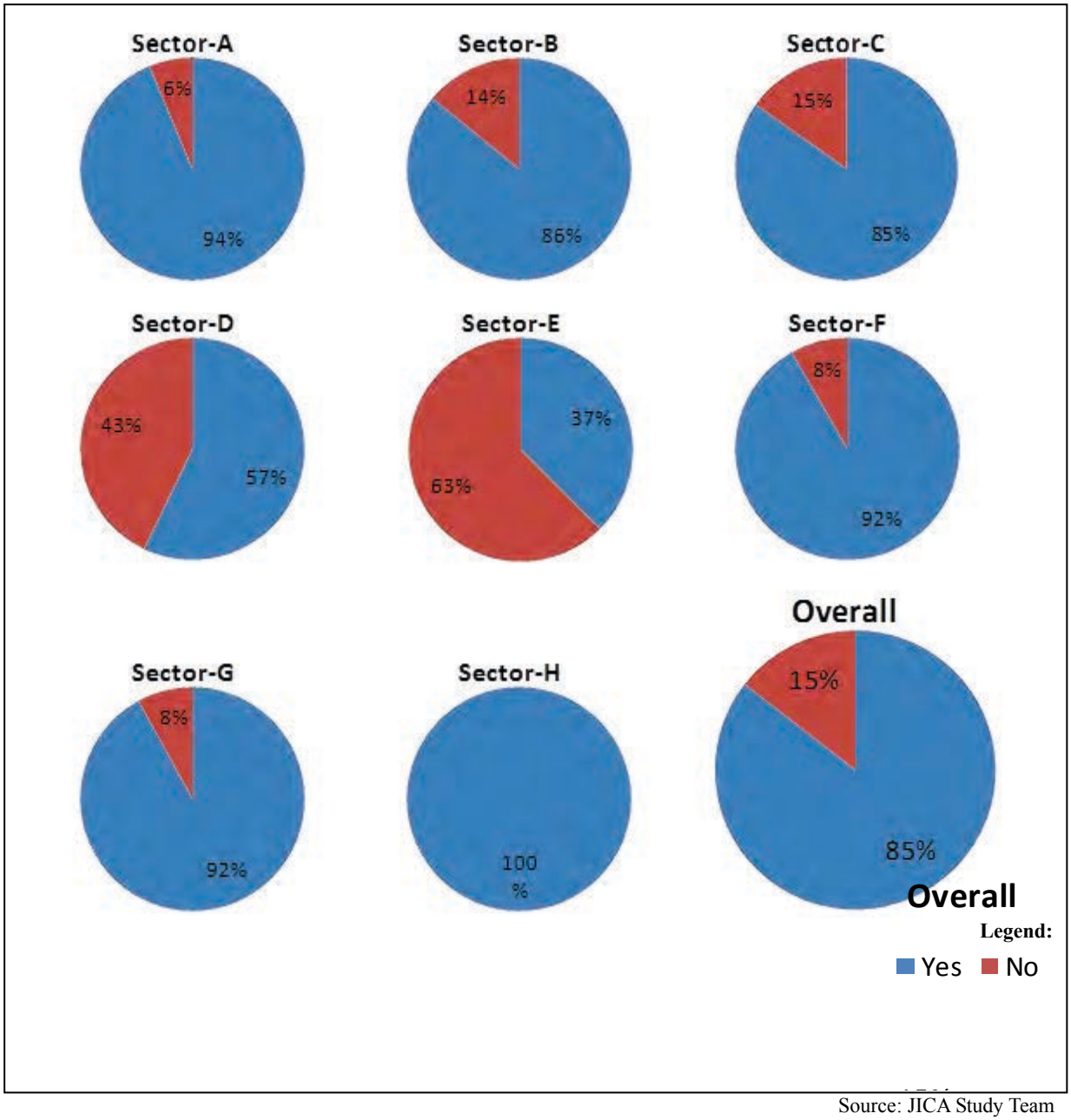


Source: JICA Study Team

Figure 2.2.21 Existence of Drainage System

(j) Existence of Sewerage/Waste Water Collection System

85% of the interviewee gave positive response about sewerage/waste water collection system in their area.

