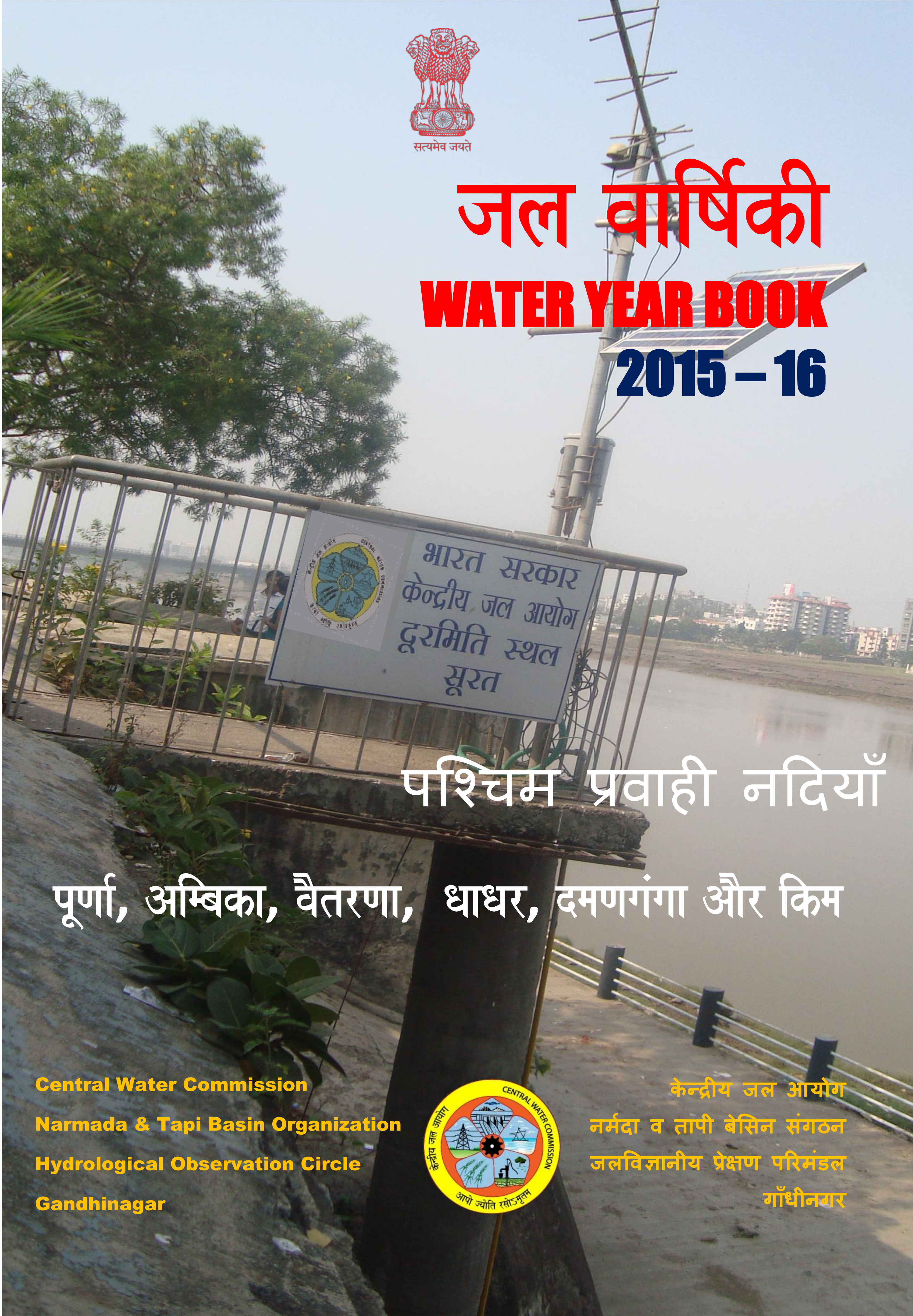
सत्यमेव जयते

जल वार्षिकी

WATER YEAR BOOK

2015 – 16



पश्चिम प्रवाही नदियाँ

पूर्णा, अम्बिका, वैतरणा, धाधर, दमणगंगा और किम

Central Water Commission
Narmada & Tapi Basin Organization
Hydrological Observation Circle
Gandhinagar

केन्द्रीय जल आयोग
नर्मदा व तापी बेसिन संगठन
जलविज्ञानीय प्रेक्षण परिमंडल
गाँधीनगर

आमुख

राष्ट्रीय जल नीति में मानकीकृत राष्ट्रीय सूचना प्रणाली डेटा बेस और डेटा बैंकों के एक नेटवर्क के साथ गुणवत्ता के आँकडे, उपलब्ध कराने और प्रसंस्करण क्षमताओं में सुधार के लिए मौजूदा केन्द्रीय और राज्य स्तरीय ऐजेन्सियों के एकीकरण की आवश्यकता पर बल दिया गया है। जल के बहु -उपयोगी स्वरूप एवं उसकी बढती मांग को पूरा करने हेतु संसाधनों के अनुकूलतम नियोजन के संदर्भ में संबंधित आँकडो, का संकलन अतिमहत्वपूर्ण है।

केन्द्रीय जल आयोग, जल संसाधनों के विकास में संलग्न भारत सरकार, जल संसाधन मंत्रालय के अन्तर्गत देश की एक शीर्षस्थ तकनीकी संस्था है जो जल विज्ञानीय आँकडो के एकत्रीकरण से लेकर परियोजनाओं का मूल्यांकन, अभिकल्पन, प्रबोधन तथा परिचालन करती है।

जल विज्ञानीय प्रेक्षण परिमंडल गाँधीनगर, नर्मदा तापी बेसिन संगठन के अन्तर्गत केन्दीय जल आयोग की एक क्षेत्रीय ईकाई है जिसके अन्तर्गत गुजरात, मध्य प्रदेश, महाराष्ट्र, राजस्थान एवं दादरा नगर हवेली (केन्द्र शासित प्रदेश) के भाग से होकर पश्चिम की ओर बहने वाली 17 नदियों के अधिसूचित महत्वपूर्ण स्थलों पर जल के सतही प्रवाह के आँकडे, एकत्रित किए जाते हैं।

तापी मंडल सूरत द्वारा पश्चिम प्रवाही स्वतंत्र नदियों, पूर्णा, अम्बिका, वैतरणा, धाधर, दमणगंगा और किम पर वर्तमान में, 7 स्थलों पर सतही प्रवाह का प्रेक्षण किया जा रहा है। इनके आँकडे, इस वार्षिकी में संकलित किए गए हैं। इन बेसिनों के वार्षिक सतही अपवाह आँकडो, में प्रवृत्ति का विश्लेषण भी इस वार्षिकी में शामिल किया गया है।

जल वर्ष 2005-06 से जल वार्षिकी का प्रकाशन, केन्द्रीय जल आयोग द्वारा निर्धारित स्वरूप (SWDES) में किया जा रहा है। इस वार्षिकी में सतही प्रवाह के आँकड़ों के साथ - साथ बेसिन से संबंधित सूचनाएँ जैसे कि जलवायु, भूगर्भ विज्ञान, कृषि, भूमि, आदि भी दिये गए हैं

इस वार्षिकी में दी गयी सूचना एवं संकलित आँकडे, उन सभी के लिये उपयोगी होंगे जो जल संसाधन से संबंधित किसी भी क्षेत्र में रूचि रखते हैं, ऐसी आशा है। इसे और उपयोगी बनाने हेतु सुझाव आमंत्रित हैं।

वार्षिकी में प्रकाशित आँकडो के संकलन, विश्लेषण तथा प्रकाशन हेतु नर्मदा - तापी बेसिन संगठन के अधिकारियों एवं कर्मचारियों ने जिस समर्पण एवं लगन से कार्य संपादित किया है, वह प्रशंसनीय है।

गाँधीनगर (गुजरात)
जुलाई -2017

(विमल कुमार)
अधीक्षण अभियंता

Preface

The National Water Policy stresses the need for a standardised national information system with a network of data base and data banks, integrating the existing Central and State agencies for providing quality data and improving the processing capabilities. Collection and compilation of data assumes greater importance in the context of optimal resource planning to meet the ever increasing demand for water in its multi-facetted use.

Central Water Commission is an apex organization of the country concerned with planned development and monitoring in water resources sector. CWC has for long been maintaining a Hydrological Observation & Flood forecasting network, which covers almost all the interstate rivers of India.

Hydrological Observation (HO) Circle, Gandhinagar, a field unit in Narmada Tapi Basin Organization of the Central Water Commission, is entrusted with the Hydrological Observation in 17 river basins of Gujarat, Madhya Pradesh, Maharashtra, Rajasthan and DNH (UT).

The Tapi Division, headquartered at Surat, under HO Circle, is at present, carrying out hydrological observations at 7 sites on independent West flowing rivers viz. Purna, Ambica, Vaitarna, Dhadar, Damanganga and Kim and its tributaries, which have been compiled in this Water Year Book. It also includes trend analysis of annual surface runoff for these basins.

The publication of Water Year Book in SWDES format has been started since the water year 2005-06 as per guidelines issued by Central Water Commission, New Delhi. This Year Book not only provides the hydrological data but also provides general information about geology, climate, agriculture, soil, cities/towns, major and medium projects in the basin, etc.

It is hoped that the information and data compiled herein will be useful to all those concerned with any field related with water resources of the country. Comments and suggestions, if any, on the Water Year Book are most welcome.

The efforts put in by all the concerned officers and staff of NTBO, Central Water Commission is acknowledged.

Vimal Kumar

Gandhinagar
July - 2017

(Vimal Kumar)
Superintending Engineer

C o n t e n t s

List of Plates and Figures

List of Tables

Abbreviations and symbols

Av	:	Average
Ann	:	Annual
A.G.R.	:	Automatic Gauge Recorder
C	:	Centigrate
Cum	:	Cubic meter
Cumec	:	Cubic meter per second
c/s	:	Cross section
C.W.C.	:	Central Water Commission
D	:	Days
Dis	:	Discharge
F	:	Float Observation
F.F.	:	Flood Forecasting
G	:	Gauge
GD	:	Gauge and Discharge
GDS	:	Gauge, Discharge and Sediment
GDWQ	:	Gauge, Discharge and Water Quality
GDSWQ	:	Gauge, Discharge, Sediment and Water Quality
GTS	:	Great Trigonometrical Survey
Hrs.	:	Hours
IWYB	:	Integrated Water Year Book
WYB	:	Water Year Book
km	:	Kilo meter
M	:	Million
m	:	Meter
mm	:	milli meter
m^3/s	:	Cubic meter per second
Mm3 / MCM	:	Million Cubic meter
Max.	:	Maximum
Min.	:	Minimum
m.s.l.	:	Mean sea level
MD	:	Mahi Division, CWC, Gandhinagar
neg.	:	Negligible
NNW	:	National Net Work
R.Days	:	Remaining days
R.L.	:	Reduced Level
R.D.	:	Reduced Distance
R.C.C.	:	Reinforced Cement Concrete
sq km	:	Square Kilometer
TD	:	Tapi Division, CWC, Surat
WQ	:	Water Quality
W.L.	:	Water Level
W.Year	:	Water Year
WRID	:	Water Resources Investigation Division, Ahmadabad
WRI C	:	Water Resources Investigation Circle, Ahmadabad
80 Key	:	80 Key Hydrological Station Scheme
163 Key	:	163 Key Hydrological Station Scheme
^{0}, ‘ . “	:	Degree (30^0) Minutes(56’) Seconds (35”)
*	:	Estimated Discharge
#	:	Discarded and estimated discharge

1.0 Introduction

1.1 General

This water year book presents data of seven hydrological observation stations, alongwith general information about basins and trend analysis for annual runoff, for the water year 2015-16 in Purna, Vaitarna, Ambica, Dhadhar, Kim, Wagh and Damanganga rivers. The data of 07 sites which are included in this book are collected by Tapi division, Central Water Commission, Surat under Hydrological Observation Circle, Gandhinagar. Jurisdiction map of Tapi division, CWC, Surat is enclosed at **Plate-1**. Central Water commission is conducting hydrological observations on major west flowing river basins under various schemes viz national network (NNW), 80-key stations, 163- key stations and flood forecasting (FF). The scheme wise distributions of sites are shown in the **table-1**.

Table-1: Scheme wise distributions of sites

Sl. No.	Name of Site	Station Code	Scheme	Type
1.	Purna at Mahuwa	01 02 19 001	NNW	GDS WQ
2.	Vaitarna At Durvesh	01 02 25 001	NNW	GDS WQ
3.	Ambica at Gadat	01 02 20 001	80 Key stations	GDSWQ
4.	Dhadhar At Pingalwada	01 02 14 001	163 Key stations	GD WQ
5.	Kim at Motinaroli	01 02 16 001	163 Key stations	GDWQ
6.	Wagh at Ozerkheda	01 02 24 002	FF	GD
7.	Damanganga at Nanipalsan	01 02 24 001	FF	GD

2.0 Description of River Basins

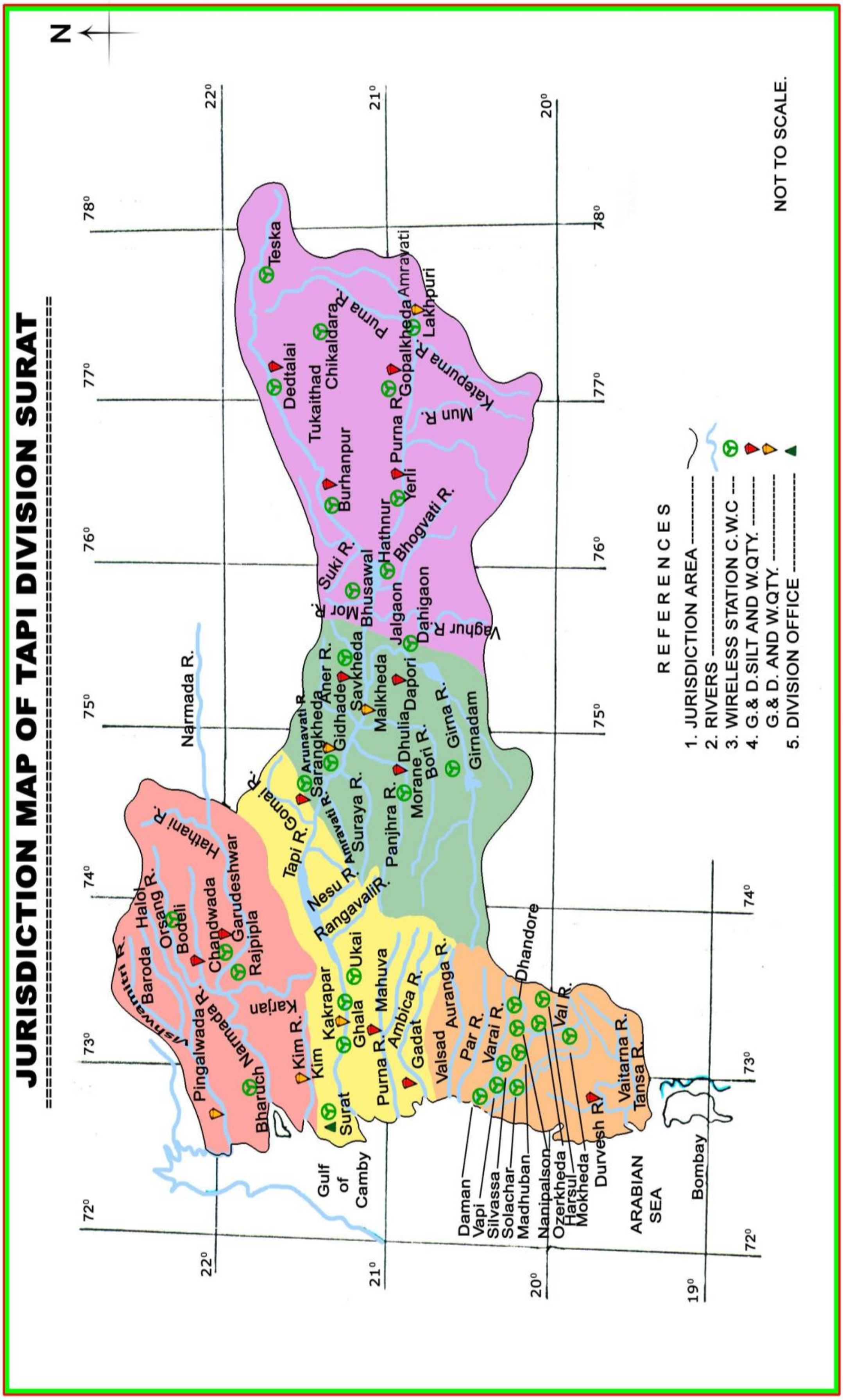
There are 6 independent river basins as given below under the jurisdiction of Tapi Division, Central Water Commission, Surat,

1. Purna Basin
2. Ambica Basin
3. Vaitarna Basin
4. Dhadhar Basin
5. Damanganga Basin
6. Kim Basin

Description of these river basin is given in subsequent sections of this year book.

1.2 Jurisdiction Map of Tapi division, CWC, Surat.

Plate – 1



2.1 Purna Basin

2.1.1 Geographical setting of Purna Bain

Purna River is an important west flowing river with its catchment lying in Ahwaa,Valsad and Navsari districts of Gujarat and in Nasik district of Maharashtra. The Purna basin can be divided into three prominent physiographic regions, i.e.

i) eastern parts, (ii) the middle reaches and (iii) the coastal zones.

The eastern parts of the basin cover a chain of rugged mountain ranges of the Western Ghats running at an elevation of above 1300 m and descending to an elevation of about 100 m at the edges of uplands of the Surat district. The middle reaches of the basin area are marked by high relief zone with ridges and valleys. The hilly zone then merges into the plains through an undulating piedmont coastal zone running parallel to the sea. Basin map of Purna River is shown in **Plate-2.1.1.**

Plate-2.1.1

2.1.2 River System

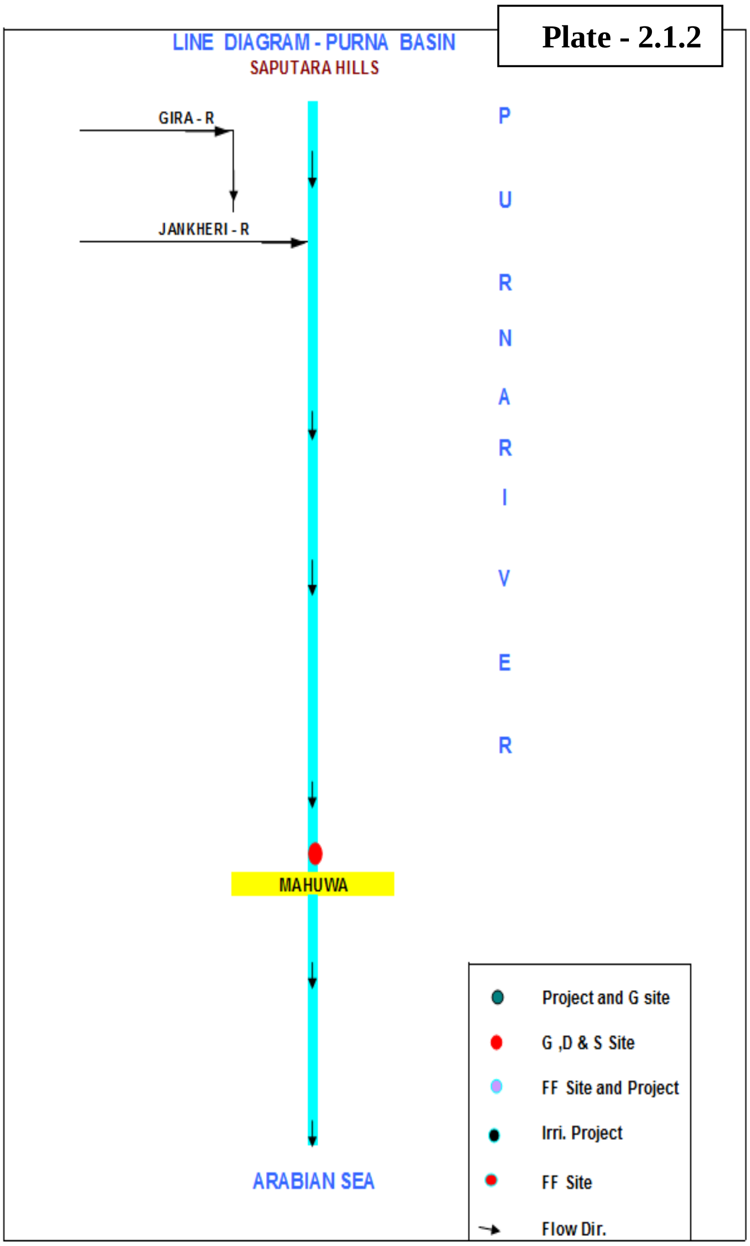
The river Purna rises in the Saputara hills of the Western Ghats near the village Chinchi in Maharashtra. The length of the river from its source to outflow in the Arabian Sea is about 180 km.

The important tributaries of the Purna River are Dhodar nala, Bardanala, Nagihpar nala, Girna River, Zankari River and Dumas khadi. The catchment area of the Purna basin is 2431 Sq. km. The basin lies between 72^0 45' to 74^0 00' East longitude and 20^0 41' to 21^0 05' North latitude. State wise distribution of drainage area is shown in **Table-2.1.1** and line diagram of Purna river system is shown in **Plate - 2.1.2**

Table -2.1.1**:** State wise distribution of catchments area of the Purna basin

Sl.No	State	C.A .in Sq. km.	% Of the total C.A.
1	Maharashtra	58	2.39
2	Gujarat	2373	97.61
	Total	2431	100.00

Plate - 2.1.2



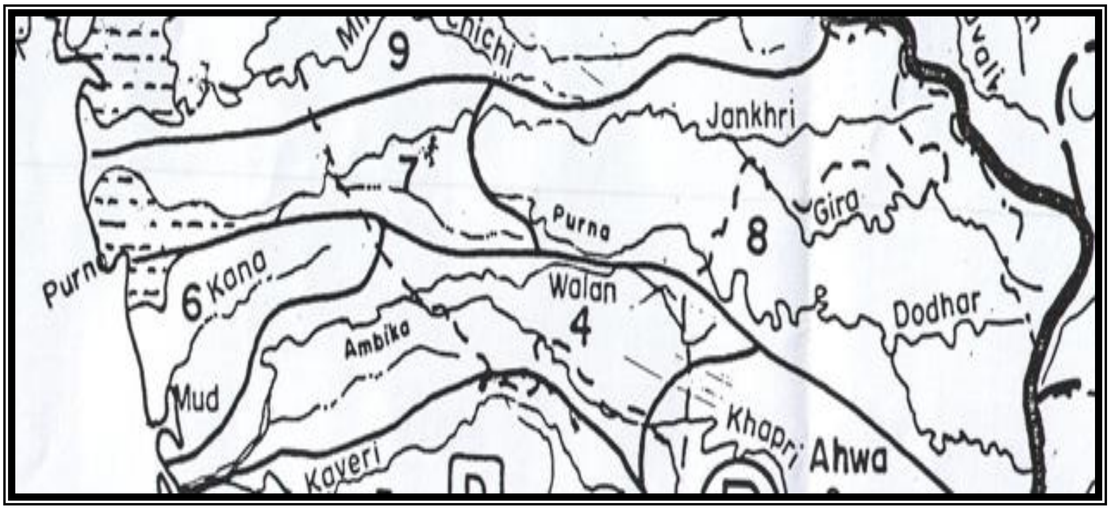
2.1.3 Purna Basin as per Watershed Atlas of India

As per Watershed Atlas of India, Published by Department of Agriculture and Cooperation, Ministry of agriculture, Krishi Bhavan New Delhi (1990), the sub catchments under 5B2D pertain to Purna Basin.

2.1.3.1 Subcatchment -5B2D (5B2D7 & 5B2D8)

This Sub Catchment is situated in the plain and hilly region of Gujarat, and Maharashtra drained by Dhodar nala, Bardanala, Nagihpar nala, Girna River, Zankari River and Dumas khadi. The total area of this Sub-Catchment is 2431 Sqkm. Subcatchment area of Purna Basin is shown in **Fig.-2.1.1**

Fig-2.1.1: Sub catchment area of Purna Basin as per water shed Atlas of India.



Source: Watershed Atlas of India, Published by Department of Agriculture and Cooperation, Ministry of agriculture, Krishi Bhavan New Delhi (1990)

2.1.4 Climate

Accordingly to Koeppan's Scheme, the climate of the basin is classified as AW-Tropical Savannah as most of the peninsular plateau, south of Tropic of Cancer is classified. In the initial reaches, the climate is influenced by the Western Ghats which becomes continued as the river reaches the coastal plains. The climatic variations are experienced in the patterns of temperature, rainfall & winds, rhythm of seasons and degree of wetness or dryness. These are described as follows:

2.1.4.1 Temperature

The Temperature is maximum in the month of May and Minimum in the month of December to January. The maximum, minimum temperatures observed at site Mahuwa varies from 27^0 C to 46^0 C and 30^0 C to 10^0 C respectively. The temperature profile in the basin is given in the **Table -2.1.2**

Table-2.1.2: Mean monthly Temperature (^{0}C) during water year at site Mahuwa

Month	Mean Monthly Maximum Temperature (^{o}C)	Mean Monthly Minimum Temperature (^{o}C)
Jun-15	32.5	26.0
Jul-15	29.6	25.6
Aug-15	29.8	25.4
Sep-15	31.6	24.1
Oct-15	34.9	23.8
Nov-15	31.5	20.2
Dec-15	28.8	15.4
Jan-16	28.4	14.5
Feb-16	29.8	17.7
Mar-16	33.6	21.1
Apr-16	35.3	23.3
May-16	36.8	27.2
Annual mean	31.9	22.0

2.1.4.2 Rainfall

The basin receives most of the rainfall from the South West monsoon from June to September. Average annual rainfall in the basin is 1556.2 mm. The rainfall at site Mahuwa in Purna Basin shown in **Table - 2.1.3.**

Table -2.1.3 Mean annual rainfall at site Mahuwa in Purna Basin

Sl.No	Name of Site	Data available (No of Years)	Average Annual Rainfall (mm)	Average no of rainy days	Rainfall in the year 2015-16	No of rainy days in 2015-16
1	Mahuwa	30	1556.2	73	847.2	46

Table-2.1.4: Seasonal Rainfall during Water Year 2015 at Mahuwa in Purna basin

Sl No	Name of Site	Seasonal Rainfall (mm) in 2015				Total Annual Rainfall
		Winter monsoon	Pre monsoon	South-West monsoon	Post monsoon	
		(Jan-Feb)	(Mar-May)	(June-Sept)	(Oct-Dec)	
1	Mahuwa	0.0	4.8	847.2	0.0	852.0

2.1.4.3 Wind

The wind speed and direction profile at site Mahuwa, based on collected data is given in **table -2.1.5**. The average monthly wind speed varies from 2.9 km/h to 0.0 km/h .In the pre and post-monsoon period, the wind speed is generally higher. The pre dominant wind direction is NE followed by SE and W.

Table 2.1.5: Wind Speed at site Mahuwa in Purna basin during Water Year 2015-16

Month	Mean monthly wind Speed (km/h)
June	1.4
July	2.4
August	0.9
September	0.3
October	0.1
November	0.1
December	0.2
January	0.1
February	0.2
March	0.2
April	0.1
May	0.5
Annual Mean	0.54

2.1.4.4 Humidity

The relative Humidity in Purna basin at site Mahuwa varies between 97.7% and 64.1% depending upon the season. It is naturally maximum in the monsoon period and is around 84.2 to 97.7%. In the winter months of November and December, the relative humidity decreases. The relative humidity profile at station Mahuwa in Purna Basin is given in **table -2.1.6**

Table 2.1.6: Mean monthly Relative Humidity at site Mahuwa in Purna Basin during Water Year 2015-16

Month	Relative Humidity (%)
June	79.5
July	85.0
August	86.2
September	87.1
October	81.3
November	77.6
December	63.5
January	71.7
February	71.4
March	68.6
April	74.5
May	76.6
Annual Mean	76.9

2.1.5 Geology

The whole basin can be divided in to three prominent physiographic zones viz. i) the Eastern zone ii) the middle zone and ii) the coastal zone. The Eastern zone of the basin covers a chain of rugged mountain ranges of the Western Ghats. The middle zone of the basin is marked by high relief zone with ridges and valleys. The hilly region then merges in to the plains through a coastal piedmont coastal zone running parallel to the sea. Deccan traps occupy the most parts of the basin. In the East there are high ridges and deep valleys and towards the west, they merge into the lower reach composed of recent and sub recent alluvium and blown sand. The straight graphical sequences of the rocks found in the basin are Neogene's, Palaeogene and early Palaeogene.

2.1.6 Soil

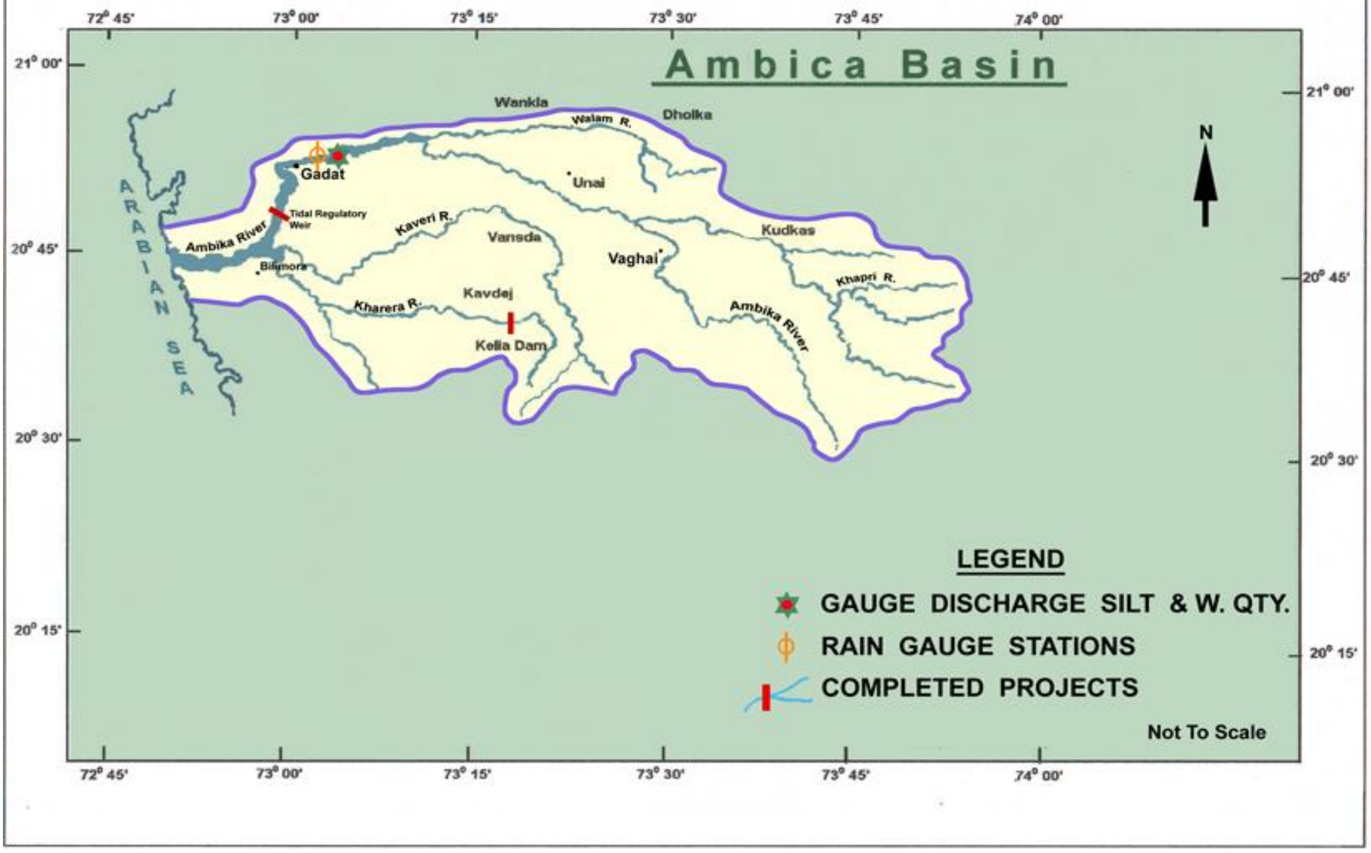
Soils of Purna basin can be classified into three groups viz lateritic soils, deep black soils and coastal alluvial soils.

2.2 Ambica Basin

2.2.1 Geographical setting of Ambica Basin

Ambica River is one of the important west flowing rivers with its catchment in Gujarat and Maharashtra. The Ambica basin which is adjacent to the Auranga basin can be divided in to two prominent physiographic zones. The eastern part comes under a rugged mountain chain of the Sahyadri Western Ghats and descending on the western side to the edge of the uplands of Surat district. This region is situated at general elevation ranging from 1050 m to 100 m. The western part consists of hills and valleys which generally lie below 100 m elevation. Its basin map is shown in **Plate -2.2.1.**

Plate -2.2.1

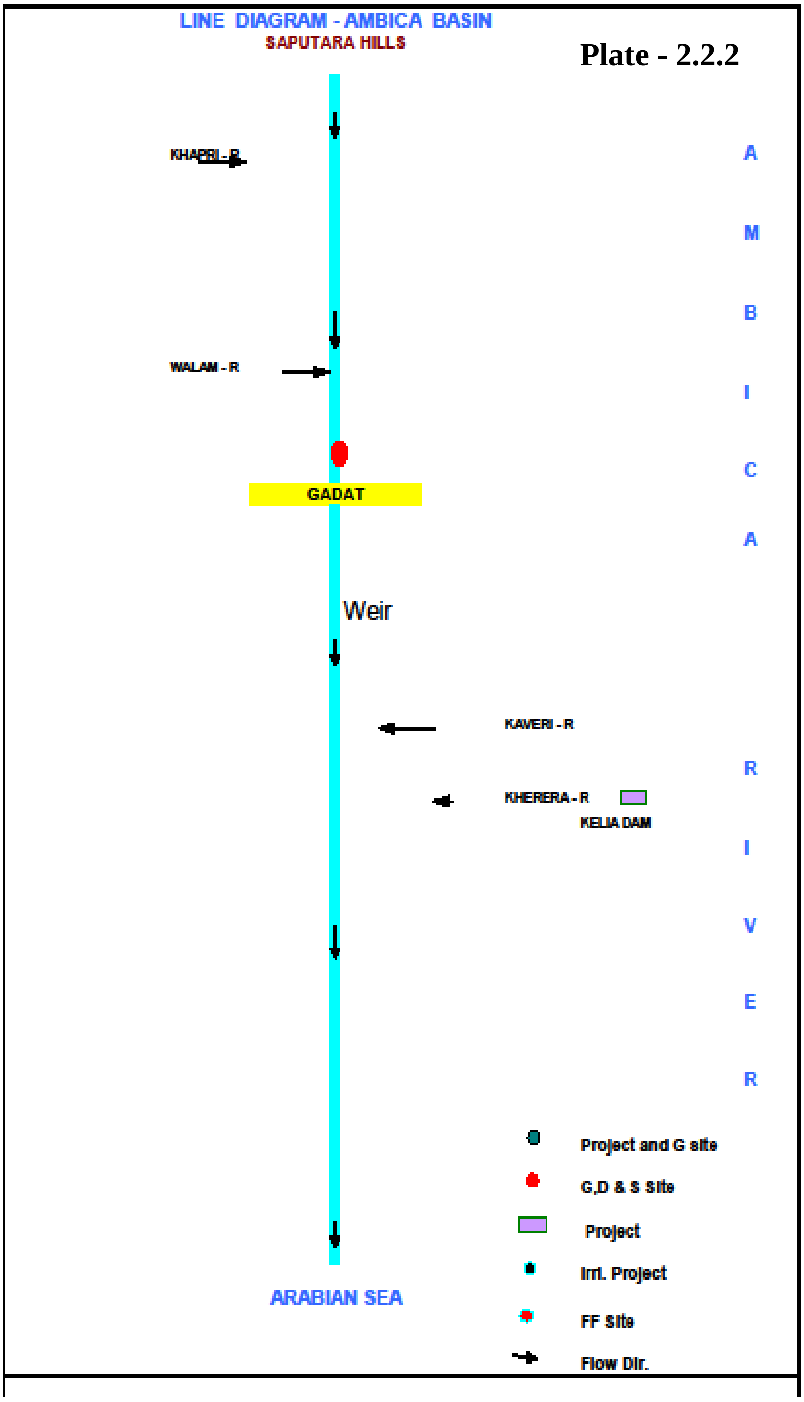


2.2.2 River System

It originates from Saputara Hill ranges near village Kotambi of Surgana taluka in the Nasik district of Maharashtra. After flowing for a length of 136 km it drains in to the Arabian Sea. The important tributaries of the Ambica River are Kapri, Wallan, Kaveri and Kharera. The river Ambica basin lies between 20° 31’ and 20° 57’ North latitude and 72° 48’ and 73° 52’ East longitude with a drainage area of 2715 Sq.km. The Valsad, Dangs and Surat Districts of Gujarat and a small portion of the Nasik district of Maharashtra falls in the basin, drainage area of Ambica River basin is shown in **Table-2.2.1** and line diagram of Ambica river system is shown in **Plate - 2.2.2.**

Table -2.2.1: State wise distribution of catchments area of the Ambica basin

Sl.No	State	Catchment Area (sq km)	% Of the total C.A.
1	Maharashtra	102	3.76
2	Gujarat	2613	97.24
	Total	2715	100.00



2.2.3 Ambica Basin as per Watershed Atlas of India

As per Watershed Atlas of India, Published by Department of Agriculture and Cooperation, Ministry of agriculture, Krishi Bhavan New Delhi (1990), the sub catchments from **5B2D** pertain to Ambica Basin, as shown in **Fig.-2.2.1.**

2.2.3.1 Sub-catchment -5B2D (5B2D3, 5B2D4 & 5B2D5)

This Sub Catchment is situated in the plain and hilly region of Gujarat, and Maharashtra drained by Kapri, Wallan, Kaveri and Kharera. The total area of this Sub-Catchment is 2715 Sqkm. Subcatchment area of Ambica Basin is shown in **Fig. 2.2.1**

Fig-2.2.1: Sub- catchment area of Ambica Basin as per water shed Atlas of India.

Source: Watershed Atlas of India, Published by Department of Agriculture and Cooperation, Ministry of agriculture, Krishi Bhavan New Delhi (1990)

2.2.4 Climate

Accordingly to Koeppan's Scheme, the climate of the basin is classified as AW-Tropical Savannah, as most of the peninsular plateau, south of Tropic of Cancer, is classified. In the initial reaches, the climate is influenced by the Western Ghats which gradually changes as the river reaches the coastal plains. The climatic variations are experienced in the patterns of temperature, rainfall & winds, rhythm of seasons and degree of wetness or dryness. These are described as follows.

2.2.4.1 Temperature

The Temperature is maximum in the month of May and Minimum in the month of December to January. The maximum, minimum temperatures observed vary from 27.4^{0}C to 40^{0}C and 28.6^{0}C to 8^0 C respectively. The temperature profile in the basin is given in the **table 2.2.2**

Table-2.2.2: Mean monthly Temperature (^{0}C) during water year at site Gadat

Month	Mean Monthly Maximum Temperature (^{o}C)	Mean Monthly Minimum Temperature (^{o}C)
Jun-15	35.6	27.7
Jul-15	31.8	27.7
Aug-15	31.3	26.6
Sep-15	31.7	24.7
Oct-15	35.2	23.8
Nov-15	33.7	21.0
Dec-15	30.6	14.0
Jan-16	31.0	12.4
Feb-16	32.8	14.8
Mar-16	37.1	19.4
Apr-16	37.8	23.4
May-16	37.0	27.8
Annual mean	33.8	21.9

2.2.4.2 Rainfall

The basin receives most of the rainfall from the South West monsoon from June to September. Average annual rainfall in the basin is 1780.9 mm. The rainfall at site in Ambica Basin shown in **Table -2.2.3 & 2.2.4.**

Table -2.2.3: Mean annual rainfall of Ambica Basin at site Gadat

Sl. No	Name of Site	Data available (No of Years)	Average Rainfall (mm)	Average no of rainy days	Rainfall in the year 2015-16	No of rainy days in 2015-16
1	Gadat	33	1780.9	73	1131.0	40

Table-2.2.4: Seasonal Rainfall during Water Year 2015 at site Gadat in Ambica Basin

Sl No	Name of Site	Seasonal Rainfall (mm) in 2015				Total Annual Rainfall
		Winter monsoon (Jan-Feb)	Pre monsoon (Mar-May)	South-West monsoon (June-Sept)	Post monsoon (Oct-Dec)	
1	Gadat	0.0	2.0	1131.0	0.0	1133.0

2.2.4.3 Wind

The wind speed and direction profile at site Gadat based on collected data is given in T**able -2.2.5**.The average monthly wind speed varies from 0.3 km/h to 2.5 km/h .In the pre and post-monsoon period, the wind speed is generally higher. The pre dominant wind direction is NE.

Table 2.2.5: Wind Speed at site Gadat in Ambica basin during Water Year 2015-16

Month	Mean monthly wind Speed (km/h)
June	2.0
July	2.2
August	1.2
September	0.9
October	0.8
November	0.9
December	0.9
January	0.7
February	1.0
March	1.1
April	1.2
May	1.9
Annual Mean	1.2

2.2.4.4 Humidity

The relative Humidity in Ambica basin varies between 93.3 % to 74.0 % depending upon the season the humidity is naturally maximum in the monsoon period and is around 93.3 to 89.9 %. In the winter months of November and December the relative humidity comes down. The relative humidity at station of CWC representative of Purna Basin is given in T**able- 2.2.6**

Table -2.2.6: Mean monthly Relative Humidity at site Gadat in Ambica Basin during Water Year 2015-16

Month	Relative Humidity (%)
June	91.7
July	91.8
August	92.0
September	91.5
October	91.4
November	90.4
December	87.8
January	88.1
February	89.1
March	90.5
April	91.4
May	92.3
Annual Mean	90.7

2.2.5 Geology

The basin can be divided into two prominent physiographic zones. The eastern part comes under rugged mountain chains of the Saputara Hills and descends on the western side to the edge of the uplands of Surat district. This region is placed at a general elevation of 1050 m to 100 m. The western part, barring the coastal plain, is essentially in the sub Sahyadrin zone of hills and valleys generally below 100 m elevation. Deccan traps and intermediate amphitheatres have developed out of the alluvial debris washed from the hills. The lower reaches of the basin upto the coastal margins are mainly alluvial plains

2.2.6 Soil

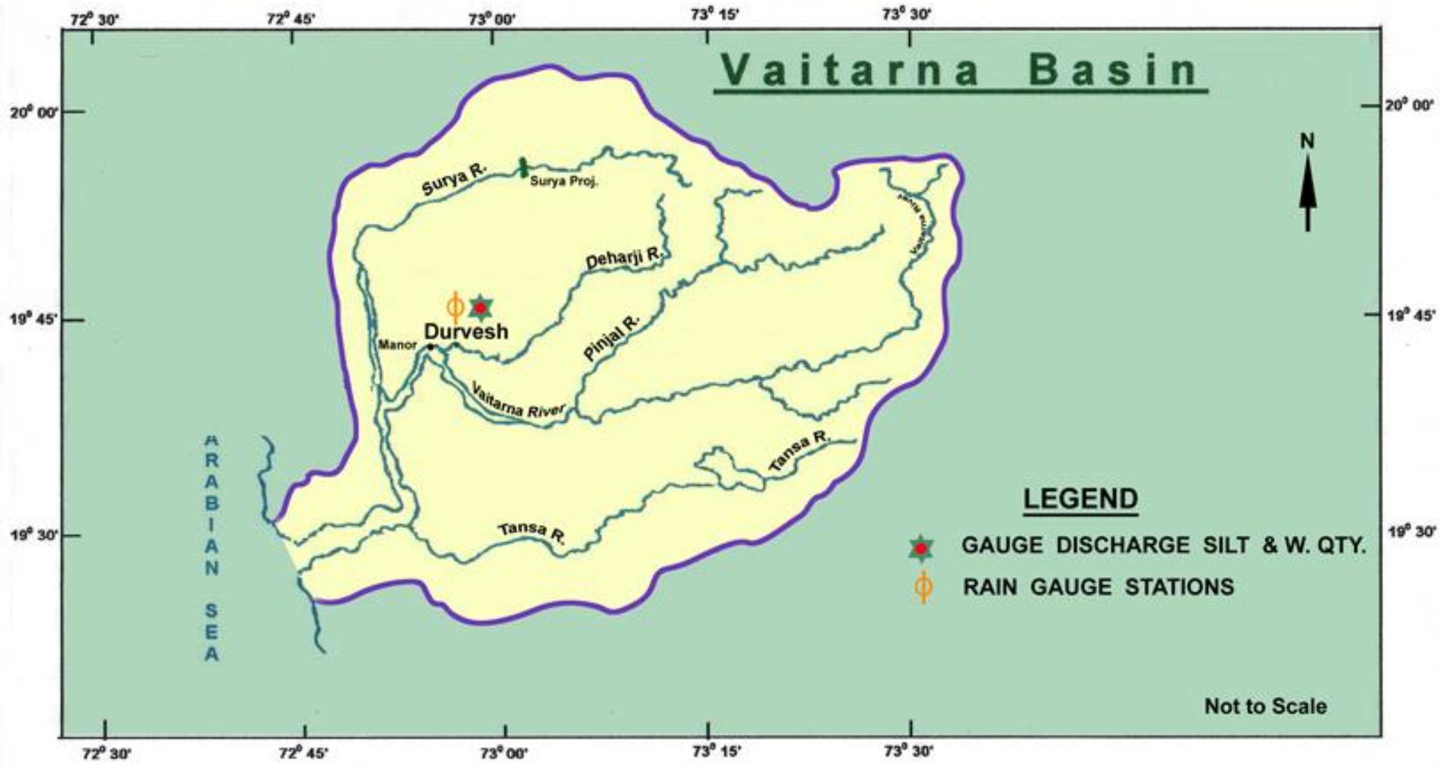
Soil of Ambica basin can be broadly classified into three group viz. Laterite soil, deep black soil and alluvial soil.