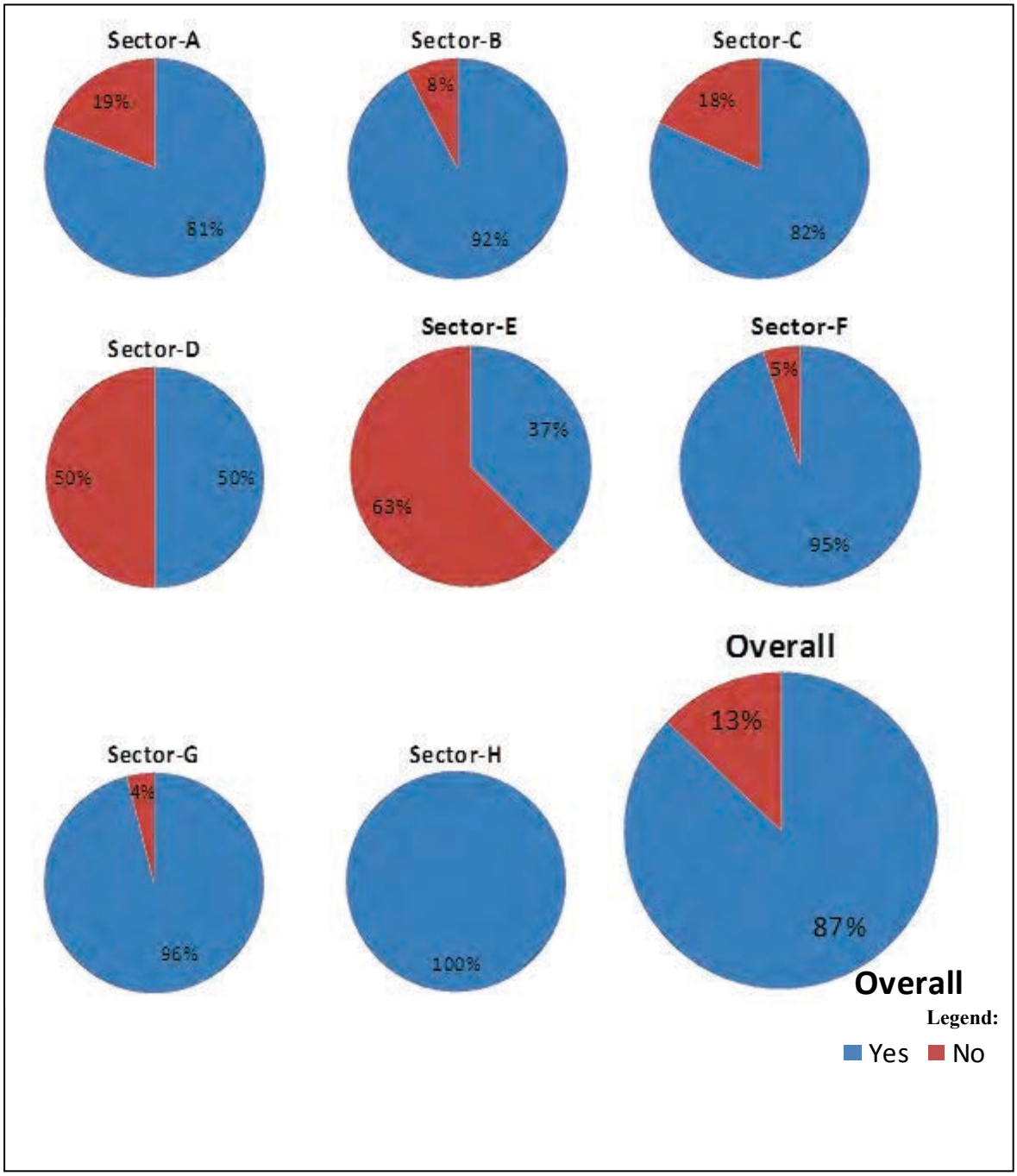


Source: JICA Study Team

Figure 2.2.22 Existence of Sewerage/Waste water Collection System

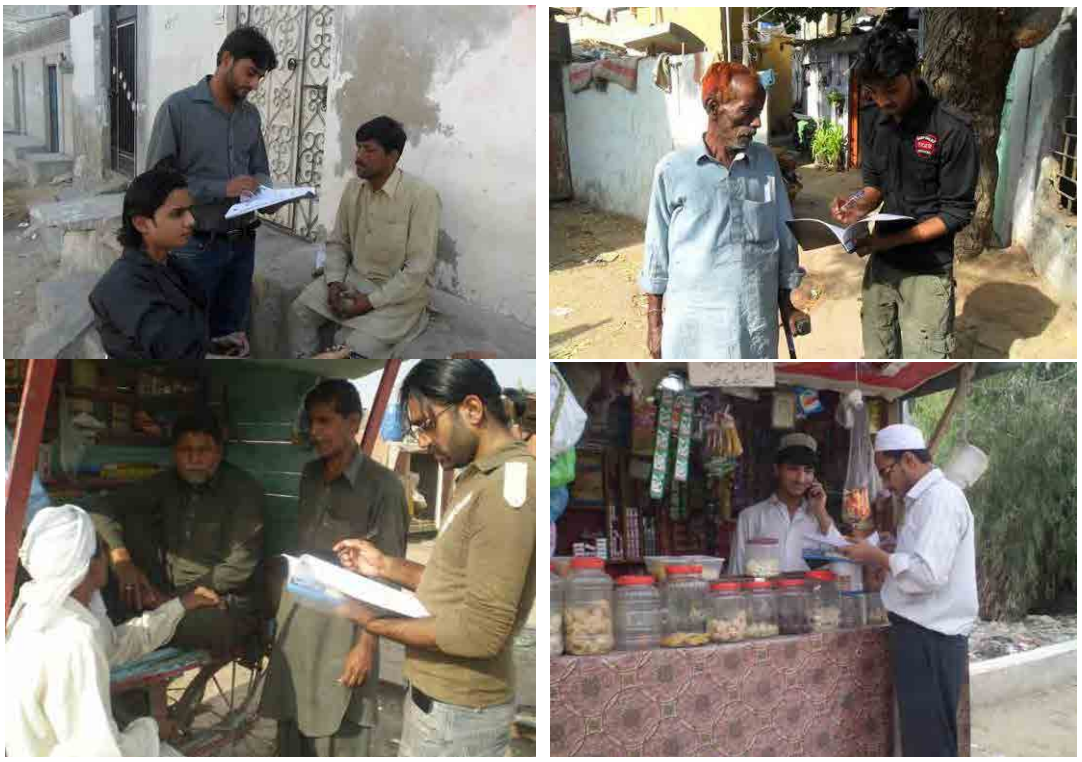
(k) Sewerage/Waste Water Collection System and Rain Water Collection System

Sewerage/waste water and rain water collection system is same as per 87% of the interviewee.



Source: JICA Study Team

Figure 2.2.23 Sewerage/Waste Water Collection System and Rain Water Collection System



Source: JICA Study Team

Figure 2.2.24 View of Interview Survey

According to the Reports of the Inter Government Panel on Climate Change (hereinafter referred to as IPCC), the global mean sea level may rise as high as 88 cm by end of 21st Century and it may severely affect coastal regions in many parts of the World. Consequently the research was to conduct a case study in Karachi. The result of a simulation is described in "MODELING AND SOCIO-ECONOMIC IMPACT ANALYSIS OF FLOODS IN COASTAL CITIES UNDER SEA LEVEL RISING SCENARIOS: A CASE STUDY OF KARACHI, PAKISTAN"

For the simulation, the observed MSL for the year 2003 was considered as present condition, and the mean sea level was increased by 14, 32, 57 and 88 cm from the present level to obtain future flood inundation condition for future years of 2025, 2050, 2075 and 2100 respectively based on IPCC, the A1 scenario. It is concluded in this paper that climate change scenarios can not affect on Rail Network in Karachi in present and future.

Maximum daily rainfall from 1981 through 2011 is shown in Table 2.2.14. The maximum rainfall occurred in 2009, and the minimum rainfall occurred in 1987. The mean maximum daily rainfall is 52.1mm. Probable daily rainfall amount is estimated using Gumbel Method, Iwai Method and Ishihara/Takase Method. Plotting position is shown in Figure 2.2.25. The probable daily rainfall amount of Iwai method, which is the best method for fitness in three methods, is shown in Table 2.2.15.

Based on this probable daily rainfall amount, the maximum daily rainfall in 2011 and 2009 are between 2-year and 3-year probable daily rainfall amount, and approximately 15-year probable daily rainfall amount respectively.

The catchment areas of Target Area P1 and P2 are 1.74 km^2 and 2.15 km^2 respectively.

Maximum Flow in Target Area P1 and P2 are roughly estimated based on this probable daily rainfall amount. The rate of flow in Target Area P1 and P2 is 0.6 on the assumption that the flow rate in Pakistan is not different to that in Japan because of no information regarding the flow rate in Pakistan.

Maximum flow in Target Area P1 and P2 is shown in Table 2.2.16.

Table 2.2.14 Maximum Daily Rainfall

year	Occurrence Day	Daily Rainfall Amount (mm)
1981	May	47.6
1982	Aug.	74.0
1983	Aug.	38.9
1984	Aug.	113.7
1985	Apr.	37.0
1986	Aug.	25.4
1987	Aug.	0.0
1988	Aug.	5.1
1989	Jul.	58.8
1990	Aug.	57.2
1991	Feb.	19.5
1992	Aug.	91.7
1993	Feb.	9.8
1994	Aug.	46.5
1995	Jan.	81.3
1996	Feb.	33.2
1997	Sep.	24.0
1998	Nov.	24.1
1999	Jan.	4.5
2000	Jan.	19.0
2001	13/Jul.	52.5
2002	27/Aug.	47.0
2003	29/Jul.	108.4
2004	3/Oct.	26.5
2005	12/Sep.	31.0
2006	31/Jul.	65.9
2007	10/Aug.	124.2
2008	30/Jul.	54.0
2009	19/Jul.	142.6
2010	6/Jun.	77.1
2011	7/Sep.	75.0
Min.		0.0
Max.		142.6
Mean		52.1

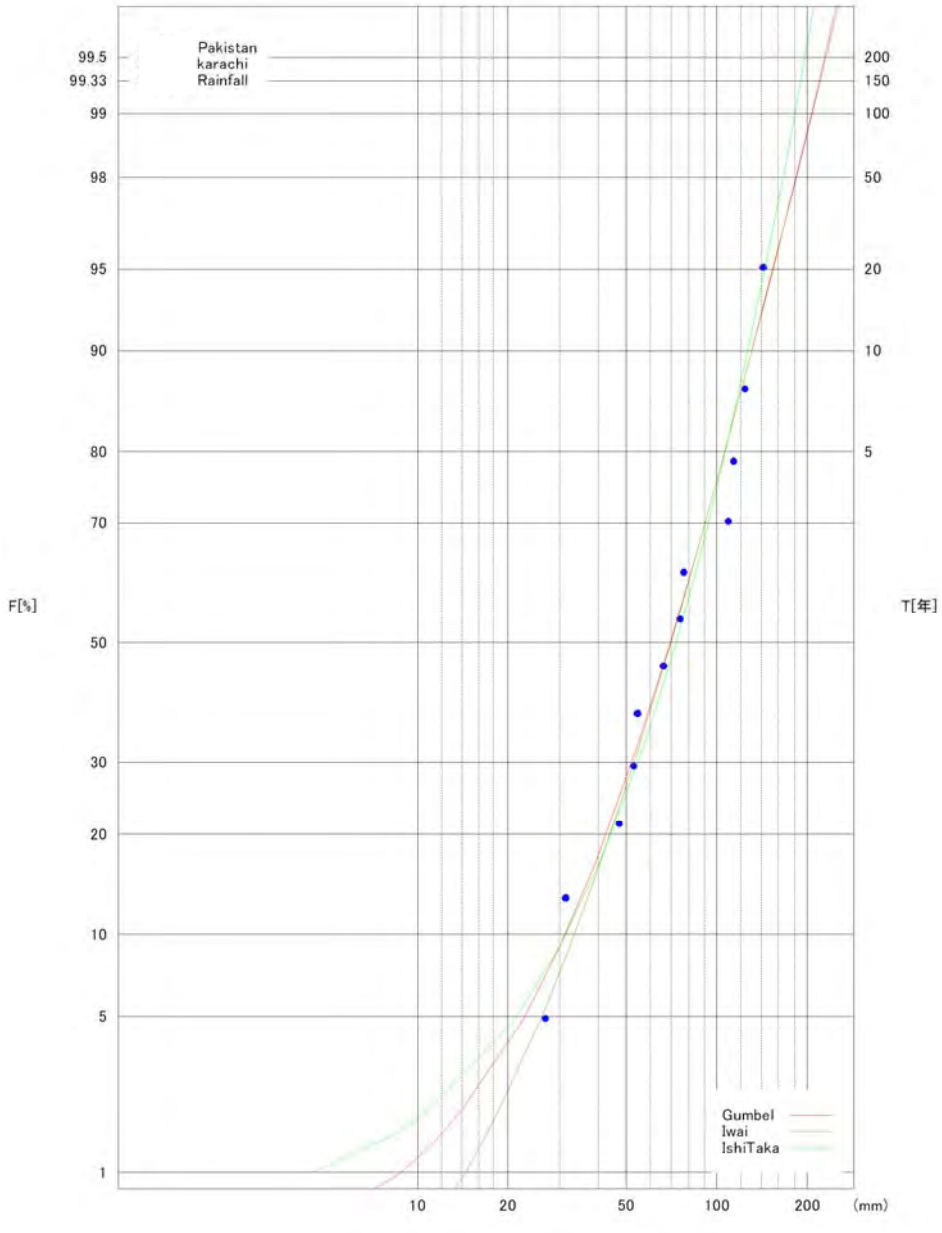
Source: PMD

Table 2.2.15 Probable Rainfall by Iwai Method

(Unit: mm)

Return Period	Iwai method
2	70.0
3	87.0
5	106.1
10	130.2
20	153.5
30	167.0
50	184.0
80	199.6
100	207.1