2.3 Vaitarna Basin

2.3.1 Geographical setting of Vaitarna Basin

The river Vaitarna is one of the west flowing rivers in the region North of Mumbai and South of the Tapi River. The river rises in the Sahyadri hill range in the Nasik district of Maharashtra State and after traversing a distance of about 120 km in Maharashtra joins the Arabian Sea. Basin map is shown in **Plate -2.3.1**. The Vaitarna basin lies between East longitude of 72^0 45' to 73^0 35' and North latitude of 19^0 25'to 20^0 20'.

Plate -2.3.1



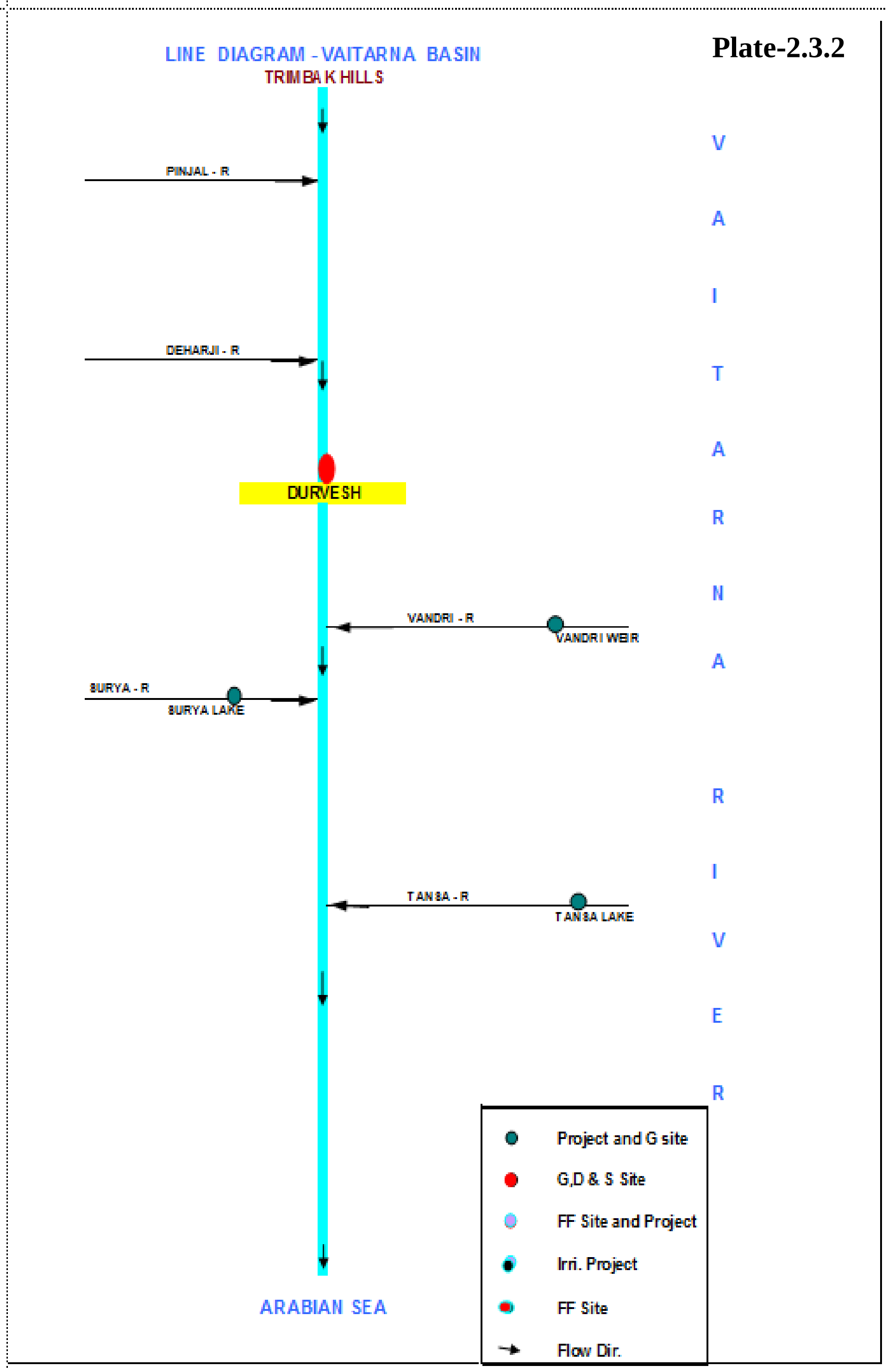
2.3.2 River System

The headstreams of the Vaitarna rise on the southern slopes of the Triambak-Anjaneri range and combine into three southward flowing streams which unite to form the Vaitarna a little north of Dapure. The Vaitarna from here has a very winding course southwards and goes round Zarwad (Jarwar) Budruk.

Due south of it, the river is joined by its tributary Alvand nadi, whose headstreams rise in the same Triambak Anjaneri range on the southern slopes of the Bhaskargad, Phani dongar and Harish dongar, which form the divide between these and those of the Val river flowing northwards. After the confluence with the Alvand river, the Vaitarna turns and flows nearly straight in a south-south-west direction cutting a deep gorge in the scarp of the Sahyadris. A small tributary from the northwest to south-east in a gorge continues the course of the Vaitarna in a remarkably deeply cut valley.

The main tributaries of Vaitarna river are Pinjal, Ganjai, Surya, Daharji, Tansa. The catchment area of Vaitarna basin completely lies in Thane and Nasik districts of Maharashtra. The Vaitarna drains an area of 2019 sq km before it falls in Gulf of Khambhat. A line diagram of Vaitarna river system is shown in **Plate -2.3.2**.

Plate-2.3.2



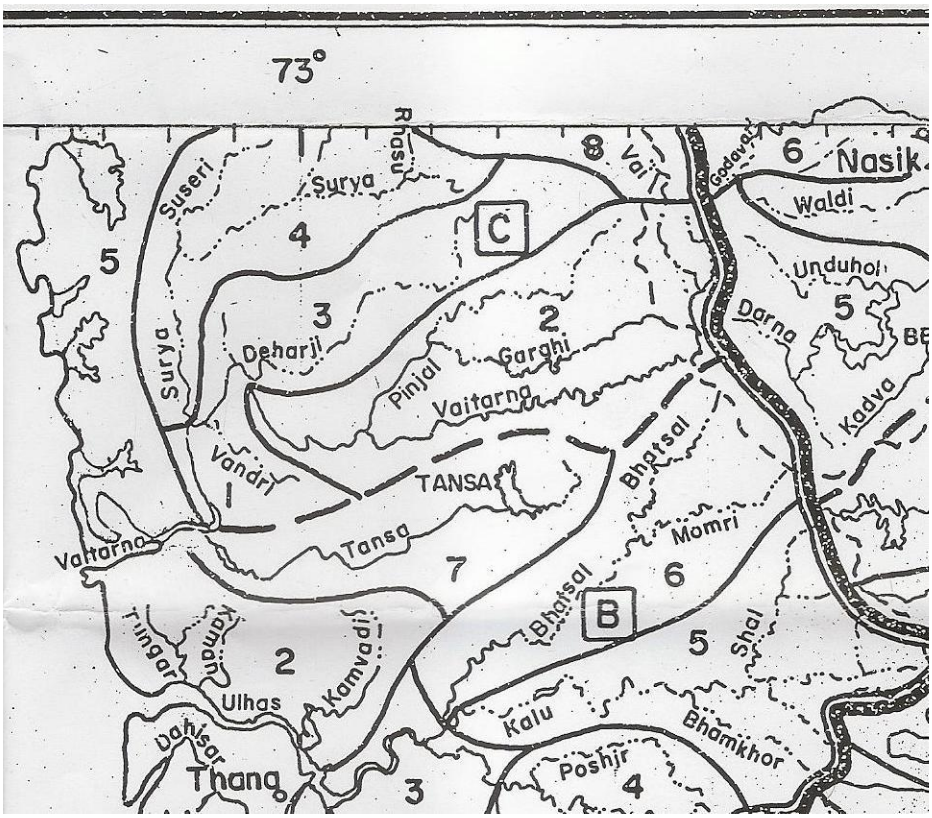
2.3.3 Vaitarna Basin as per Watershed Atlas of India

As per Watershed Atlas of India, Published by Department of Agriculture and Cooperation, Ministry of agriculture, Krishi Bhavan New Delhi (1990), the sub catchments from 5B2C pertain to Vaitarna Basin as shown in **Fig 2.3.1**.

2.3.3.1 Sub-catchment -5B2C (5B2C2 to 5B2C5)

This Sub Catchment is situated in the plain region of Maharashtra. Drained by main tributaries of Vaitarana River , Pinjal, Surya, Daharji, Tansa. The total area of this Sub-Catchment is 2019 sq km.

Fig 2.3.1 **Sub catchment area of Vaitarna Basin as per water shed Atlas of India.**



Source: Watershed Atlas of India, Published by Department of Agriculture and Cooperation, Ministry of agriculture, Krishi Bhavan New Delhi (1990)

2.3.4 Climate

Accordingly to Koeppan's Scheme, the climate of the basin is classified as AW-Tropical Savannah, as most of the peninsular plateau, south of Tropic of Cancer is classified. In the initial reaches, the climate is influenced by the Western Ghats that becomes coastal as the river reaches coastal plains. The climatic variations are experienced in the patterns of temperature, rainfall & winds, rhythm of seasons and degree of wetness or dryness. These are described as follows.

2.3.4.1 Temperature

The Temperature is maximum in the month of May and Minimum in the month of December to January. The temperature profile in the basin is given in the Table-2.3.1.

Table-2.3.1: Mean monthly Temperature (^{0}C) during water year at site Durvesh

Month	Mean Monthly Maximum Temperature (^{o}C)	Mean Monthly Minimum Temperature (^{o}C)
Jun-15	33.7	26.3
Jul-15	30.8	26.6
Aug-15	31.0	25.5
Sep-15	32.4	24.8
Oct-15	35.3	24.6
Nov-15	33.1	21.7
Dec-15	32.8	16.4
Jan-16	33.2	13.4
Feb-16	34.2	16.4
Mar-16	35.9	21.5
Apr-16	37.6	24.6
May-16	37.6	27.9
Annual mean	34.0	22.5

2.3.4.2 Rainfall

The basin receives most of the rainfall from the South West monsoon during June to October. Almost 98% of the annual rainfall of the basin is received during this period. The rainfall at site in Vaitarna Basin shown in **Table-2.3.2** and **Table-2.3.3**.

Table-2.3.2 Mean annual rainfall of Vaitarna Basin at site Durvesh

Sl. No	Name of Site	Data available (No of Years)	Average Rainfall (mm)	Average no of rainy days	Rainfall in the year 2015-16	No of rainy days in 2015-16
1	Durvesh	34	2579.3	95	2241.4	71

Table-2.3.3: Seasonal Rainfall during Water Year 2015at site Durvesh in Vaitarna basin

Sl No	Name of Site	Seasonal Rainfall (mm) in 2015				Total Annual Rainfall
		Winter monsoon	Pre monsoon	South-West monsoon	Post monsoon	
		(Jan-Feb)	(Mar-May)	(June-Sept)	(Oct-Dec)	
1	Durvesh	0.0	2.0	2181.8	57.0	2240.8

2.3.4.3 Wind

The wind speed and direction profile at site Durvesh based on collected data is given in **Table-2.3.4**. The average wind speed in the Vaitarna basin varies about 1.7 km/h to 6.8 km/h. In the pre and post-monsoon period, the wind speed is generally higher. The predominant wind direction is SW.

Table-2.3.4: Wind Speed at site Durvesh inVaitarna basin during Water Year 2015-16

Month	Mean monthly wind Speed (km/h)
June	6.7
July	6.5
August	3.1
September	2.6
October	2.3
November	2.4
December	2.1
January	2.2
February	2.5
March	2.7
April	2.9
May	4.2
Annual Mean	3.4

2.3.4.4 Humidity

The relative Humidity in Vaitarna basin varies between 92.0 % and 70.0 % depending upon the season. Humidity is maximum in the monsoon period about 92.0 % to 87.9 %. In the winter months of November and December, it decreases. Relative humidity at Durvesh station of CWC is given in **Table-2.3.5**.

Table-2.3.5: Mean monthly Relative Humidity at site Durvesh in Vaitarna Basin during Water Year 2015-16

Month	Relative Humidity (%)
June	86.2
July	90.2
August	91.3
September	91.0
October	90.5
November	88.6
December	87.4
January	88.2
February	86.8
March	83.5
April	85.2
May	80.2
Annual Mean	87.4

2.3.5 Geology

The Great Trap region of the Deccan covers the maximum part of the Basin. It is entirely of volcanic formation. The volcanic portion consists of compact, stratified basalts, and an earthy trap. The basalts are the most conspicuous geological feature. To the west they lie in flat-topped ranges, separated by valleys, trending from west to east. In some flows the- basalt is columnar and then it weathers into the fantastic shapes. The formation at the base of the traps is chiefly amygdaloidal, containing quartz in vertical veins, crystals and zeolitic minerals, especially apophyllite weathering into a gray soil. The absence of laterite, which caps the summits of the hills to the south, is a curious feature in the geology of the area. The basalt is either fine textured or it is coarse and nodular.

2.3.6 Soil

The valleys are filled with disintegrated basalt of various shades from gray to black, washed down by rain. It is of argillaceous nature. This soil is not favorable to the growth of large trees but it is very fertile for cereals and pulses. The black soil contains high alumina and carbonates of calcium and magnesium with variable amounts of potash, low nitrogen and phosphorus. There are broadly two groups of soils: 1) Red coarse soil & 2) Alluvial soil

The red soil is less common and is suitable for cultivation under a heavy and consistent rainfall. Red coarse soil derived from disintegration of basaltic rock fragments under heavy rainfall. The rock fragments have undergone intensive weathering and beaching with the surface weathered and fragmented materials being carried away with the heavy run off in the monsoon period. The residual soil left behind is usually reddish yellow in colour, shallow in depth, coarse sandy loam to sandy loam in texture, rapidly drained and low in fertility. Alluvial soil formed with the deposition of transported materials brought out by heavy run off. This soil is deep to very deep yellowish brown to grayish brown in colour and clay loam to salty loam in texture. This soil is normally free from salinity and alkalinity.

2.3.7 Major / Medium/ multipurpose/ irrigation projects

The major and medium projects completed / ongoing on Vaitarna river basin are as shown in **Table-2.3.6**

Table-2.3.6: List of major and medium projects completed / on going on Vaitarna river basin

Sl. No	Name of the project	River	Status	Capacity in Mcm		Utilisation
				Gross	Live	
1.	Vaitarn Hydro Electric Project. (upper Vaitarna)	Vaitarna	Major	301.60	295.80	Multipurpose
2.	Surya Project.	Surya	Major	285.31	276.35	Multipurpose
3.	Modak Sagar (Lower Vaitarna)	Vaitarna	Medium	N.A.	N.A.	Irrigation
4.	Wandra Project	Wandria	Medium	37.11	35.938	-do-
5.	Deharji River Project	Deharji	Medium	93.120	89.840	-do-
6.	Tansa Dam	Tansa	Medium	N.A.	N.A.	Multipurpose

2.3.7.1 Vaitarna hydropower project

Vaitarna hydropower project is located near Vaitarna and Alwandi masonry and earthen dam on Vaitarna and Alwandi Rivers, 30 km from Ghoti, in Nashik District, Maharashtra. The catchment area at the dam is 160.8 km2. The height and length of the dam is 47 m and 555 m respectively. The reservoir has a live storage capacity of 35 MCM at FRL 603.5 m and the MDDL is at 580 m. The power house has a unit of 60 MW. It has a firm power of 11 MW with mean annual inflow of 635 MCM. MSEB commissioned the project in 1976.

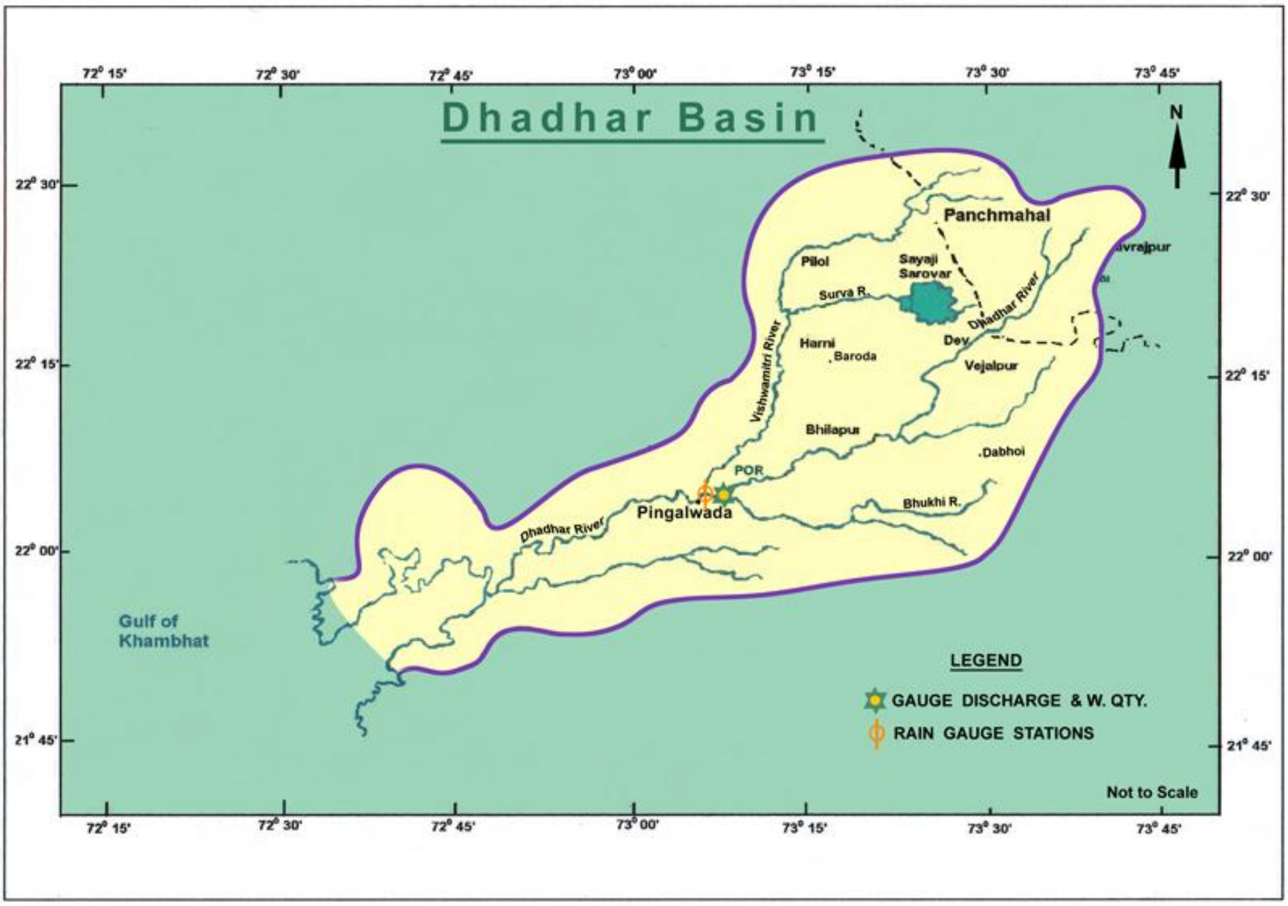
2.4 Dhadhar Basin

2.4.1 Geographical setting of Dhadhar Basin

The Dhadhar River is one of the west flowing rivers in Gujarat state. It originates from the Pavagadh Hills of Gujarat state and flows through Vadodara and Bharuch districts. The river Dhadhar after flowing 87 km receives Vishwamitri tributary from right bank at Pingalwada village 500 m upstream of Gauge and Discharge site. After flowing another 55 km it falls into the Gulf of Khambhat. The total length of the river from its source to outfall in the Gulf of Khambhat is about 142 km.

Basin map is shown in **Plate -2.4.1**.

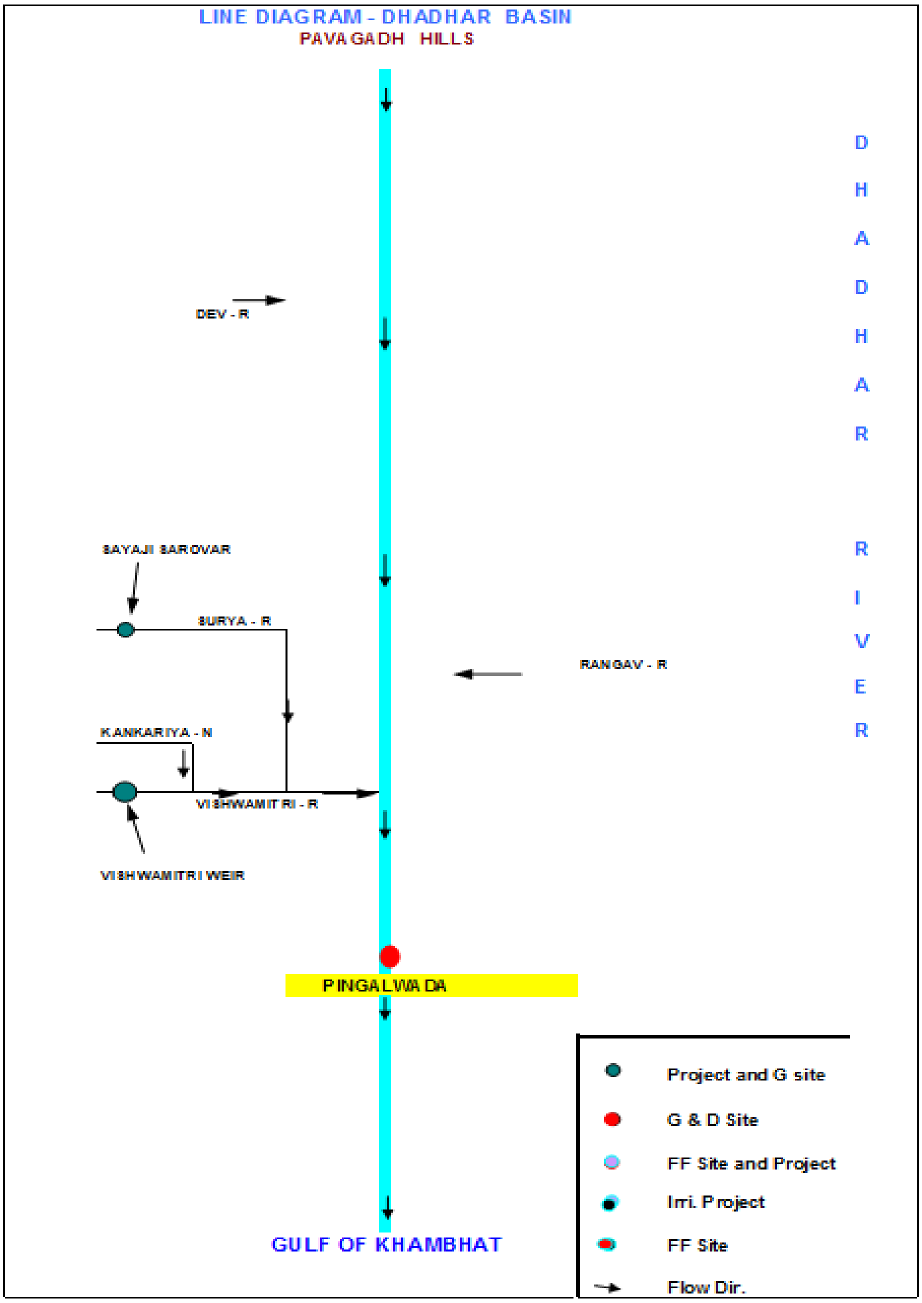
Plate- 2.4.1



2.4.2 River System

The important tributaries of the Dhadhar River are Vishwamitri, Jambuoriver, Dev and Surya River. The catchment area of the Dhadhar basin is 3423 Sq.km. and catchment area up to the site is 2400 Sq.km. It lies between east longitude 72° 30’ and 73° 45’ and North latitude 21° 45’ and 22° 45’. Line diagram of Dhadhar river system is shown in **Plate -2.4.2**.

Plate -2.4.2.



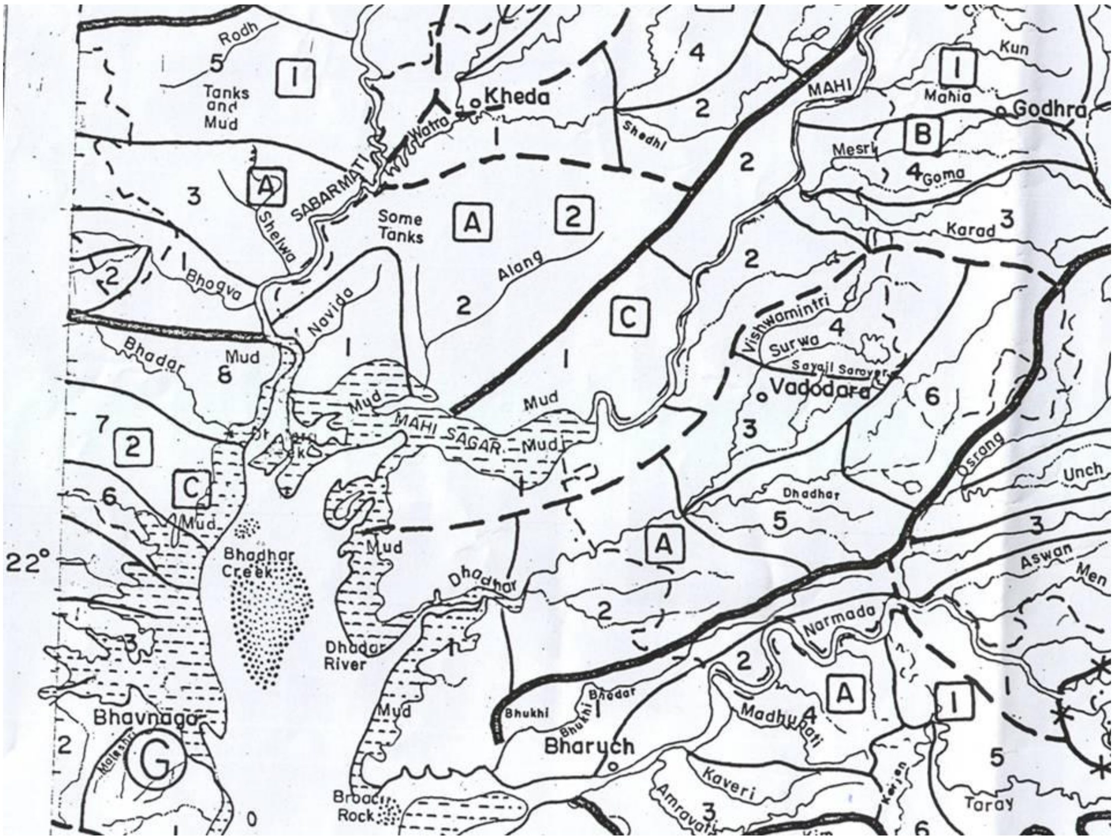
2.4.3 Dhadhar Basin as per Water Shed Atlas of India

As per Watershed Atlas of India, Published by Department of Agriculture and Cooperation, Ministry of agriculture, Krishi Bhavan New Delhi (1990), the sub catchments from 5E1A pertain to Dhadhar Basin as shown in **Fig 2.4.1**.

2.4.3.1 Subcatchment -5E1A (5E1A1 to 5E1A6)

This Sub Catchment is situated in the plain region of Gujarat, The important tributaries of the Dhadhar River are Vishwamitri, Jambuo river, Dev and Surya river. The total area of this Sub-Catchment is 3423 sqkm.

Fig 2.4.1: Sub catchment area of Dhadhar Basin as per water shed Atlas of India**.**



Source: Watershed Atlas of India, Published by Department of Agriculture and Cooperation, Ministry of Agriculture, Krishi Bhavan New Delhi (1990)

2.4.4 Climate

The Dhadar basin experiences seasons – summer (Mar-May), Monsoon (June-Sep) & winter (Oct-Feb). The major part of basin comprises tropical wet climate, caused mainly due to existence of the Western Ghats. Due to relatively high elevation in forest land, the area of the basin near the origin of the river experiences relatively cooler climate.

Accordingly to Koeppan's Scheme, the climate of the basin is classified as AW-Tropical Savannah as most of the peninsular plates, south of Tropic of Cancer are classified. The climatic variations are experienced in the patterns of temperature, rainfall & winds, whether of seasons and degree of wetness or dryness. These are described as follows.

2.4.4.1 Temperature

The Temperature is maximum in the month of May and Minimum in the month of December to January. The temperature profile in the basin is given in the **table -2.4.1**

Table-2.4.1: Mean monthly Temperature (^{0}C) during water year at site Pingalwada

Month	Mean Monthly Maximum Temperature (^{o}C)	Mean Monthly Minimum Temperature (^{o}C)
Jun-15	34.3	26.7
Jul-15	30.6	26.4
Aug-15	31.9	26.7
Sep-15	32.1	25.6
Oct-15	33.9	24.9
Nov-15	30.1	20.9
Dec-15	27.0	13.2
Jan-16	26.8	12.4
Feb-16	31.1	14.9
Mar-16	35.6	19.0
Apr-16	39.0	22.6
May-16	40.8	28.1
Annual mean	32.8	21.6

2.4.4.2 Rainfall

The basin receives most of the rainfall from the South West monsoon during June to October. Almost 98% of the annual rainfall of the basin is received during this period. The average annual rainfall in the Dhadar basin is 872.1 mm. The South - West monsoon sets in by the middle of June and withdraws by the first week of October. The rainfall is mainly influenced by the southwest monsoon. The effect is most pronounced in Vadodara lying on the windward side of the Western Ghats.

The rainfall at site Pingalwada in Dhadhar Basin is shown in **Table -2.4.2** and **Table-2.4.3.**

Table-2.4.2 Mean annual rainfall of Dhadhar Basin at site Pingalwada

Sl. No	Name of Site	Data available (No of Years)	Average Annual Rainfall (mm)	Average no of rainy days	Rainfall in the year 2015-16	No of rainy days in 2015-16
1	Pingalwada	25	872.1	43	470.0	31

Table-2.4.3 Seasonal Rainfall during Water Year 2015 at site Pingalwada

Sl No	Name of Site	Seasonal Rainfall (mm) in 2015				Total Annual Rainfall
		Winter monsoon (Jan-Feb)	Pre monsoon (Mar-May)	South-West monsoon (June-Sept)	Post monsoon (Oct-Dec)	
1	Pingalwada	0.0	9.0	470.0	0.0	479.0

2.4.4.3 Wind

The wind speed data of the Dhadhar basin is given in table -2.4.4. The monthly average wind speed in the Dhadhar basin varies about 1.7 km/h and 6.8 km/h. in the pre and post monsoon period. During monsoon the monthly average wind speed is generally higher than 4.2 km/h.

In general, wind speed is the lowest in post monsoon period (Oct-Nov) & the highest in June. The pre dominant wind direction is NE/SE. The wind direction remains uniform from post monsoon till early winter i.e. Oct – Feb. Change of direction takes place in March/April. It is observed at site that the dominant wind direction is from North east and east respectively during post monsoon and in winter changes to Westerly and South westerly.

Table-2.4.4: Wind Speed at site Pingalwada in Dhadhar basin during Water Year 2015-16

Month	Mean monthly wind Speed (km/h)
June	1.7
July	2.2
August	1.4
September	1.0
October	0.2
November	0.2
December	0.3
January	0.3
February	0.4
March	0.4
April	0.6
May	1.6
Annual Mean	0.9

2.4.4.4 Humidity

The relative Humidity in Dhadhar basin varies between 90.1 % to 66.8 % depending upon the season. Humidity is maximum in the monsoon period and is around 90.1 to 73.8 %. In the winter months of November and December, it decreases. Relative humidity at station Pingalwada in Dhadhar Basin is given in table -2.4.5.

Table-2.4.5: Mean monthly Relative Humidity at site Pingalwada in Dhadhar Basin during Water Year 2015-16

Month	Relative Humidity (%)
June	83.7
July	82.3
August	83.4
September	81.3
October	81.2
November	77.7
December	76.4
January	78.7
February	77.9
March	77.5
April	76.2
May	77.1
Annual Mean	79.5

2.4.5 Geology

The Late Pleistocene fluvial succession is exposed as 18–20 m high incised vertical cliffs all along the Dhadhar River basin in western India. The major fluvial sedimentary facies of the Late Pleistocene deposits in the Dhadhar River basin have preserved evidence of palaeo-drainage and could provide an important link between the sub-humid Narmada basin in the south and the semi-arid Mahi basin in the north. The sedimentary facies documented include overbank fines, which are associated with crevasse splays. Fine grained overbank sediments are interpreted as having formed by sheet flow of sediments over the banks of minor distributary channels during the flood stage. The overlying thinly stratified fluvial sands and silts, at the top of the exposed sediment succession show a thin cap of aeolian sediments suggesting less intense aeolian activity than that observed in Sabarmati, Mahi and Orsang basins, though a significant reduction in fluvial activity is suggested during the arid phase of the LGM.

However, the river may still have been perennial assuming that it retained the larger part of the catchment.

2.4.6 Major/Medium/Multipurpose/Irrigation projects

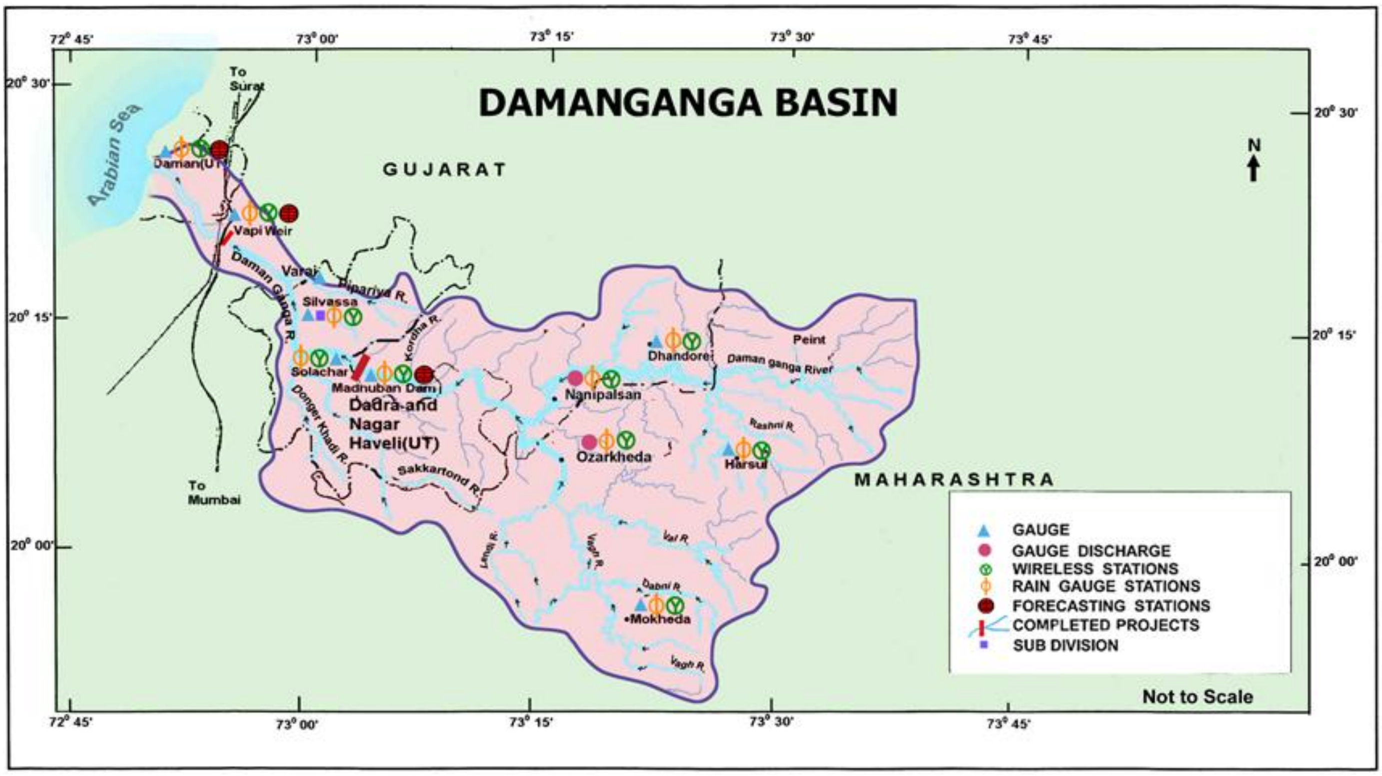
Ajwa tank, Pratap pura, Uma Bhariara, Dhanora, Ghansarva, Haripura, Vadodara, Deo Dam are the medium existing/ongoing projects in the basin.

2.5 Damanganga Basin

2.5.1 Geographical setting of Damanganga Basin

The Damanganga river rises in the Sahyadri hill ranges near village Ambegaon in Dindori taluka of Nasik district of Maharashtra State at an elevation of 950 m above MSL and traverses a total distance of about 131.30 km before it drains into the Arabian Sea at Daman. Damanganga along with its tributaries mainly flows through the hilly areas of Maharashtra, Gujarat and Union Territory Dadra and Nagar Haveli and Daman. Basin map is shown in **Plate-2.5.1**. It drains total area of 2318 sq km in Maharashtra State, Gujarat State and the Union Territories of Dadra, Nagar Haveli (DNH) and Daman & Diu before it drains into the Arabian Sea. The Damanganga River flows through Maharashtra State, Gujarat State and U.Ts. of DNH and Daman & Diu, while Vagh river up to Khargihill dam entirely lies in Maharashtra State.

Plate-2.5.1



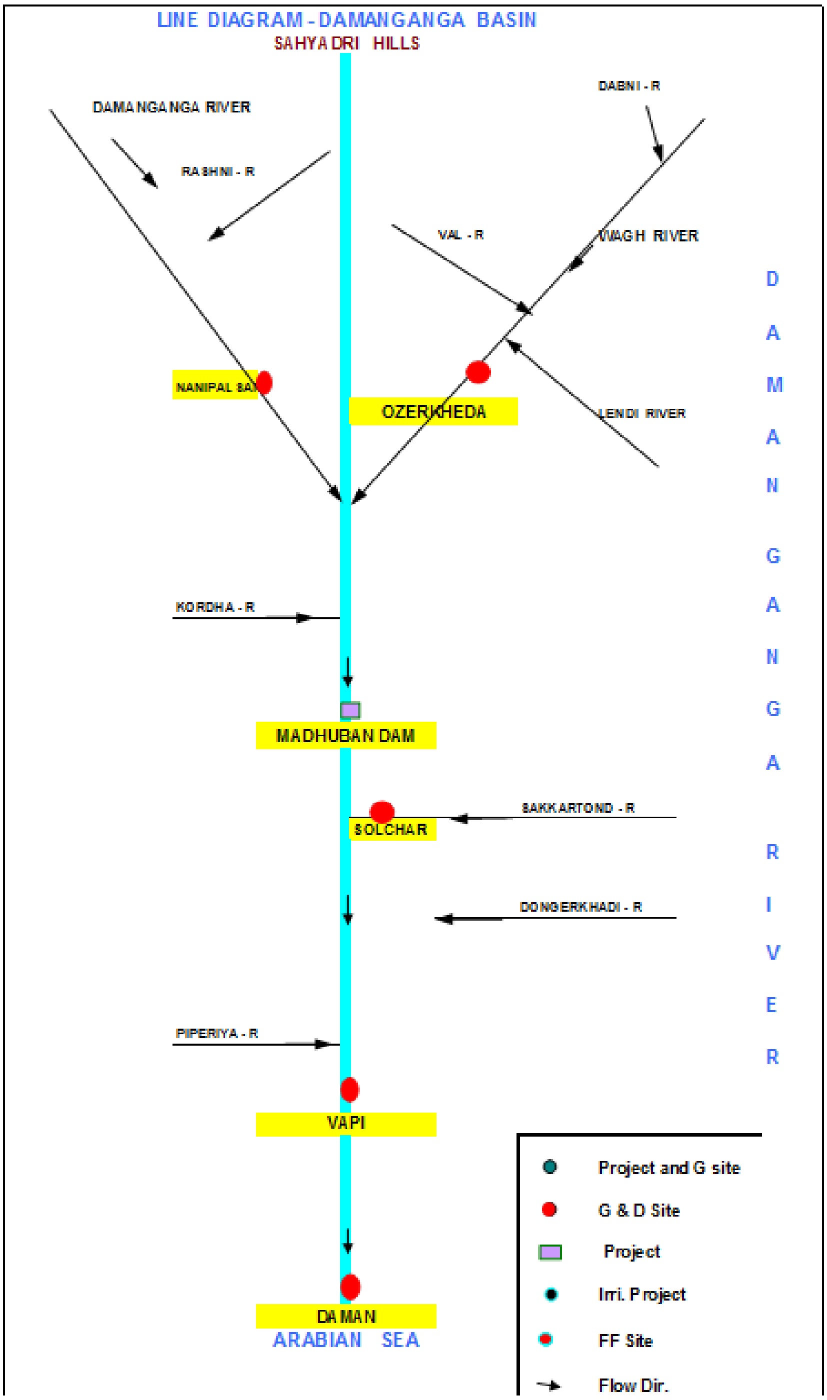
2.5.2 River System

The catchment of the river is fan shaped and the river is prone to severe flashy floods The important tributaries of the Damanganga river are Dawan, Shrimant, Val, Rayte, Lendi, Vagh, Sakartond, Dongarkhadi, Roshni and Dudhni. The Damanganga river drains total 2318 sq km. Drainage area of Damanganga River basin is shown in **Table-2.5.1** and line diagram of Damanganga river system is shown in **Plate-2.5.2**.