Source: JICA Study Team



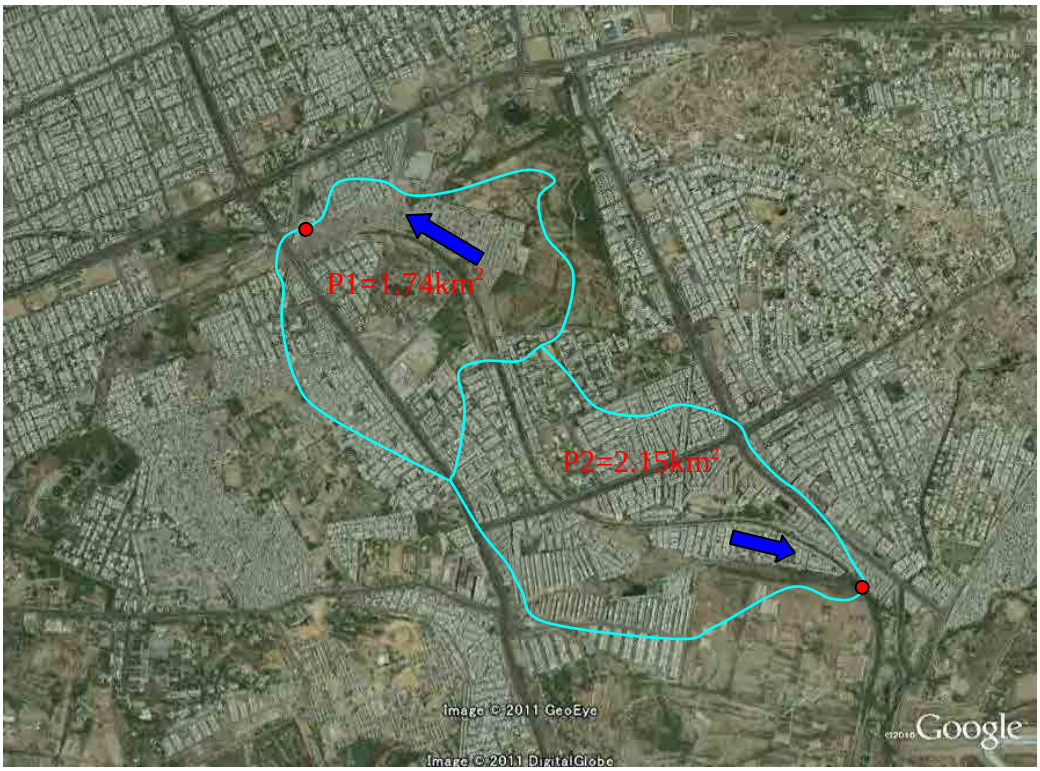
Source: JICA Study Team

Figure 2.2.25 Plotting Position

Table 2.2.16 Maximum Flow in Target Area P1 and P2l

Target Area	Catchment Area (km^2)	Maximum Flow (m^3/s)	Return period
P1	1.74	2.6	5-year
		3.1	10-year
		3.7	20-year
P2	2.15	3.2	5-year
		3.9	10-year
		4.6	20-year

Source: JICA Study Team



Source: JICA Study Team

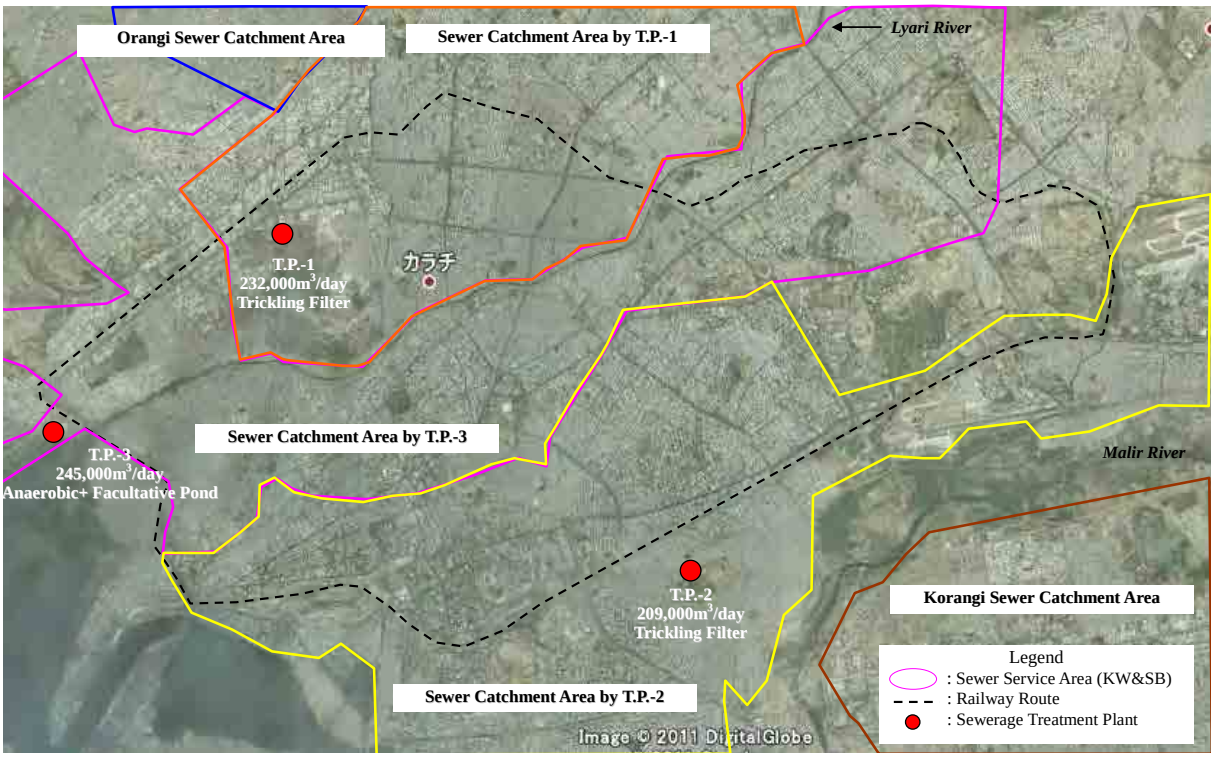
Figure 2.2.26 Catchment Area of Target Area P1 and P2

2.2.4 Drainage and Sewerage

As mentioned above, there is the water supply and sewerage system which is managed by Karachi Water Supply and Sewerage Board (KW and SB) throughout Karachi circular railway. The existing sewerage catchment area which covers 18 towns in Karachi city is divided into three districts, namely: respective catchment area of T.P-1, T.P-2 and T.P-3 as shown in Figure 2.2.27.

Total design capacity of three treatment plant is 686,000m^3/day (T.P-1: 232,000m^3/day, T.P-2: 209,000m^3/day, T.P-3: 245,000m^3/day) but currently, only T.P-1 and T.P-3 are operational. T.P-2 has suspended since three years ago because of O&M matters such as technical troubles and budget, etc. Of total quantity of wastewater of 1.76 million m^3/day being discharged in Karachi, only approximately 25% of the total quantity is treated in T.P-1 and T.P-3. The remained wastewater has being discharged into 'Nala'.