Table -2.5.1: State wise Distribution of drainage area of Damanganga River

Sl. No	Name of District / State	Catchment area (Sq km)	% of total catchment area
1	Nasik / Maharashtra	1408	60.74
2	Valsad / Gujarat	495	21.36
3	Dadara & Nagar Havali & Daman U.T.	415	17.90
	Total	2318	100.00

Plate-2.5.2



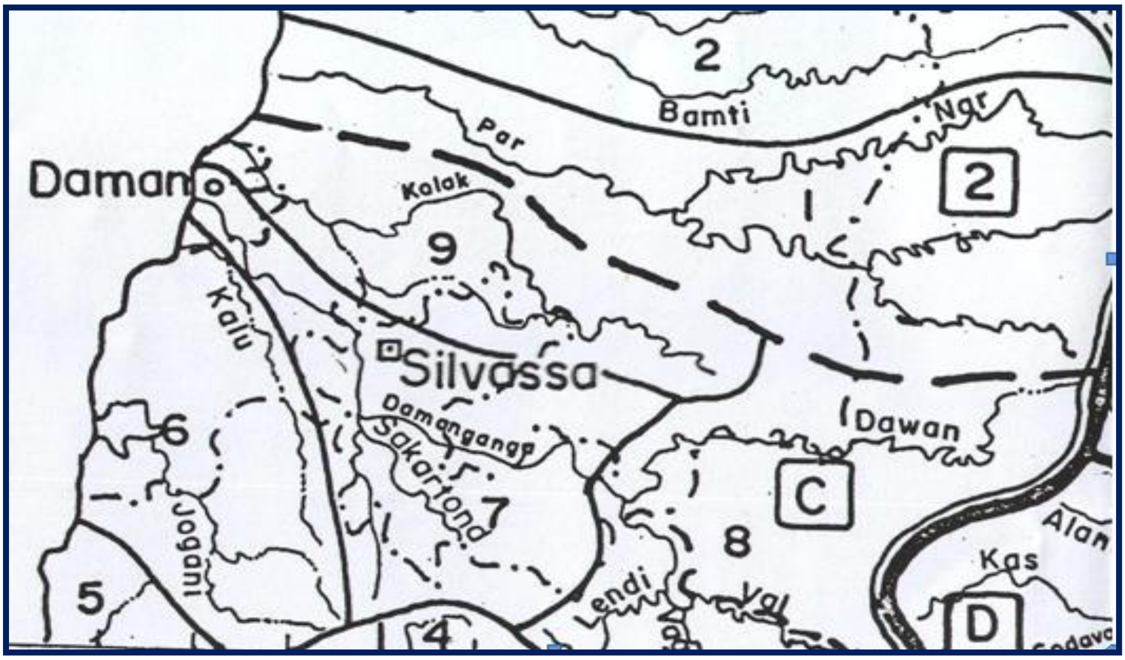
2.5.3 Damanganga Basin as per Watershed Atlas of India

As per Watershed Atlas of India, Published by Department of Agriculture and Cooperation, Ministry of agriculture, Krishi Bhavan New Delhi (1990), the sub catchments from 5B2C pertain to Damanganga Basin. Shown in **Fig-2.5.1**.

2.5.3.1 Sub catchment -5B2C (5B2C7 & 5B2C8)

This Sub Catchment is situated in the plain and hilly region of Gujarat, Maharashtra and Union territory (DNH) drained by Lendi, Sakkartond, Rashni, Val, Vagh, Donger Khadi, Pipariya, and Varai. The total area of this Sub-Catchment is 2318 sq km.

Fig-2.5.1: Sub-catchment area of Damanganga Basin as per watershed Atlas of India.



Source: Watershed Atlas of India, Published by Department of Agriculture and Cooperation, Ministry of agriculture, Krishi Bhavan New Delhi (1990)

2.5.4 The Climate

The entire Damanganga Basin lies in the Western Ghats region. It is bound on the west by Arabian Sea and on the east by Sahyadri ranges. The climate of the basin is characterised by a hot summer, which is generally dry except the southwest monsoon during June to September.

Accordingly to Koeppan’s Scheme, the climate of the basin is classified as AW-Tropical Savannah as most of the peninsular plateau, south of Tropic of Cancer, is classified. The climatic variations are experienced in the patterns of temperature, rainfall & winds, whether of seasons and degree of wetness or dryness. These are described as follows

2.5.4.1 Temperature

The Temperature is maximum in the month of May and Minimum in the month of December to January. The temperature profile in the basin is given in the Table-2.5.2

Table-2.5.2; Mean monthly Temperature (^{0}C) during water year at site Nanipalsan & Ozerkheda in Damanganga Basin

Name of Site	Nanipalsan		Ozerkheda	
Month	Mean Monthly Maximum Temperature (^{o}C)	Mean Monthly Minimum Temperature (^{o}C)	Mean Monthly Maximum Temperature (^{o}C)	Mean Monthly Minimum Temperature (^{o}C)
Jun-15	32.3	24.7	33.9	27.0
Jul-15	30.6	24.8	32.0	22.7
Aug-15	29.7	24.2	27.8	21.6
Sep-15	30.5	22.4	28.8	21.0
Oct-15	35.1	22.3	31.7	20.4
Nov-15	34.2	19.5	32.4	19.9
Dec-15	32.9	13.9	30.1	13.5
Jan-16	32.6	11.9	30.5	11.4
Feb-16	34.2	14.0	32.1	13.1
Mar-16	37.7	18.1	35.2	18.0
Apr-16	39.2	21.2	37.5	20.4
May-16	38.9	24.9	37.3	24.4
Annual mean	34.0	20.2	32.4	19.5

2.5.4.2 Rainfall

The basin receives most of the rainfall from the South West monsoon during June to October. Almost 98% of the annual rainfall of the basin is received during this period. The rainfall at site in Damanganga Basin as shown in Table **-2.5.3**. & table **2.5.4**

Table -2.5.3: Mean annual rainfall of Damanganga Basin

Sl. No	Name of Site	Data available (No of Years)	Average Rainfall (mm)	Average no of rainy days	Rainfall in the year 2015-16	No of rainy days in 2015-16
1	Ozerkheda	30	2070.1	90	1337.8	85
2	Nanipalsan	30	2135.6	91	1380.4	81

Table-2.5.4: Seasonal Rainfall during Water Year 2015 at site Nanipalsan & Ozerkheda in Damanganga Basin

Sl No	Name of Site	Seasonal Rainfall (mm) in 2015				Total Annual Rainfall
		Winter monsoon (Jan-Feb)	Pre monsoon (Mar-May)	South-West monsoon (June-Sept)	Post monsoon (Oct-Dec)	
1	Nanipalsan	0.0	85.8	1328.4	51.0	1465.2
2	Ozerkheda	0.0	74.4	1282.6	54.0	1411.0

2.5.4.3 Wind

The wind speed data of the Damanganga basin at two sites viz Ozerkheda and Nanipalsan are given in **Table -2.5.5**. The average wind speed in the Damanganga basin varies about 0.7 km/h to 4.3 km/h. in the pre and post monsoon period.

Table -2.5.5: Wind Speed at site Ozerkheda & Nanipalsan in Damanganga basin basin during Water Year 2015-16

Month	Mean monthly wind Speed (km/h)	
	Ozerkheda	Nanipalsan
June	2.4	3.1
July	2.8	3.3
August	1.0	1.7
September	0.9	1.5
October	0.5	1.1
November	0.7	1.2
December	0.9	1.4
January	1.2	1.5
February	1.8	2.2
March	2.5	2.9
April	2.3	3.5
May	3.3	4.5
Annual Mean	1.7	2.3

2.5.4.4 Humidity

The relative Humidity in Damanganga basin varies between 65.5 % and 91.9 %, depending upon the season. Humidity reaches maximum value during the monsoon period in the range of about 91.9 to 81.8 %. In the winter months of November and

December, it decreases. Relative humidity at Ozerkheda and Nanipalsan stations of CWC in Damanganga Basin is given in **Table-2.5.6**.

Table-2.5.6: Mean monthly Relative Humidity at site Ozerkheda & Nanipalsan in Damanganga Basin during Water Year 2015-16

Month	Relative Humidity (%)	
Name of Site	Ozerkheda	Nanipalsan
June	87.1	89.9
July	88.6	91.8
August	91.8	91.9
September	91.4	91.6
October	90.5	91.0
November	80.4	90.1
December	76.9	88.5
January	80.1	87.3
February	75.1	88.5
March	70.5	85.9
April	74.9	86.0
May	78.7	84.1
Annual Mean	82.2	88.9

2.5.5 Geology

The Great Trap region of the Deccan covers substantial part of the Basin. It is entirely of volcanic formation. The volcanic portion consists of compact, stratified basalts, and an earthy trap. The basalts are the most conspicuous geological feature. To the west they lie in flat-topped ranges, separated by valleys, trending from west to east. In some flows the basalt is columnar and then it weathers into the fantastic shapes. The formation at the base of the traps is chiefly amygdaloidal, containing quartz in vertical veins, crystals and zeolitic minerals, especially apophyllite weathering into a gray soil. The absence of laterite, which caps the summits of the hills to the south, is a curious feature in the geology of the area. The basalt is either fine textured or it is coarse and nodular.

2.5.6 Soil

Soils found in Damanganga basin can broadly be divided in three groups:

1) Red coarse soil
2) Coastal Alluvial soil
3) Black soil

The red soil is less common and is suitable for cultivation under a heavy and consistent rainfall. Red coarse soil is derived from disintegration of basaltic rock fragments under heavy rainfall. It is shallow in depth, coarse sandy loam to sandy loam in texture, rapidly drained and low in fertility. The alluvium is deep to very deep yellowish brown to grayish brown in colour and clay loam to salty loam in texture. This soil is normally free from salinity and alkalinity. The black soil is very fertile for cereals and pulses. The black soil contains high alumina and carbonates of calcium and magnesium with variable amounts of potash, low nitrogen and phosphorus.

2.5.7 Major / Medium/multipurpose/irrigation projects

The important project of this basin is Damanganga project. The salient features of the important components of Madhuban dam of Damanganga projects are as follows.

2.5.7.1 Madhuban Dam

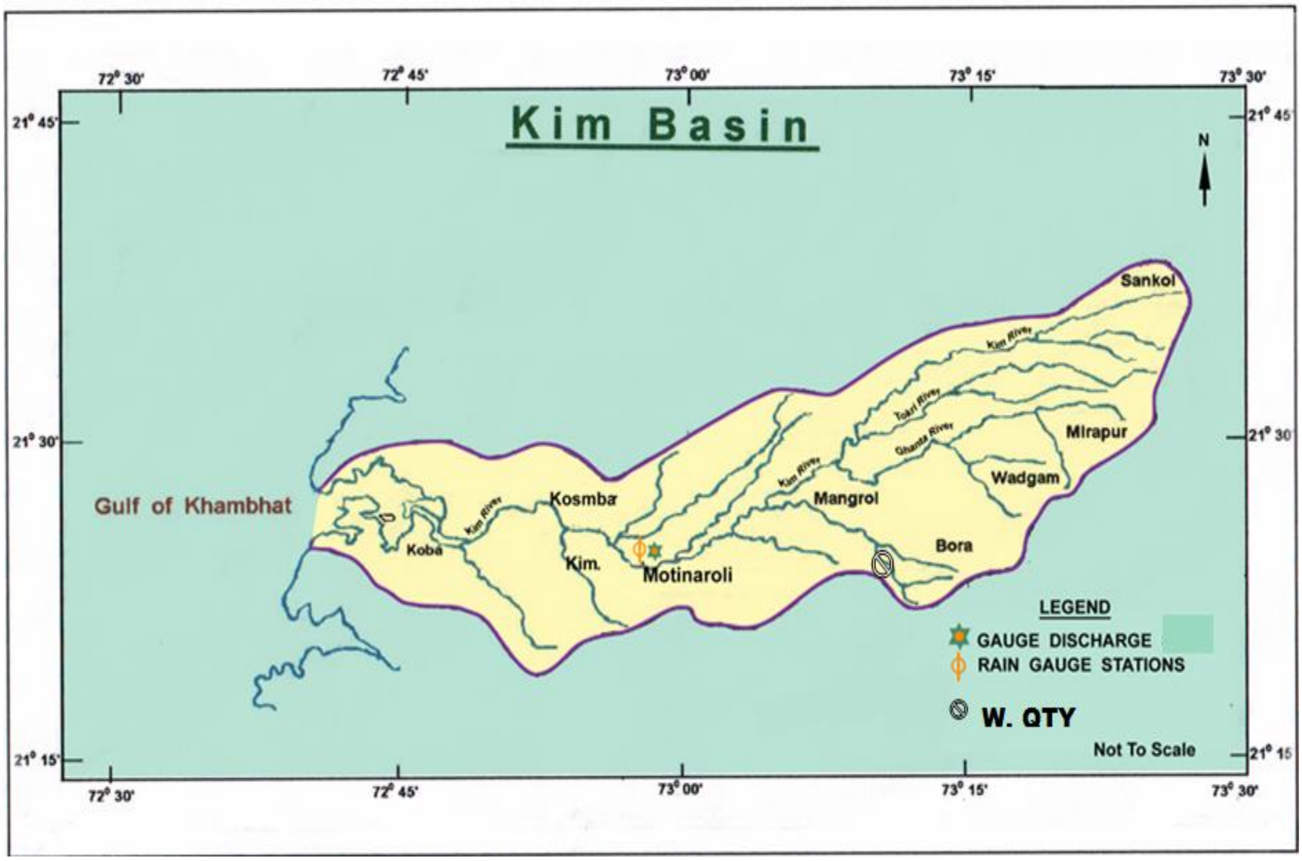
This is a composite dam constructed across the river Damanganga near village Madhuban of Dharampur Taluka, Valsad district of Gujarat state. The main purpose of the project is irrigation, other being water supply for domestic and industrial use and for generation of 2.0 MW of power. The project has a network of canal system on either bank of the river to provide irrigation to an area of 56630-ha of land. The dam has height of 50 m above the deepest foundation to store 567 Mm^3 of water.

2.6 Kim Basin

2.6.1 Geographical setting of Kim Basin

Kim River is one of the west flowing rivers in Gujarat state. It originates from Saputara Hill ranges in Bharuch district and falls in Gulf of Khambhat near village Kantiajal of Hansot taluka of Bharuch district after flowing south west direction for a length of 107 km. The river Kim, for the first 80 km of its course passes through Rajpipala and Valia talukas. For the remaining part, the river flows in a western direction between Ankleshwar and Olpad taluka of Surat District. Basin map is shown in **Plate -2.6.1**.

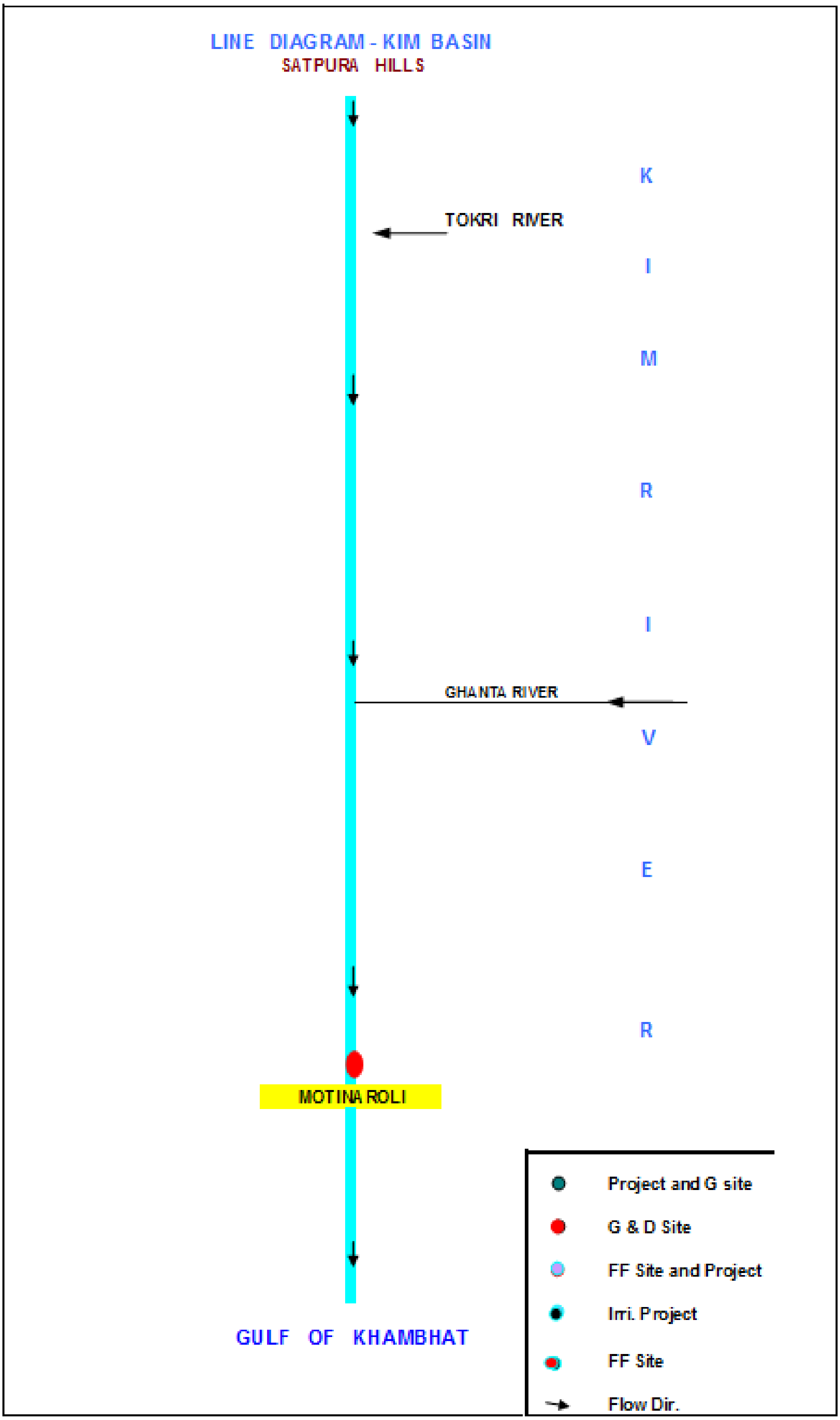
Plate -2.6.1



2.6.2 River System

The main tributaries of Kim river are Ghanta river and Tokri river. The river basin extends over an area of 1286 sq km of which the catchment area up to the site is 804 sq km. The river basin lies between21° 19' to 21° 38' North latitude and 72° 40' to 73° 27' East longitude. A line diagram of Kim basin is shown in **Plate -2.6.2**.

Plate -2.6.2



LINE DIAGRAM - KIM BASIN
SATPURA HILLS
TOKRI RIVER
GHANTA RIVER
K I M R I V E R
MOTINAROLI
GULF OF KHAMBHAT
Project and G site
G & D Site
FF Site and Project
Irri. Project
FF Site
Flow Dir.

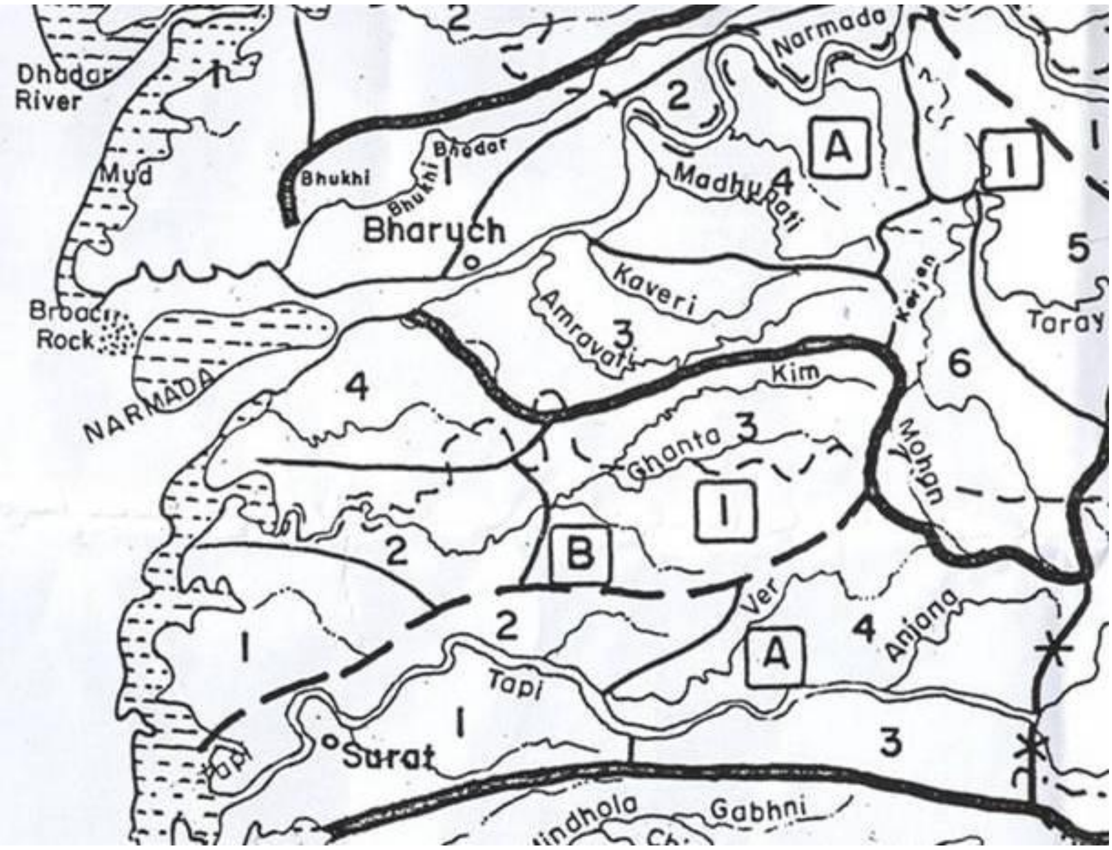
2.6.3 Kim Basin as per Water Shed Atlas of India

As per Watershed Atlas of India, Published by Department of Agriculture and Cooperation, Ministry of agriculture, Krishi Bhavan New Delhi (1990), the sub catchments from 5C1B pertain to Kim Basin as shown in **Fig.-2.6.1**.

2.6.3.1 Subcatchment -5C1B (5C1B2 & 5C1B3)

This Sub Catchment is situated in the plain region of Gujarat, drained by Ghanta and Tokri River. The total area of this Sub-Catchment is 1286 Sqkm.

Fig.-2.6.1: Kim Basin as per water shed Atlas of India**.**



Source: Watershed Atlas of India, Published by Department of Agriculture and Cooperation, Ministry of agriculture, Krishi Bhavan New Delhi (1990)

2.6.4 The Climate

Most of the Kim Basin lies in coastal plains near the sea, where the climate is moderate and humid. The month of May is the hottest and January is the generally coldest month of the Basin.

Accordingly to Kocppan’s Scheme, the climate of the basin is classified as AW-Tropical Savannah, as most of the peninsular plateau, south of Tropic of Cancer, is classified. The climatic variations are experienced in the patterns of temperature, rainfall & winds, rhythm of seasons and degree of wetness or dryness. These are described as follows

2.6.4.1 Temperature

Temperature is maximum in the month of May and Minimum in the month of December to January. The temperature profile in the basin is given in the **Table-2.6.1**.

Table-2.6.1: Mean monthly Temperature (^{0}C) during water year at site Kim at Motinaroli

Month	Mean Monthly Maximum Temperature	Mean Monthly Minimum Temperature
Jun-15	32.1	27.1
Jul-15	30.0	27.5
Aug-15	30.2	26.9
Sep-15	31.1	26.7
Oct-15	34.9	24.8
Nov-15	33.5	20.5
Dec-15	31.2	14.1
Jan-16	31.5	13.6
Feb-16	31.8	15.9
Mar-16	36.3	21.4
Apr-16	37.7	23.8
May-16	37.6	28.1
Annual mean	33.2	22.5

2.3.4.2 Rainfall

The basin receives most of the rainfall from the South West monsoon during June to October. Almost 98% of the annual rainfall of the basin is received during this period. The rainfall at site in Kim Basin shown in **Table-2.6.2** & **Table-2.6.3**.

Table-2.6.2: Mean annual rainfall of site Kim at Motinaroli

Sl. No	Name of Site	Data available (No of Years)	Average Annual Rainfall (mm)	Average no of rainy days	Rainfall in the year 2015-16	No of rainy days in 2015-16
1	Motinaroli	24	1248.4	54	1289.0	47

Table-2.6.3: Seasonal Rainfall during Water Year 2015 at site Motinaroli

Sl No	Name of Site	Seasonal Rainfall (mm) in 2015				Total Annual Rainfall
		Winter monsoon (Jan-Feb)	Pre monsoon (Mar-May)	South-West monsoon (June-Sept)	Post monsoon (Oct-Dec)	
1	Motinaroli	0.0	37.4	1281.0	0.0	1318.4

2.6.4.3 Wind

The wind speed data of the Kim basin is given in Table-2.6.4. The average wind speed in the Kim basin varies about 0.3 km/h to 7.9 km/h. The pre dominant wind direction is NE

Table-2.6.4:Wind Speed at site Motinaroli in Kim basin during Water Year 2015-16

Month	Mean monthly wind Speed (km/h)
June	1.6
July	4.6
August	3.0
September	1.9
October	0.5
November	0.3
December	0.4
January	0.2
February	0.1
March	0.0
April	4.3
May	4.5
Annual Mean	1.8

2.6.4.4 Humidity

The relative Humidity in Kim basin varies between 97.1% to 78.7% depending upon the season. It is maximum in the monsoon period and is about 78.7 % to 97.1 %. In the winter months of November and December, relative humidity comes down. Relative humidity at station Motinaroli of CWC in the Kim Basin is given in Table-2.6.5.

Table-2.6.5: Mean monthly Relative Humidity at site Motinaroli in Kim Basin during Water Year 2015-16

Month	Relative Humidity (%)
June	81.3
July	83.2
August	87.7
September	87.5
October	83.9
November	80.4
December	80.0
January	82.5
February	85.6
March	84.5
April	82.4
May	84.1
Annual Mean	83.6

2.6.5 Soil

The soil found in Kim basin can be broadly classified into three groups i.e.Lateritic soils, deep black soils and coastal alluvial soils.

2.6.6 Major / Medium/multipurpose/irrigation projects

The major and medium projects completed / ongoing on Kim river basin are as shown in Table-2.6.6.

Table-2.6.6: Major and medium projects completed / ongoing in Kim basin

Sl.No.	Name of the project	River	Status	Capacity in Mm^3		Utilisation
				Gross	Live	Irrigation
1	Baldeva Irrigation Scheme	Tokri	Medium	8.15	7.84	Domestic
2	Pigut Irrigation S Scheme	Tokri	Medium	7.52	7.27	-do-

Hydrological observations by State government

Source of information

Apart from the sites maintained by central water commission the state government of Gujarat, Madhya Pradesh, Rajasthan and Maharashtra are also conducting gauge and discharge observations in among 14 Basins. The Basin wise list of sites and the authority maintaining the sites are listed in the following para.

Basin wise list of sites

1	Purna Basin	1 Purna 2 Purna 3 Purna 4 Zankhari 5 Zankhari 6 Zankhari	At Wankla At Navsari At Kalibel At Malotha At Ghat At ZanKhari	Sup. Engineer, WRI Circle LD Engg. College campus, near Gujarat university, Ahmedabad & Executive engineer WRI Divn., Bhadra fort, Laldarwaja, Ahmedabad
2	Ambica Basin	1 Ambica 2 Ambica 3 Khapri 4 Kharera 5 Kharera 6 Kaveri 7 Valam 8 Valam	At Unai At Bilimora At Kundkas At Kavdej At Lalia Dam At Vansda At Wankla At Dholka	Sup. Engineer, WRI Circle LD Engg. College campus, near Gujarat university, Ahmedabad & Executive engineer WRI Divn., Bhadra fort, Laldarwaja, Ahmedabad
3	Vaitarna Basin No state govt. Sites in this Basin			
4	Dhadhar Basin	1 Dhadhar 2 Dhadhar 3 Dhadhar 4 Deo 5 Deo 6 Vishwamitri 7 Vishwamitri 8 Surya	At Bhilapur At Por At Pingalwada At Vejalpur At Shivrajpur At Pilol At Harni At Bhaniyara	Sup. Engineer, WRI Circle LD Eengg. College campus, near Gujarat university, Ahmedabad & Executive engineer WRI Divn., Bhadra fort, Laldarwaja, Ahmedabad
5	Damanganga Basin	1 Damanganga 2 Sakertond	At Vapi Bridge At Khanvel	Water resources investigation Sub Division, Navsari
6	Kim Basin	1 Kim	At Vellachha	Water resources investigation Sub Division, Navsari

3.0 Methodology: Stream flow measurement

3.1 Gauge measurement

Water level or stage of the River is measured as its elevation above the g t s datum. Water level measurement was conducted by reading non-recording gauges. A series of vertical staff gauges as per the specifications laid down in is 4080-1977 have been fixed at three sections at each site i.e. Upstream, station gauge and downstream. The gauge posts are of RCC/wooden/ metallic with cut and edge waters and are fixed securely in position by installing them in m-150 concrete blocks of suitable size. Enameled gauge plate with marking in metric unit is fixed on the gauge posts with least count 0.005 m. Out of the three gauge lines the central line is used as station gauge line and readings of the other two lines are used for calculating the surface slope. The gauges were read hourly during Monsoon season and three hourly i.e. 0800, 1300 and 1800 Hrs during non Monsoon season at station gauge line.

3.2 Discharge observation

Discharge observation is conducted once a day at 0800 Hrs, at all the sites by area velocity method except on Sunday and holidays in non Monsoon period. However additional observations were conducted during floods to cover different stages, irrespective of holidays. The River width is generally divided into 15 to 25 segments based on the degree of accuracy as outlined in is: 1192-1981. The width of the River is measured by steel/metallic tape or wire rope stretched across the River with segment markings indicated thereon, when the River width is quite small and the flow depths permit wading. For larger width and deeper flow conditions and in unmanageable flood conditions segment points vertically are located by measuring the navigation craft with reference to pivot point and segment blocks constructed at sites.the depth measurement is carried out by using sounding rod for depths up to 3 meter and by using long bamboos for depths between 3 meter and 6 meter. For depths exceeding 6 meter sounding reel measurements at segment points are resorted to, and in Some cases, the depths are measured by echo sounder or are computed from the most recent x-sections of the River. The velocity is measured as per is 3918 - 1976 by using a cup type current meter conforming to is 3910 - 1976. The current meter is lowered to the requisite depth i.e. 0.6 of total depth down the vertical at every segment point by suspension equipment as specified in is 6064 - 1981 and where the depth is less than 0.3 meters, the velocity is observed just below the water surface. In medium and high stages with significant flow velocities, boats fitted with power engines are used. Measurements of velocity are sometimes carried out from the bridges when the River flow condition does not permit the boat to be kept stable for velocity observation. When none of the above procedures are possible, the velocity is measured by float observations.

The data observed as above at the site is entered in the prescribed standard format to compute the total River discharge and it is further scrutinised at various levels before finalisation.

The daily observed/estimated discharge data is presented in this book.

Table-3.1.1 : Equipment used for observation

Sl. No	**Name of equipment**	**By wading**	**By boat**	**Bridge**	**By float**
1	Current meter	√	√	√	X
2	Pigmy current meter	√	X	X	X
3	Stop watch	√	√	√	√
4	Wading rod	√	X	X	X
5	Nylon rope & tag	√	X	X	X
6	Measuring tape	√	X	X	X
7	Protractor	√	√	√	X
8	Ranging rod	√	√	X	√
9	Sounding rod	√	√	X	X
10	Automatic battery counter	√	√	√	X
11	Thermometer	√	√	√	√
12	Prismatic compass	X	X	X	√
13	Balloon	X	X	X	√
14	Sounding cable with fish weight	X	√	X	X
15	Echo sounder	X	√	√	X
16	Bridge out fit	X	X	√	X
17	Boat out fit	X	√	X	X

3.3 Explanatory notes

Explanatory notes given here have been designed to assist in the data interpretation of hydrological parameters contained in the data presented. The notes are therefore, applicable in so far as the data presented in this book.

1. Water Year covers the period from June 1st of one calendar year to may 31st of next calendar year and includes one complete hydrological cycle.

2. Discharge is given in cubic meters per second.

3. Discharges given are daily observed / estimated discharges.

4. The zero of gauge is a datum level / RL Fixed for a given site, which is kept 1 or 2 m lower than the lowest water level recorded in a perennial stream. In a non - perennial stream, it is kept 1 or 2 m lower than the lowest bed level of the stream.

5. Maximum and minimum discharges are taken from the daily observed flows / estimated.

6. Runoff in "mm" is the notional depth of water in millimeters over the catchment area equivalent to annual runoff calculated at the discharge measurement station.

$$\textbf{Runoff (mm)} = \frac{\textbf{Annual runoff (Mm3)}}{\textbf{Catchment area (km}^2\textbf{)}} \times 1000$$

7. Peak and lowest flows correspond to the highest and lowest water levels recorded during the period of record.

8. Measuring authority refers to the field division responsible for the operation of the gauge station. The name of the division is abbreviated by taking first alphabet of the River name followed by alphabets "DN" for division. For example Mahi division is denoted by MDN and Tapi division is denoted as TDN. These abbreviations are given cross-reference in the list of abbreviations and symbols.

9. Gauging station code number is a unique nine-digit reference number, which facilitates retrieval of flow data in data bank. The first two digits denote the

measuring authority. The third and fourth digits are the Basin/zone identifier and fifth and sixth digits are the independent River Basin identifier. The last three digits of the code number indicate gauging site no. which is given from origin to mouth.

11. The month and the year from which data are available in the data bank are indicated against the record available.

3.4 Method of presentation

The data presented in this book is processed discharge data obtained from application of SWDES/HYMOS software.

The station wise hydrological data is presented comprising history sheet, daily flow table and pictorial summary. The sequence of hydrological station arranged from its outfall to origin giving inter-priority to an intermediate tributary station.

4.0 Hydrological data

The hydrological data presented hereby mainly consist of the following

History sheet

Its manly consist of some salient features of particular site as Site name, state, district, River Basin, tributary, catchment area, latitude / longitude, opening / closing date for various types of data& maximum –minimum discharge values.

Data sheet

It consists of stage- discharge data (both observed & estimated from stage discharge curve for the season), for the current year with mean water level during the discharge observation and peak observed and computed discharge with corresponding water level with date during the year, Lowest discharge with corresponding water level with date during the year, Peak discharge with corresponding water level with date since inception, Lowest discharge with corresponding water level with date since inception.

Stage discharge curve

It gives a relationship between the stage of the river and the corresponding discharge.

Annual run-off

It gives the value of Annual run off in MCM for all the years from the opening of the site.

Water level v/s time graph

Hourly observed water level for one to three important highest peak flood events of current Water Year covering the period well before the start and upto well beyond the completion of these flood events.

Charts / Maps

Basin map showing sites / projects

The site-wise pre – Monsoon and post – Monsoon cross sections

The site-wise pie chart

Site-wise bar charts

The site-wise hydrographs (flood events)

Chapter-4: Hydrological data

4.1 Purna Basin

4.1.1 History sheet

HISTORY SHEET

			Water Year	**:**	**2015-16**
Site	**:**	**Purna at Mahuwa**	**Code**	**:**	**01 02 19 001**
State	:	Gujarat	District		Surat
Basin	:	WFR South of Tapi	Independent River	:	Purna
Tributary	:		Sub Tributary	:	
Sub-Sub Tributary	:		Local River	:	
Division	:	Tapi Division, Surat	Sub-Division	:	LTSD,CWC,Surat
Drainage Area	:	1995 Sq. Km.	Bank	:	Right
Latitude	:	21°00'52"	Longitude	:	73°08'25"
Zero of Gauge (m)	:	9 (m.s.l)	04/10/1970		
		Opening Date	Closing Date		
Gauge	:	04/10/1970			
Discharge	:	12/11/1970			
Sediment	:	18/06/1973			
Water Quality	:	15/06/1977			

Annual Maximum / Minimum discharge with corresponding water Level (m.s.l)

	Maximum			Minimum		
Year	Q (cumecs)	WL (m)	Date	Q (cumecs)	WL (m)	Date
1971-1972	682.3	13.655	13/08/1971	0.099	10.055	30/04/1972
1972-1973	454.6	12.800	19/08/1972	0.020	9.895	31/05/1973
1973-1974	1550	13.914	25/09/1973	0.026	9.930	09/06/1973
1974-1975	183.0	11.225	01/10/1974	0.071	10.095	31/05/1975
1975-1976	964.3	13.730	13/08/1975	0.030	10.055	12/06/1975
1976-1977	4380	20.550	31/07/1976	0.040	10.150	02/06/1976
1977-1978	4020	19.765	03/09/1977	0.100	10.060	07/06/1977
1978-1979	1692	15.252	09/07/1978	0.200	10.110	10/06/1978
1979-1980	3378	20.100	10/08/1979	0.200	10.110	13/06/1979
1980-1981	775.0	13.667	02/08/1980	0.480	10.190	15/05/1981
1981-1982	1572	16.430	10/07/1981	0.000	10.050	01/04/1982
1982-1983	2815	20.390	25/07/1982	0.100	10.065	09/05/1983
1983-1984	1818	15.666	20/07/1983	0.100	10.010	02/06/1983
1984-1985	846.3	13.955	13/09/1984	0.500	10.310	08/06/1984
1985-1986	3255	20.560	01/08/1985	0.300	10.060	13/04/1986
1986-1987	527.2	12.775	16/08/1986	0.300	10.125	08/03/1987
1987-1988	873.7	15.260	07/07/1987	0.100	10.035	29/01/1988
1988-1989	1526	15.700	27/07/1988	0.200	9.970	18/04/1989
1989-1990	2362	17.920	25/07/1989	0.600	10.020	07/06/1989
1990-1991	1396	17.625	17/08/1990	1.420	9.870	27/03/1991
1991-1992	300.8	10.970	24/07/1991	0.600	9.850	29/05/1992
1992-1993	1386	17.100	03/09/1992	0.280	9.720	30/05/1993
1993-1994	1254	15.250	10/07/1993	0.385	9.635	13/05/1994
1994-1995	3078	20.470	16/06/1994	0.286	9.755	19/04/1995
1995-1996	404.6	11.995	25/07/1995	0.100	9.720	09/06/1995
1996-1997	781.5	13.330	09/09/1996	0.600	9.720	10/06/1996
1997-1998	2174	17.410	25/08/1997	0.430	9.370	27/05/1998
1998-1999	2359	17.720	08/07/1998	0.350	9.355	08/06/1998
1999-2000	695.6	13.030	16/07/1999	0.598	9.320	17/02/2000
2000-2001	782.8	13.250	14/07/2000	0.061	9.160	27/04/2001
2001-2002	1233	14.400	16/08/2001	0.085	9.075	30/04/2002
2002-2003	2517	17.550	25/08/2002	0.089	9.150	05/06/2002
2003-2004	2946	18.365	28/07/2003	0.071	9.075	05/06/2003
2004-2005	8836	23.490	04/08/2004	0.779	9.230	31/01/2005
2005-2006	5437	21.280	29/06/2005	0.500	9.180	16/06/2005
2006-2007	3273	19.050	05/07/2006	0.827	9.140	26/05/2007
2007-2008	3058	18.350	02/07/2007	1.116	9.160	01/06/2007
2008-2009	1853	16.360	19/09/2008	2.163	9.170	06/06/2008
2009-2010	667.2	12.900	07/09/2009	0.000	9.050	01/06/2009
2010-2011	744.5	13.330	09/09/2010	0.007	9.010	27/03/2011
2011-2012	607.5	12.750	29/08/2011	0.000	9.010	10/06/2011
2012-2013	692.4	13.030	13/08/2012	0.000	9.020	01/06/2012
2013-2014	1508	15.500	24/09/2013	0.000	9.000	As per SD Curve
2014-2015	843.3	13.630	30/07/2014	0.000	9.010	01/06/2014
2015-2016	548.0	12.400	19/09/2015	0.000	8.690	01/06/2015

4.1.2 Annual Maximum flood Peaks

Year	Annual Maximum flood Peaks (m)	Date	Hour
1970	9.780	13/10/1970	08:00:00
1971	13.655	13/08/1971	08:00:00
1972	14.805	06/07/1972	18:00:00
1973	18.215	25/09/1973	16:00:00
1974	12.035	15/07/1974	03:00:00
1975	18.680	12/08/1975	18:00:00
1976	21.200	12/07/1976	19:00:00
1977	20.550	03/09/1977	11:00:00
1978	17.700	29/08/1978	22:00:00
1979	20.210	10/08/1979	19:00:00
1980	15.330	02/08/1980	15:00:00
1981	16.440	10/07/1981	17:00:00
1982	20.710	25/07/1982	15:00:00
1983	17.130	13/08/1983	18:00:00
1984	22.550	18/07/1984	19:00:00
1985	21.050	01/08/1985	04:00:00
1986	13.120	19/07/1986	21:00:00
1987	15.680	07/07/1987	11:00:00
1988	18.185	29/07/1988	01:00:00
1989	19.890	24/07/1989	07:00:00
1990	19.500	17/08/1990	06:00:00
1991	13.670	24/07/1991	18:00:00
1992	17.810	03/09/1992	07:00:00
1993	19.400	14/07/1993	02:00:00
1994	24.800	16/06/1994	17:00:00
1995	13.660	28/07/1995	15:00:00
1996	17.500	23/07/1996	15:00:00
1997	18.000	31/07/1997	21:00:00
1998	17.840	08/07/1998	10:00:00
1999	13.500	19/07/1999	18:00:00
2000	14.640	14/07/2000	02:00:00
2001	19.300	17/06/2001	22:00:00
2002	19.500	26/06/2002	19:00:00
2003	19.880	28/07/2003	06:00:00
2004	23.900	04/08/2004	00:00:00
2005	21.280	29/06/2005	08:00:00
2006	20.300	05/07/2006	12:00:00
2007	20.500	02/07/2007	12:00:00
2008	18.800	19/09/2008	15:00:00
2009	14.740	22/07/2009	21:00:00
2010	14.400	07/08/2010	15:00:00
2011	14.140	14/08/2011	21:00:00
2012	13.800	13/08/2012	05:00:00
2013	19.700	23/09/2013	20:00:00
2014	14.200	30/07/2014	14:00:00
2015	15.800	18/09/2015	24:00:00

4.1.3 Summary of Discharge Data

Stage –Discharge data for the period 2015-16

Station Name: Purna at Mahuwa (010219001) Division : Tapi Division Surat Local River: Purna Sub -Division : LTSD, CWC, Surat

Day	Jun		Jul		Aug		Sep		Oct		Nov	
	W.L	Q	W.L	Q	W.L	Q	W.L	Q	W.L	Q	W.L	Q
1	8.690	0.000	8.850	0.000	10.020	56.58	9.100	2.028	9.300	5.029	8.930	0.000
2	8.690	0.000	8.840	0.000	9.820	32.86 *	9.100	2.063	9.240	4.240 *	8.950	0.000
3	8.690	0.000	8.830	0.000	9.700	24.02	9.100	1.988	9.220	2.871	8.960	0.000
4	8.710	0.000	8.800	0.000	9.580	11.52	9.080	1.692	9.210	3.520 *	8.970	0.000
5	8.720	0.000	8.790	0.000	9.560	10.15	9.070	1.499	9.300	4.824	8.980	0.000
6	8.710	0.000	8.780	0.000	9.540	9.772	9.040	0.000	9.260	4.157	8.980	0.000
7	8.700	0.000	8.770	0.000	9.560	10.10	9.020	0.000	9.230	2.941	8.970	0.000
8	8.700	0.000	8.780	0.000	9.540	9.828	9.000	0.000	9.200	2.343	8.970	0.000
9	8.690	0.000	8.790	0.000	9.500	13.52 *	8.980	0.000	9.180	2.230	8.970	0.000
10	8.690	0.000	8.790	0.000	9.460	8.976	8.980	0.000	9.160	2.145	8.970	0.000
11	8.690	0.000	8.780	0.000	9.390	8.234	8.980	0.000	9.140	2.120 *	8.960	0.000
12	8.670	0.000	8.810	0.000	9.350	7.125	8.980	0.000	9.120	1.546	8.960	0.000
13	8.670	0.000	8.810	0.000	9.330	6.292	8.990	0.340 *	9.100	0.000	8.950	0.000
14	8.690	0.000	8.790	0.000	9.330	6.279	9.220	3.436	9.080	0.000	8.950	0.000
15	8.710	0.000	8.790	0.000	9.320	6.500 *	9.240	3.643	9.070	0.000	8.950	0.000
16	8.780	0.000	8.760	0.000	9.320	6.500 *	9.180	2.723	9.070	0.000	8.940	0.000
17	8.780	0.000	8.750	0.000	9.310	5.902	9.160	2.480 *	9.070	0.000	8.940	0.000
18	8.780	0.000	8.740	0.000	9.280	5.218	9.140	2.773	9.060	0.000	8.940	0.000
19	8.770	0.000	8.740	0.000	9.270	4.633	12.400	548.0	9.060	0.000	8.940	0.000
20	8.740	0.000	8.790	0.000	9.230	3.573	10.640	125.3 *	9.040	0.000	8.960	0.000