To review the existing Master Plan of the sewerage system as well as water supply which was prepared from 1985 to 1988, KW and SB formulated the Master Plan of the water supply and sewerage system in cooperation with JICA in 2008. However, most of the projects for rehabilitation and augmentation proposed in the Master Plan study, etc have not been carried out due to financial constraint of KW and SB.



Source: JICA Study Team

Figure 2.2.27 Sewer Catchment Areas

Effluent standards for inland waters, sea and sewerage treatment in 32 parameters are regulated by the Ministry of Environment and Local Government Development through the Pakistan Environmental Protection Act 1997 in Pakistan. Basically effluent wastewater should be monitored and directed by Environmental Protection Agency (EPA). However, industrial wastewater in the Sindh Industrial Trading Estate (S.I.T.E.) has been discharged to public areas such as rainstorm water drainage and 'Nala', etc. without any treatment.

There is a penalty system on a strict effluent standard. According to the regulation, PKR 1.0 million (min.) is imposed as a penalty for exceeding the effluent standard. If effluent flow is not suspended after a warning by EPA, a further penalty of PKR 0.1 million per day is imposed. However, the penalty has not been imposed on industrial companies because of a lack of appropriate monitoring by EPA. This is caused by shortage of human resource of EPA.

2.2.5 Issues on Water in the Right of Way

As far as JICA Study Team had a field reconnaissance along KCR, the issues on water being present in the ROW so as to steadily implement the railway project are summarized as follows:

a. Eliminate stagnant wastewater (Area 'P') from the ROW.
b. Eliminate seepage (Area 'P') through the ground from the ROW.
c. Protect the ROW from flood entirely.
d. Stop flushing wastewater (Area 'P' and Gulistan-e-Johar) from dwellers along the ROW.
e. Deal with industrial wastewater (S.I.T.E) in the ROW.

2.2.6 Drainage Measures against Stagnant and Inflow Water Drainage

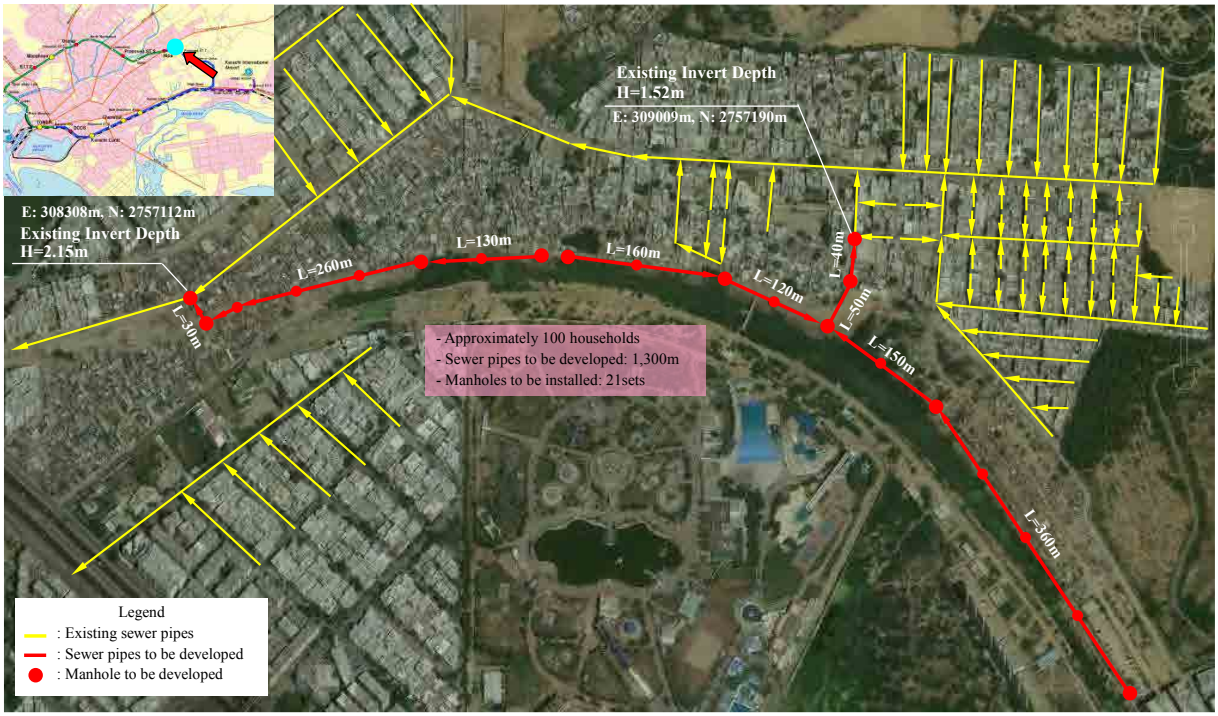
To solve the issues as mentioned in '2.2.5', countermeasures are categorized into '(1) Drainage Measures at the Stage under Construction' and '(2) Drainage Measure at the Post-construction Stage'. Furthermore, '(1)' is divided into the respective measure against domestic, industrial wastewater and flood disaster.

(1) Drainage Measures at the Stage under Construction

a) Drainage Measures against Stagnant and Inflow of Domestic Wastewater

Four measures at the construction stage are proposed as follows:

- Method-1 Stagnant wastewater removed by lorry trucks and submersible pump(s): The stagnant wastewater of 15,000 m^3 at Point 'A' as shown in Figure 2.2.2 will be pumped up by private lorry truck (bowser) by submersible pumps and transported to the existing treatment plant of KWandSB by the lorry trucks (bowser). It is proposed that the stagnant wastewater should be transported to be T.P-3 considering its treatment performance.
- Method-2 Diversion of existing sewer pipes: The wastewater which is being flushed from outlet of domestic wastewater of approximately 100 households will be directly connected to the existing sewer pipes (See Figure 2.2.28 and Figure 2.2.29). In addition, wastewater which has been leaked from the damaged existing sewer pipes will be flown in the sewer pipes to be replaced (See Figure 2.2.28 and Figure 2.2.29).
- Method-3 Dredging of sludge in the ROW: Even if stagnant wastewater is dewatered, seepage of groundwater may be remained in the ROW. Sludge heaped up on the ROW will be excavated with excavator to flush seepage water to 'Nala' at downstream in gravity (See Figure 2.2.30).
- Method-4 Diversion of rainstorm drainage: The quantity of domestic wastewater flowing currently in the existing drainage and small trench is very little and the distance of their drainages is relatively short. Most of wastewater has been discharged from informal settlers. Through the project, the informal settlers who live along KCR will be relocated to a candidate suburb area based on an assessment of RAP. Rainstorm drainage or small trench will be utilized for the drainage of wastewater until the informal settlers move (See Figure 2.2.31 and Figure 2.2.32).