21	8.740	0.000	8.790	0.000	9.220	3.461	10.160	72.69	9.020	0.000	8.960	0.000
22	8.780	0.000	8.850	0.000	9.190	2.966	10.060	63.70	9.010	0.000	8.960	0.000
23	8.980	0.000	9.200	0.000	9.170	2.670 *	9.940	52.63	9.000	0.000	8.960	0.000
24	9.060	0.000	9.300	0.000	9.160	2.798	9.700	23.94	8.990	0.000	8.970	0.000
25	9.250	0.000	10.580	137.6	9.180	2.986	9.650	21.47 *	8.980	0.000	8.970	0.000
26	8.980	0.000	11.300	247.2 *	9.190	3.079	9.580	17.52	8.980	0.000	8.970	0.000
27	8.970	0.000	10.320	92.59	9.180	2.764	9.510	13.99 *	8.970	0.000	8.970	0.000
28	8.860	0.000	12.100	454.3	9.160	2.584	9.460	9.345	8.950	0.000	8.980	0.000
29	8.790	0.000	11.870	404.0	9.130	2.675	9.410	8.346	8.940	0.000	8.970	0.000
30	8.770	0.000	10.580	133.2	9.130	1.950 *	9.340	6.600	8.930	0.000	8.970	0.000
31			10.180	73.67	9.120	2.193			8.920	0.000		
<u>Ten-Daily Mean</u>												
I Ten-Daily	8.699	0.000	8.802	0.000	9.628	18.73	9.047	0.927	9.230	3.430	8.965	0.000
II Ten-Daily	8.728	0.000	8.776	0.000	9.313	6.026	9.593	68.87	9.081	0.367	8.949	0.000
III Ten-Daily	8.918	0.000	10.279	140.2	9.166	2.739	9.681	29.02	8.972	0.000	8.968	0.000
<u>Monthly</u>												
Min.	8.670	0.000	8.740	0.000	9.120	1.950	8.980	0.000	8.920	0.000	8.930	0.000
Max.	9.250	0.000	12.100	454.3	10.020	56.58	12.400	548.0	9.300	5.029	8.980	0.000
Mean	8.782	0.000	9.318	49.76	9.363	8.958	9.440	32.94	9.090	1.225	8.961	0.000

Annual Runoff in MCM = 246 **Annual Runoff in mm = 123**

Peak Observed Discharge = 548.0 cumecs on 19-09-2015 **Corres. Water Level :12.40 m**

Lowest Observed Discharge = 0.000 cumecs on 01-06-2015 **Corres. Water Level :8.69 m**

Water Level(m.s.l) in m *:Computed Discharge #:Discarded Discharge (values changed as per rating curve)

Note: River remained in pooling/ no flow condition w.e.f. 01/06/15to 24/07/15 and from 13/10/15 to 31/05/16

Stage –Discharge data for the period 2015-16

Station Name: Purna at Mahuwa (010219001) Division: Tapi Division Surat Local River: Purna Sub -Division: LTSD, CWC, Surat

Day	Dec		Jan		Feb		Mar		Apr		May		
	W.L	Q	WL	Q	WL	Q	WL	Q	WL	Q	WL	Q	
1	8.970	0.000	8.900	0.000	8.720	0.000	8.840	0.000	8.850	0.000	8.810	0.000	
2	8.970	0.000	8.900	0.000	8.740	0.000	8.850	0.000	8.860	0.000	8.810	0.000	
3	8.970	0.000	8.900	0.000	8.740	0.000	8.850	0.000	8.860	0.000	8.810	0.000	
4	8.960	0.000	8.880	0.000	8.740	0.000	8.850	0.000	8.870	0.000	8.800	0.000	
5	8.960	0.000	8.870	0.000	8.750	0.000	8.850	0.000	8.870	0.000	8.800	0.000	
6	8.960	0.000	8.860	0.000	8.750	0.000	8.850	0.000	8.880	0.000	8.800	0.000	
7	8.960	0.000	8.850	0.000	8.750	0.000	8.850	0.000	8.880	0.000	8.820	0.000	
8	8.960	0.000	8.840	0.000	8.750	0.000	8.840	0.000	8.880	0.000	8.820	0.000	
9	8.950	0.000	8.830	0.000	8.770	0.000	8.840	0.000	8.870	0.000	8.830	0.000	
10	8.950	0.000	8.810	0.000	8.780	0.000	8.840	0.000	8.870	0.000	8.820	0.000	
11	8.950	0.000	8.800	0.000	8.790	0.000	8.840	0.000	8.870	0.000	8.830	0.000	
12	8.950	0.000	8.790	0.000	8.790	0.000	8.840	0.000	8.870	0.000	8.850	0.000	
13	8.960	0.000	8.650	0.000	8.790	0.000	8.840	0.000	8.860	0.000	8.860	0.000	
14	8.970	0.000	8.650	0.000	8.790	0.000	8.840	0.000	8.860	0.000	8.860	0.000	
15	8.970	0.000	8.650	0.000	8.790	0.000	8.830	0.000	8.850	0.000	8.870	0.000	
16	8.980	0.000	8.650	0.000	8.800	0.000	8.830	0.000	8.850	0.000	8.880	0.000	*
17	8.980	0.000	8.650	0.000	8.800	0.000	8.820	0.000	0.850	0.000	8.880	0.000	
18	8.980	0.000	8.650	0.000	8.800	0.000	8.820	0.000	8.850	0.000	8.880	0.000	
19	8.980	0.000	8.640	0.000	8.800	0.000	8.820	0.000	8.840	0.000	8.880	0.000	
20	8.980	0.000	8.630	0.000	8.800	0.000	8.820	0.000	8.840	0.000	8.890	0.000	

21	8.980	0.000	8.630	0.000	8.800	0.000	8.820	0.000	8.830	0.000	8.890	0.000
22	8.980	0.000	8.620	0.000	8.810	0.000	8.810	0.000	8.830	0.000	8.890	0.000
23	8.980	0.000	8.620	0.000	8.810	0.000	8.810	0.000	8.830	0.000	8.890	0.000
24	8.980	0.000	8.610	0.000	8.810	0.000	8.810	0.000	8.830	0.000	8.900	0.000
25	8.980	0.000	8.610	0.000	8.810	0.000	8.810	0.000	8.830	0.000	8.900	0.000
26	8.980	0.000	8.610	0.000	8.830	0.000	8.810	0.000	8.820	0.000	8.900	0.000
27	8.970	0.000	8.610	0.000	8.830	0.000	8.810	0.000	8.820	0.000	8.890	0.000
28	8.970	0.000	8.650	0.000	8.830	0.000	8.810	0.000	8.820	0.000	8.890	0.000
29	8.950	0.000	8.680	0.000	8.840	0.000	8.810	0.000	8.820	0.000	8.890	0.000
30	8.940	0.000	8.680	0.000			8.830	0.000	8.820	0.000	8.890	0.000
31	8.930	0.000	8.690	0.000			8.850	0.000			8.880	0.000
Ten-Daily Mean												
I Ten-Daily	8.961	0.000	8.864	0.000	8.749	0.000	8.846	0.000	8.869	0.000	8.812	0.000
II Ten-Daily	8.970	0.000	8.676	0.000	8.795	0.000	8.830	0.000	8.054	0.000	8.868	0.000
III Ten-Daily	8.967	0.000	8.637	0.000	8.819	0.000	8.816	0.000	8.825	0.000	8.892	0.000
Monthly												
Min.	8.930	0.000	8.610	0.000	8.720	0.000	8.810	0.000	0.850	0.000	8.800	0.000
Max.	8.980	0.000	8.900	0.000	8.840	0.000	8.850	0.000	8.880	0.000	8.900	0.000
Mean	8.966	0.000	8.723	0.000	8.787	0.000	8.830	0.000	8.583	0.000	8.858	0.000

Peak Computed Discharge = 247.2 cumecs on 26-07-2015 **Corres. Water Level :11.30 m**

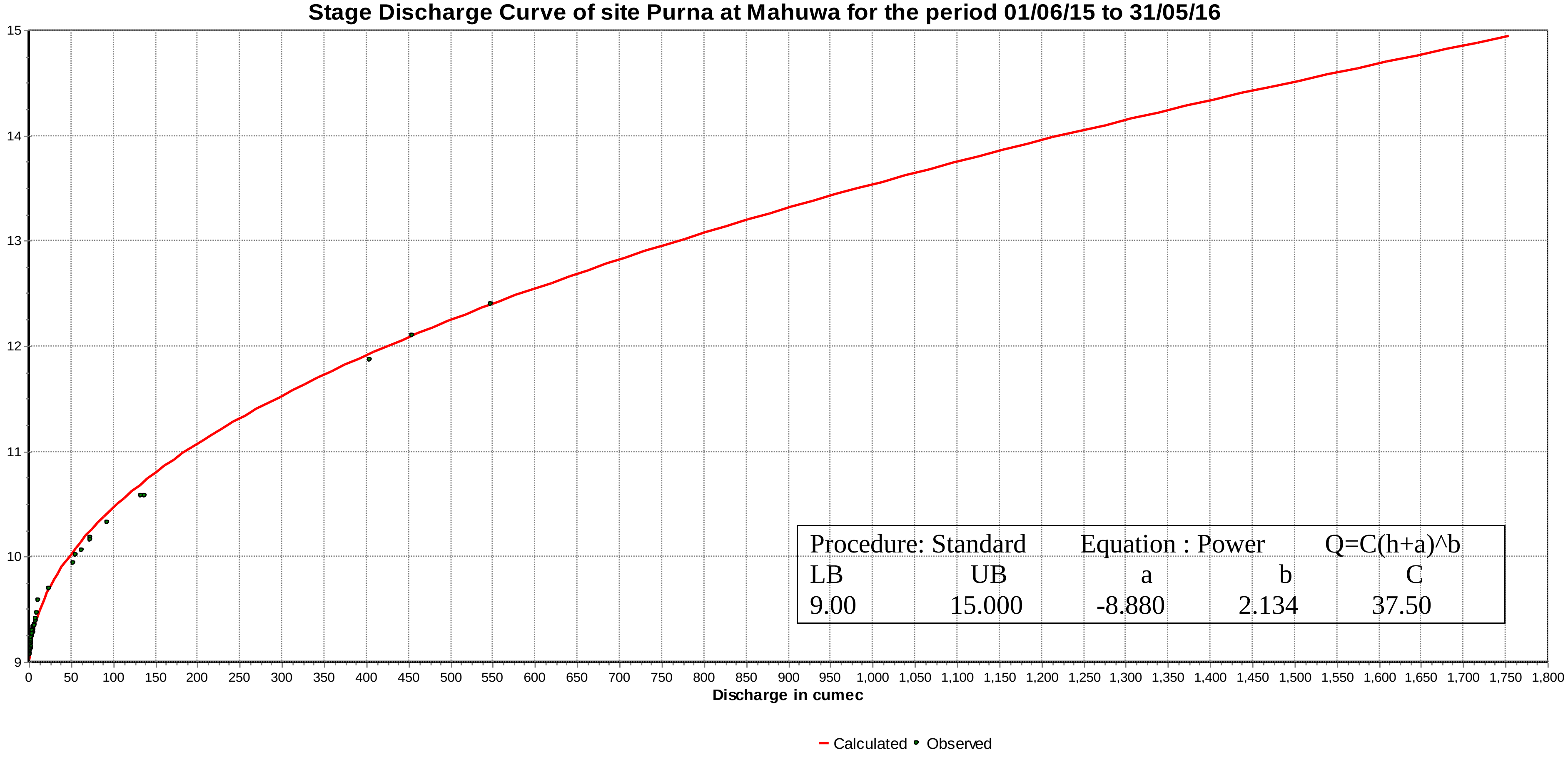
Lowest Computed Discharge = 0.000 cumecs on 16-05-2016 **Corres. Water Level : 8.88 m**

Water Level(m.s.l) in m *:Computed Discharge #:Discarded Discharge (values changed as per rating curve)

Note: River remained in pooling/ no flow condition w.e.f. 01/06/15to 24/07/15 and from 13/10/15 to 31/05/16

4.1.4 Stage Discharge Curve

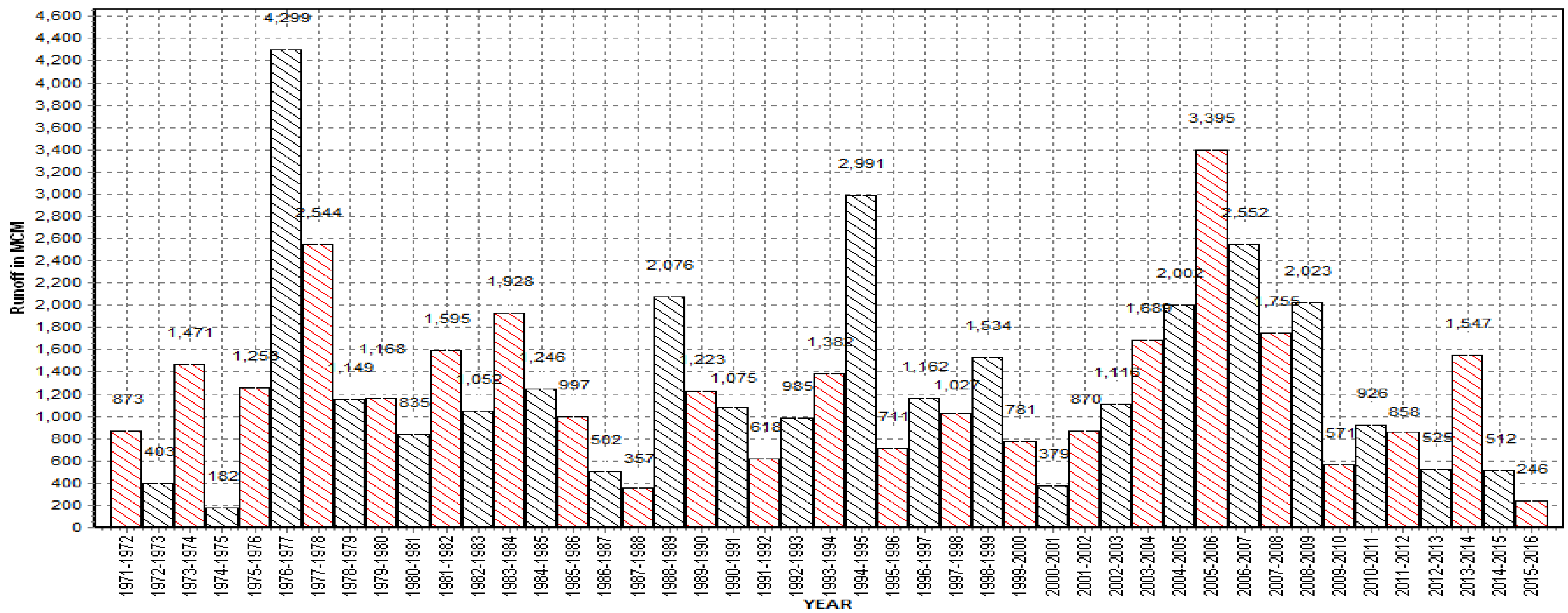
Station Name: Purna at Mahuwa (010219001)   Division: Tapi Division Surat   Local River: Purna   Sub -Division: LTSD, CWC, Surat



4.1.5 Annual runoff

Annual Runoff Values Runoff Based on period 1971 to 2016

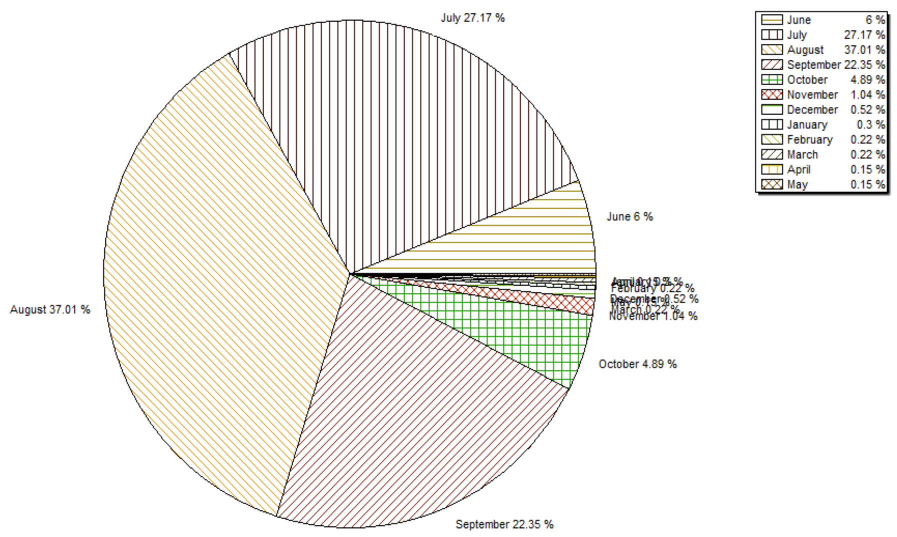
Station Name: Purna at Mahuwa (010219001) Division: Tapi Division Surat Local River: Purna Sub -Division: LTSD, CWC, Surat



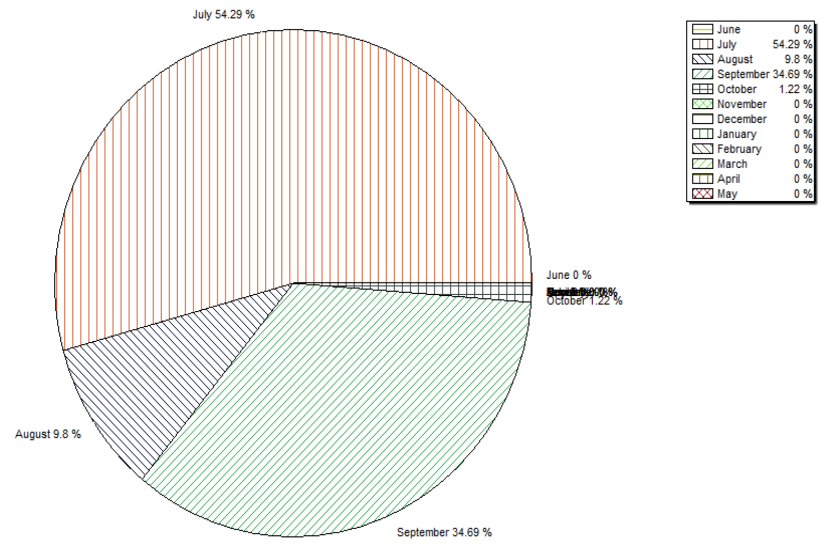
4.1.6 Monthly Average Runoff

Station Name: Purna at Mahuwa (010219001) Division: Tapi Division, Surat Local River: Purna Sub -Division: LTSD, CWC, Surat

Monthly Average Runoff Based on period: 1971 -2015



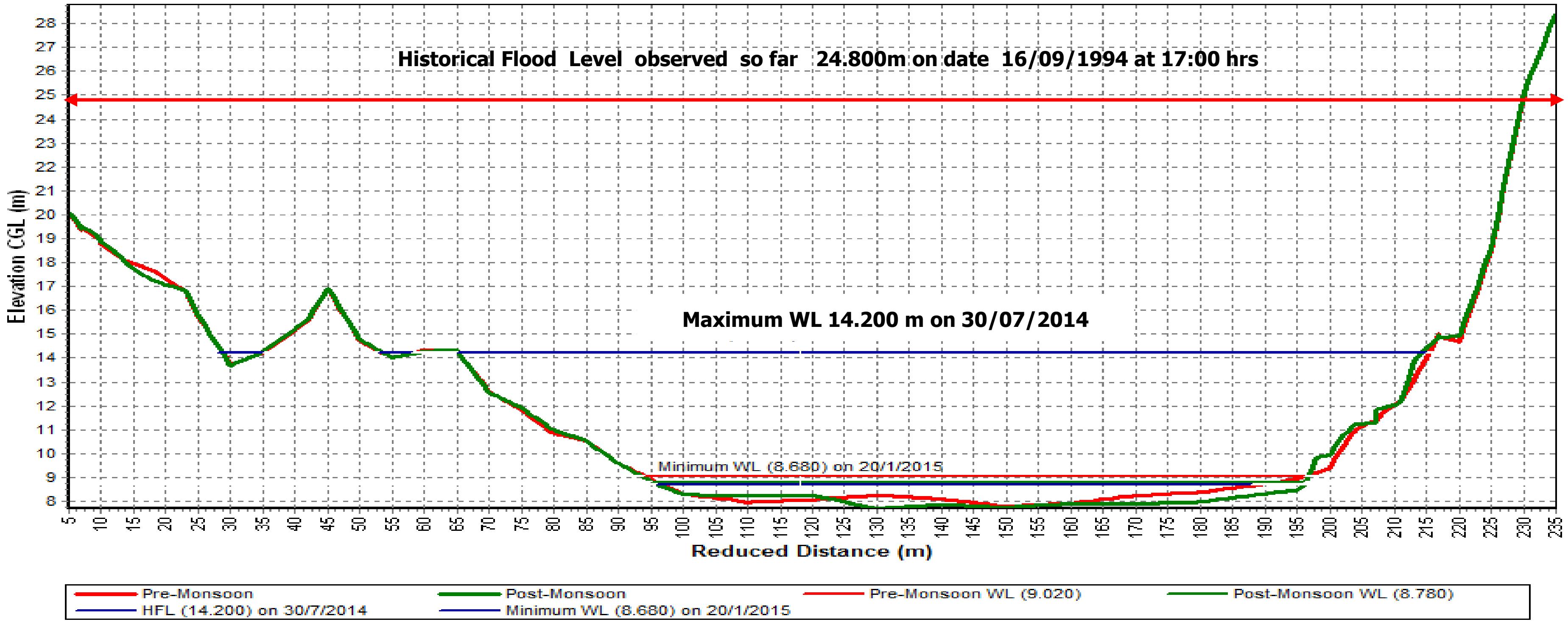
Monthly Average Runoff Based on period: 2015-16



4.1.7 Superimposed cross section

Station Name: Purna at Mahuwa (010219001) Division: Tapi Division Surat Local River: Purna Sub -Division: LTSD, CWC, Surat

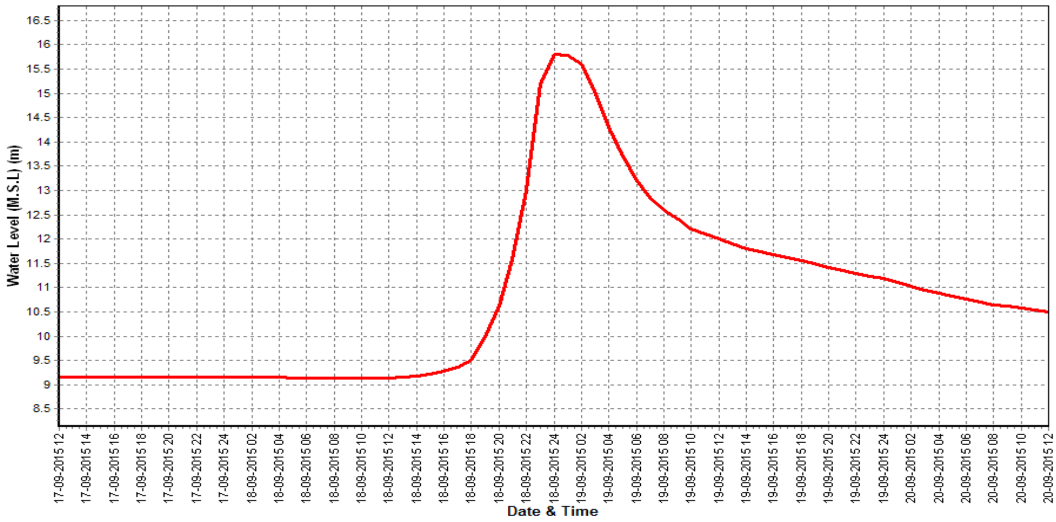
Superimposed cross section at SG line



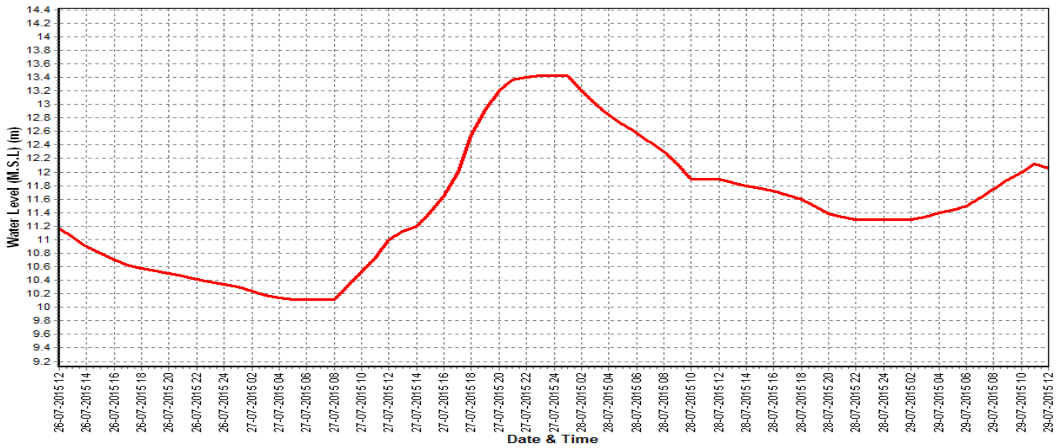
4.1.8 Water Level vs. Time- Graph of Highest Flood Peaks during 2015-16

Station Name: Purna at Mahuwa (010219001) Division : Tapi Division Surat
Local River : Purna Sub -Division : LTSD, CWC, Surat

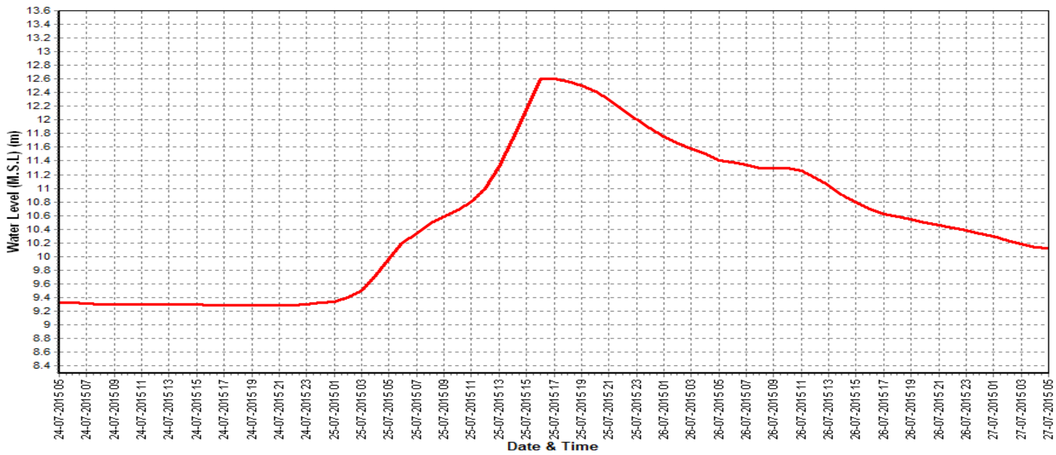
Water Level Vs. Time –Graph of I peak during the year 2015-16



Water Leel Vs. Time –Graph of II peak during the year 2015-16



Water Level Vs. Time –Graph of III peak during the year 2015-16



4.2 Ambica Basin

4.2.1 History sheet

HISTORY SHEET

			Water Year	**:**	**2015-16**
Site	**:**	**Ambica at Gadat**	**Code**	**:**	**01 02 20 001**
State	:	Gujarat	District		Valsad
Basin	:	WFR South of Tapi	Independent River	:	Ambika
Tributary	:		Sub Tributary	:	
Sub-Sub Tributary	:		Local River	:	
Division	:	Surat	Sub-Division	:	Surat
Drainage Area	:	1510 Sq. Km.	Bank	:	
Latitude	:	20°51'22"	Longitude	:	72°59'05"
Zero of Gauge (m)	:	1.5 (m.s.l)	14/01/1979		
		Opening Date	Closing Date		
Gauge	:	14/01/1979			
Discharge	:	12/03/1979			
Sediment	:	01/02/1985			
Water Quality	:	01/04/1980			

Annual Maximum / Minimum discharge with corresponding Water Level (m.s.l)

	Maximum			Minimum		
Year	Q (cumecs)	WL (m)	Date	Q (cumecs)	WL (m)	Date
1979-1980	1686	9.900	10/08/1979	0.180	3.350	16/06/1979
1980-1981	1492	9.160	02/08/1980	0.700	3.460	03/06/1980
1981-1982	1449	8.950	02/07/1981	0.000	3.500	13/06/1981
1982-1983	1537	9.400	25/07/1982	0.000	3.410	13/05/1983
1983-1984	1881	10.500	16/08/1983	0.000	1.500	07/06/1983
1984-1985	1551	9.430	06/07/1984	0.390	3.410	13/06/1984
1985-1986	1876	10.255	01/08/1985	0.100	3.315	17/04/1986
1986-1987	658.7	7.005	19/07/1986	0.100	3.315	13/06/1986
1987-1988	825.7	7.955	26/08/1987	0.000	3.200	05/04/1988
1988-1989	2308	10.110	27/07/1988	0.700	3.340	30/04/1989
1989-1990	2508	11.025	24/07/1989	0.456	3.285	08/06/1989
1990-1991	1385	10.220	17/08/1990	1.070	3.240	23/03/1991
1991-1992	450.7	6.440	28/07/1991	0.000	2.940	28/04/1992
1992-1993	1898	11.550	03/09/1992	0.000	3.020	14/06/1992
1993-1994	1245	5.185	25/06/1993	0.433	2.945	09/06/1993
1994-1995	2764	11.500	16/06/1994	0.364	2.940	03/05/1995
1995-1996	750.0	6.900	03/09/1995	0.091	2.810	16/04/1996
1996-1997	1255	8.425	24/07/1996	0.274	2.700	10/06/1996
1997-1998	1350	8.730	25/08/1997	0.465	2.200	30/05/1998
1998-1999	1200	8.800	08/07/1998	0.446	2.190	08/06/1998
1999-2000	2989	11.395	16/07/1999	0.783	2.130	26/04/2000
2000-2001	910.8	8.450	14/07/2000	0.748	2.425	13/01/2001
2001-2002	1873	9.810	20/07/2001	2.385	2.255	06/11/2001
2002-2003	1217	8.605	28/06/2002	2.210	3.955	21/10/2002
2003-2004	3650	10.075	28/07/2003	0.000	3.020	10/06/2003
2004-2005	2700	12.170	04/08/2004	1.812	3.700	30/10/2004
2005-2006	2894	13.010	29/06/2005	0.000	6.465	25/02/2006
2006-2007	1783	9.840	29/07/2006	0.000	6.460	02/03/2007
2007-2008	1601	9.400	02/07/2007	5.400	3.710	29/10/2007
2008-2009	1295	9.640	12/08/2008	40.43	3.840	30/08/2008
2009-2010	599	7.090	21/07/2009	0.000	4.820	01/06/2009
2010-2011	870.2	7.815	09/09/2010	0.000	4.590	01/06/2010
2011-2012	1594	9.67	29/08/2011	0.000	3.550	07/07/2011
2012-2013	548.7	6.930	13/08/2012	0.000	4.930	01/06/2012
2013-2014	1399	8.715	14/08/2013	0.000	3.750	As per SD curve
2014-2015	2086	10.120	30/07/2014	0.000	4.970	01/06/2014
2015-2016	1227	8.250	19/09/2015	0.000	4.830	01/06/2015

4.2.2 Annual Maximum Flood Peak

Year	Annual Maximum flood Peaks (m)	Date	Hour
1979	12.180	11/08/1979	01:00:00
1980	10.690	02/08/1980	16:00:00
1981	9.980	10/07/1981	15:00:00
1982	10.950	25/07/1982	14:00:00
1983	11.070	16/08/1983	06:00:00
1984	13.470	18/07/1984	20:00:00
1985	13.020	01/08/1985	00:00:00
1986	7.780	19/07/1986	00:00:00
1987	9.870	26/08/1987	03:00:00
1988	11.650	27/07/1988	16:00:00
1989	11.490	24/07/1989	13:00:00
1990	10.270	17/08/1990	09:00:00
1991	6.710	28/07/1991	18:00:00
1992	11.950	03/09/1992	12:00:00
1993	11.710	25/06/1993	18:00:00
1994	13.985	16/06/1994	18:00:00
1995	7.970	20/07/1995	12:00:00
1996	10.400	23/07/1996	16:00:00
1997	12.400	31/07/1997	21:00:00
1998	10.760	08/07/1998	11:00:00
1999	12.760	16/07/1999	02:00:00
2000	10.550	14/07/2000	03:00:00
2001	11.570	20/07/2001	15:00:00
2002	12.360	26/06/2002	22:00:00
2003	13.520	28/07/2003	04:00:00
2004	13.980	04/08/2004	02:00:00
2005	13.450	29/06/2005	16:00:00
2006	12.900	05/07/2006	14:00:00
2007	10.200	02/07/2007	13:00:00
2008	11.420	12/08/2008	13:00:00
2009	9.300	21/07/2009	13:00:00
2010	7.980	09/09/2010	04:00:00
2011	11.800	29/08/2011	06:00:00
2012	8.100	10/08/2012	01:00:00
2013	12.460	23/09/2013	20:00:00
2014	10.400	30/07/2014	11:00:00
2015	8.600	19/09/2015	06:00:00

4.2.3 Summary of Data

Stage –Discharge data for the period 2015-16

Station Name: Ambica at Gadat (01 02 20 001) Division : Tapi Division Surat Local River: Ambica Sub -Division : LTSD, CWC, Surat

Day	Jun		Jul		Aug			Sep			Oct			Nov	
	W.L	Q	W.L	Q	W.L	Q		W.L	Q		W.L	Q		W.L	Q
1	4.830	0.000	3.580	0.000	4.255	90.42		3.805	11.70		3.880	23.97	#	3.670	0.000
2	4.830	0.000	3.570	0.000	4.130	64.88	*	3.800	8.362		3.860	21.07	*	3.670	0.000
3	4.830	0.000	3.570	0.000	4.045	53.25		3.780	0.000		3.850	23.85		3.660	0.000
4	4.800	0.000	3.560	0.000	3.993	47.65		3.780	0.000		4.000	42.90	*	3.640	0.000
5	4.800	0.000	3.550	0.000	3.945	37.01		3.770	0.000		3.910	36.07		3.640	0.000
6	4.780	0.000	3.550	0.000	3.915	31.73		3.760	0.000		3.860	20.75		3.640	0.000
7	4.770	0.000	3.540	0.000	3.935	34.91		3.750	0.000		3.830	21.49		3.640	0.000
8	4.760	0.000	3.530	0.000	3.930	35.18		3.750	0.000		3.800	17.34		3.640	0.000
9	4.750	0.000	3.520	0.000	3.910	27.70	*	3.730	0.000		3.790	12.33		3.780	0.000
10	4.730	0.000	3.520	0.000	3.895	30.16		3.730	0.000		3.780	10.47		3.950	0.000
11	4.740	0.000	3.510	0.000	3.875	28.01		3.730	0.000		3.780	10.42	*	4.090	0.000
12	4.650	0.000	3.510	0.000	3.870	26.69		3.700	0.000		3.780	10.05		4.270	0.000
13	4.690	0.000	3.510	0.000	3.870	28.30		3.700	1.950	*	3.780	10.23		4.310	0.000
14	4.690	0.000	3.510	0.000	3.865	26.27		3.880	27.39		3.800	11.92		4.360	0.000
15	4.900	0.000	3.510	0.000	3.860	21.07	*	3.930	32.66		3.830	22.79		4.410	0.000
16	5.000	0.000	3.510	0.000	3.860	21.07	*	3.920	27.11		3.800	13.06		4.470	0.000
17	4.950	0.000	3.510	0.000	3.860	26.25		3.850	19.65	*	3.780	10.48		4.530	0.000
18	4.210	0.000	3.500	0.000	3.865	25.63		3.800	6.538		3.760	8.050		4.600	0.000
19	4.070	0.000	3.500	0.000	3.860	24.91		8.250	1227		3.750	0.000		4.650	0.000
20	3.750	0.000	3.500	0.000	3.850	18.46		5.440	373.2	*	3.740	0.000		4.700	0.000

21	3.660	0.000	3.500	0.000	3.790	4.675	4.830	187.1	3.730	0.000	4.740	0.000
22	3.660	0.000	3.550	0.000	3.740	0.000	4.665	177.7 #	3.740	0.000	4.800	0.000
23	3.660	0.000	4.130	0.000	3.800	12.92 *	4.340	108.8	3.740	0.000	4.860	0.000
24	3.680	0.000	3.890	0.000	3.815	14.24	4.185	80.20	3.730	0.000	4.930	0.000
25	3.710	0.000	4.040	0.000	3.893	23.70	4.110	62.13 *	3.730	0.000	4.990	0.000
26	3.700	0.000	4.750	0.000	3.885	15.93	4.050	56.10	3.700	0.000	5.020	0.000
27	3.660	0.000	5.000	225.0	3.845	14.60	4.000	42.90 *	3.690	0.000	4.990	0.000
28	3.620	0.000	6.320	627.6 #	3.835	14.63	3.960	41.31	3.720	0.000	4.990	0.000
29	3.600	0.000	5.690	361.1	3.820	8.740	3.930	43.24	3.680	0.000	4.990	0.000
30	3.600	0.000	4.905	195.7	3.805	13.57 *			3.680	0.000	4.990	0.000
31			4.500	137.7	3.810	11.84 *			3.670	0.000		
Ten-Daily Mean												
I Ten-Daily	4.788	0.000	3.549	0.000	3.995	45.29	3.765	2.007	3.856	23.02	3.693	0.000
II Ten-Daily	4.565	0.000	3.507	0.000	3.863	24.67	4.420	171.5	3.780	9.700	4.439	0.000
III Ten-Daily	3.655	0.000	4.570	140.6	3.822	12.26	4.230	88.84	3.710	0.000	4.930	0.000
Monthly												
Min.	3.600	0.000	3.500	0.000	3.740	0.000	3.700	0.000	3.670	0.000	3.640	0.000
Max.	5.000	0.000	6.320	627.6	4.255	90.42	8.250	1227	4.000	42.90	5.020	0.000
Mean	4.336	0.000	3.898	49.91	3.891	26.92	4.135	87.41	3.780	10.56	4.354	0.000

Annual Runoff in MCM = 453 **Annual Runoff in mm = 300**

Peak Observed Discharge = 1227 cumecs on 19-09-2015 **Corres. Water Level :8.25 m**

Lowest Observed Discharge = 0.000 cumecs on 01-06-2015 **Corres. Water Level :4.83 m**

Q: Observed/Computed discharge in cumecs WL: Corresponding Mean Water Level (m.s.l) in m * : Computed Discharge #:Discarded Discharge (values changed as per rating curve)

Note: River remained in pooling/ no flow condition w.e.f. 01/06/15 to 26/07/15 and from 19/10/2015 to 31/05/2016**. No flow,**Back water effect from Dewadha Dam exists at site during this period.

Stage –Discharge data for the period 2015-16

Station Name: Ambica at Gadat (01 02 20 001) Division : Tapi Division Surat Local River: Ambica Sub -Division : LTSD, CWC, Surat

Day	Dec		Jan		Feb		Mar		Apr		May	
	W.L	Q	WL	Q	WL	Q	WL	Q	WL	Q	WL	Q
1	3.510	0.000	3.520	0.000	3.240	0.000	3.450	0.000	3.430	0.000	3.410	0.000
2	3.540	0.000	3.510	0.000	3.230	0.000	3.440	0.000	3.430	0.000	3.410	0.000
3	3.540	0.000	3.500	0.000	3.230	0.000	3.440	0.000	3.430	0.000	3.410	0.000
4	3.540	0.000	3.490	0.000	3.220	0.000	3.440	0.000	3.425	0.000	3.450	0.000
5	3.540	0.000	3.470	0.000	3.220	0.000	3.460	0.000	3.425	0.000	3.450	0.000
6	3.530	0.000	3.460	0.000	3.190	0.000	3.460	0.000	3.425	0.000	3.450	0.000
7	3.530	0.000	3.460	0.000	3.180	0.000	3.460	0.000	3.425	0.000	3.450	0.000
8	3.530	0.000	3.440	0.000	3.180	0.000	3.460	0.000	3.425	0.000	3.450	0.000
9	3.540	0.000	3.440	0.000	3.260	0.000	3.470	0.000	3.420	0.000	3.440	0.000
10	3.550	0.000	3.430	0.000	3.270	0.000	3.470	0.000	3.420	0.000	3.440	0.000
11	3.550	0.000	3.430	0.000	3.315	0.000	3.460	0.000	3.450	0.000	3.440	0.000
12	3.545	0.000	3.420	0.000	3.320	0.000	3.460	0.000	3.450	0.000	3.430	0.000
13	3.545	0.000	3.420	0.000	3.320	0.000	3.460	0.000	3.450	0.000	3.430	0.000
14	3.545	0.000	3.415	0.000	3.310	0.000	3.460	0.000	3.450	0.000	3.430	0.000
15	3.550	0.000	3.410	0.000	3.310	0.000	3.460	0.000	3.450	0.000	3.430	0.000
16	3.550	0.000	3.410	0.000	3.310	0.000	3.440	0.000	3.450	0.000	3.450	0.000
17	3.550	0.000	3.410	0.000	3.350	0.000	3.440	0.000	3.450	0.000	3.450	0.000
18	3.550	0.000	3.410	0.000	3.410	0.000	3.440	0.000	3.400	0.000	3.450	0.000
19	3.560	0.000	3.380	0.000	3.410	0.000	3.440	0.000	3.400	0.000	3.450	0.000
20	3.560	0.000	3.380	0.000	3.430	0.000	3.440	0.000	3.400	0.000	3.450	0.000

21	3.550	0.000	3.350	0.000	3.430	0.000	3.470	0.000	3.400	0.000	3.450	0.000
22	3.540	0.000	3.330	0.000	3.430	0.000	3.470	0.000	3.400	0.000	3.450	0.000
23	3.540	0.000	3.330	0.000	3.445	0.000	3.470	0.000	3.420	0.000	3.440	0.000
24	3.540	0.000	3.325	0.000	3.450	0.000	3.470	0.000	3.420	0.000	3.440	0.000
25	3.540	0.000	3.320	0.000	3.465	0.000	3.470	0.000	3.420	0.000	3.440	0.000
26	3.540	0.000	3.300	0.000	3.465	0.000	3.470	0.000	3.420	0.000	3.470	0.000
27	3.540	0.000	3.285	0.000	3.465	0.000	3.465	0.000	3.420	0.000	3.470	0.000
28	3.550	0.000	3.280	0.000	3.450	0.000	3.465	0.000	3.420	0.000	3.470	0.000
29	3.550	0.000	3.250	0.000	3.450	0.000	3.465	0.000	3.420	0.000	3.470	0.000
30	3.535	0.000	3.250	0.000			3.465	0.000	3.410	0.000	3.470	0.000
31	3.530	0.000	3.250	0.000			3.450	0.000			3.470	0.000
Ten-Daily Mean												
I Ten-Daily	3.535	0.000	3.472	0.000	3.222	0.000	3.455	0.000	3.425	0.000	3.436	0.000
II Ten-Daily	3.550	0.000	3.409	0.000	3.348	0.000	3.450	0.000	3.435	0.000	3.441	0.000
III Ten-Daily	3.541	0.000	3.297	0.000	3.450	0.000	3.466	0.000	3.415	0.000	3.458	0.000
Monthly												
Min.	3.510	0.000	3.250	0.000	3.180	0.000	3.440	0.000	3.400	0.000	3.410	0.000
Max.	3.560	0.000	3.520	0.000	3.465	0.000	3.470	0.000	3.450	0.000	3.470	0.000
Mean	3.542	0.000	3.390	0.000	3.336	0.000	3.457	0.000	3.425	0.000	3.445	0.000

Peak Computed Discharge = 373.2 cumecs on 20-09-2015 Corres. Water Level :5.44 m
Lowest Computed Discharge = 1.950 cumecs on 13-09-2015 Corres. Water Level :3.70 m

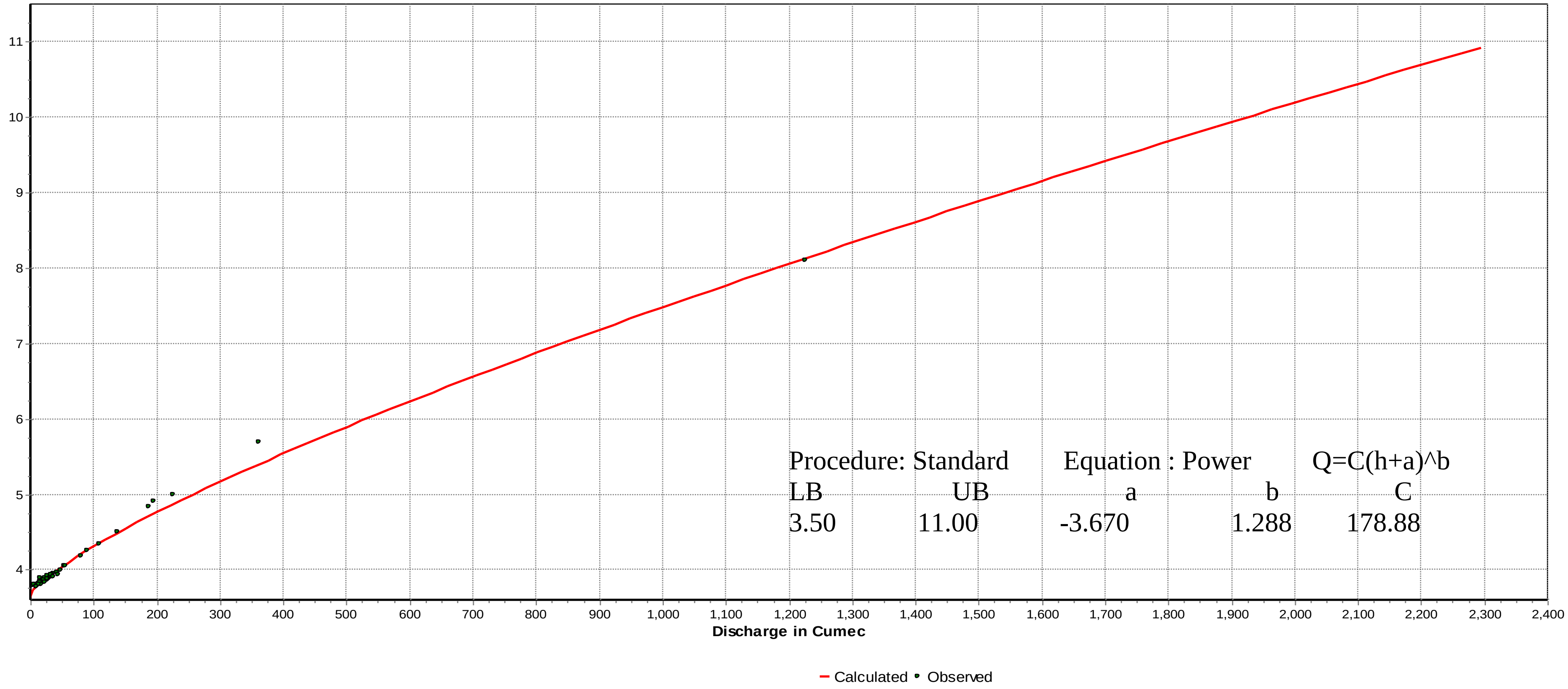
Q: Observed/Computed discharge in cumecs WL: Corresponding Mean Water Level (m.s.l) in m * : Computed Discharge #:Discarded Discharge (values changed as per rating curve)

Note: River remained in pooling/ no flow condition w.e.f. 01/06/15 to 26/07/15 and from 19/10/2015 to 31/05/2016.**No flow,** Back water effect from Dewadha Dam exists at site during this period.

4.2.4 Stage Discharge Curve

Station Name: Ambica at Gadat (01 02 20 001) Division : Tapi Division Surat Local River: Ambica Sub -Division : LTSD, CWC, Surat

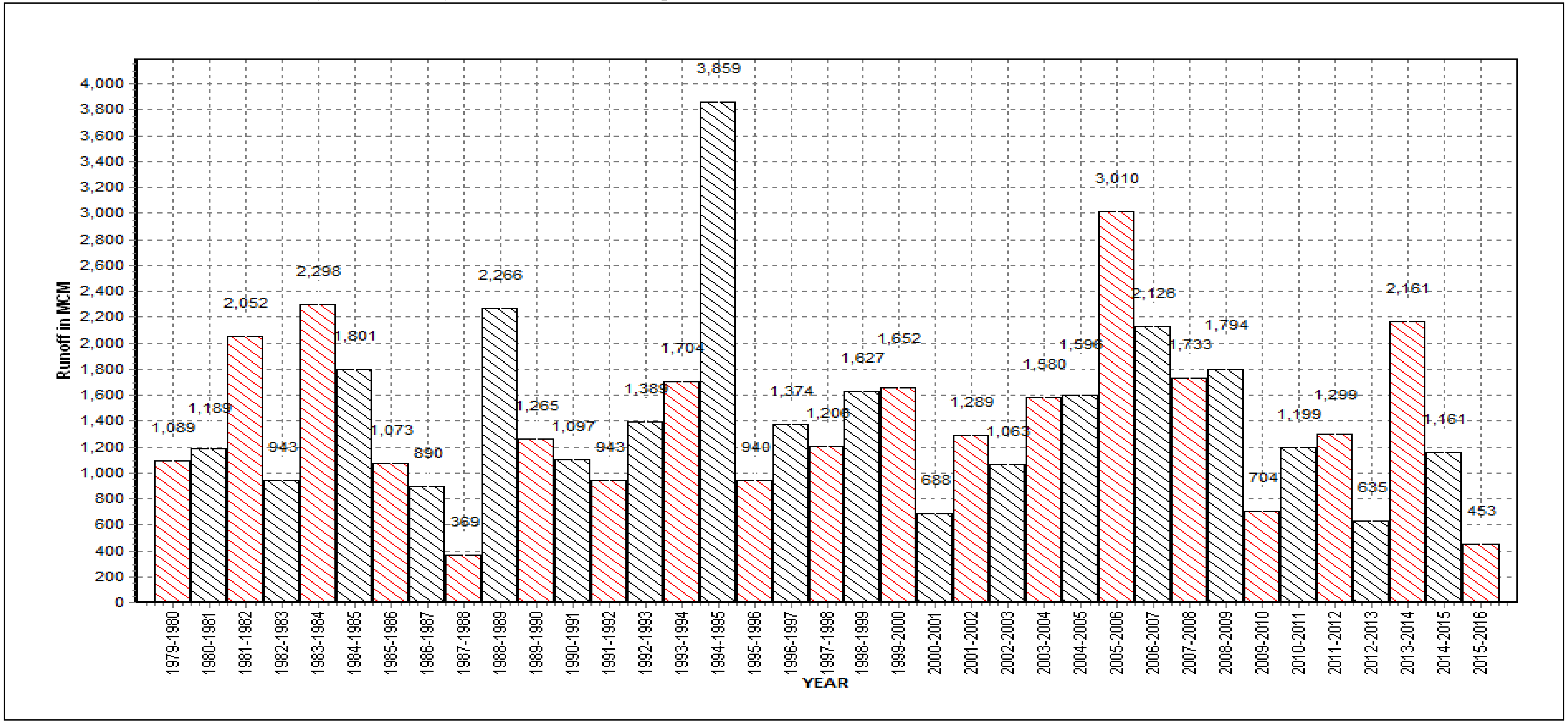
Stage Discharge Curve of river Ambica at Gadatfor the period 01/06/15 to 31/05/16



4.2.5 Annual runoff

Annual Runoff Values Runoff Based on period 1979 to 2016

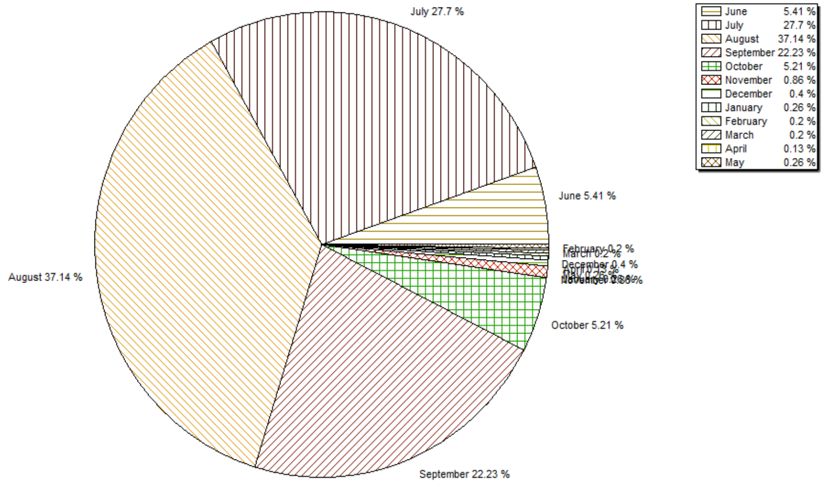
Station Name: Ambica at Gadat (01 02 20 001) Division : Tapi Division, Surat Local River: Ambica Sub -Division : LTSD, CWC, Surat



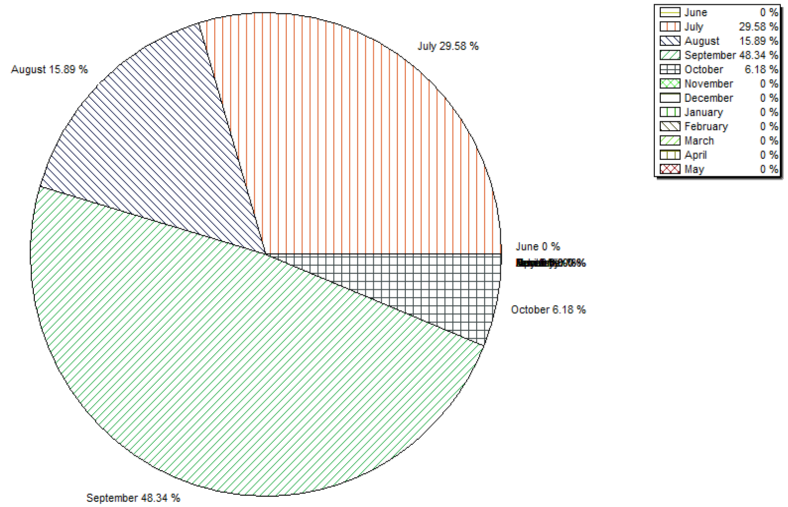
4.2.6 Monthly average Runoff

Station Name: Ambica at Gadat (01 02 20 001)   Division : Tapi Division, Surat   Local River: Ambica   Sub -Division : LTSD, CWC, Surat

Monthly Average Runoff Based on period: 1979 -2015



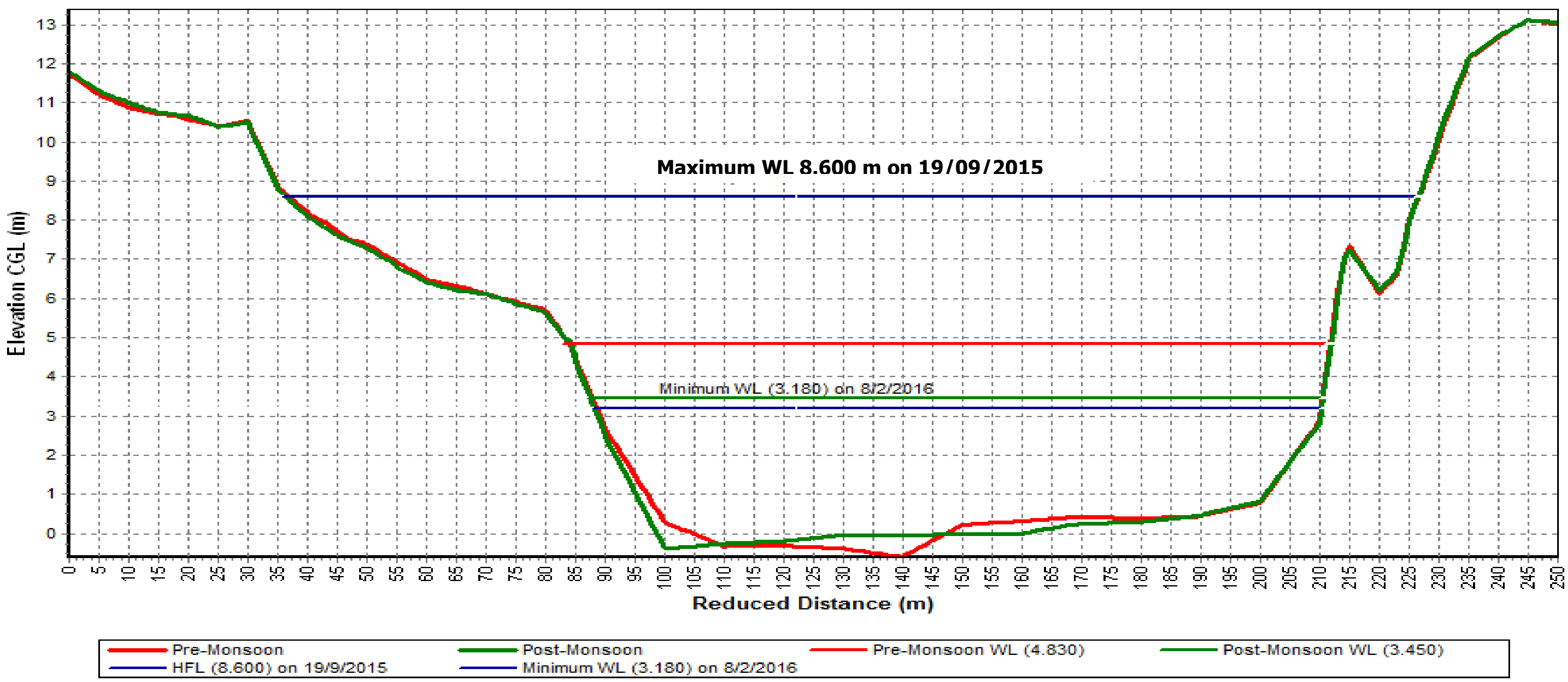
Monthly Average Runoff Based on period: 2015-16



4.2.7 Superimposed Cross section

Station Name: Ambica at Gadat (01 02 20 001)   Division: Tapi Division, Surat   Local River: Ambica   Sub -Division: LTSD, CWC, Surat

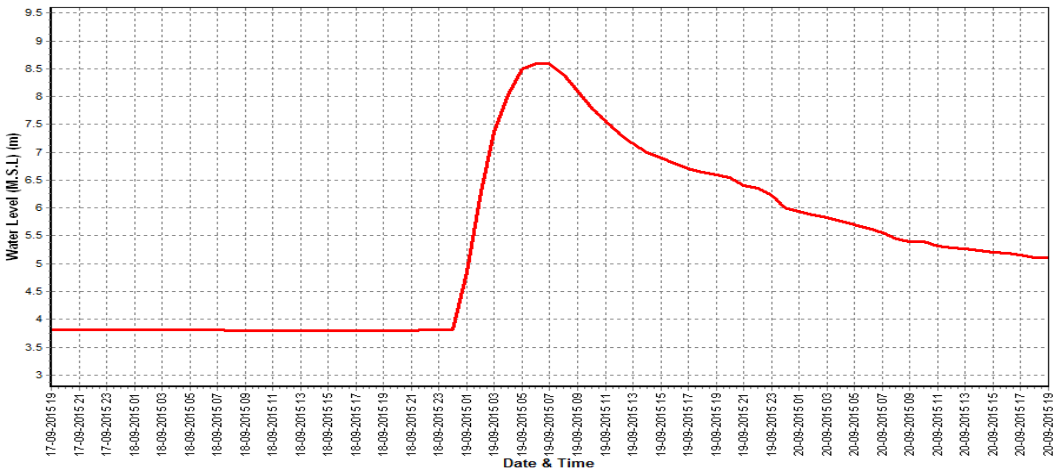
Historical Flood Level observed so far 13.98 m on date 04/08/2004 at 02:00 hrs



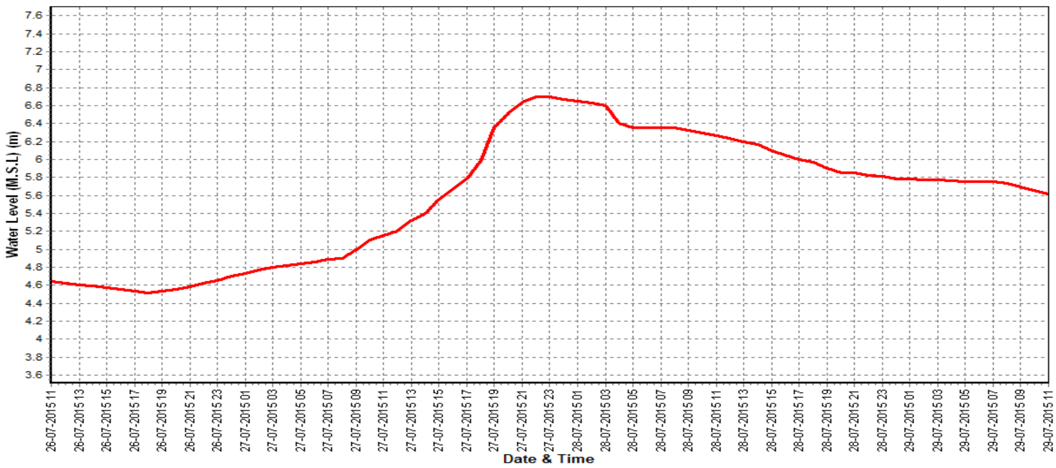
4.2.8 Water Level vs. Time- Graph of Highest Flood Peaks during 2015-16

Station Name: Ambica at Gadat (01 02 20 001) Division : Tapi Division Surat
Local River: Ambica Sub -Division : LTSD, CWC, Surat

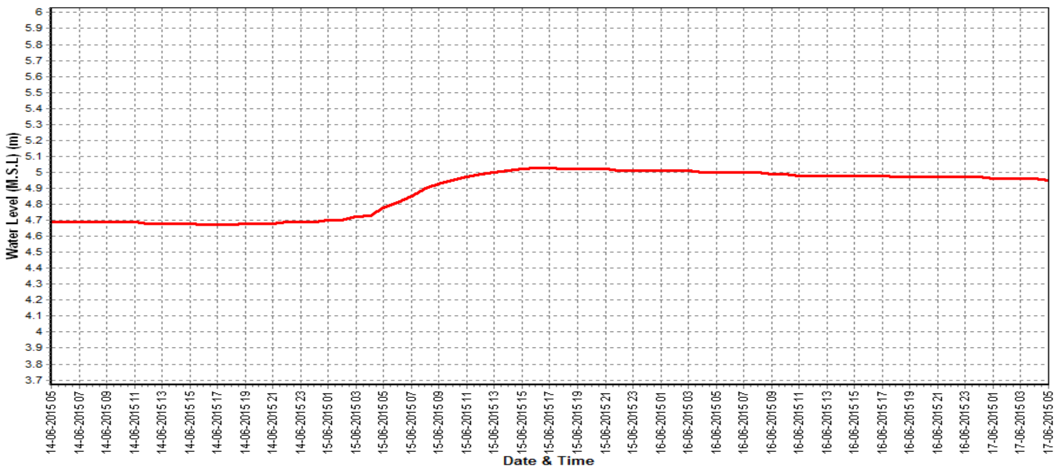
Water level vs. Time graph of 1st flood peak during the year 2015-16



Water level vs. Time graph of 2nd flood peak during the year 2015-16



Water level vs. Time graph of 3rd flood peak during the year 2015-16



4.3 Vaitarna at Durvesh

4.3.1 History sheet

HISTORY SHEET

Water Year : 2015-16

Site	**:**	**Vaitarna at Durvesh**	**Code**	**:**	**01 02 25 001**
State	:	Maharashtra	District		Thane
Basin	:	WFR South of Tapi	Independent River	:	Vaitarna
Tributary	:		Sub Tributary	:	
Sub-Sub Tributary	:		Local River	:	
Division	:	Tapi Division, Surat	Sub-Division	:	DGSD,CWC,Silvassa
Drainage Area	:	2019 Sq. Km.	Bank	:	
Latitude	:	19°42'45"	Longitude	:	72°55'50"
Zero of Gauge (m) : 0 (m.s.l)			26/10/1970		
		Opening Date	Closing Date		
Gauge	:	26/10/1970			
Discharge	:	26/01/1971			
Sediment	:	26/01/1971			
Water Quality	:	01/06/1977			

Annual Maximum / Minimum discharge with corresponding Water Level (m.s.l)

	Maximum			Minimum		
Year	Q (cumecs)	WL (m)	Date	Q (cumecs)	WL (m)	Date
1971-1972	4386	11.330	30/09/1971	0.000	1.975	21/06/1971
1972-1973	1543	6.463	02/07/1972	0.000	0.680	03/06/1972
1973-1974	3826	10.950	23/09/1973	0.000	0.890	09/05/1974
1974-1975	1655	6.743	04/07/1974	0.000	0.880	09/05/1975
1975-1976	3303	8.437	11/08/1975	0.000	0.855	29/04/1976
1976-1977	7744	14.250	31/07/1976	0.000	0.975	09/05/1977
1977-1978	4374	11.522	03/09/1977	0.020	0.825	14/06/1977
1978-1979	1796	7.277	21/06/1978	0.000	0.800	03/05/1979
1979-1980	5000	9.060	11/08/1979	0.000	1.045	19/06/1979
1980-1981	2460	9.025	04/08/1980	0.000	1.010	13/02/1981
1981-1982	1748	8.675	10/07/1981	0.000	1.400	17/12/1981
1982-1983	1140	8.900	22/08/1982	2.000	1.620	08/11/1982
1983-1984	2249	9.635	13/08/1983	0.000	0.920	14/06/1983
1984-1985	3180	12.900	19/07/1984	0.100	1.250	15/06/1984
1985-1986	1032	7.155	03/08/1985	0.000	1.440	05/07/1985
1986-1987	1293	7.850	19/07/1986	0.000	1.240	30/10/1986
1987-1988	1287	7.065	07/07/1987	0.000	1.954	02/07/1987
1988-1989	3396	11.000	16/07/1988	0.000	0.000	02/02/1989
1989-1990	1672	9.075	25/07/1989	0.000	1.610	30/06/1989
1990-1991	1761	7.690	18/08/1990	0.000	0.000	03/01/1991
1991-1992	1361	8.800	28/07/1991	0.000	0.000	26/01/1992
1992-1993	1405	8.675	12/08/1992	0.000	0.000	27/01/1993
1993-1994	1497	6.045	16/07/1993	0.000	0.000	15/02/1994
1994-1995	2340	12.550	13/07/1994	0.000	0.000	05/02/1995
1995-1996	1039	7.250	21/07/1995	0.000	0.000	02/02/1996
1996-1997	1611	7.380	23/07/1996	0.900	1.120	10/12/1996
1997-1998	4100	12.330	31/07/1997	0.000	1.200	14/06/1997
1998-1999	8000	15.220	17/09/1998	0.000	1.200	26/04/1999
1999-2000	4536	12.180	16/07/1999	0.000	1.190	14/05/2000
2000-2001	1749	8.440	13/07/2000	0.000	1.140	30/12/2000
2001-2002	1469	7.200	04/07/2001	0.000	1.140	31/12/2001
2002-2003	4400	10.830	27/06/2002	0.000	1.100	24/12/2002
2003-2004	6038	12.350	28/07/2003	0.000	1.090	28/12/2003
2004-2005	5080	12.050	03/08/2004	0.000	1.080	20/04/2005
2005-2006	4997	10.450	28/07/2005	0.000	1.030	13/04/2006
2006-2007	4086	10.680	07/08/2006	0.659	1.060	26/12/2006
2007-2008	2034	7.530	03/07/2007	0.853	1.070	24/12/2007
2008-2009	2941	9.830	20/09/2008	0.470	1.060	22/12/2008
2009-2010	1633	7.750	23/07/2009	0.000	1.000	01/06/2009
2010-2011	1422	7.060	02/08/2010	13.48	0.700	10/06/2010
2011-2012	3408	9.930	29/08/2011	0.000	0.950	03/06/2011
2012-2013	1394	6.460	04/09/2012	0.000	0.840	01/06/2012
2013-2014	2070	7.200	12/07/2013	0.000	0.780	01/06/2013
2014-2015	1942	7.040	01/09/2014	0.000	1.200	01/07/2014
2015-2016	1475	7.170	22/07/2015	0.000	0.960	01/06/2015

4.3.2 Annual Maximum Flood Peak

Year	Annual Maximum flood Peaks (m)	Date	Hour
1974	7.690	04/07/1974	15:00:00
1975	9.860	30/07/1975	03:00:00
1976	14.700	31/07/1976	15:00:00
1977	12.075	03/09/1977	06:00:00
1978	7.720	21/06/1978	10:00:00
1979	9.510	11/08/1979	06:00:00
1980	10.830	04/08/1980	00:00:00
1981	10.500	10/07/1981	20:00:00
1982	9.200	22/08/1982	09:00:00
1983	12.000	15/08/1983	19:00:00
1984	14.460	18/07/1984	18:00:00
1985	8.050	03/08/1985	18:00:00
1986	8.300	15/07/1986	20:00:00
1987	10.800	20/08/1987	15:00:00
1988	13.800	16/07/1988	16:00:00
1989	11.540	25/07/1989	01:00:00
1990	10.250	03/07/1990	20:00:00
1991	10.500	28/07/1991	00:00:00
1992	10.500	03/09/1992	21:00:00
1993	11.900	17/07/1993	00:00:00
1994	12.800	13/07/1994	08:00:00
1995	8.100	21/07/1995	18:00:00
1996	8.220	23/07/1996	18:00:00
1997	12.920	31/07/1997	13:00:00
1998	16.130	17/09/1998	13:00:00
1999	12.500	16/07/1999	09:00:00
2000	8.670	13/07/2000	14:00:00
2001	8.300	09/07/2001	18:00:00
2002	14.500	26/06/2002	18:00:00
2003	12.400	28/07/2003	09:00:00
2004	15.120	02/08/2004	22:00:00
2005	11.340	02/08/2005	14:00:00
2006	11.300	08/08/2006	16:00:00
2007	9.680	05/08/2007	19:00:00
2008	14.220	11/08/2008	20:00:00
2009	9.600	22/07/2009	15:00:00
2010	8.160	31/08/2010	19:00:00
2011	12.720	28/08/2011	19:00:00
2012	7.480	04/09/2012	18:00:00
2013	8.260	02/08/2013	04:00:00
2014	11.950	29/07/2014	14:00:00
2015	7.480	22/07/2015	14:00:00

4.3.1 Summary of Data **Stage –Discharge data for the period 2015-2016**

Station Name: Vaitarna at Durvesh (01 02 25 001) Division : Tapi Division Surat Sub -Division : DGSD, CWC, Silvasa

Local River: Vaitarna

Day	Jun		Jul			Aug			Sep			Oct			Nov		
	W.L	Q	W.L	Q		W.L	Q		W.L	Q		W.L	Q		W.L	Q	
1	0.960	0.000	2.220	41.74		3.520	189.7	#	2.430	46.64		1.950	14.77		1.470	2.870	*
2	1.030	0.000	2.190	36.23		3.010	111.9	*	2.400	40.45		1.900	16.06	*	1.440	1.742	
3	1.110	0.000	2.160	32.64		2.670	86.08		2.280	31.93		2.220	25.66		1.400	1.087	
4	1.170	0.000	2.130	26.25		2.510	60.55		2.210	20.90		2.040	23.01	*	1.320	0.525	
5	1.210	0.000	1.930	17.43	*	2.390	44.58		2.140	20.83		2.020	14.86		1.270	0.000	
6	1.210	0.000	2.180	38.89		2.450	51.42		2.000	20.88	*	2.060	18.28		1.250	0.000	
7	1.110	0.000	2.130	27.02		2.650	75.38		1.900	23.40		2.050	17.19		1.300	0.000	
8	1.310	0.000	1.790	20.75		2.450	50.73		1.890	22.39		2.020	14.91		1.320	0.000	
9	1.210	0.000	1.720	20.30		2.500	55.95	*	1.860	20.00		2.010	14.47		1.340	0.000	
10	1.160	0.000	1.740	21.78		2.440	49.31		1.820	18.78		2.000	13.82		1.380	0.000	
11	1.150	0.000	1.700	18.86		2.360	40.08		1.970	16.09		1.950	18.38	*	1.400	0.000	
12	1.190	0.000	1.780	11.18	*	2.460	52.78		2.160	22.16		1.920	12.00		1.410	0.000	
13	1.240	0.000	1.730	20.93		2.490	60.09		2.100	26.42	*	2.010	14.03		1.390	0.000	
14	1.260	0.000	1.710	19.66		2.400	46.81		2.200	20.13		1.950	13.15		1.350	0.000	
15	1.260	0.000	1.760	22.60		2.760	81.82	*	2.300	32.94		1.970	15.76		1.320	0.000	
16	1.260	0.000	1.750	21.55		2.390	46.62	*	2.130	21.11		1.950	13.35		1.300	0.000	
17	1.350	0.000	1.730	20.77		2.405	46.99		2.000	20.88	*	1.930	12.03		1.290	0.000	
18	1.370	0.000	1.790	11.55	*	2.450	51.21		2.090	18.77		1.820	12.70	*	1.270	0.000	
19	1.380	0.000	1.760	10.46	*	2.360	40.09		2.630	70.63		1.720	7.011		1.260	0.000	
20	1.370	0.000	1.750	21.55		2.260	28.91		3.900	262.6	*	1.600	5.166		1.240	0.000	

21	1.670	0.000	5.680	765.2	2.310	34.06	4.850	503.8 #	1.625	7.235	1.250	0.000
22	5.300	648.7 *	7.170	1475 #	2.260	29.17	3.680	218.8 #	1.610	5.880 *	1.260	0.000
23	3.440	197.1	4.820	494.9 #	2.090	25.83 *	2.900	98.01 #	1.590	5.380 #	1.290	0.000
24	4.210	379.7	3.540	193.2 #	2.015	16.16	2.620	67.22 #	1.580	5.140 *	1.310	0.000
25	3.520	237.2	5.630	758.0	2.150	21.02	2.440	50.75 *	1.560	4.670 *	1.340	0.000
26	2.890	129.7	3.500	186.2 *	4.460	395.3	2.270	37.50 #	1.500	5.928	1.360	0.000
27	2.450	80.10	3.300	153.4 #	3.165	133.2 #	2.210	33.34 *	1.460	2.413	1.400	0.000
28	2.380	45.82 *	5.340	672.2	2.640	71.16	2.170	22.87	1.450	2.287	1.420	0.000
29	2.330	59.38	5.050	567.2	2.680	80.11	2.110	20.10	1.430	2.121	1.390	0.000
30	2.280	51.88	4.730	467.3	2.530	58.66 *	2.050	17.30	1.400	1.695	1.370	0.000
31			3.510	187.9 #	2.570	62.90			1.450	1.908		
<u>Ten-Daily Mean</u>												
I Ten-Daily	1.148	0.000	2.019	28.30	2.659	77.56	2.093	26.62	2.027	17.30	1.349	0.622
II Ten-Daily	1.283	0.000	1.746	17.91	2.434	49.54	2.348	51.17	1.882	12.36	1.323	0.000
III Ten-Daily	3.047	183.0	4.752	538.2	2.625	84.32	2.730	107.0	1.514	4.060	1.339	0.000
<u>Monthly</u>												
Min.	0.960	0.000	1.700	10.46	2.015	16.16	1.820	16.09	1.400	1.695	1.240	0.000
Max.	5.300	648.7	7.170	1475	4.460	395.3	4.850	503.8	2.220	25.66	1.470	2.870
Mean	1.826	60.99	2.901	205.9	2.574	70.92	2.390	61.59	1.798	11.01	1.337	0.207

Annual Runoff in MCM = 1089 **Annual Runoff in mm = 539**
Peak Observed Discharge = 1475 cumecs on 22-07-2015 **Corres. Water Level :7.17 m**
Lowest Observed Discharge = 0.000 cumecs on 01-06-2015 **Corres. Water Level :0.96 m**

Q: Observed/Computed discharge in cumec WL: Corresponding Mean Water Level (m.s.l) in m * : Computed Discharge
#:Discarded Discharge (values changed as per rating curve)
Note: River remained in pooling/ no flow condition w.e.f. 01/06/15 to 21/06/15 & from 05/11/15 to 31/05/16.

Stage –Discharge data for the period 2015-2016

Station Name: Vaitarna at Durvesh (01 02 25 001) Division : Tapi Division, Surat Sub -Division : DGSD, CWC, Silvassa Local River: Vaitarna

Day	Dec		Jan		Feb		Mar		Apr		May	
	W.L	Q	WL	Q	WL	Q	WL	Q	WL	Q	WL	Q
1	1.350	0.000	1.180	0.000	1.000	0.000	1.050	0.000	0.890	0.000	0.820	0.000
2	1.330	0.000	1.100	0.000	0.990	0.000	0.970	0.000	0.900	0.000	0.760	0.000
3	1.250	0.000	1.090	0.000	0.930	0.000	0.910	0.000	0.920	0.000	0.780	0.000
4	1.220	0.000	1.060	0.000	0.900	0.000	0.920	0.000	0.960	0.000	0.870	0.000
5	1.240	0.000	1.080	0.000	0.920	0.000	0.950	0.000	1.050	0.000	0.990	0.000
6	1.220	0.000	1.040	0.000	1.000	0.000	0.990	0.000	1.120	0.000	1.090	0.000
7	1.180	0.000	1.020	0.000	1.090	0.000	1.040	0.000	1.200	0.000	1.200	0.000
8	1.200	0.000	1.040	0.000	1.150	0.000	1.100	0.000	1.260	0.000	1.020	0.000
9	1.260	0.000	1.030	0.000	1.200	0.000	1.210	0.000	1.370	0.000	1.080	0.000
10	1.310	0.000	1.000	0.000	1.220	0.000	1.300	0.000	1.270	0.000	1.180	0.000
11	1.350	0.000	0.990	0.000	1.190	0.000	1.360	0.000	1.360	0.000	1.130	0.000
12	1.370	0.000	1.020	0.000	1.300	0.000	1.400	0.000	1.380	0.000	1.000	0.000
13	1.340	0.000	1.010	0.000	1.340	0.000	1.300	0.000	1.280	0.000	0.910	0.000
14	1.320	0.000	1.000	0.000	1.350	0.000	1.400	0.000	1.050	0.000	0.940	0.000
15	1.300	0.000	0.990	0.000	1.360	0.000	1.220	0.000	0.940	0.000	0.910	0.000
16	1.270	0.000	0.980	0.000	1.150	0.000	1.050	0.000	0.900	0.000	0.880	0.000
17	1.240	0.000	0.940	0.000	0.980	0.000	0.960	0.000	0.890	0.000	0.830	0.000
18	1.230	0.000	0.960	0.000	0.940	0.000	0.900	0.000	0.880	0.000	0.800	0.000
19	1.250	0.000	1.020	0.000	0.950	0.000	0.910	0.000	0.930	0.000	0.780	0.000
20	1.260	0.000	1.050	0.000	0.970	0.000	0.890	0.000	0.870	0.000	0.840	0.000

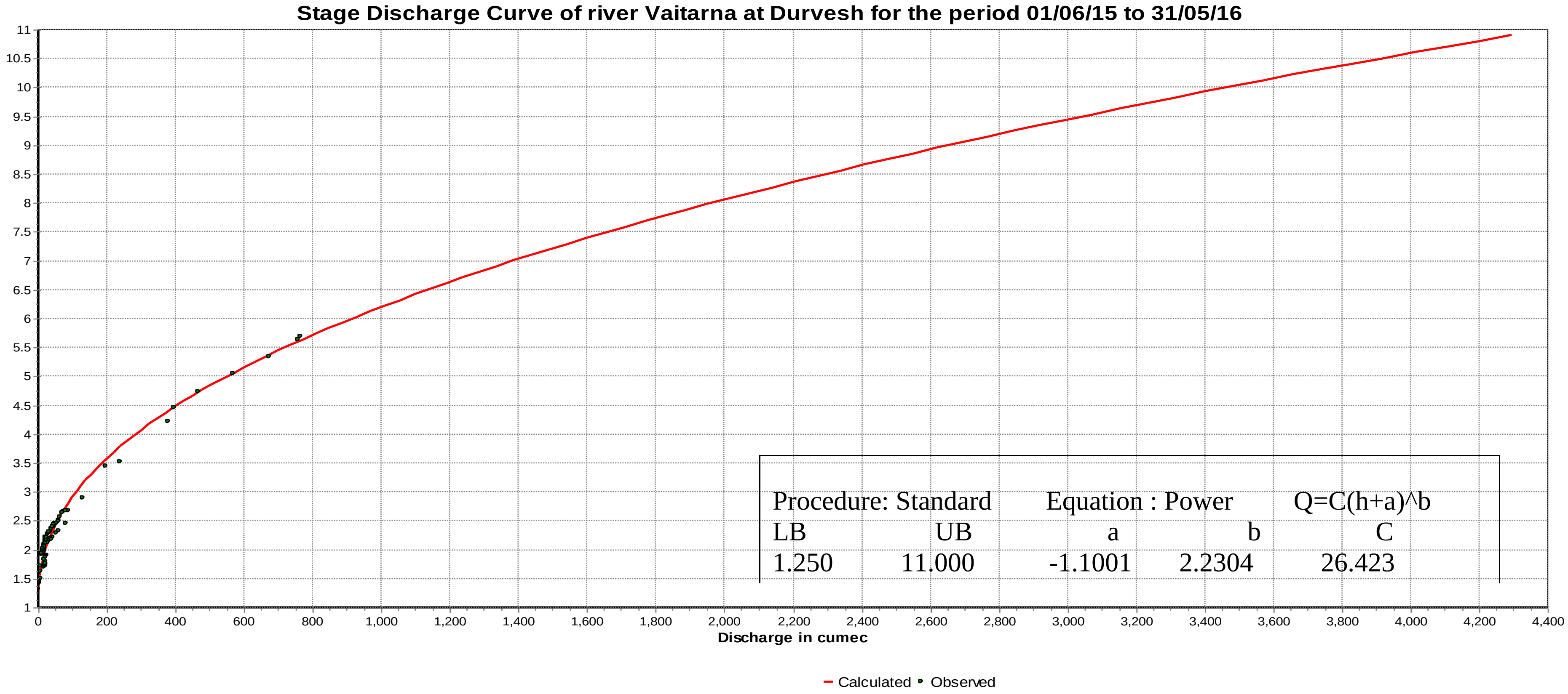
21	2.270	0.000	1.010	0.000	0.990	0.000	0.920	0.000	0.860	0.000	0.980	0.000
22	1.280	0.000	1.250	0.000	1.020	0.000	1.030	0.000	1.160	0.000	1.100	0.000
23	1.300	0.000	1.370	0.000	1.210	0.000	1.300	0.000	1.310	0.000	1.160	0.000
24	1.320	0.000	1.310	0.000	1.290	0.000	1.350	0.000	1.280	0.000	1.120	0.000
25	1.380	0.000	1.360	0.000	1.350	0.000	1.360	0.000	1.170	0.000	0.990	0.000
26	1.400	0.000	1.340	0.000	1.390	0.000	1.370	0.000	1.100	0.000	0.910	0.000
27	1.300	0.000	1.320	0.000	1.370	0.000	1.280	0.000	0.980	0.000	0.840	0.000
28	1.290	0.000	1.300	0.000	1.280	0.000	1.180	0.000	0.930	0.000	0.790	0.000
29	1.270	0.000	1.290	0.000	1.230	0.000	1.000	0.000	0.900	0.000	0.740	0.000
30	1.250	0.000	1.220	0.000			0.920	0.000	0.860	0.000	0.780	0.000
31	1.240	0.000	1.100	0.000			0.900	0.000			0.820	0.000
Ten-Daily Mean												
I Ten-Daily	1.256	0.000	1.064	0.000	1.040	0.000	1.044	0.000	1.094	0.000	0.979	0.000
II Ten-Daily	1.293	0.000	0.996	0.000	1.153	0.000	1.139	0.000	1.048	0.000	0.902	0.000
III Ten-Daily	1.391	0.000	1.261	0.000	1.237	0.000	1.146	0.000	1.055	0.000	0.930	0.000
Monthly												
Min.	1.180	0.000	0.940	0.000	0.900	0.000	0.890	0.000	0.860	0.000	0.740	0.000
Max.	2.270	0.000	1.370	0.000	1.390	0.000	1.400	0.000	1.380	0.000	1.200	0.000
Mean	1.316	0.000	1.112	0.000	1.140	0.000	1.111	0.000	1.066	0.000	0.937	0.000

Peak Computed Discharge = 648.7 cumecs on 22-06-2015 Corres. Water Level :5.30 m
Lowest Computed Discharge = 2.870 cumecs on 01-11-2015 Corres. Water Level :1.47 m

Q: Observed/Computed discharge in cumec WL: Corresponding Mean Water Level (m.s.l) in m * : Computed Discharge
#:Discarded Discharge (values changed as per rating curve)
Note: River remained in pooling/ no flow condition w.e.f. 01/06/15 to 21/06/15 & from 05/11/15 to 31/05/16.