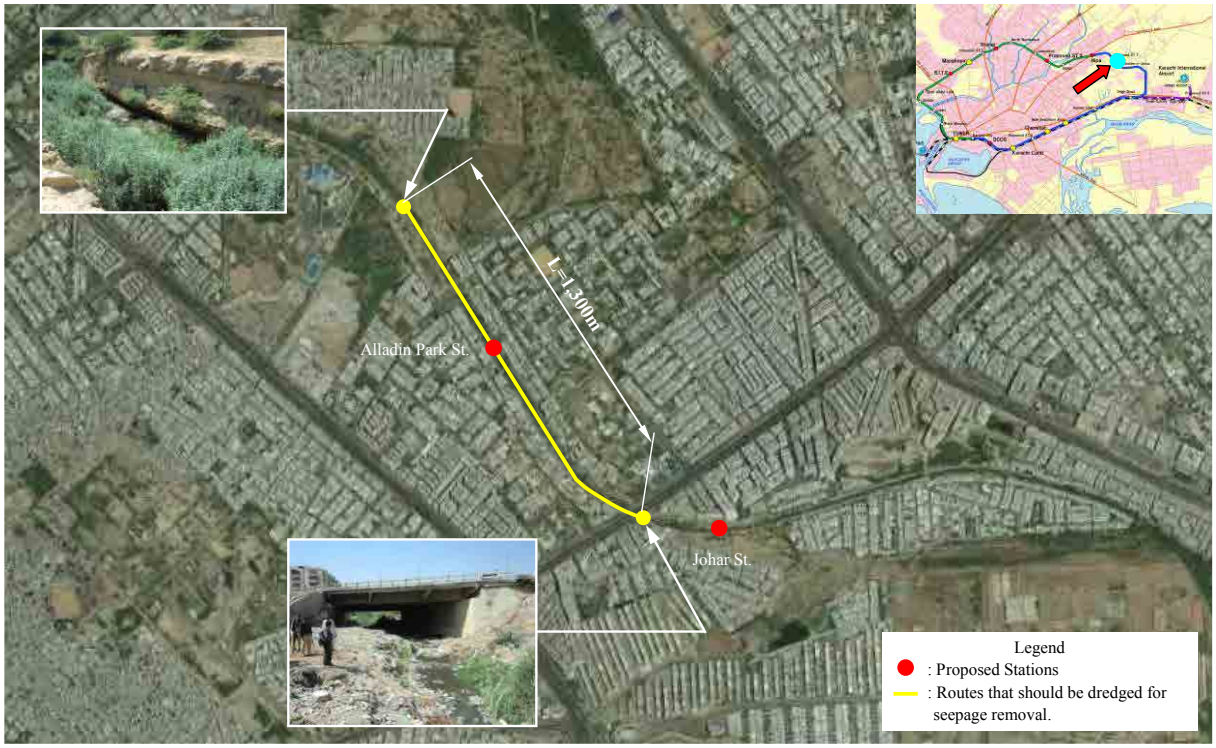


Source: JICA Study Team

Figure 2.2.28 Existing Sewer Pipes and Newly Sewer Pipes to be Developed around Nipa (Method-2)

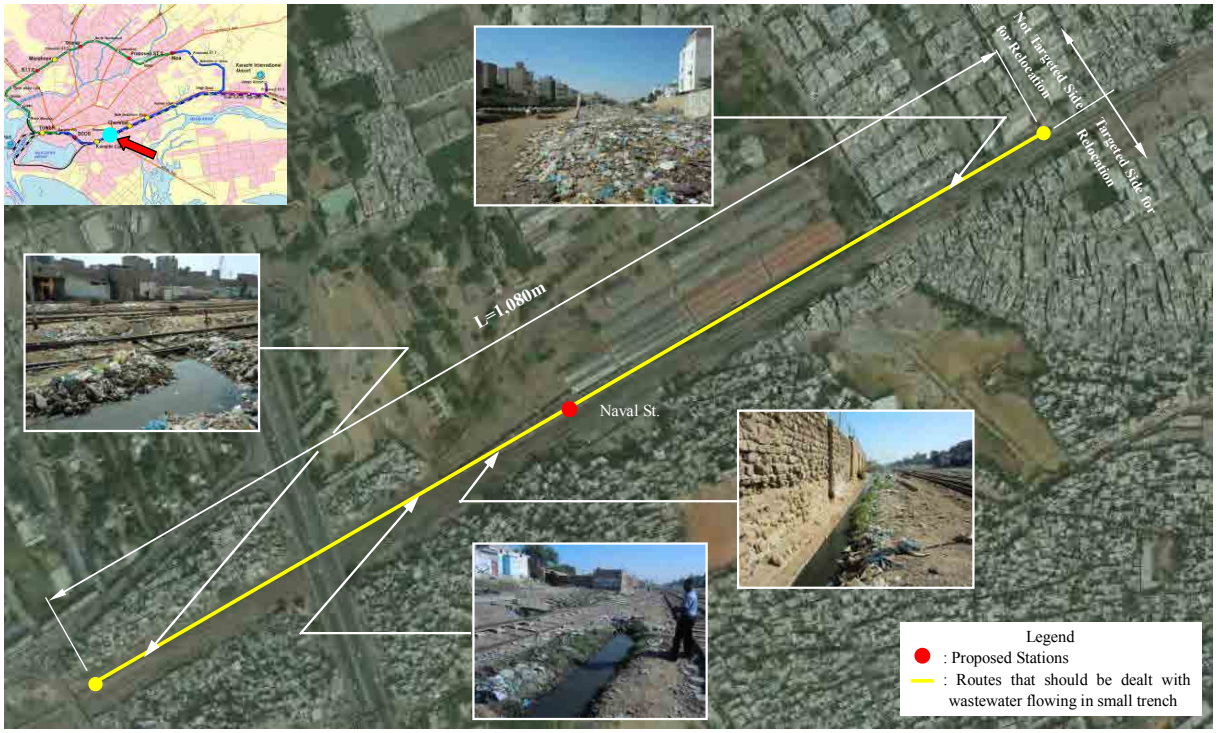
Source: JICA Study Team

Figure 2.2.29 Existing Sewer Pipes and Newly Sewer Pipes to be Developed around Gulistan-e-Johar (Method-2)