4.3.4 Stage Discharge Curve

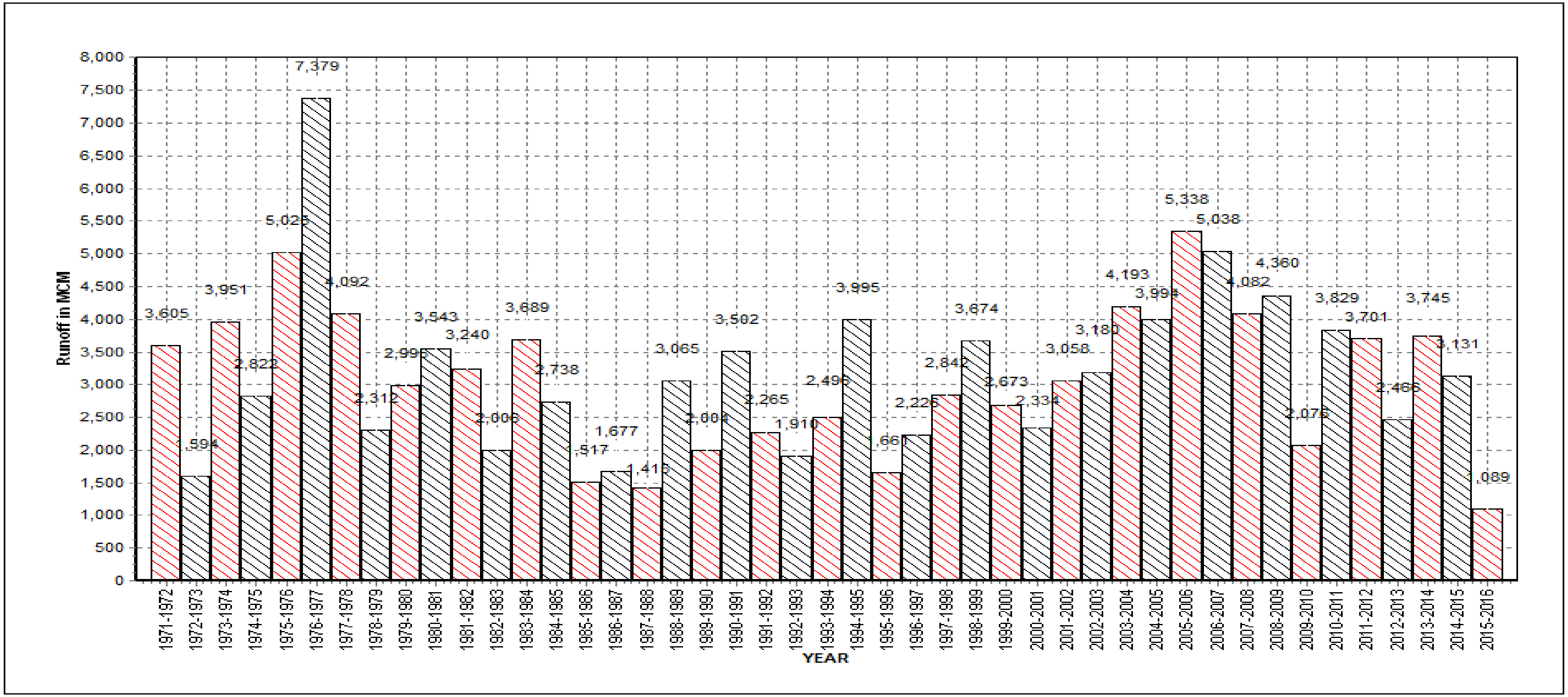
Station Name: Vaitarna at Durvesh (01 02 25 001) Division : Tapi Division Surat Local River: Vaitarna Sub -Division : DGSD, CWC, Silvassa



4.3.5 Annual Runoff

Annual Runoff Values- Runoff Based on period 1971 to 2016

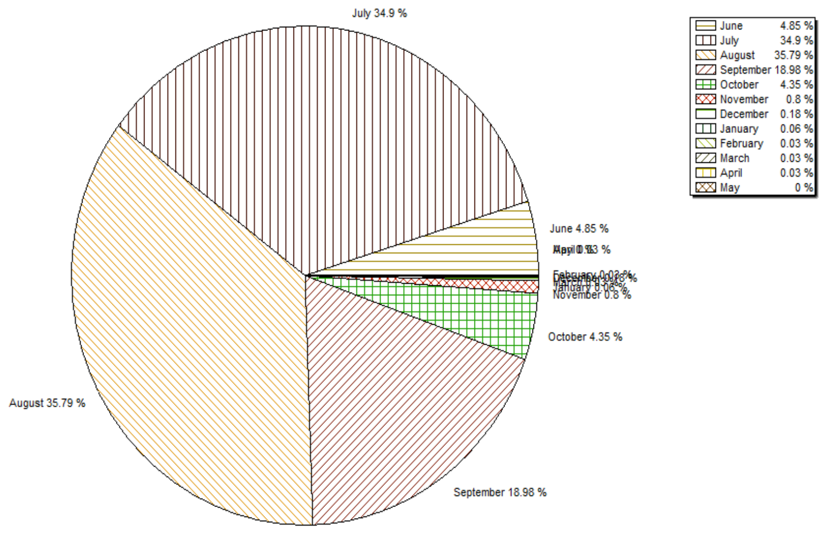
Station Name: Vaitarna at Durvesh (01 02 25 001)   Division : Tapi Division Surat Local River: Vaitrana   Sub -Division : DGSD, CWC, Silvassa



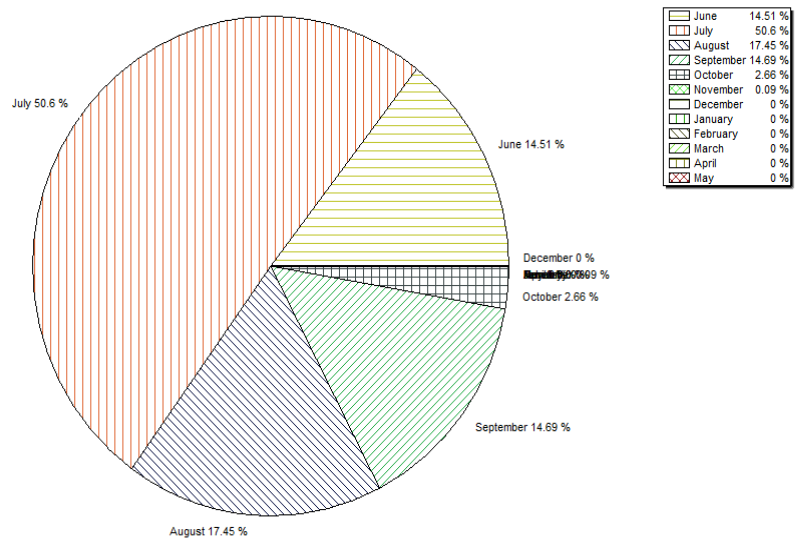
4.3.6 Monthly Average Runoff

Station Name: Vaitarna at Durvesh (01 02 25 001) Division : Tapi Division Surat Local River: Vaitarna Sub -Division : DGSD, CWC, Silvassa

Monthly Average Runoff Based on period: 1971 -2015

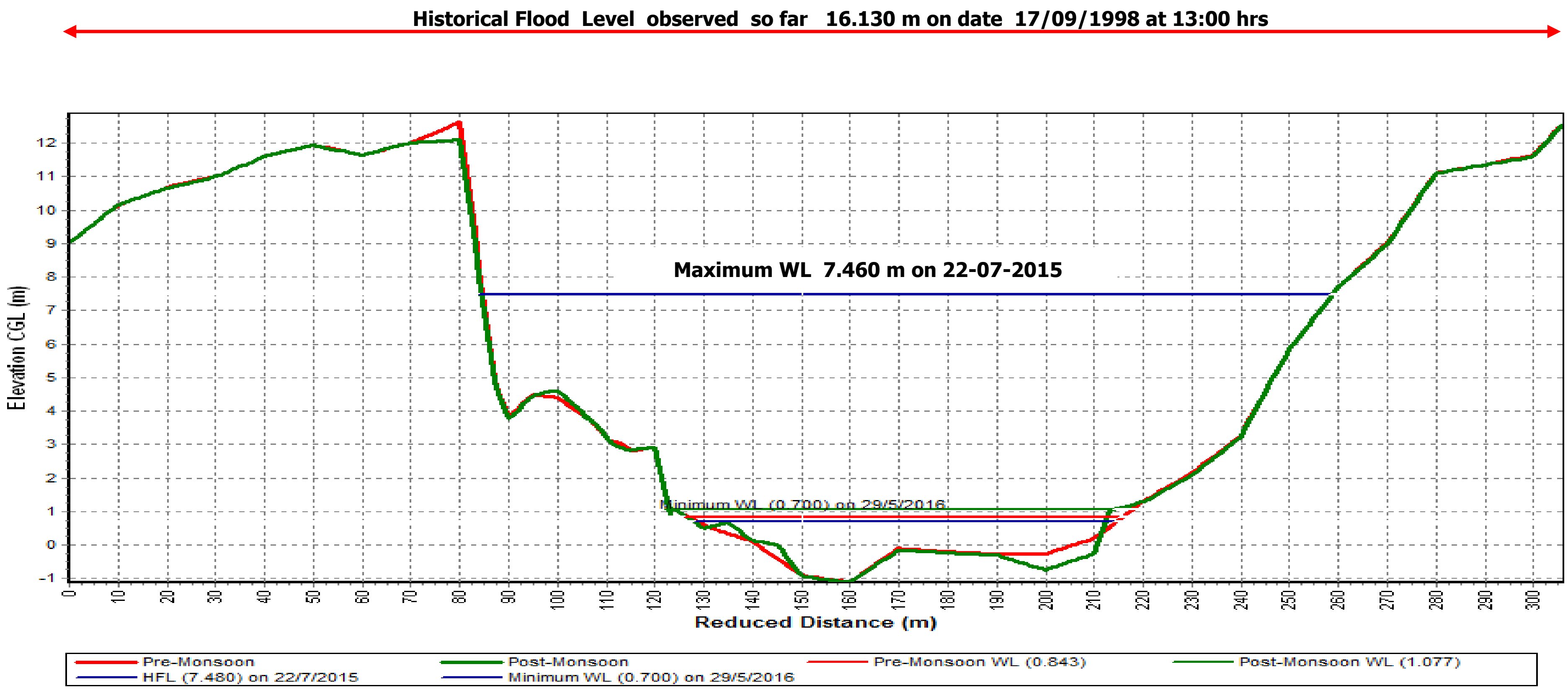


Monthly Average Runoff Based on period: 2015-16



4.3.7 Superimposed Cross section

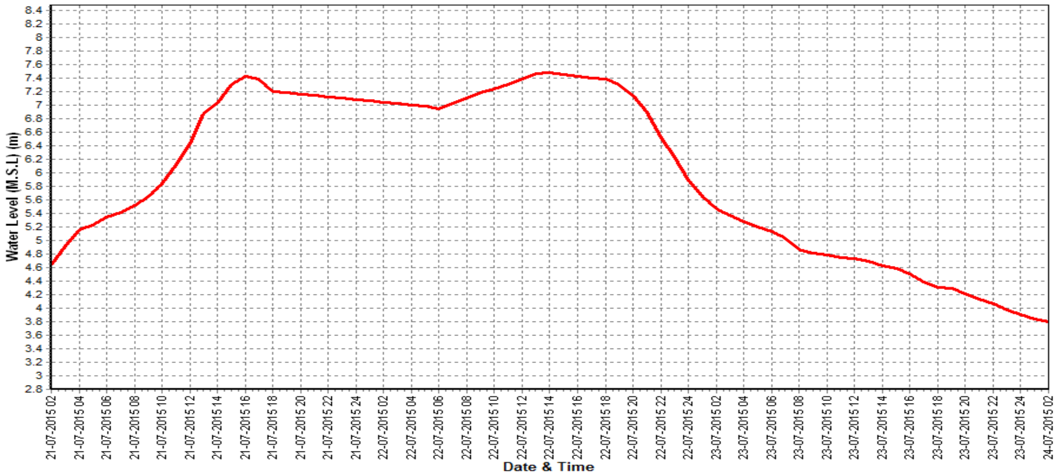
Station Name: Vaitarna at Durvesh (01 02 25 001) Division : Tapi Division Surat Local River: Vaitarna Sub -Division : DGSD, CWC, Silvassa



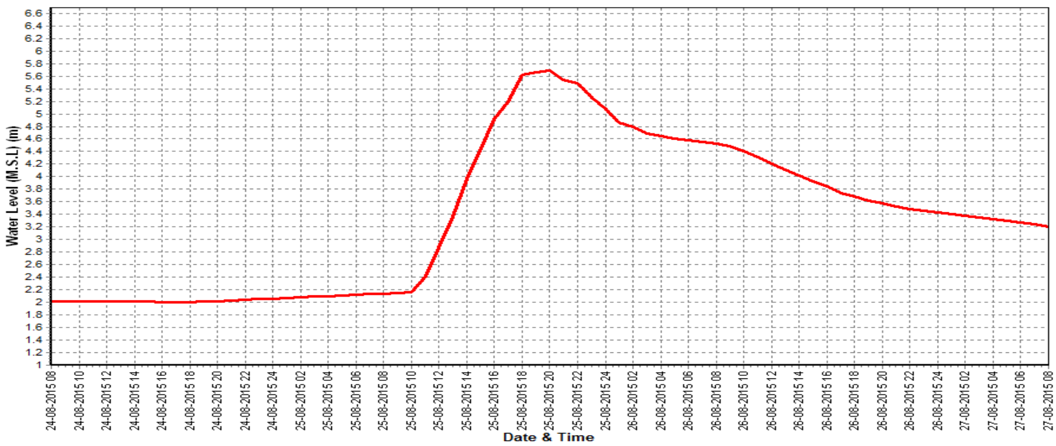
4.3.8 Water Level vs. Time- Graph of Highest Flood Peaks during 2015-16

Station Name: Vaitarna at Durvesh (01 02 25 001) Division : Tapi Division Surat
Local River: Vaitarna Sub -Division : DGSD, CWC, Silvassa

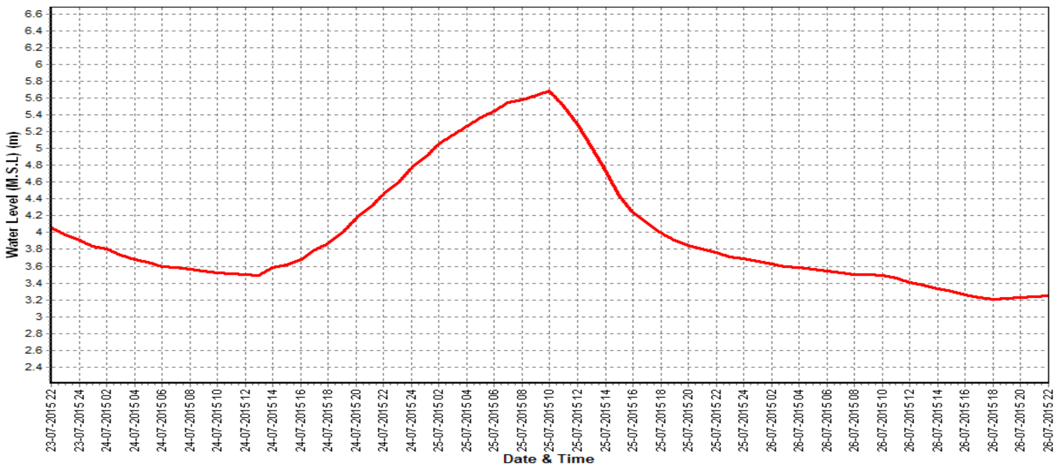
Water level vs. Time graph of I flood peak during the year 2015-16



Water level vs. Time graph of II flood peak during the year 2015-16



Water level vs. Time graph of III flood peak during the year 2015-16



4.4 Dhadhar Basin

4.4.1 History Sheet

HISTORY SHEET

			Water Year	**:**	**2015-16**
Site	**:**	**Pingalwada**	**Code**	**:**	**01 02 14 001**
State	:	Gujarat	District		Vadodara
Basin	:	Narmada	Independent River	:	Dhadhar
Tributary	:	-	Sub Tributary	:	-
Sub-Sub Tributary	:	-	Local River	:	Dhadhar
Division	:	Tapi Dvision, Surat	Sub-Division	:	LNSD Bharuch
Drainage Area	:	2400 Sq. Km.	Bank	:	Right
Latitude	:	22°06’37” N	Longitude	:	73°04’44” E
Zero of Gauge (m)	:	2 (m.s.l)	07/04/1989		
		Opening Date	Closing Date		
Gauge	:	07/04/1989			
Discharge	:	30/06/1989			
Sediment	:				
Water Quality	:	15/03/1990			

Annual Maximum / Minimum discharge with corresponding Water Level (m.s.l)

	Maximum			Minimum		
Year	**Q (cumecs)**	**WL (m)**	**Date**	**Q (cumecs)**	**WL (m)**	**Date**
1989-1990	334.9	10.768	21/08/1989	0.185	4.840	08/05/1990
1990-1991	985.4	18.200	25/08/1990	0.002	5.050	01/04/1991
1991-1992	424.3	13.025	25/07/1991	0.053	5.320	29/05/1992
1992-1993	197.7	10.368	04/09/1992	0.152	5.110	22/01/1993
1993-1994	674.5	15.300	18/07/1993	0.350	5.000	19/03/1994
1994-1995	1056	19.050	09/09/1994	0.280	5.040	12/06/1994
1995-1996	442.0	12.700	23/07/1995	0.650	5.000	30/05/1996
1996-1997	641.7	15.390	30/07/1996	0.500	5.000	25/11/1996
1997-1998	1014	17.400	26/08/1997	0.500	5.120	11/01/1998
1998-1999	602.0	16.835	18/09/1998	0.356	5.120	12/05/1999
1999-2000	23.02	6.500	14/10/1999	0.500	5.040	19/12/1999
2000-2001	503.1	15.425	15/07/2000	0.231	4.980	20/04/2001
2001-2002	418.2	13.500	12/08/2001	0.302	4.990	09/06/2001
2002-2003	427.1	13.700	05/09/2002	0.690	5.050	20/04/2003
2003-2004	839.9	15.710	26/08/2003	0.712	5.060	20/03/2004
2004-2005	681.5	15.260	16/08/2004	0.765	5.070	12/06/2004
2005-2006	807.5	18.450	02/07/2005	0.995	5.180	26/02/2006
2006-2007	759.0	18.245	31/07/2006	0.000	5.000	06/04/2007
2007-2008	586.9	15.250	03/07/2007	2.134	5.050	31/05/2008
2008-2009	682.7	15.750	13/08/2008	1.250	5.110	08/05/2009
2009-2010	21.98	6.745	31/08/2009	0.000	5.090	13/06/2009
2010-2011	655.0	15.850	09/08/2010	0.000	5.210	01/06/2010
2011-2012	250.1	13.200	14/08/2011	0.000	5.370	27/11/2011
2012-2013	148.2	12.090	12/09/2012	0.000	5.230	01/06/2012
2013-2014	593.6	15.700	24/09/2013	0.000	5.200	01/06/2013
2014-2015	301.8	12.500	28/07/2014	2.110	5.040	21/06/2014
2015-2016	40.57	7.270	30/07/2015	1.542	5.300	03/05/2016

4.4.2 Annual Maximum Flood Peak

Year	Annual Maximum flood Peaks (m)	Date	Hour
1989	7.860	01/09/1989	08:00:00
1990	18.870	25/08/1990	16:00:00
1991	13.250	25/07/1991	14:00:00
1992	10.500	04/09/1992	23:00:00
1993	15.300	18/07/1993	08:00:00
1994	19.700	08/09/1994	18:00:00
1995	13.300	22/07/1995	23:00:00
1996	15.750	29/07/1996	23:00:00
1997	17.400	26/08/1997	00:00:00
1998	16.950	18/09/1998	02:00:00
1999	7.000	21/07/1999	17:00:00
2000	15.430	15/07/2000	09:00:00
2001	13.500	11/08/2001	21:00:00
2002	13.850	05/09/2002	17:00:00
2003	15.840	26/08/2003	17:00:00
2004	15.260	15/08/2004	22:00:00
2005	18.450	02/07/2005	17:00:00
2006	18.500	31/07/2006	16:00:00
2007	15.350	02/07/2007	21:00:00
2008	17.700	14/08/2008	07:00:00
2009	7.000	29/08/2009	19:00:00
2010	16.300	09/08/2010	19:00:00
2011	13.200	14/08/2011	07:00:00
2012	12.800	12/09/2012	08:00:00
2013	19.300	26/09/2013	05:00:00
2014	19.400	11/09/2014	18:00:00
2015	7.500	29/07/2015	12:00:00

4.4.3 Summary of Data

Stage discharge data for the period of 2015-16

Station Name: Dhadar at Pingalwada(01 02 14 001) Division : Tapi Division, Surat Local River: Pingalwada Sub -Division : LNSD, CWC, Bharuch

Day	Jun		Jul		Aug		Sep		Oct		Nov	
	W.L	Q	W.L	Q	W.L	Q	W.L	Q	W.L	Q	W.L	Q
1	5.460	2.210	5.700	8.680	6.460	33.53 #	5.560	5.962	5.520	5.270	5.470	7.620 *
2	5.450	2.184	5.650	8.051	6.000	13.62 *	5.540	5.417	5.520	5.250 *	5.480	7.752
3	5.440	2.130	5.600	6.911	5.900	10.82	5.530	5.320	5.510	5.054	5.470	7.591
4	5.450	2.174	5.580	6.244	5.720	8.857	5.540	5.442	5.540	5.560 *	5.470	6.399
5	5.450	2.159	5.560	5.880 *	5.670	8.361	5.550	5.520	5.530	5.230	5.490	7.161
6	5.440	2.112	5.520	5.335	5.650	8.001	5.520	5.250 *	5.510	5.051	5.480	7.023
7	5.440	2.110 *	5.500	4.841	5.670	7.523	5.520	5.155	5.510	5.028	5.480	6.982
8	5.430	2.060	5.500	4.833	5.640	7.833	5.500	4.824	5.510	5.037	5.470	7.620 *
9	5.440	2.116	5.480	4.490	5.600	6.530 *	5.530	5.339	5.500	4.834	5.470	6.796
10	5.430	2.051	5.510	4.928	5.580	6.243	5.550	5.585	5.520	5.241	5.460	6.633
11	5.420	2.005	5.490	4.565	5.560	6.169	5.540	5.432	5.500	4.930 *	5.440	7.230 *
12	5.440	2.157	5.500	4.930 *	5.550	5.906	5.560	5.595	5.500	4.793	5.380	7.785
13	5.450	2.194	5.480	4.481	5.580	6.217	5.540	5.560 *	5.520	5.172	5.360	7.449
14	5.450	2.190 *	5.470	4.394	5.610	7.060	5.520	5.236	5.510	9.644	5.350	7.164
15	5.650	3.876	5.470	4.347	5.630	7.030 *	5.520	5.241	5.520	9.713	5.350	6.090 *
16	5.600	3.651	5.460	4.233	5.620	6.860 *	5.540	5.440	5.500	9.175	5.360	7.392
17	5.800	10.46	5.450	4.036	5.600	6.937	5.530	5.400 *	5.490	8.897	5.360	7.285
18	5.740	9.804	5.450	4.170 *	5.580	6.246	5.520	5.240	5.480	7.750 *	5.350	6.994
19	5.760	9.948	5.470	4.470 *	5.570	6.031	5.645	7.893	5.480	7.804	5.350	6.932
20	5.720	9.418	5.490	4.566	5.560	5.956	5.780	9.600 *	5.490	8.002	5.370	7.591

21	5.680	7.870 *	5.480	4.476	5.580	6.244	5.840	10.67	5.480	7.855	5.370	7.496
22	5.670	8.450	5.540	5.514	5.590	6.328	5.790	9.605	5.470	7.620 *	5.360	6.220 *
23	5.700	8.692	5.800	10.44	5.570	6.040 *	5.720	8.921	5.490	7.971	5.380	7.724
24	5.800	10.45	5.900	10.85	5.560	5.888	5.640	7.867	5.480	7.750 *	5.370	7.377
25	6.000	12.05	5.840	10.60	5.550	5.609	5.600	6.530 *	5.470	7.620 *	5.360	6.220 *
26	6.150	13.33	6.000	13.62 *	5.550	5.602	5.570	5.769	5.470	7.678	5.370	7.347
27	6.000	12.02	6.330	20.08 #	5.540	5.443	5.560	5.880 *	5.490	7.977	5.370	7.262
28	5.900	11.76 *	6.600	25.69 #	5.540	5.415	5.540	5.499	5.480	7.752	5.360	7.263
29	5.800	10.48	7.150	37.81 #	5.530	5.315	5.520	5.245	5.470	6.512	5.350	6.090 *
30	5.740	9.820	7.270	40.57 #	5.520	5.250 *	5.540	5.424	5.470	6.502	5.360	7.263
31			6.960	33.53 #	5.520	5.185			5.480	7.814		
Ten-Daily Mean												
I Ten-Daily	5.443	2.131	5.560	6.020	5.789	11.13	5.534	5.381	5.517	5.155	5.474	7.158
II Ten-Daily	5.603	5.570	5.473	4.419	5.586	6.441	5.569	6.064	5.499	7.588	5.367	7.191
III Ten-Daily	5.844	10.49	6.261	19.38	5.550	5.665	5.632	7.141	5.477	7.550	5.365	7.026
Monthly												
Min.	5.420	2.005	5.450	4.036	5.520	5.185	5.500	4.824	5.470	4.793	5.350	6.090
Max.	6.150	13.33	7.270	40.57	6.460	33.53	5.840	10.67	5.540	9.713	5.490	7.785
Mean	5.630	6.065	5.781	10.24	5.639	7.679	5.579	6.195	5.497	6.79	5.402	7.125

Annual Runoff in MCM = 204 **Annual Runoff in mm = 85**

Peak Observed Discharge = 40.47 cumecs on 30/07/2015 **Corres. Water Level :7.270 m**

Lowest Observed Discharge = 1.542 cumecs on 03/05/2016 **Corres. Water Level :5.300 m**

Q: Observed/Computed discharge in cumec WL: Corresponding Mean Water Level (m.s.l) in m * : Computed Discharge

#:Discarded Discharge (values changed as per rating curve)

Note: Estimation of discharge carried out from 01/06/2015 to 16/05/2015 & 01/5/16 to 31/05/16 by interpolation for non observation days, rest estimation by approved curves.

Stage discharge data for the period of 2015-16

Station Name: Dhadar at Pingalwada (01 02 14 001) Division: Tapi Division, Surat Local River: Pingalwada Sub-Division:LNSD, CWC, Bharuch

Day	Dec		Jan		Feb		Mar		Apr		May	
	W.L	Q	WL	Q	WL	Q	WL	Q	WL	Q	WL	Q
1	5.360	7.285	5.350	5.899	5.340	5.502	5.380	6.636	5.380	6.460	5.350	5.400 *
2	5.370	7.239	5.350	5.865	5.350	5.520	5.370	6.026	5.370	6.289	5.340	4.953
3	5.370	7.222	5.350	6.090 *	5.360	5.861	5.380	6.639	5.370	6.340 *	5.300	1.542
4	5.360	7.209	5.360	6.106	5.370	6.236	5.380	6.611	5.370	6.221	5.690	2.470
5	5.370	7.150	5.360	6.030	5.390	6.853	5.370	5.972	5.390	6.699	5.680	2.353
6	5.360	6.220 *	5.350	5.824	5.380	6.715	5.360	6.220 *	5.370	6.306	5.680	2.337
7	5.360	7.126	5.350	5.790	5.390	6.590 *	5.360	5.754	5.380	6.443	5.670	2.246
8	5.350	6.043	5.340	5.651	5.390	6.756	5.370	5.944	5.380	6.424	5.670	2.250 *
9	5.350	5.968	5.340	5.653	5.380	6.689	5.370	5.896	5.370	6.288	5.680	2.366
10	5.370	6.475	5.360	6.220 *	5.380	6.701	5.380	6.622	5.380	6.470 *	5.670	2.243
11	5.370	6.463	5.350	5.798	5.390	6.727	5.380	6.787	5.380	6.435	5.670	2.239
12	5.360	6.297	5.350	5.791	5.390	6.668	5.370	6.366	5.390	6.650	5.660	2.127
13	5.350	6.090 *	5.340	5.657	5.380	6.636	5.370	6.340 *	5.380	6.450	5.660	2.091
14	5.350	6.107	5.350	6.090 *	5.380	6.470 *	5.360	5.611	5.370	6.340 *	5.670	2.217
15	5.360	6.213	5.350	5.748	5.370	6.319	5.360	5.588	5.370	6.371	5.660	2.090 *
16	5.360	6.089	5.360	6.031	5.370	6.408	5.380	6.519	5.370	6.400	5.650	2.020
17	5.350	6.019	5.350	6.090 *	5.380	6.594	5.380	6.526	5.380	6.470 *	5.500	1.800 *
18	5.350	5.981	5.350	5.899	5.370	6.342	5.370	6.373	5.380	6.484	5.540	1.900 *
19	5.360	6.117	5.340	5.624	5.370	6.273	5.370	6.410	5.380	6.467	5.540	1.900 *
20	5.350	6.090 *	5.340	5.530	5.380	6.571	5.370	6.340 *	5.370	6.340 *	5.540	1.900 *

21	5.350	5.964	5.350	5.565	5.380	6.470 *	5.360	5.510	5.370	6.366	5.550	1.900 *
22	5.350	5.914	5.360	5.830	5.370	6.284	5.360	5.516	5.380	6.510	5.550	1.900 *
23	5.350	5.914	5.350	5.535	5.390	6.697	5.370	5.609	5.380	6.503	5.540	1.900 *
24	5.350	6.090 *	5.360	6.220 *	5.390	6.590 *	5.380	6.470 *	5.370	6.340 *	5.550	1.900 *
25	5.350	6.090 *	5.350	5.534	5.380	6.551	5.390	6.590 *	5.370	6.351	5.540	1.900 *
26	5.360	6.083	5.350	6.090 *	5.370	6.161	5.390	6.760	5.360	5.888	5.600	2.000 *
27	5.350	6.090 *	5.340	5.463	5.370	6.102	5.380	6.470 *	5.360	5.800	5.600	2.000 *
28	5.370	6.389	5.340	5.410	5.380	6.470 *	5.380	6.500	5.370	5.981	5.590	1.950 *
29	5.370	6.400	5.360	5.675	5.380	6.549	5.380	6.474	5.360	5.567	5.580	1.950 *
30	5.360	6.209	5.350	5.497			5.370	6.352	5.360	5.499	5.590	1.950 *
31	5.360	6.181	5.340	5.970 *			5.370	6.315			5.580	1.950 *
Ten-Daily Mean												
I Ten-Daily	5.362	6.794	5.351	5.913	5.373	6.342	5.372	6.232	5.376	6.394	5.573	2.816
II Ten-Daily	5.356	6.146	5.348	5.826	5.378	6.501	5.371	6.286	5.377	6.441	5.609	2.028
III Ten-Daily	5.356	6.120	5.350	5.708	5.379	6.431	5.375	6.233	5.368	6.081	5.570	1.936
Monthly												
Min.	5.350	5.914	5.340	5.410	5.340	5.502	5.360	5.510	5.360	5.499	5.300	1.542
Max.	5.370	7.285	5.360	6.220	5.390	6.853	5.390	6.787	5.390	6.699	5.690	5.400
Mean	5.358	6.346	5.350	5.812	5.377	6.424	5.373	6.25	5.374	6.305	5.584	2.25

Peak Computed Discharge = 13.62 cumecs on 26/07/2015 Corres. Water Level :6.00 m

Lowest Computed Discharge = 1.800 cumecs on 17/05/2016 Corres. Water Level :5.50 m

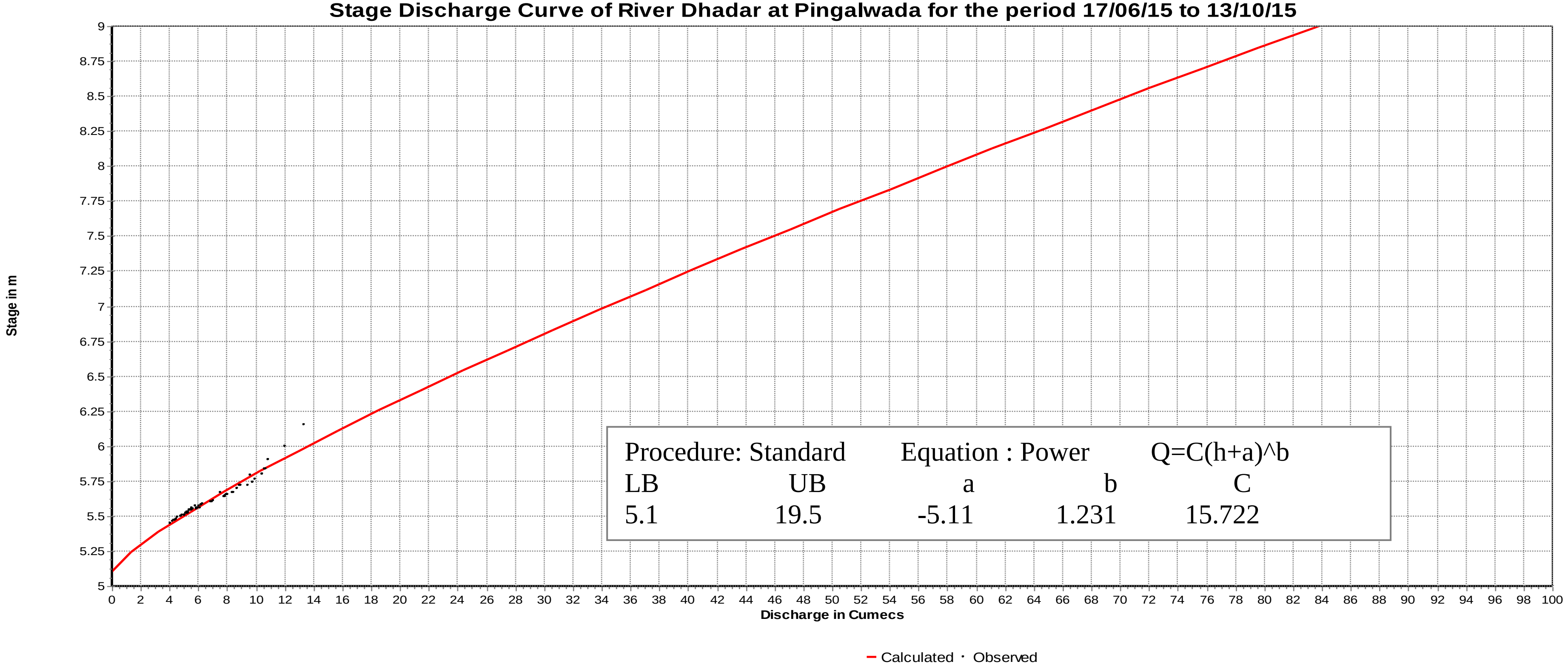
Q: Observed/Computed discharge in cumec WL: Corresponding Mean Water Level (m.s.l) in m * : Computed Discharge

#:Discarded Discharge (values changed as per rating curve)

Note: Estimation of discharge carried out from 01/06/2015 to 16/05/2015 & 01/5/16 to 31/05/16 by interpolation, for non observation days, rest estimation by approved curves.

4.4.4 Stage Discharge curve

Station Name: Dhadar at Pingalwada(01 02 14 001) Division : Tapi Division, Surat Local River: Pingalwada Sub -Division : LNSD, CWC, Bharuch



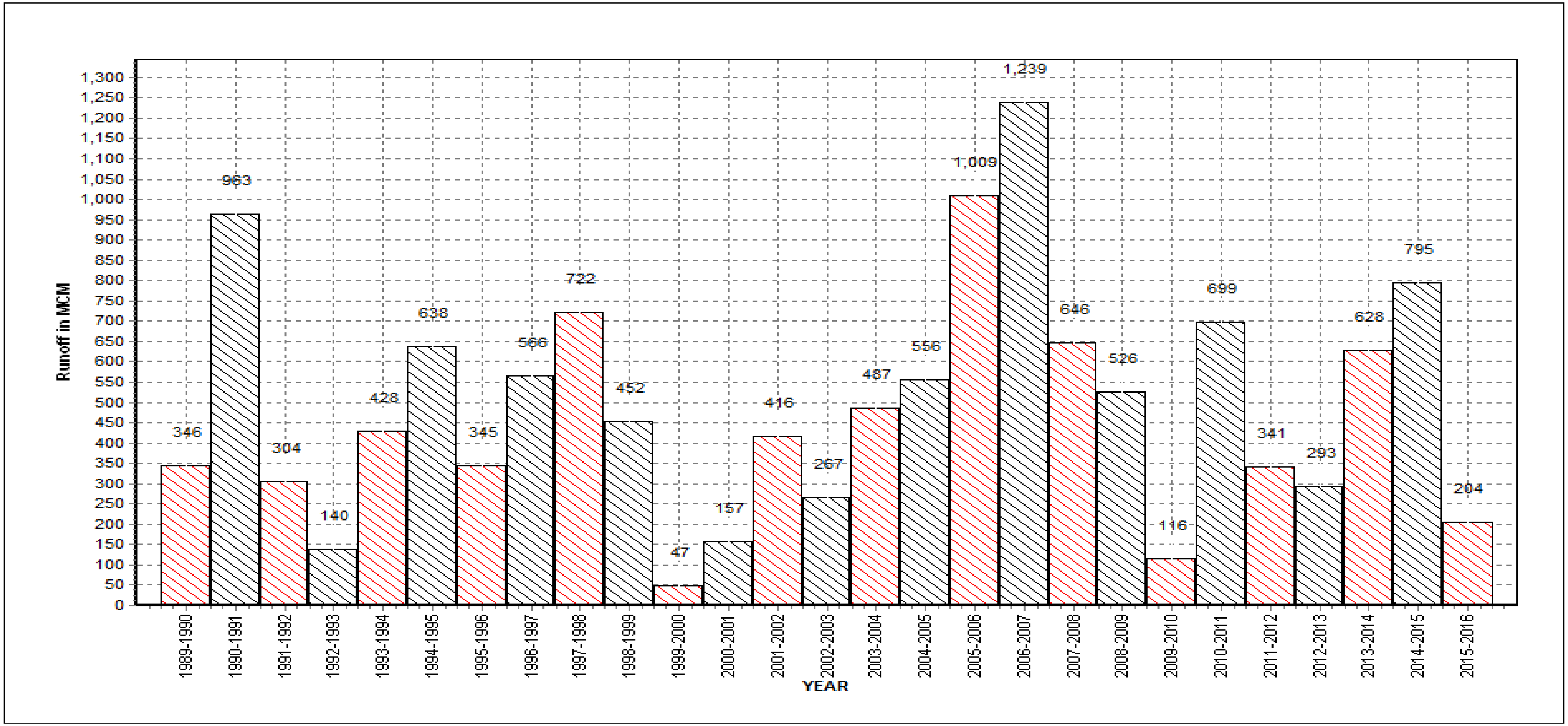
Equation of stage discharge curve for the period 14/10/15 to 30/04/16

Procedure: Standard		Equation : Power		Q=C(h+a)^b
LB	UB	a	b	C
5.1	8.0	-4.62	1.4698	9.678

4.4.5 Annual Runoff

Annual Runoff Values Runoff Based on period: 1989-2016

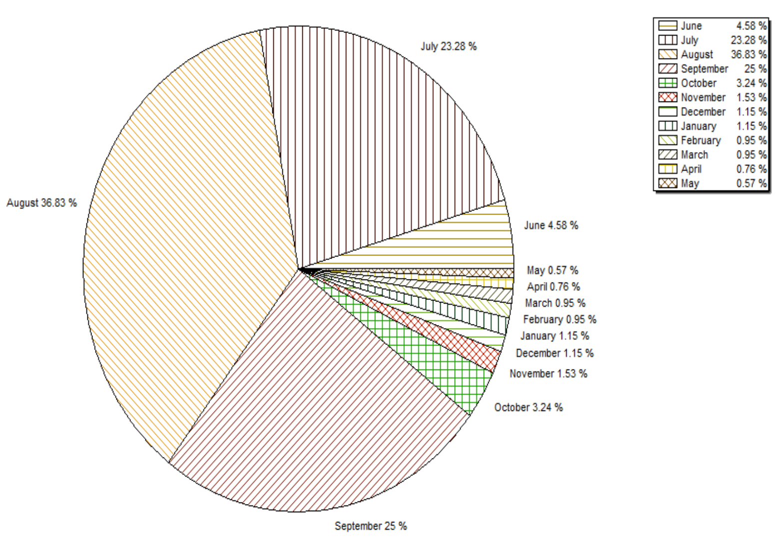
Station Name: Dhadhar at Pingalwada (01 02 14 001) Division : Tapi Division, Surat Local River: Pingalwada Sub -Division : LNSD, CWC, Bharuch



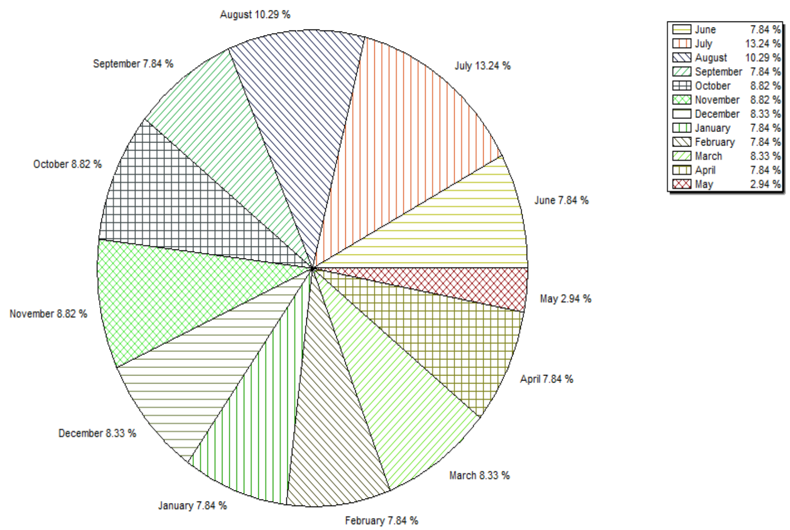
4.4.6 Monthly Average Runoff

Station Name: Dhadar at Pingalwada(01 02 14 001) Division : Tapi Division, Surat Local River: Pingalwada Sub -Division : LNSD, CWC, Bharuch

Monthly Average Runoff Based on period: 1989-2015



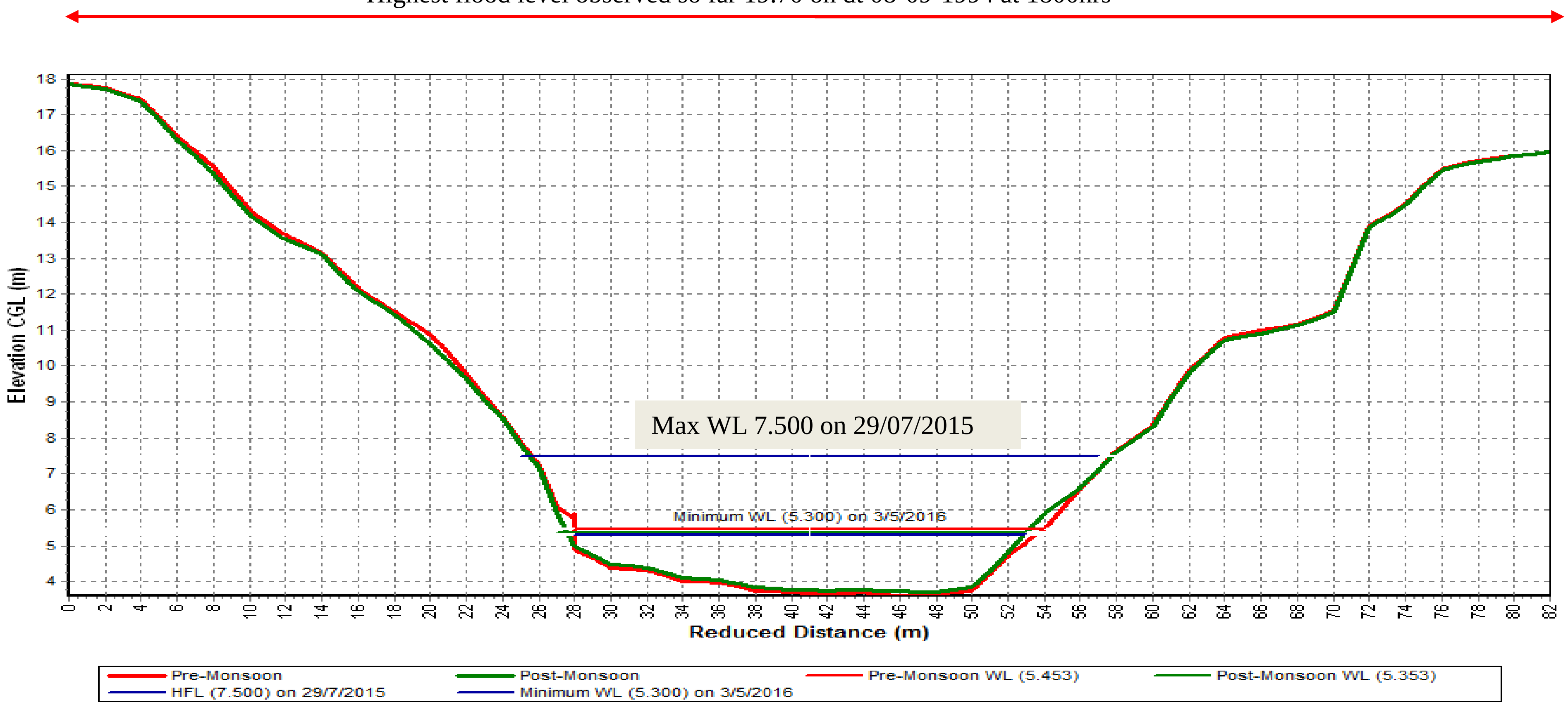
Monthly Average Runoff Based on period: 2015-2016



4.4.7 Superimposed Cross section

Station Name: Dhadar at Pingalwada (01 02 14 001) Division : Tapi Division, Surat Local River: Pingalwada Sub -Division : LNSD, CWC, Bharuch

Highest flood level observed so far 19.70 on dt 08-09-1994 at 1800hrs

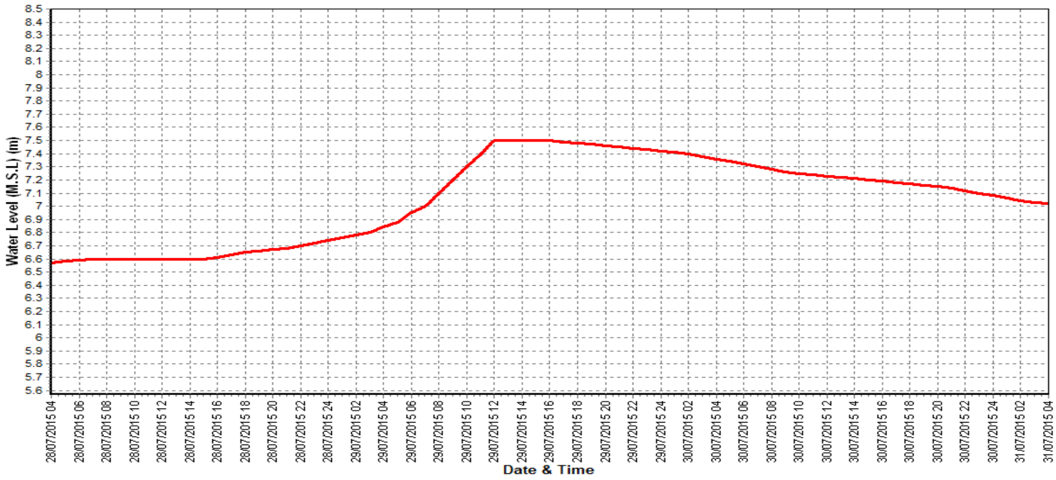


4.4.8 Water Level vs. Time- Graph of Highest Flood Peaks during 2015-16

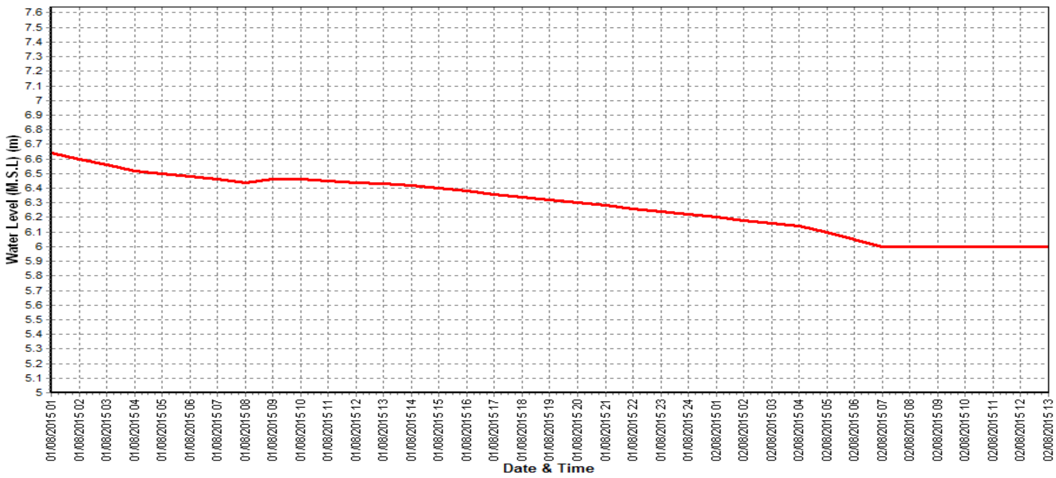
Station Name: Dhadar at Pingalwada
Local River: Pingalwada

Division : Tapi Division, Surat
Sub -Division : LNSD, CWC, Bharuch

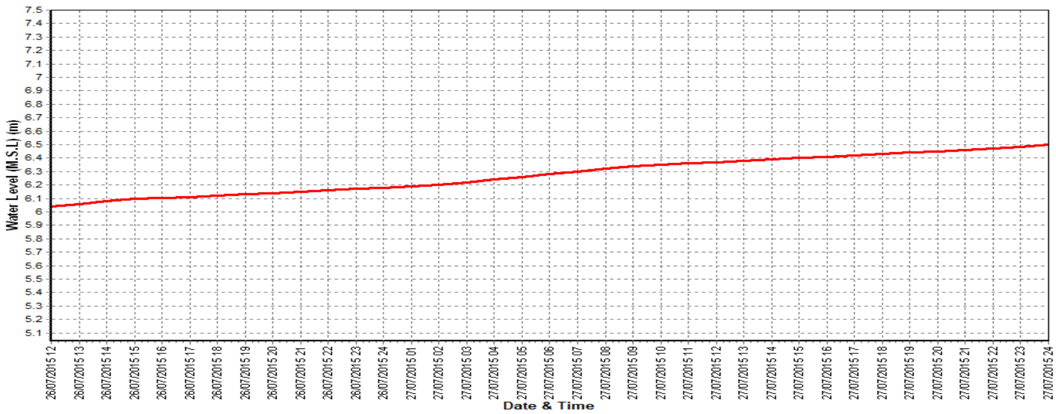
Water level vs. Time graph of I flood peak during the year 2015-16



Water level vs. Time graph of II flood peak during the year 2015-16



Water level vs. Time graph of III flood peak during the year 2015-16



4.5 Wagh Basin

4.5.1.1 History Sheet

HISTORY SHEET

			Water Year	**:**	**2015-16**
Site	**:**	**Wagh at Ozerkheda**	**Code**	**:**	**01 02 24 002**
State	:	Maharashtra	District		Nashik
Basin	:	WFR South of Tapi	Independent River	:	Daman Ganga
Tributary	:	Wagh	Sub Tributary	:	
Sub-Sub Tributary	:		Local River	:	
Division	:	Tapi Division, Surat	Sub-Division	:	DGSD,CWC,Silvassa
Drainage Area	:	640 Sq. Km.	Bank	:	
Latitude	:	20°06'01"	Longitude	:	73°16'16"
Zero of Gauge (m)	:	80.1 (m.s.l)	15/06/1983		
		Opening Date	Closing Date		
Gauge	:	28/06/1983			
Discharge	:	01/06/1984 Seasonal			
		01/06/1991 (Regular)			

Annual Maximum / Minimum discharge with corresponding Water Level (m.s.l)

	Maximum			Minimum		
Year	**Q (cumecs)**	**WL (m)**	**Date**	**Q (cumecs)**	**WL (m)**	**Date**
1991-1992	878.8	86.950	27/07/1991	0.000	81.400	17/05/1992
1992-1993	770.9	86.285	12/08/1992	0.000	81.080	22/05/1993
1993-1994	1117	87.100	13/07/1993	0.000	80.980	18/05/1994
1994-1995	1306	88.300	13/07/1994	0.000	81.340	10/02/1995
1995-1996	650.0	85.450	03/09/1995	0.000	80.610	04/03/1996
1996-1997	264.0	84.430	24/07/1996	0.000	80.410	04/02/1997
1997-1998	635.5	86.330	31/07/1997	0.000	80.860	18/03/1998
1998-1999	477.9	85.700	17/09/1998	0.000	80.650	05/05/1999
1999-2000	1144	87.175	16/07/1999	0.000	81.070	14/04/2000
2000-2001	774.8	85.750	13/07/2000	0.000	81.460	22/05/2001
2001-2002	284.0	84.620	16/08/2001	0.000	81.190	05/05/2002
2002-2003	1414	88.050	29/06/2002	0.000	81.110	07/05/2003
2003-2004	1145	87.200	28/07/2003	0.000	81.330	15/02/2004
2004-2005	2700	90.390	03/08/2004	0.000	81.670	20/04/2005
2005-2006	1660	88.550	29/06/2005	0.000	81.140	20/02/2006
2006-2007	1080	86.740	08/08/2006	0.042	81.210	13/01/2007
2007-2008	934.6	86.690	09/08/2007	0.100	81.130	09/01/2008
2008-2009	1421	87.855	12/08/2008	0.072	81.140	15/12/2008
2009-2010	1687	88.595	23/07/2009	0.000	81.090	01/06/2009
2010-2011	578.7	85.320	23/07/2010	0.000	81.080	01/06/2010
2011-2012	1289	87.200	29/08/2011	0.000	81.260	02/12/2011
2012-2013	1365	85.950	11/09/2012	0.000	81.140	01/06/2012
2013-2014	577.1	85.550	12/07/2013	0.000	81.300	01/06/2013
2014-2015	1267.0	87.100	31/07/2014	5.363	81.450	09/07/2014
2015-2016	251.7	84.000	28/07/2015	9.730	81.735	15/06/2015

4.5.1.2 Annual Maximum Flood Peak

Year	Annual Maximum flood Peaks (m)	**Date**	**Hour**
1991	87.400	17/07/1991	11:00:00
1992	86.600	12/08/1992	13:00:00
1993	89.700	13/07/1993	16:00:00
1994	88.400	13/07/1994	07:00:00
1995	86.230	02/09/1995	16:00:00
1996	85.720	27/08/1996	19:00:00
1997	89.650	31/07/1997	18:00:00
1998	85.900	17/09/1998	09:00:00
1999	87.350	16/07/1999	07:00:00
2000	85.980	13/07/2000	18:00:00
2001	84.660	16/08/2001	12:00:00
2002	89.200	29/06/2002	13:00:00
2003	87.320	27/07/2003	12:00:00
2004	96.100	04/08/2004	01:00:00
2005	90.000	29/06/2005	05:00:00
2006	87.100	10/08/2006	16:00:00
2007	87.680	08/08/2007	16:00:00
2008	91.000	11/08/2008	17:00:00
2009	88.700	23/07/2009	09:00:00
2010	85.320	23/07/2010	08:00:00
2011	89.500	28/08/2011	16:00:00
2012	86.700	11/09/2012	12:00:00
2013	86.950	01/08/2013	11:00:00
2014	88.45	30/07/2014	20:00:00
2015	84.30	28/07/2015	18:00:00

4.5.1.3 Summary of Data

Stage Discharge Data for The period 2015-16

Station Name: Wagh at Ozerkheda (01 02 24 002) Division: Tapi Division, Surat Local River: Wagh Sub -Division: DGSD, CWC, Silvasssa

Day	Jun		Jul		Aug		Sep		Oct		Nov	
	W.L	Q	W.L	Q	W.L	Q	W.L	Q	W.L	Q	W.L	Q
1	81.500	7.340 *	81.950	27.93	83.100	96.80	82.260	43.83	82.220	36.99	81.770	14.97 *
2	81.500	7.340 *	81.800	20.43	82.800	80.74 *	82.200	36.37	82.180	33.52 *	81.760	14.63 *
3	81.490	7.120 *	81.800	21.32	82.400	45.42	82.060	24.80	82.160	34.08	81.760	14.63 *
4	81.490	7.120 *	81.750	12.36	82.250	42.70	82.040	23.81	82.250	37.63 *	81.760	14.63 *
5	81.490	7.120 *	81.740	13.96 *	82.200	36.39	82.020	23.71	82.310	44.47	81.760	14.63 *
6	81.490	7.120 *	81.740	11.18	82.200	36.35	82.000	24.26 *	82.280	39.48 *	81.760	14.63 *
7	81.490	7.120 *	81.700	11.73	82.300	45.80	81.980	23.49	82.250	41.90	81.760	14.63 *
8	81.490	7.120 *	81.700	11.78	82.200	36.22	81.970	23.34	82.230	38.85	81.760	14.63 *
9	81.490	7.120 *	81.700	11.94	82.220	34.66 *	81.950	23.07	82.200	36.01	81.760	14.63 *
10	81.490	7.120 *	81.700	12.67 *	82.000	30.69	81.940	20.70	82.180	34.39	81.750	14.29 *
11	81.500	7.340 *	81.700	11.70	81.940	25.46	82.030	23.74	82.150	31.85 *	81.750	14.29 *
12	81.500	7.340 *	81.700	12.67 *	82.000	30.78	82.040	24.12	82.145	29.84	81.750	14.29 *
13	81.600	9.780 *	81.690	11.83	81.980	28.92	81.970	22.89 *	82.120	29.41	81.750	14.29 *
14	81.600	9.780 *	81.690	11.14	81.970	29.25	82.050	23.43	82.100	29.68	81.750	14.29 *
15	81.735	9.730	81.690	11.78	81.990	23.80 *	82.050	26.20	82.050	25.00	81.750	14.29 *
16	81.800	22.36	81.680	11.75	82.100	29.18 *	82.020	24.31	82.000	23.48	81.750	14.29 *
17	81.800	20.41	81.680	12.95	82.150	34.50	82.000	24.26 *	81.960	23.65	81.740	13.96 *
18	81.700	11.34	81.690	12.36 *	82.130	31.91	81.990	23.89	81.920	20.71 *	81.740	13.96 *
19	81.700	11.32	81.700	12.67 *	82.100	31.33	83.300	151.2	81.880	21.66	81.740	13.96 *
20	81.700	11.36	81.775	12.42	82.080	25.42	83.100	113.2 *	81.840	18.09	81.740	13.96 *

21	81.600	9.780 *	83.250	106.2	82.070	25.13	82.925	86.95	81.840	18.02	81.740	13.96 *
22	82.100	27.71	83.875	240.6	82.060	24.89	82.800	85.24	81.840	17.51 *	81.740	13.96 *
23	82.950	92.23	83.700	204.0	82.050	26.65 *	82.600	64.94	81.830	17.74	81.740	13.96 *
24	82.890	81.74	83.150	104.4	82.030	23.85	82.500	50.09	81.820	16.76 *	81.740	13.96 *
25	84.000	243.3	83.200	101.0	82.380	50.91	82.400	47.43 *	81.820	16.76 *	81.740	13.96 *
26	83.350	155.5	83.000	101.6 *	83.135	109.2	82.300	44.19	81.810	16.77	81.740	13.96 *
27	82.500	52.67	83.100	93.75	82.550	54.43	82.270	38.85 *	81.800	13.29	81.740	13.96 *
28	82.300	40.74 *	84.000	251.7	82.450	56.50	82.250	42.96	81.790	12.91	81.740	13.96 *
29	82.100	25.78	83.850	237.9	82.350	53.16	82.245	39.45	81.780	12.66	81.740	13.96 *
30	82.000	30.58	83.750	212.1	82.330	42.68 *	82.230	39.16	81.780	12.66	81.740	13.96 *
31			83.500	158.9	82.300	46.63			81.770	12.16		
Ten-Daily Mean												
I Ten-Daily	81.492	7.164	81.758	15.53	82.367	48.58	82.042	26.74	82.226	37.73	81.760	14.63
II Ten-Daily	81.663	12.08	81.700	12.13	82.044	29.06	82.255	45.72	82.017	25.34	81.746	14.16
III Ten-Daily	82.579	76.01	83.489	164.7	82.337	46.73	82.452	53.93	81.807	15.20	81.740	13.96
Monthly												
Min.	81.490	7.120	81.680	11.14	81.940	23.80	81.940	20.70	81.770	12.16	81.740	13.96
Max.	84.000	243.3	84.000	251.7	83.135	109.2	83.300	151.2	82.310	44.47	81.770	14.97
Mean	81.911	31.75	82.353	67.38	82.252	41.62	82.250	42.13	82.010	25.74	81.749	14.25

Annual Runoff in MCM = 700 **Annual Runoff in mm 1093**
Peak Observed Discharge = 251.7 cumecs on 28/07/2015 **Corres. Water Level :84.000 m**
Lowest Observed Discharge = 9.730 cumecs on 15/06/2015 **Corres. Water Level :81.735 m**

Q: Observed/Computed discharge in cumec WL: Corresponding Mean Water Level (m.s.l) in m * : Computed Discharge
#:Discarded Discharge (values changed as per rating curve)
Note: Estimation of discharge carried out from 01/11/2015 to 31/05/2016 . Q not observed due to shortage of staff.

Stage Discharge Data for the period 2015-16

Station Name: Wagh at Ozerkheda (01 02 24 002) Division : Tapi Division, Surat Local River: Wagh Sub -Division : DGSD, CWC, Silvasa

Day	Dec			Jan			Feb			Mar			Apr			May		
	W.L	Q		WL	Q		WL	Q		WL	Q		WL	Q		WL	Q	
1	81.730	13.63	*	81.680	12.06	*	81.500	7.340	*	81.410	5.500	*	81.360	4.610	*	81.290	3.530	*
2	81.730	13.63	*	81.680	12.06	*	81.500	7.340	*	81.410	5.500	*	81.350	4.440	*	81.290	3.530	*
3	81.730	13.63	*	81.680	12.06	*	81.480	6.900	*	81.410	5.500	*	81.350	4.440	*	81.280	3.385	*
4	81.730	13.63	*	81.680	12.06	*	81.480	6.900	*	81.410	5.500	*	81.350	4.440	*	81.280	3.385	*
5	81.730	13.63	*	81.680	12.06	*	81.480	6.900	*	81.410	5.500	*	81.340	4.280	*	81.280	3.385	*
6	81.730	13.63	*	81.680	12.06	*	81.470	6.690	*	81.410	5.500	*	81.340	4.280	*	81.280	3.385	*
7	81.720	13.30	*	81.680	12.06	*	81.470	6.690	*	81.400	5.310	*	81.340	4.280	*	81.280	3.385	*
8	81.720	13.30	*	81.670	11.76	*	81.470	6.690	*	81.400	5.310	*	81.340	4.280	*	81.280	3.385	*
9	81.720	13.30	*	81.670	11.76	*	81.470	6.690	*	81.400	5.310	*	81.340	4.280	*	81.270	3.250	*
10	81.720	13.30	*	81.670	11.76	*	81.470	6.690	*	81.400	5.310	*	81.340	4.280	*	81.270	3.250	*
11	81.720	13.30	*	81.670	11.76	*	81.470	6.690	*	81.400	5.310	*	81.340	4.280	*	81.270	3.250	*
12	81.720	13.30	*	81.660	11.46	*	81.460	6.480	*	81.390	5.130	*	81.330	4.280	*	81.270	3.250	*
13	81.710	12.99	*	81.660	11.46	*	81.460	6.480	*	81.390	5.130	*	81.330	4.120	*	81.260	3.110	*
14	81.710	12.99	*	81.660	11.46	*	81.460	6.480	*	81.390	5.130	*	81.330	4.120	*	81.260	3.110	*
15	81.710	12.99	*	81.660	11.46	*	81.460	6.480	*	81.390	5.130	*	81.320	4.120	*	81.260	3.110	*
16	81.710	12.99	*	81.660	11.46	*	81.460	6.480	*	81.390	5.130	*	81.320	3.970	*	81.260	3.110	*
17	81.710	12.99	*	81.660	11.46	*	81.450	6.275	*	81.380	4.950	*	81.320	3.970	*	81.250	2.980	*
18	81.700	12.67	*	81.650	11.17	*	81.450	6.275	*	81.380	4.950	*	81.320	3.970	*	81.250	2.980	*
19	81.700	12.67	*	81.580	9.260	*	81.450	6.275	*	81.380	4.950	*	81.320	3.970	*	81.240	2.860	*
20	81.700	12.67	*	81.570	9.005	*	81.440	6.075	*	81.380	4.950	*	81.320	3.970	*	81.240	2.860	*

21	81.700	12.67	*	81.570	9.005	*	81.440	6.075	*	81.380	4.950	*	81.300	3.670	*	81.240	2.860	*
22	81.700	12.67	*	81.570	9.005	*	81.440	6.075	*	81.380	4.950	*	81.300	3.670	*	81.240	2.860	*
23	81.690	12.36	*	81.550	8.510	*	81.430	5.880	*	81.370	4.780	*	81.300	3.670	*	81.230	2.730	*
24	81.690	12.36	*	81.550	8.510	*	81.430	5.880	*	81.370	4.780	*	81.300	3.670	*	81.230	2.730	*
25	81.690	12.36	*	81.530	8.030	*	81.430	5.880	*	81.370	4.780	*	81.300	3.670	*	81.230	2.730	*
26	81.690	12.36	*	81.530	8.030	*	81.420	5.685	*	81.370	4.780	*	81.300	3.670	*	81.230	2.730	*
27	81.690	12.36	*	81.530	8.030	*	81.420	5.685	*	81.370	4.780	*	81.300	3.670	*	81.230	2.730	*
28	81.690	12.36	*	81.510	7.565	*	81.420	5.685	*	81.370	4.780	*	81.290	3.530	*	81.220	2.610	*
29	81.690	12.36	*	81.510	7.565	*	81.420	5.685	*	81.360	4.610	*	81.290	3.530	*	81.220	2.610	*
30	81.690	12.36	*	81.500	7.340	*				81.360	4.610	*	81.290	3.530	*	81.220	2.610	*
31	81.690	12.36	*	81.500	7.340	*				81.360	4.610	*				81.220	2.610	*
Ten-Daily Mean																		
I Ten-Daily	81.726	13.50		81.677	11.97		81.479	6.883		81.406	5.424		81.345	4.361		81.280	3.387	
II Ten-Daily	81.709	12.96		81.643	11.00		81.456	6.399		81.387	5.076		81.325	4.077		81.256	3.062	
III Ten-Daily	81.692	12.42		81.532	8.085		81.428	5.837		81.369	4.765		81.297	3.628		81.228	2.710	
Monthly																		
Min.	81.690	12.36		81.500	7.340		81.420	5.685		81.360	4.610		81.290	3.530		81.220	2.610	
Max.	81.730	13.63		81.680	12.06		81.500	7.340		81.410	5.500		81.360	4.610		81.290	3.530	
Mean	81.708	12.94		81.615	10.28		81.455	6.391		81.387	5.078		81.322	4.022		81.254	3.042	

Peak Computed Discharge = 113.2 cumecs on 20/09/2015 **Corres. Water Level :83.100 m**

Lowest Computed Discharge = 2.610 cumecs on 28/05/2016 **Corres. Water Level :81.220 m**

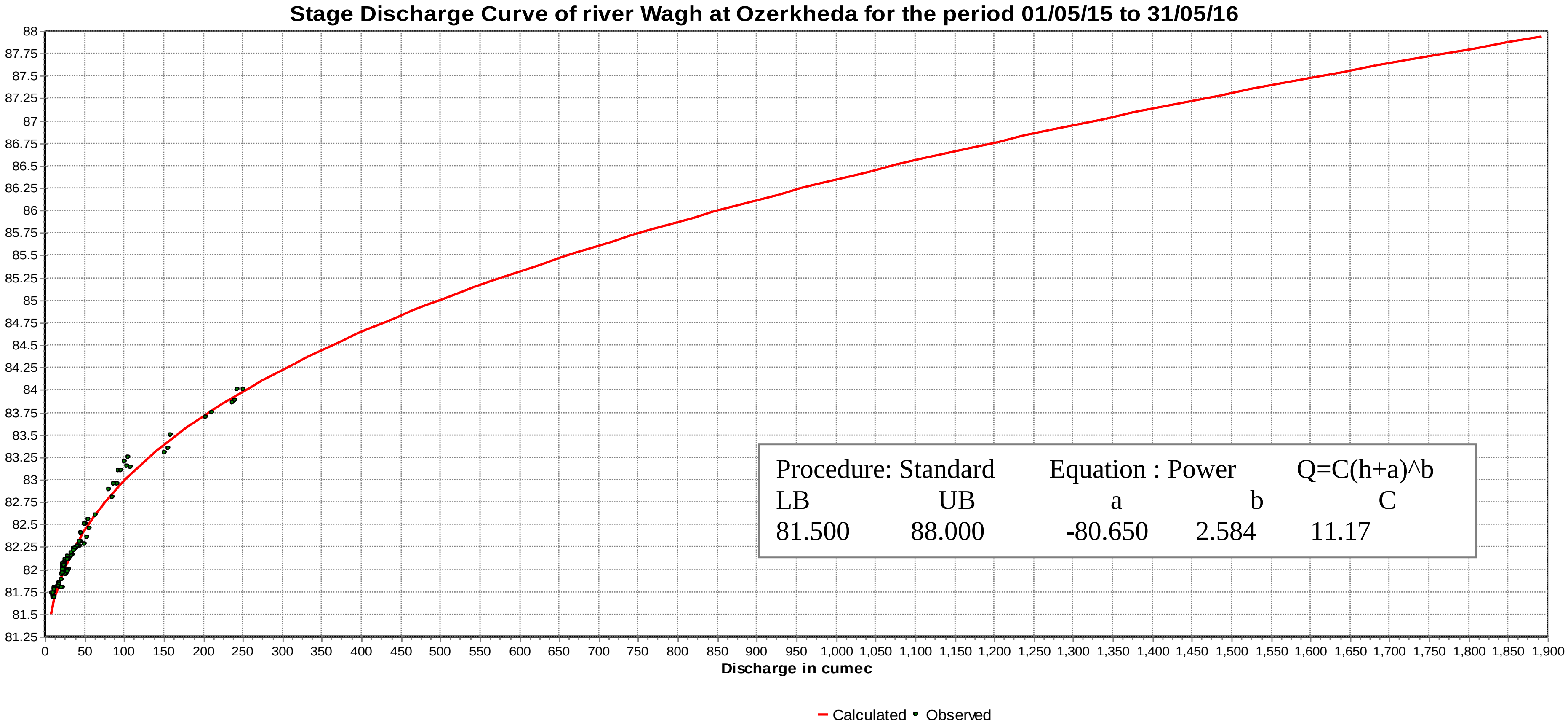
Q: Observed/Computed discharge in cumec WL: Corresponding Mean Water Level (m.s.l) in m * : Computed Discharge

#:Discarded Discharge (values changed as per rating curve)

Note: Estimation of discharge carried out from 01/11/2015 to 31/05/2016. Q not observed due to shortage of staff.

4.5.1.4 Stage Discharge Curve

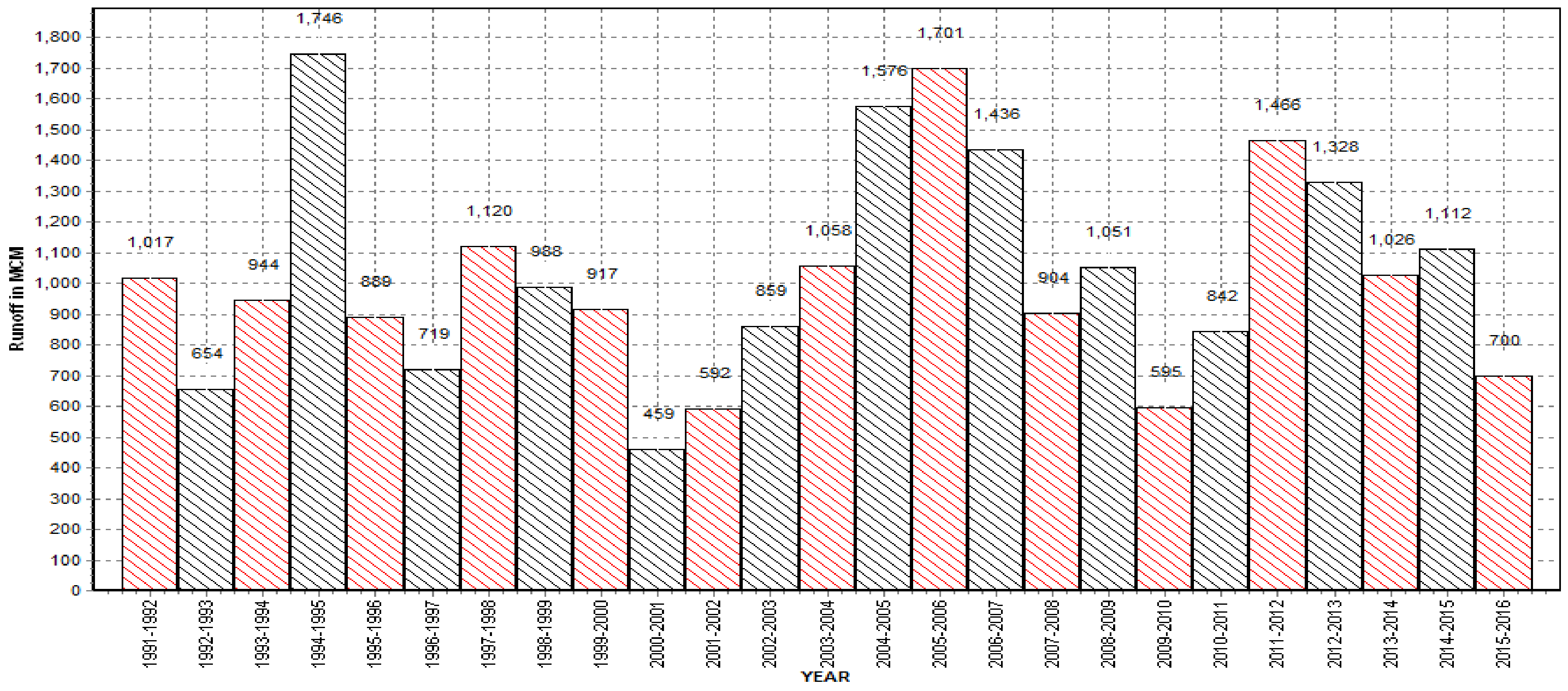
Station Name: Wagh at Ozerkheda (01 02 24 002) Division: Tapi Division, Surat Local River: Wagh Sub -Division: DGSD, CWC, Silvasssa



4.5.1.5 Annual Runoff

Annual Runoff Values Runoff Based on period 1991-2016

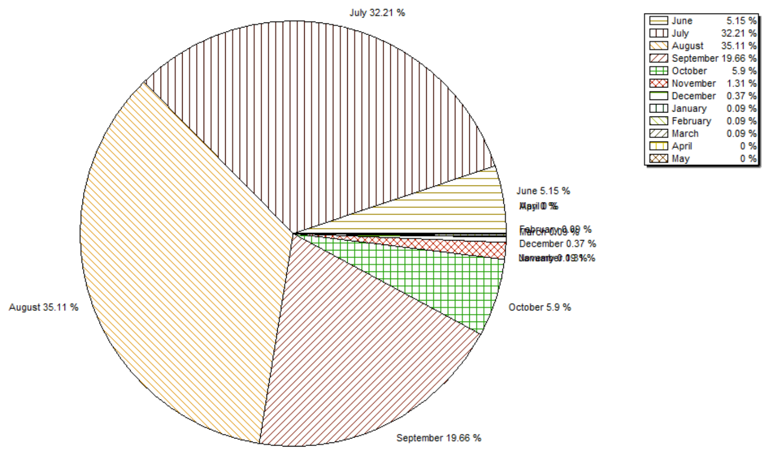
Station Name: Wagh at Ozerkheda (01 02 24 002) Division: Tapi Division, Surat Local River: Wagh Sub -Division: DGSD, CWC, Silvasssa



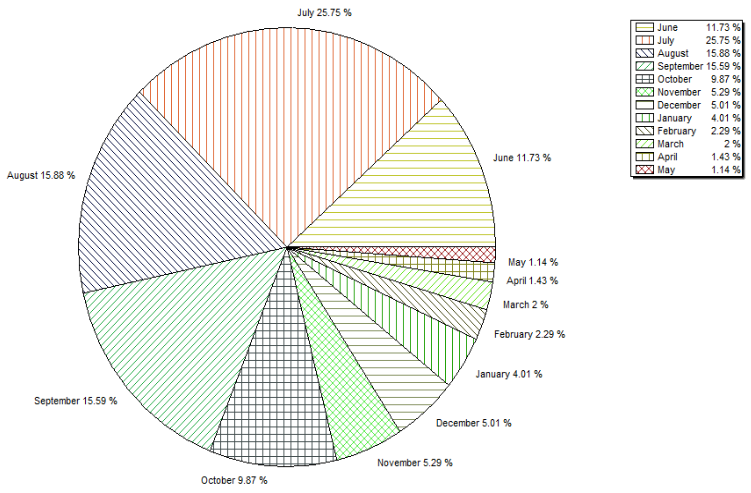
4.5.1.6 Monthly Average Runoff

Station Name: Wagh at Ozerkheda (01 02 24 002) Division: Tapi Division, Surat Local River: Wagh Sub -Division: DGSD, CWC, Silvasa

Monthly Average Runoff Based on period 1991-2015



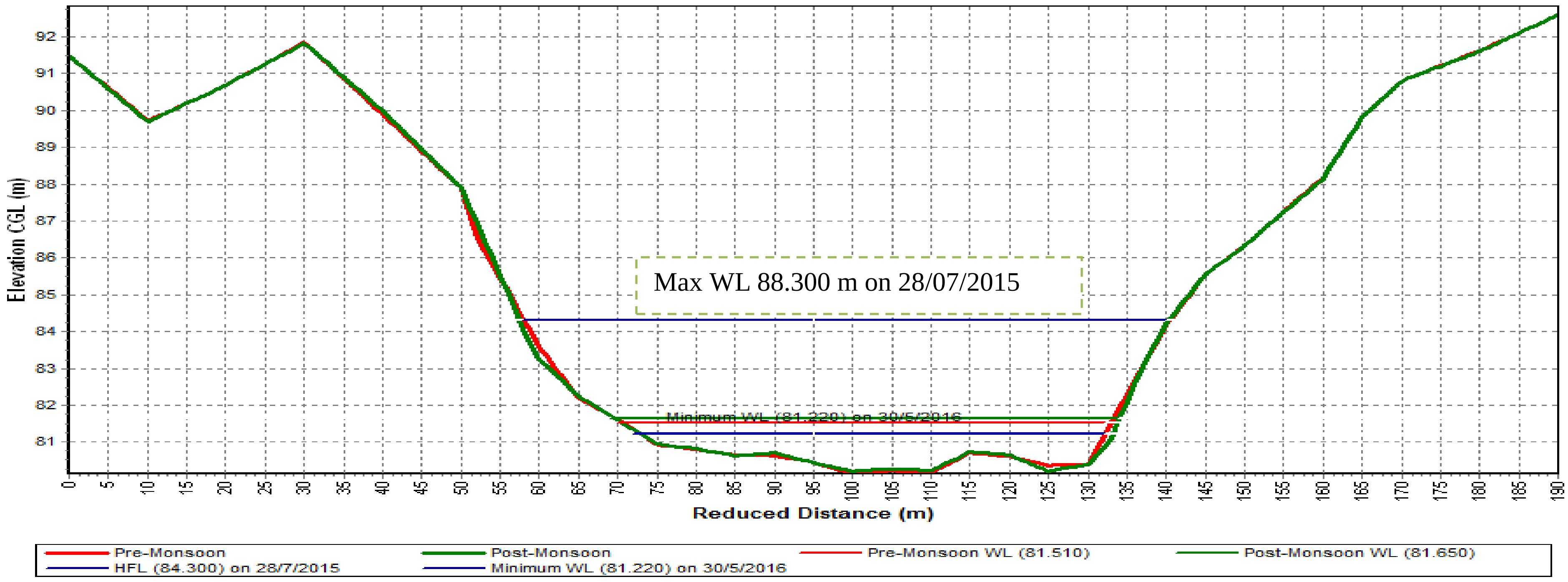
Monthly Average Runoff Based on period 2015-16



4.5.1.7 Superimposed cross section

Station Name: Wagh at Ozerkheda (01 02 24 002)   Division: Tapi Division, Surat   Local River: Wagh   Sub -Division: DGSD, CWC, Silvasa

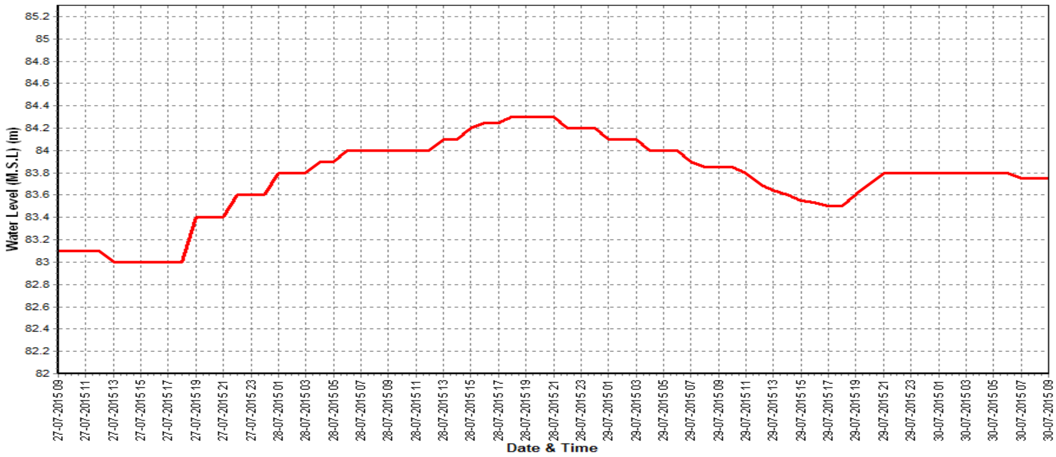
Highest flood level observed so far 96.100 on dt 04/08/2004 at 0100hrs



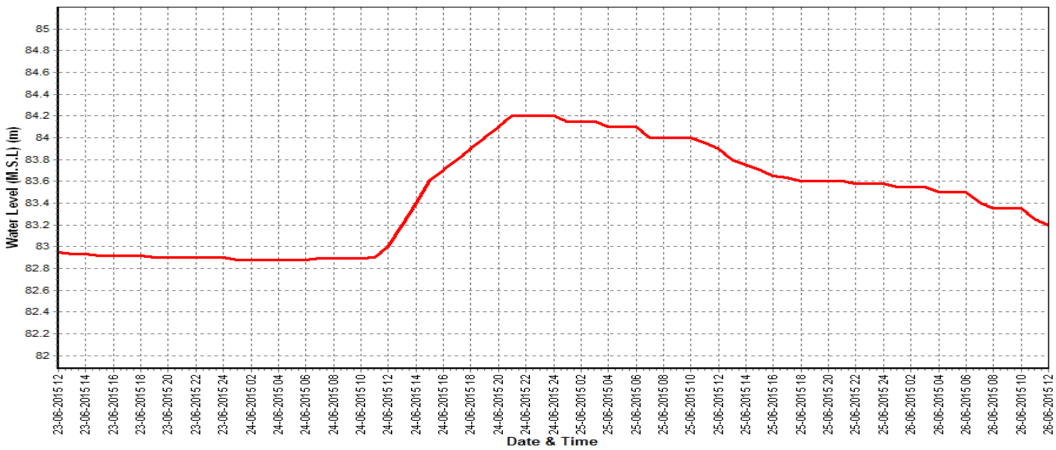
4. .5.1.8 Water Level vs. Time- Graph of Highest Flood Peaks during 2015-16

Station Name: Wagh at Ozerkheda
Division : Tapi Division, Surat
Local River: Wagh
Sub -Division : DGSD, CWC, Silvasssa

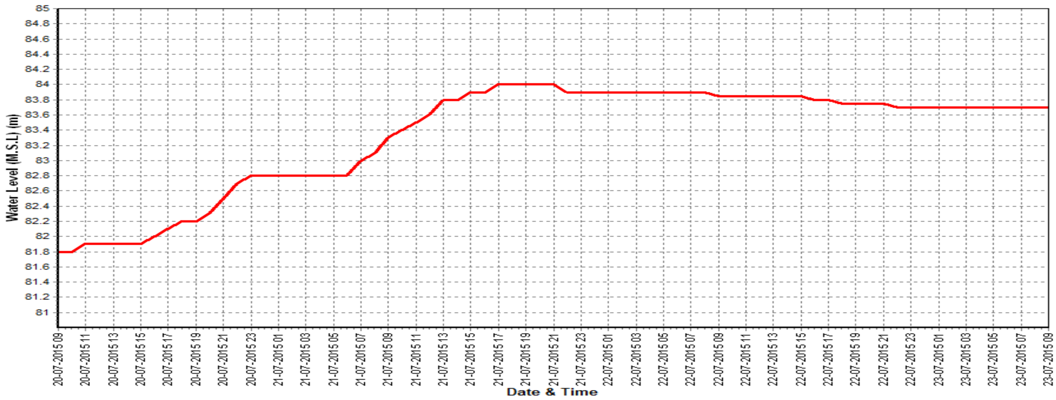
Water level vs. Time graph of I flood peak during the year 2015-16



Water level vs. Time graph of II flood peak during the year 2015-16



Water level vs. Time graph of III flood peak during the year 2015-16



4.5 Damanganga Basin

4.5.2.1 History sheet

History Sheet

			Water Year	**:**	**2015-16**
Site	**:**	**Damanganga at Nanipalsan**	**Code**	**:**	**01 02 24 001**
State	:	Gujarat	District		Valsad
Basin	:	WFR South of Tapi	Independent River	:	Daman Ganga
Tributary	:		Sub Tributary	:	
Sub-Sub Tributary	:		Local River	:	
Division	:	Tapi Division, Surat	Sub-Division	:	DGSD,CWC,Silvasa
Drainage Area	:	764 Sq. Km.	Bank	:	
Latitude	:	20°12'00" N	Longitude	:	73°17'00" E
Zero of Gauge (m)	:	95 (m.s.l)	6/15/1982		
		Opening Date	Closing Date		
Gauge	**:**	**15/06/1982**			
Discharge	**:**	**13/10/1983 Seasonal** **01/06/1991 regular**			

Annual Maximum / Minimum discharge with corresponding Water Level (m.s.l)

Year	Maximum			Minimum		
	Q (cumecs)	WL (m)	Date	Q (cumecs)	WL (m)	Date
1991-1992	1018	101.200	28/07/1991	0.000	96.120	26/01/1992
1992-1993	703.1	99.875	12/08/1992	0.000	96.340	22/02/1993
1993-1994	1393	101.485	13/07/1993	0.000	96.100	18/04/1994
1994-1995	1184	102.040	13/07/1994	0.000	96.020	27/04/1995
1995-1996	440.1	99.700	03/09/1995	0.000	96.070	09/03/1996
1996-1997	219.6	99.650	09/08/1996	0.000	96.320	13/03/1997
1997-1998	340.0	100.480	25/08/1997	0.000	96.260	12/03/1998
1998-1999	902.5	102.490	17/09/1998	0.000	96.230	27/06/1998
1999-2000	360.0	100.600	15/07/1999	0.000	96.250	13/06/1999
2000-2001	997.5	102.375	14/07/2000	0.000	96.250	03/03/2001
2001-2002	252.5	99.250	18/06/2001	0.000	96.580	19/02/2002
2002-2003	300.8	99.850	25/08/2002	0.521	96.670	30/11/2002
2003-2004	362.0	100.110	28/07/2003	0.716	96.710	10/12/2003
2004-2005	3173	103.925	03/08/2004	0.290	96.540	31/12/2004
2005-2006	1439	102.050	29/06/2005	0.000	96.420	28/02/2006
2006-2007	2728	103.590	09/08/2006	0.000	96.370	19/02/2007
2007-2008	895.1	100.900	09/08/2007	0.393	96.600	06/01/2008
2008-2009	1304	102.100	11/08/2008	0.000	96.400	25/04/2009
2009-2010	972.5	101.380	05/09/2009	0.000	96.460	19/02/2010
2010-2011	309.9	99.300	02/08/2010	0.000	96.320	01/06/2010
2011-2012	692.8	100.4	29/08/2011	0.000	96.580	24/12/2011
2012-2013	617.7	99.800	11/09/2012	0.000	96.300	01/06/2012
2013-2014	416.8	99.750	24/09/2013	0.000	96.400	01/06/2013
2014-2015	450.3	99.850	30/07/2014	0.000	96.460	01/06/2014
2015-2016	269.1	99.000	29/07/2015	0.000	96.400	01/06/2015

4.5.2.2 Annual Maximum Flood Peak

Year	Annual Maximum flood Peaks (m)	**Date**	**Hour**
1982	100.000	16/08/1982	07:00:00
1983	102.300	15/08/1983	10:00:00
1984	99.700	18/07/1984	13:00:00
1985	99.900	31/07/1985	15:00:00
1986	99.500	19/07/1986	06:00:00
1987	104.000	07/07/1987	13:00:00
1988	100.170	26/07/1988	14:00:00
1989	100.250	24/07/1989	06:00:00
1990	101.000	20/08/1990	03:00:00
1991	101.660	28/07/1991	00:00:00
1992	101.670	12/08/1992	16:00:00
1993	107.890	13/07/1993	13:00:00
1994	103.700	13/07/1994	06:00:00
1995	99.840	21/07/1995	21:00:00
1996	99.980	08/08/1996	19:00:00
1997	104.000	31/07/1997	14:00:00
1998	103.020	17/09/1998	13:00:00
1999	103.200	15/07/1999	13:00:00
2000	103.010	14/07/2000	01:00:00
2001	99.280	18/06/2001	03:00:00
2002	101.850	02/09/2002	18:00:00
2003	100.990	27/07/2003	17:00:00
2004	110.030	03/08/2004	18:00:00
2005	102.200	03/07/2005	15:00:00
2006	104.580	09/08/2006	12:00:00
2007	102.860	08/08/2007	23:00:00
2008	102.100	11/08/2008	08:00:00
2009	101.600	22/07/2009	18:00:00
2010	100.550	24/07/2010	23:00:00
2011	100.580	28/08/2011	01:00:00
2012	101.650	31/07/2012	13:00:00
2013	100.740	23/07/2013	24:00:00
2014	102.800	30/07/2014	17:00:00
2015	99.300	28/07/2015	16:00:00

4.5.2.3 Summary of Data

Stage Discharge Data for the period 2015-16

Station Name: Damanganga at Nanipalsan (01 02 24 001) Division : Tapi Division, Surat Local River: Damanganga Sub-Division:DGSD,CWC, Silvasssa

Day	Jun		Jul		Aug			Sep			Oct			Nov		
	W.L	Q	W.L	Q	W.L	Q		W.L	Q		W.L	Q		W.L	Q	
1	96.400	0.000	96.400	0.000	97.940	108.2		97.580	68.35		97.360	29.79		96.950	8.970	*
2	96.400	0.000	96.390	0.000	97.850	83.44	*	97.530	59.45		97.340	32.10	*	96.820	2.922	
3	96.400	0.000	96.390	0.000	97.740	79.10		97.510	59.26		97.320	25.63		96.810	2.927	
4	96.400	0.000	96.380	0.000	97.690	77.59		97.480	32.40		97.300	29.09	*	96.810	2.850	
5	96.400	0.000	96.380	0.000	97.650	69.65		97.460	38.15		97.340	27.53		96.810	2.820	
6	96.400	0.000	96.370	0.000	97.610	67.40		97.440	40.30	*	97.320	26.17		96.800	2.730	
7	96.400	0.000	96.370	0.000	97.580	68.29		97.420	33.85		97.300	25.81		96.800	2.728	
8	96.410	0.000	96.370	0.000	97.560	67.75		97.410	33.51		97.260	25.23		96.790	3.580	*
9	96.480	0.000	96.370	0.000	97.540	49.40	*	97.390	32.33		97.230	22.13		96.780	2.730	
10	96.500	0.000	96.370	0.000	97.500	37.19		97.380	31.22		97.210	21.93		96.780	2.434	
11	96.520	0.000	96.370	0.000	97.470	38.33		97.440	36.76		97.190	21.54	*	96.760	2.840	*
12	96.520	0.000	96.360	0.000	97.440	37.26		97.450	37.43		97.170	19.12		96.760	2.347	
13	96.470	0.000	96.360	0.000	97.430	36.82		97.410	37.74	*	97.160	19.33		96.760	2.236	
14	96.450	0.000	96.360	0.000	97.430	37.19		97.390	31.42		97.230	21.85		96.750	2.064	
15	96.480	0.000	96.360	0.000	97.560	51.34	*	97.430	36.88		97.220	22.02		96.750	2.610	*
16	96.500	0.000	96.360	0.000	97.520	47.51	*	97.410	33.27		97.190	21.76		96.750	2.064	
17	96.480	0.000	96.380	0.000	97.540	60.25		97.380	27.20		97.150	18.60		96.740	1.960	
18	96.470	0.000	96.380	0.000	97.540	60.72		97.360	26.99		97.110	16.76	*	96.740	1.911	
19	96.460	0.000	96.390	0.000	97.520	59.60		98.420	165.2		97.090	18.39		96.740	1.916	
20	96.460	0.000	96.410	0.000	97.500	35.46		98.480	179.5	*	97.070	18.26		96.730	1.932	

21	96.450	0.000	97.860	105.2	97.480	38.72	98.210	136.8	97.060	18.42	96.730	1.930
22	96.490	0.000	97.780	92.24	97.450	33.08	98.150	121.4	97.050	13.56 *	96.730	2.180 *
23	96.580	0.000	97.840	101.5	97.420	38.58 *	97.920	94.29	97.040	15.66	96.730	1.856
24	96.620	0.000	97.510	61.87	97.390	32.10	97.780	92.00	97.030	12.57 *	96.730	1.784
25	96.790	0.000	98.700	214.6	97.650	69.55	97.700	65.88 *	97.020	12.09 *	96.750	2.610 *
26	96.470	0.000	98.500	183.1 *	97.950	108.9	97.600	68.80	97.020	15.38	96.750	2.094
27	96.380	0.000	98.450	186.3	97.720	77.90	97.490	44.74 *	97.010	15.24	96.750	2.064
28	96.380	0.000	98.560	200.8	97.680	76.66	97.430	33.13	97.010	15.19	96.740	1.978
29	96.370	0.000	99.000	269.1	97.660	69.71	97.400	32.48	97.000	15.10	96.720	1.980 *
30	96.400	0.000	98.500	185.5	97.640	59.43 *	97.380	28.94	97.000	14.97	96.720	1.871
31			98.350	154.0	97.610	69.00			96.990	14.90		
Ten-Daily Mean												
I Ten-Daily	96.419	0.000	96.379	0.000	97.666	70.80	97.460	42.88	97.298	26.54	96.815	3.469
II Ten-Daily	96.481	0.000	96.373	0.000	97.495	46.45	97.617	61.23	97.158	19.76	96.748	2.188
III Ten-Daily	96.493	0.000	98.277	159.5	97.605	61.24	97.706	71.85	97.021	14.83	96.735	2.035
Monthly												
Min.	96.370	0.000	96.360	0.000	97.390	32.10	97.360	26.99	96.990	12.09	96.720	1.784
Max.	96.790	0.000	99.000	269.1	97.950	108.9	98.480	179.5	97.360	32.10	96.950	8.970
Mean	96.464	0.000	97.051	56.59	97.589	59.55	97.594	58.66	97.155	20.20	96.766	2.564

Annual Runoff in MCM = 526 **Annual Runoff in mm = 688**

Peak Observed Discharge = 269.1 cumecs on 29-07-2015 **Corres. Water Level :99.00 m**

Lowest Observed Discharge = 0.000 cumecs on 01-06-2015 **Corres. Water Level :96.40 m**

Q: Observed/Computed discharge in cumec WL: Corresponding Mean Water Level (m.s.l) in m * : Computed Discharge

#:Discarded Discharge (values changed as per rating curve)

Note: River remained in pooling/ no flow condition w.e.f. 01/06/15 to 20/07/15 & 19/12/2015 to 31/05/2016.