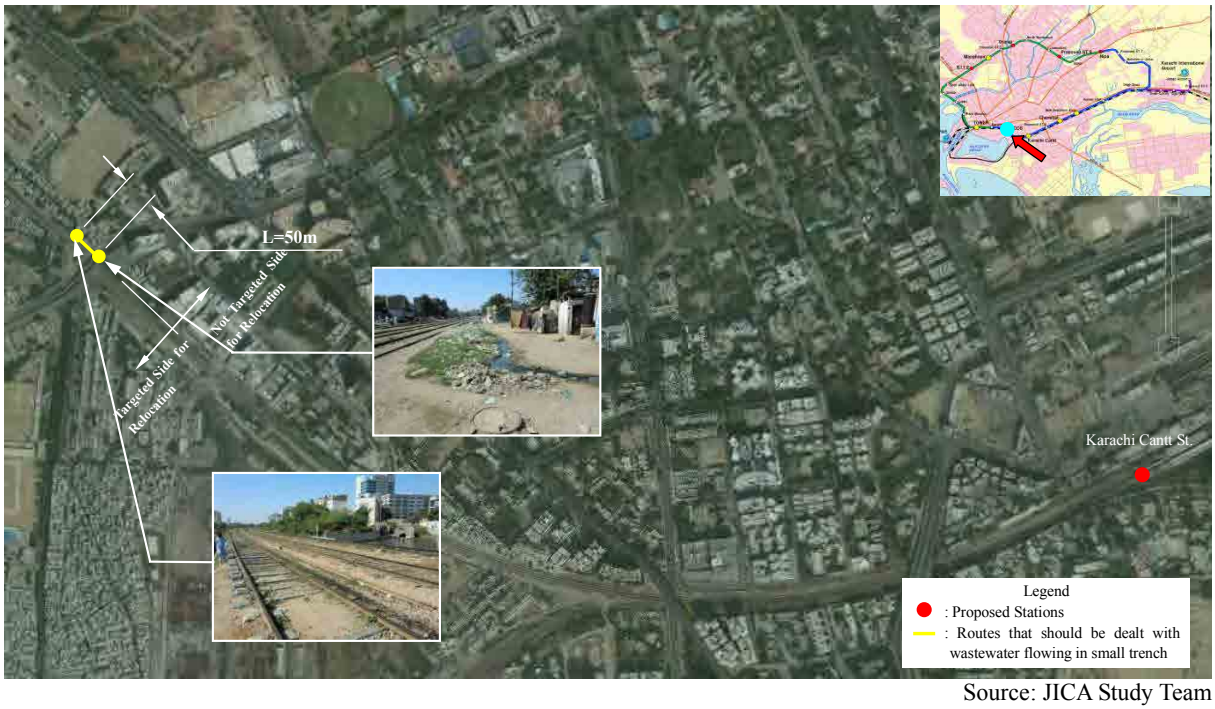
Source: JICA Study Team

Figure 2.2.30 Area of Wastewater Stagnated (Method -3)



Source: JICA Study Team

Figure 2.2.31 Area of Wastewater Flowing near Naval Station (Method -4)



Source: JICA Study Team

Figure 2.2.32 Area of Wastewater Flowing near Karachi Cantt. Station (Method -4)

Table 2.2.17 shows the result of technical and cost evaluation on the measures at the stage under construction. The cost was estimated based on the unit cost which had been provided by local contractors. The cost of Method-1 to Method -3 must be included in the railway project cost.

Table 2.2.17 Evaluation on the Drainage Measures at the Stage under Construction

No.	Measures	Description	Cost
Method -1	Stagnant wastewater removed by Lorry Trucks (bowser) and submersible pump	The method of dewatering stagnant wastewater by lorry trucks will be useful for wastewater disposal after flushing points are connected to the existing sewer pipes. KWandSB has 18 suction vehicles as reported by Deputy Managing Director of KWandSB. All the Vehicle has been allocated in 18 towns of Karachi. Therefore, it is too limited to divert the vehicles to dewatering of stagnant wastewater in this project. Lorry trucks will be leased from private company.	Condition: (General) Quantity of stagnant wastewater: 15,000m^3 Cost includes mobilization and VAT (Bowser) Capacity of truck: 37m^3/ bowser Number of trucks: 3bowzers Daily trips: 3trips Cost of one bowser including man-power and fuel for one trip per day: PKR32,000/truck/ trip Cost of three bowsers including man-power and fuel for three trips per day: PKR288,000 Daily performance: 3trips x 3bowzers x 37m^3= 333m^3 per day Required work days: 15,000m^3 / 333 m^3 = 45days (Treatment) PKR2/Gal=PKR528/m^3 (Pump and Generator) Cost of three submersible pumps @ 300,000/- per pump in PKR900,000 Cost of 25 KVA Diesel Driven Generator in PKR1,100,000 (Fuel for Generator) Quantity of fuel required for a one hour operation for generator: 4 liter/hour Operation hours for a day: 4.5hours Total Quantity of fuel required for 45 days: 810liter Unit cost of fuel: PKR110/liter Cost: (Bowser) 45days x PKR288,000 = PKR12,960,000---(A) (Treatment) 15,000 m^3 x PKR528/m^3= PKR7,920,000---(B) (Pump and Generator) PKR900,000 + PKR1,100,000 = PKR2,000,000---(C) (Fuel for Generator) 810liter x PKR110/liter = PKR89,100---(D) **Sub-Total Cost: (A)+(B)+(C)+(D)= PKR22,969,100** **Total Cost: 23.0-Million (Including overhead of 5%)**

No.	Measures	Description	Cost
Method -2	Diversion of Existing Sewer Pipes	Prior to dewatering the stagnant water, the sewer pipes which receive wastewater being discharged in the ROW of KCR from dwellers around Area 'P' must essentially be laid and connected to existing sewer system by KWandSB. However, JICA may consider supporting KWandSB for laying of new sewer pipes to connect to the existing sewerage system due to lack of KWandSB's budget. It is anticipated that the cost of the sewer pipes in rehabilitation and expansion is PKR37.2Million. Invert depth of two existing manholes is 1.52m and 2.15m respectively. Their invert depths are enough to be connected to the new sewer pipes.	Condition: Including Mobilization, VAT and overhead Cost: Households to be covered with sewer pipes at Area 'P': 100 Sewer pipes (PVC: 200-300mm) to be expanded and rehabilitated: 4,270m (1,250m+3,020m) Connection sewer pipe: 5,00m (5m per household) Manholes to be installed: 61sets Sewer pipe (200-300mm): PKR4,900 /m Connection sewer pipe (150mm): PKR3,000 /m Manhole: PKR21,000 /set Pipe: PKR4,900 x 4,270m = PKR20.9Million Connection pipe: PKR3,000 x 5,00m =PKR1.5Million Manhole: PKR21,000 x 61sets = PKR1.3Million **Total Cost: PKR23.7Million*1**
Method -3	Dredging of sludge in the ROW	To drain the seepage of groundwater after dewatering stagnant wastewater, the ROW of approximately 1,300m as shown in Figure 2.2-11 shall be dredged by excavators.	Condition: Including Mobilization, VAT and overhead Cost: Excavation: PKR900/m^3 for hard soil with excavator of 1.0m^3 Cost: PKR900/m^3 x 1,300m x 11m x 1m = PKR12.9Million **Total Cost: PKR12.9Million*1**
Method -4	Diversion of Rainstorm Drainage and raising foundation of railway	Domestic wastewater flowing in the small trench in the ROW will be solved if informal settlers are relocated.	The cost of Method-4 will be not required as Drainage Measures against Stagnant and Inflow of Domestic Wastewater.

Note: *1; Including overhead of 5%
Price escalation is not included the cost.
Source: JICA Study Team

b) Drainage Measures against Stagnant and Inflow of Industrial Wastewater

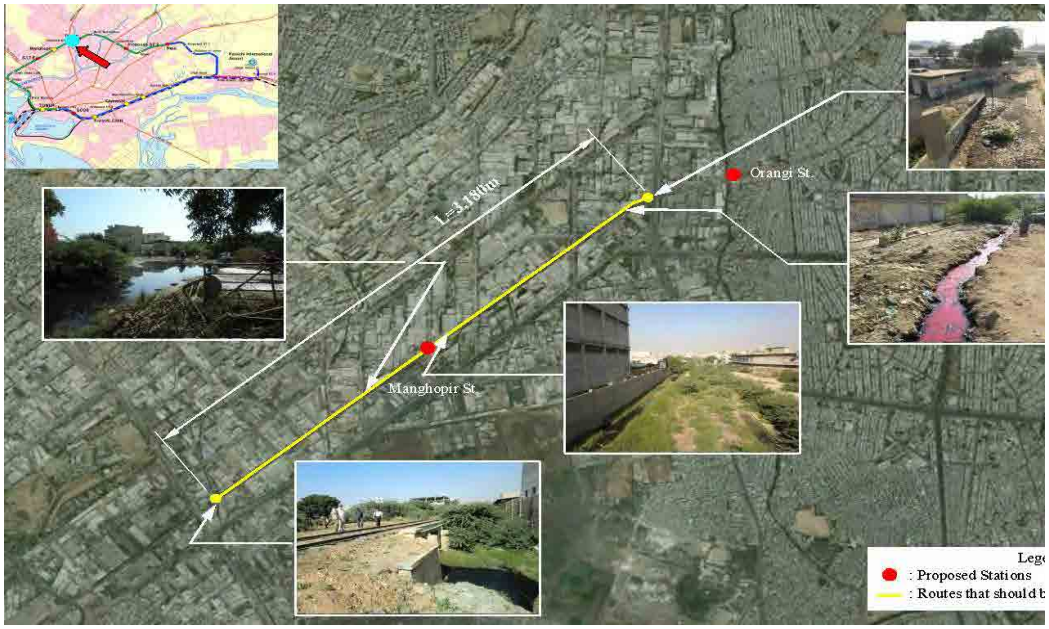
According to Environmental Protection Act 1997 in Pakistan, even if industrial companies need to discharge wastewater into sewer system, it must be treated by themselves as effluent quality of treated wastewater is subject to the effluent standard.

However, effluent has actually not been regulated strictly with industrial companies as mentioned above. Judging from an aspect of EPA's performance, to smoothly implement the project, the following measures should be applied to design the circular railway to avoid

inundation due to overflow of industrial wastewater:

- Installation of fence with which is isolated rain storm drainage from the railway.
- Securing of a capacity of the existing rainstorm drainage channel by excavation.

Figure 2.2.33 shows the pictures of industrial wastewater flowing in the ROW. About 3,180 m in the ROW should be dealt with either above measure during the railway construction.



Source: JICA Study Team

Figure 2.2.33 Area of Industrial Wastewater Flowing in the Right of Way-4

c) Drainage Measures against Flood Disaster

To protect trains against the overflow during rainy season, rising of the railway foundation is one of the efficient measures. Although there is no record regarding the flood disaster in the Target Area 'W', the useful information is obtained through the interview survey on the state of the flood disaster along the KCR line.

Raising amount of the ground level of the KCR line is quite different on the ground level condition. The amount of the ground level raise of the KCR line by the sector is shown in Table 2.2.18. In addition, it is desirable that the size of the existing rainstorm drainage in the ROW should be enlarged.

Table 2.2.18 Amount of the Ground Level Raise of KCR Line Foundation by Sector

Sector	Raising	Mileage	Remarks
A	3 inches – 36 inches	5.5 km	Drigh Road – Shaheed-e-Millat Flyover
B	3 inches – 60 inches	5.9 km	Shaheed-e-Millat Flyover – Clifton Bridge
C	3 inches – 36 inches	5.5 km	Clifton Bridge – Machhar Colony
D	9 inches – 24 inches	4.75 km	Machhar Colony – Sher Shah bridge
E	3 inches – 24 inches	5.0 km	Sher Shah bridge – Bara maidan
F	3 inches – 36 inches	5.05 km	Bara maidan – Gharibabad Furniture market
G	3 inches – 36 inches	5.5 km	Gharibabad Furniture market – Lal Flat/Railway Societ Bridge
H	3 inches – 18 inches	2.6 km	Lal Flat/Railway Societ Bridge – Rabia City

Source: JICA Study Team

(2) Drainage Measure at the Post-construction Stage

Drainage measure at the post-construction stage depends on types such as seepage or inflow of groundwater and domestic wastewater. Groundwater will be able to be drained with the drainage in the ROW which will be designed for the KCR revival project, because the ROW for the existing railway was not affected by rainwater and groundwater, while the KCR was operational.