Stage Discharge Data for The period 2015-16

Station Name: Damanganga at Nanipalsan (01 02 24 001) Division : Tapi Division, Surat Local River: Damanganga Sub -Division: DGSD, CWC, Silvasssa

Day	Dec		Jan		Feb		Mar		Apr		May	
	W.L	Q	WL	Q	WL	Q	WL	Q	WL	Q	WL	Q
1	96.720	1.826	96.550	0.000	96.650	0.000	96.540	0.000	96.460	0.000	96.410	0.000
2	96.700	1.755	96.550	0.000	96.640	0.000	96.540	0.000	96.460	0.000	96.410	0.000
3	96.700	1.712	96.540	0.000	96.640	0.000	96.540	0.000	96.460	0.000	96.410	0.000
4	96.690	1.613	96.540	0.000	96.640	0.000	96.540	0.000	96.460	0.000	96.400	0.000
5	96.690	1.474	96.540	0.000	96.640	0.000	96.540	0.000	96.460	0.000	96.400	0.000
6	96.690	1.440 *	96.540	0.000	96.640	0.000	96.530	0.000	96.450	0.000	96.400	0.000
7	96.690	1.408	96.540	0.000	96.640	0.000	96.520	0.000	96.450	0.000	96.400	0.000
8	96.680	1.343	96.540	0.000	96.640	0.000	96.520	0.000	96.450	0.000	96.400	0.000
9	96.680	1.333	96.530	0.000	96.640	0.000	96.520	0.000	96.450	0.000	96.400	0.000
10	96.680	1.318	96.530	0.000	96.620	0.000	96.510	0.000	96.450	0.000	96.400	0.000
11	96.660	1.041	96.530	0.000	96.620	0.000	96.510	0.000	96.450	0.000	96.390	0.000
12	96.660	1.006	96.530	0.000	96.620	0.000	96.510	0.000	96.440	0.000	96.390	0.000
13	96.640	0.720 *	96.530	0.000	96.600	0.000	96.510	0.000	96.440	0.000	96.390	0.000
14	96.640	0.871	96.530	0.000	96.600	0.000	96.510	0.000	96.440	0.000	96.390	0.000
15	96.620	0.754	96.530	0.000	96.600	0.000	96.490	0.000	96.440	0.000	96.390	0.000
16	96.620	0.685	96.530	0.000	96.580	0.000	96.490	0.000	96.440	0.000	96.390	0.000
17	96.600	0.571	96.520	0.000	96.580	0.000	96.490	0.000	96.440	0.000	96.390	0.000
18	96.580	0.489	96.520	0.000	96.580	0.000	96.490	0.000	96.440	0.000	96.390	0.000
19	96.570	0.000	96.520	0.000	96.570	0.000	96.480	0.000	96.430	0.000	96.380	0.000
20	96.570	0.000	96.660	0.000	96.570	0.000	96.480	0.000	96.430	0.000	96.380	0.000

21	96.570	0.000	96.660	0.000	96.570	0.000	96.480	0.000	96.430	0.000	96.380	0.000
22	96.570	0.000	96.660	0.000	96.570	0.000	96.480	0.000	96.430	0.000	96.380	0.000
23	96.560	0.000	96.650	0.000	96.570	0.000	96.480	0.000	96.430	0.000	96.380	0.000
24	96.560	0.000	96.650	0.000	96.560	0.000	96.480	0.000	96.420	0.000	96.380	0.000
25	96.560	0.000	96.650	0.000	96.560	0.000	96.480	0.000	96.420	0.000	96.380	0.000
26	96.560	0.000	96.650	0.000	96.560	0.000	96.480	0.000	96.420	0.000	96.380	0.000
27	96.560	0.000	96.650	0.000	96.550	0.000	96.470	0.000	96.420	0.000	96.380	0.000
28	96.560	0.000	96.650	0.000	96.550	0.000	96.470	0.000	96.410	0.000	96.380	0.000
29	96.550	0.000	96.650	0.000	96.550	0.000	96.470	0.000	96.410	0.000	96.380	0.000
30	96.550	0.000	96.650	0.000			96.470	0.000	96.410	0.000	96.380	0.000
31	96.550	0.000	96.650	0.000			96.470	0.000			96.380	0.000
Ten-Daily Mean												
I Ten-Daily	96.692	1.522	96.540	0.000	96.639	0.000	96.530	0.000	96.455	0.000	96.403	0.000
II Ten-Daily	96.616	0.614	96.540	0.000	96.592	0.000	96.496	0.000	96.439	0.000	96.388	0.000
III Ten-Daily	96.559	0.000	96.652	0.000	96.560	0.000	96.475	0.000	96.420	0.000	96.380	0.000
Monthly												
Min.	96.550	0.000	96.520	0.000	96.550	0.000	96.470	0.000	96.410	0.000	96.380	0.000
Max.	96.720	1.826	96.660	0.000	96.650	0.000	96.540	0.000	96.460	0.000	96.410	0.000
Mean	96.620	0.689	96.580	0.000	96.598	0.000	96.500	0.000	96.438	0.000	96.390	0.000

Peak Computed Discharge = 183.1 cumecs on 26-07-2015 Corres. Water Level :98.5 m

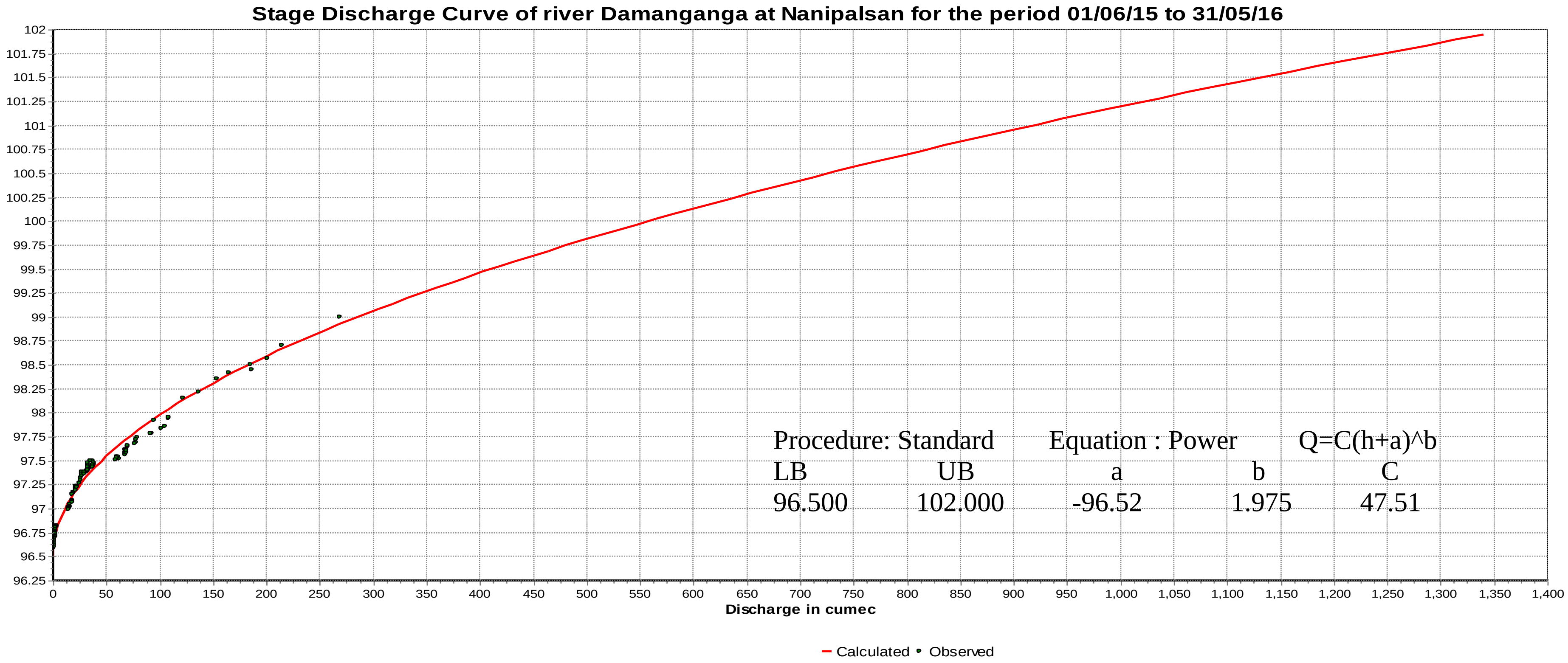
Q: Observed/Computed discharge in cumec WL: Corresponding Mean Water Level (m.s.l) in m * : Computed Discharge

#:Discarded Discharge (values changed as per rating curve)

Note: River remained in pooling/ no flow condition w.e.f. 01/06/15 to 20/07/15 & 19/12/2015 to 31/05/2016.

4.5.2.4 Stage Discharge Curve

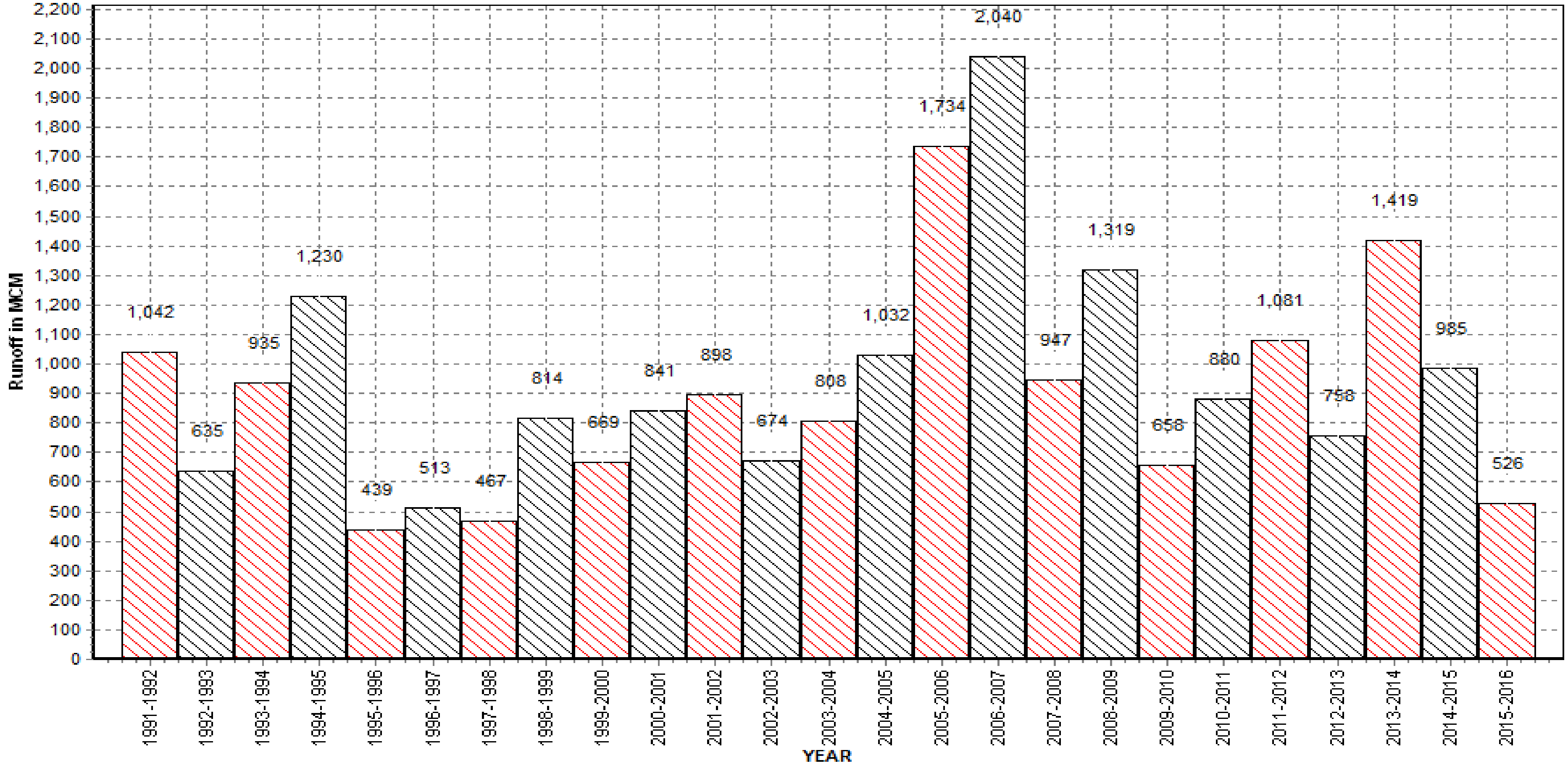
Station Name: Damanganga at Nanipalsan (01 02 24 001) Division : Tapi Division, Surat Local River: Damanganga Sub -Division: DGSD, CWC, Silvassa



4.5.2.5 Annual runoff

Annual Runoff values for the year 1991-2016

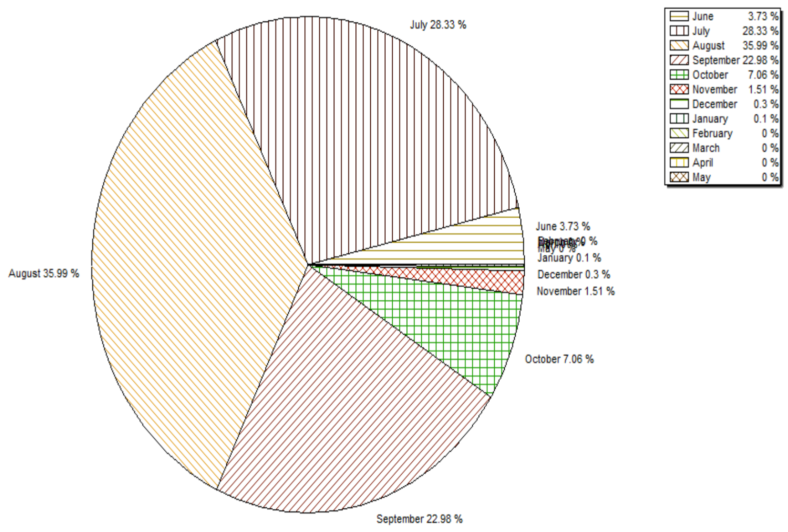
Station Name: Damanganga at Nanipalsan (01 02 24 001) Division : Tapi Division, Surat Local River: Damanganaga Sub -Division : DGSD, CWC, Silvassa



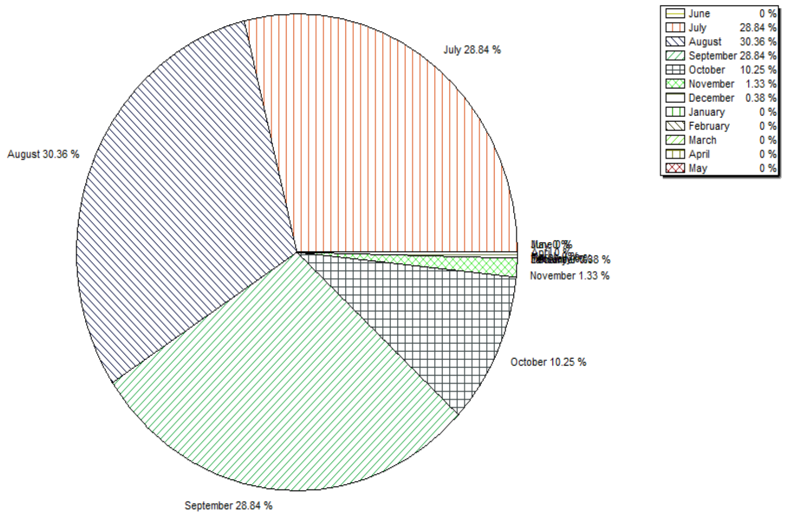
5.2.6 Monthly Average Runoff

Station Name: Damanganga at Nanipalsan (01 02 24 001) Division : Tapi Division, Surat Local River: Damanganga Sub -Division : DGSD, CWC, Silvasa

Monthly Average Runoff Based on period 1991-2015

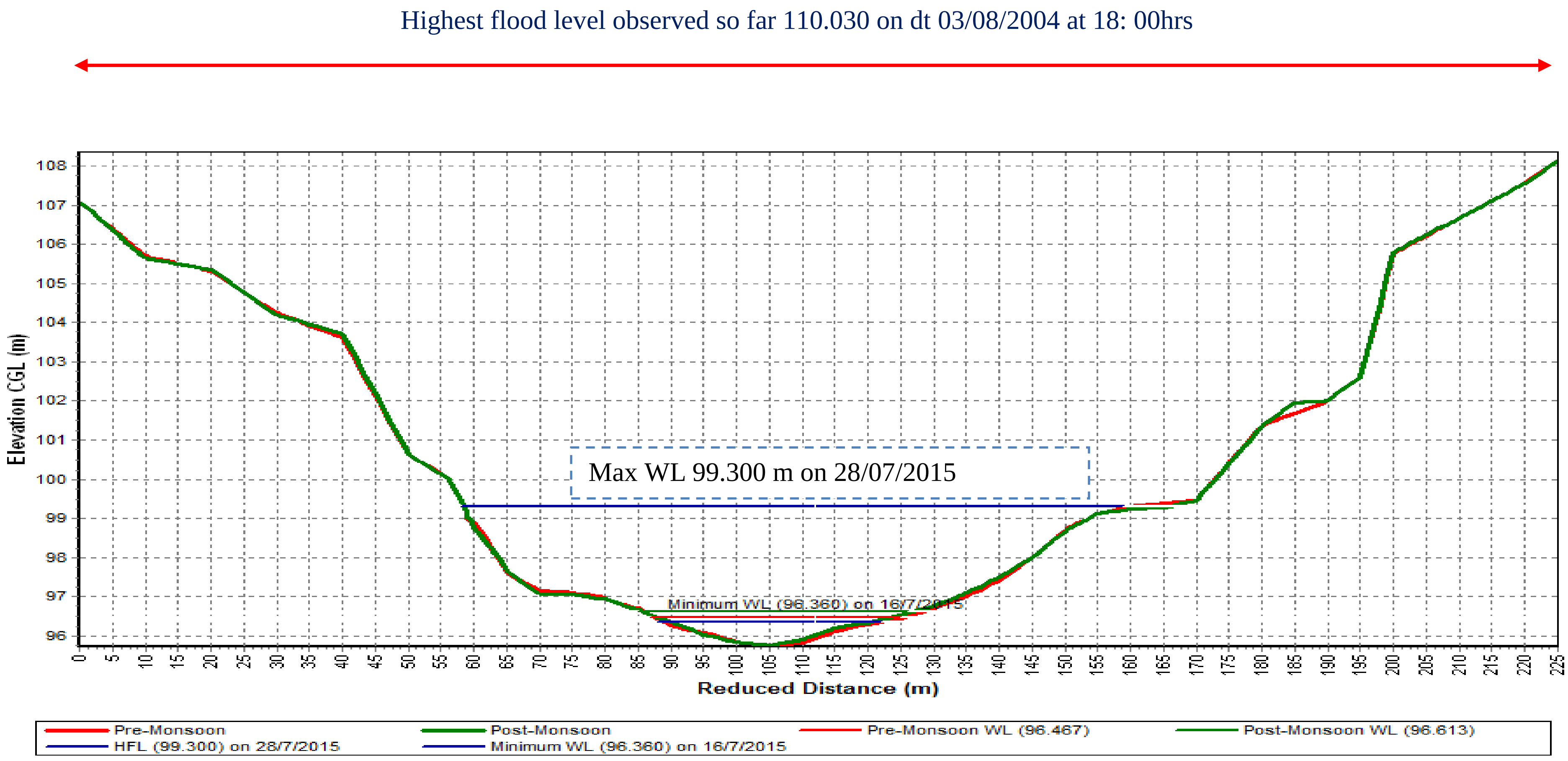


Monthly Average Runoff Based on period 2015-16



4.5.2.7 Superimposed cross section

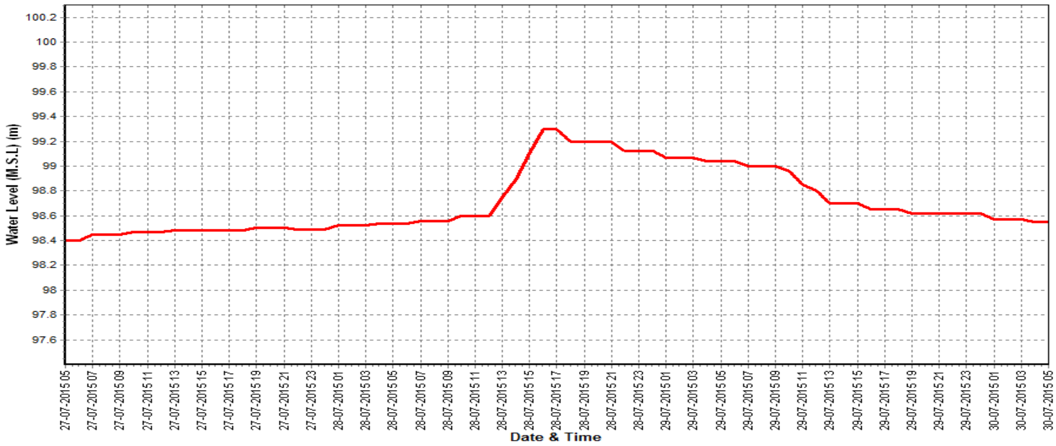
Station Name: Damanganga at Nanipalsan (01 02 24 001) Division : Tapi Division, Surat Local River: Damanganga Sub-Division:DGSD, CWC, Silvasa



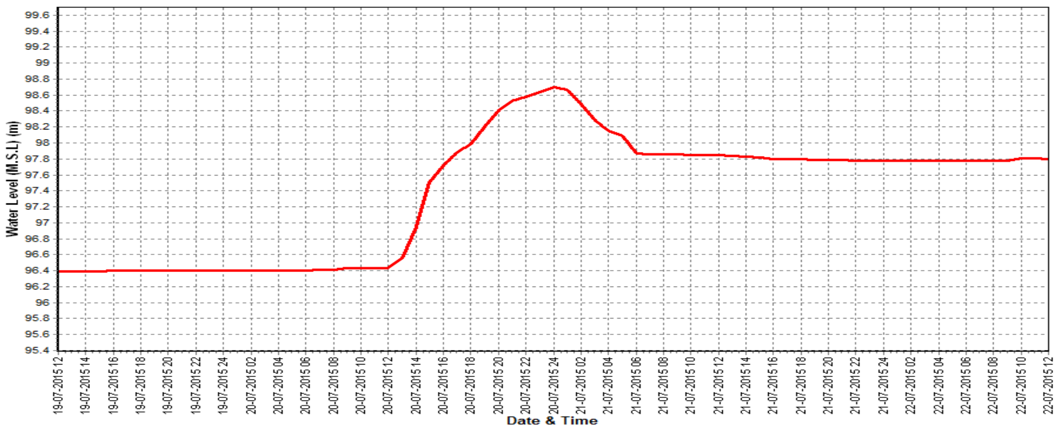
4.5.2.8 Water Level vs. Time- Graph of Highest Flood Peaks during 2015-16

Station Name: Damanganga at Nanipalsan (01 02 24 001) Division: Tapi Division, Surat
Local River: Damanganga Sub -Division: DGSD, CWC, Silvasa

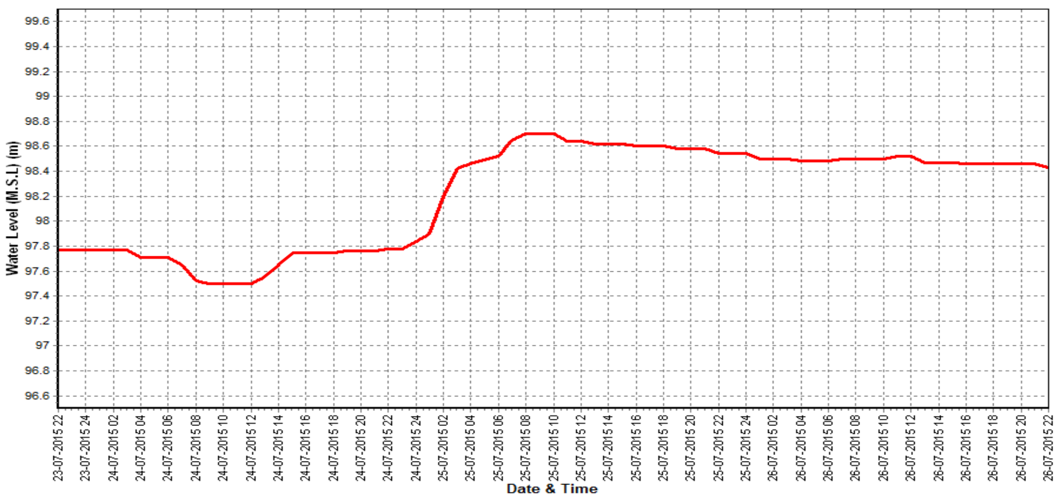
Water level vs. Time graph of I flood peak during the year 2015-16



Water level vs. Time graph of II flood peak during the year 2015-16



Water level vs. Time graph of III flood peak during the year 2015-16



4.6 Kim basin

4.6.1 History sheet

HISTORY SHEET

			Water Year	**:**	**2015-156**
Site	**:**	**Motinaroli**	**Code**	**:**	**01 02 16 001**
State	:	Gujarat	District		Surat
Basin	:	Narmada	Independent River	:	Kim
Tributary	:	-	Sub Tributary	:	-
Sub-Sub Tributary	:	-	Local River	:	Kim
Division	:	Tapi Dvision, Surat	Sub-Division	:	LNSD Bharuch
Drainage Area	:	804 Sq. Km.	Bank	:	Right
Latitude	:	21°24’16”	Longitude	:	72°57’48”
Zero of Gauge **m**	:	5 (m.s.l)	17/10/1990		

		Opening Date	Closing Date
Gauge	:	17/10/1990	
Discharge	:	17/10/1990	
Sediment	:		
Water Quality	:	1/7/1991	

Annual maximum/minimum discharge with corresponding Water level (above m.s.l)

Year	Maximum			Minimum		
	Q (cumecs)	**WL (m)**	**Date**	**Q (cumecs)**	**WL (m)**	**Date**
1991-1992	58.73	10.140	01/08/1991	0.000	6.245	06/05/1992
1992-1993	736.4	17.510	22/06/1992	0.191	7.515	30/03/1993
1993-1994	426.3	13.890	16/07/1993	0.170	7.520	17/05/1994
1994-1995	700.5	13.750	22/07/1994	0.000	7.350	04/04/1995
1995-1996	668.6	15.700	21/07/1995	0.240	7.280	05/04/1996
1996-1997	676.0	16.800	24/07/1996	0.112	7.470	23/04/1997
1997-1998	372.0	16.355	24/08/1997	0.080	7.300	10/03/1998
1998-1999	404.0	15.900	16/09/1998	0.099	7.230	26/03/1999
1999-2000	282.5	13.500	20/07/1999	0.170	7.360	26/03/2000
2000-2001	296.2	13.625	14/07/2000	0.041	7.200	28/05/2001
2001-2002	377.1	14.650	16/08/2001	0.000	7.220	07/05/2002
2002-2003	526.8	14.930	04/09/2002	0.000	7.100	13/04/2003
2003-2004	649.0	14.640	25/07/2003	0.000	7.190	29/05/2004
2004-2005	1288	17.200	04/08/2004	0.000	7.340	14/02/2005
2005-2006	720.2	16.380	30/06/2005	0.000	7.310	22/06/2005
2006-2007	923.2	17.650	29/07/2006	0.956	7.710	27/02/2007
2007-2008	851.7	16.815	02/07/2007	0.280	7.530	08/03/2008
2008-2009	735.6	15.985	12/08/2008	0.500	7.440	25/03/2009
2009-2010	206.8	13.660	07/09/2009	0.000	7.550	25/01/2010
2010-2011	384.2	14.625	10/09/2010	0.770	7.620	04/01/2011
2011-2012	497.8	14.425	26/08/2011	0.000	7.630	19/12/2012
2012-2013	47.64	13.480	04/09/2012	0.000	7.720	07/01/2013
2013-2014	399.3	15.150	23/09/2013	0.000	7.790	09/10/2014
2014-2015	498.0	13.740	01/08/2014	0.000	7.660	02/06/2014
2015-2016	538.4	15.000	28/07/2015	0.000	7.840	21/12/2015

4.6.2 Annual Maximum Flood peak

Year	Annual Maximum Flood peak (m)	Date	Hour
1990	7.320	20/11/1990	08:00:00
1991	10.160	01/08/1991	08:00:00
1992	17.660	22/06/1992	11:00:00
1993	15.480	18/07/1993	22:00:00
1994	18.150	16/06/1994	23:00:00
1995	15.850	21/07/1995	15:00:00
1996	16.800	24/07/1996	03:00:00
1997	16.550	24/08/1997	11:00:00
1998	16.600	16/09/1998	13:00:00
1999	16.480	20/07/1999	19:00:00
2000	14.000	14/07/2000	06:00:00
2001	14.800	16/08/2001	08:00:00
2002	15.080	04/09/2002	13:00:00
2003	16.630	25/07/2003	20:00:00
2004	17.400	04/08/2004	12:00:00
2005	17.500	29/06/2005	18:00:00
2006	18.225	29/07/2006	21:00:00
2007	18.090	02/07/2007	20:00:00
2008	16.400	12/08/2008	15:00:00
2009	18.000	19/02/2009	08:00:00
2010	16.130	10/09/2010	05:00:00
2011	14.630	26/08/2011	11:00:00
2012	13.500	04/09/2012	10:00:00
2013	18.710	25/09/2013	22:00:00
2014	14.780	01/08/2014	02:00:00
2015	17.240	21/07/2015	23:00:00

4.6.3 Summary of data

Stage Discharge Data for the period 2015-16

Station Name: Kim at Motinaroli (01 02 16 001) Division : Tapi Division, Surat Local River:Kim Sub -Division : LNSD, CWC, Bharuch

Day	Jun		Jul		Aug		Sep		Oct		Nov	
	W.L	Q	W.L	Q	W.L	Q	W.L	Q	W.L	Q	W.L	Q
1	8.280	5.943	8.150	4.123	9.060	40.91	8.420	12.11	8.250	9.188	8.290	9.000 *
2	8.290	6.115	8.150	4.175	9.050	34.93 *	8.440	15.15	8.240	7.780 *	8.300	9.342
3	8.290	6.202	8.140	4.113	9.020	40.18	8.460	15.67	8.260	9.230	8.310	9.415
4	8.280	5.927	8.140	4.112	9.020	40.08	8.480	16.13	8.190	6.630 *	8.290	9.220
5	8.270	5.759	8.100	4.740 *	9.060	40.50	8.460	15.72	8.280	9.350	8.280	9.057
6	8.270	5.742	8.090	4.078	8.940	36.93	8.440	13.07 *	8.290	9.411	8.270	8.968
7	8.270	8.510 *	8.080	4.047	8.910	35.36	8.400	12.04	8.300	9.485	8.260	8.900
8	8.260	5.701	8.100	4.100	8.880	32.28	8.400	12.03	8.320	9.734	8.300	9.260 *
9	8.240	5.626	8.200	4.404	8.840	26.51 *	8.380	11.86	8.290	9.316	8.310	9.415
10	8.145	5.588	8.270	5.725	8.490	16.44	8.370	12.02	8.300	9.487	8.340	9.855
11	8.110	5.515	8.360	11.66	8.460	16.27	8.340	11.80	8.310	9.510 *	8.340	10.29 *
12	8.080	5.129	8.400	11.93 *	8.460	15.72	8.310	10.71	8.330	9.771	8.350	10.74
13	8.080	5.157	8.440	17.77	8.450	15.54	8.270	8.510 *	8.320	9.606	8.370	11.06
14	8.070	4.160 *	8.370	11.32	8.440	15.30	8.370	12.07	8.320	9.680	8.290	9.220
15	8.440	17.87	8.350	10.89	8.440	13.07 *	8.400	11.99	8.330	9.763	8.270	8.510 *
16	8.230	4.844	8.350	10.90	8.500	14.85 *	8.480	14.77	8.340	9.840	8.260	8.900
17	8.095	4.698	8.400	12.11	8.490	16.44	8.450	13.46 *	8.320	9.603	8.230	7.550 *
18	8.360	11.94	8.410	12.24	8.480	16.12	8.440	14.54	8.320	9.770 *	8.150	8.096
19	8.295	10.83	8.350	10.56 *	8.470	15.89	8.480	14.64	8.320	9.690	8.090	7.151
20	8.105	4.925	8.330	10.81	8.470	15.90	9.800	71.73 *	8.310	9.456	7.900	4.104

21	8.170	6.190 *	8.320	10.59	8.460	15.67	8.800	22.51	8.330	9.751	8.080	6.394
22	8.230	4.778	8.340	10.70	8.410	12.08	8.480	14.70	8.330	10.03 *	8.150	5.760 *
23	8.390	11.82	8.390	11.88	8.370	11.10 *	8.440	14.14	8.320	9.621	8.230	8.243
24	8.610	18.57	8.490	16.38	8.400	12.03	8.410	11.10	8.310	9.510 *	8.250	8.784
25	9.600	60.78	10.800	163.0	8.420	12.18	8.390	11.65 *	8.300	9.260 *	8.260	8.260 *
26	8.860	25.56	9.500	55.82 *	8.430	12.39	8.370	11.06	8.320	9.574	8.280	8.894
27	8.350	11.60	12.950	341.7	8.420	12.08	8.350	10.56 *	8.340	9.855	8.320	9.459
28	8.330	10.03 *	15.000	538.4	8.390	11.90	8.340	11.76	8.320	9.561	8.330	9.607
29	8.280	5.979	11.800	212.7 #	8.400	12.05	8.310	10.68	8.300	9.343	8.340	10.29 *
30	8.190	4.400	9.500	69.42	8.410	12.21 *	8.270	9.574	8.310	9.438	8.350	9.762
31			9.100	42.06	8.400	12.01			8.310	9.447		
Ten-Daily Mean												
I Ten-Daily	8.260	6.111	8.142	4.362	8.927	34.41	8.425	13.58	8.272	8.961	8.295	9.243
II Ten-Daily	8.186	7.507	8.376	12.02	8.466	15.51	8.534	18.42	8.322	9.669	8.225	8.562
III Ten-Daily	8.501	15.97	10.199	133.9	8.410	12.34	8.416	12.77	8.317	9.581	8.259	8.545
Monthly												
Min.	8.070	4.160	8.080	4.047	8.370	11.10	8.270	8.510	8.190	6.630	7.900	4.104
Max.	9.600	60.78	15.000	538.4	9.060	40.91	9.800	71.73	8.340	10.03	8.370	11.06
Mean	8.316	9.863	8.947	52.79	8.595	20.48	8.458	14.92	8.304	9.409	8.260	8.783

Annual Runoff in MCM = 419 Annual Runoff in mm = 522

Peak Observed Discharge = 538.4 cumecs on 28/07/2015 Corres. Water Level :15.00 m

Lowest Observed Discharge = 0.000 cumecs on 21/12/2015 Corres. Water Level : 7.84 m

Q: Observed/Computed discharge in cumec WL: Corresponding Mean Water Level (m.s.l) in m * : Computed Discharge

#:Discarded Discharge (values changed as per rating curve)

Note: River in pooling or no flow condition on 21/12/15 to 18/01/16.

Stage Discharge Data for The period 2015-16

Station Name: Kim at Motinaroli (01 02 16 001) Division : Tapi Division, Surat Local River: Kim Sub -Division : LNSD, CWC, Bharuch

Day	Dec		Jan		Feb		Mar		Apr		May	
	W.L	Q	WL	Q	WL	Q	WL	Q	WL	Q	WL	Q
1	8.360	9.855	7.820	0.000	8.250	7.848	8.070	4.361	8.090	4.298	8.300	9.260 *
2	8.360	9.855	7.820	0.000	8.280	8.358	8.150	5.675	8.070	4.247	8.300	8.714
3	8.380	10.69	7.810	0.000	8.310	9.061	8.160	5.537	8.220	7.310 *	8.340	9.314
4	8.390	10.71	7.800	0.000	8.320	9.012	8.170	5.431	8.250	7.828	8.370	10.48
5	8.420	11.06	7.790	0.000	8.330	9.396	8.190	6.596	8.260	7.936	8.380	11.28
6	8.400	11.93 *	7.780	0.000	8.330	9.353	8.190	6.630 *	8.270	8.066	8.390	11.62
7	8.380	10.72	7.770	0.000	8.330	10.03 *	8.210	8.150	8.280	8.208	8.400	11.78
8	8.360	9.840	7.770	0.000	8.340	10.70	8.210	8.150	8.290	8.602	8.370	11.10 *
9	8.360	9.781	7.760	0.000	8.360	11.06	8.240	8.253	8.300	8.735	8.350	9.790
10	8.370	9.995	7.750	0.000	8.280	9.230	8.260	7.860	8.310	9.510 *	8.330	9.479
11	8.380	10.13	7.740	0.000	8.270	9.351	8.270	8.549	8.320	8.931	8.280	8.387
12	8.300	8.894	7.740	0.000	8.220	8.372	8.290	8.880	8.340	9.249	7.980	3.938
13	8.260	8.260 *	7.730	0.000	8.200	8.333	8.300	9.260 *	8.360	9.865	8.230	8.164
14	8.260	7.890	7.730	0.000	8.190	6.630 *	8.310	9.012	8.370	10.11	8.280	8.272
15	8.240	7.848	7.720	0.000	8.180	6.516	8.320	9.044	8.380	10.41	8.340	10.29 *
16	8.100	4.352	7.720	0.000	8.160	6.083	8.330	9.380	8.360	9.922	8.410	11.92
17	7.930	4.154	7.720	0.000	8.150	5.716	8.340	9.804	8.350	10.56 *	8.380	11.40
18	7.910	3.097	7.720	0.000	8.150	5.675	8.340	8.697	8.340	9.277	8.370	11.06
19	7.870	0.486	7.880	0.486	8.150	5.537	8.230	8.347	8.310	8.673	8.405	11.72
20	7.850	0.900 *	8.000	4.331	8.150	5.533	8.220	7.310 *	8.320	9.770 *	8.380	11.28

21	7.840	0.000	8.130	4.352	8.160	5.970 *	8.230	8.253	8.350	9.624	8.400	11.93 *
22	7.840	0.000	8.240	7.848	8.160	6.092	8.190	6.596	8.380	10.41	8.440	13.07 *
23	7.840	0.000	8.260	7.890	8.140	4.304	8.180	6.581	8.370	10.11	8.480	14.64
24	7.840	0.000	8.250	8.020 *	8.130	4.393	8.180	6.410 *	8.360	10.83 *	8.450	13.43
25	7.850	0.000	8.260	8.009	8.110	4.352	8.170	6.190 *	8.360	9.930	8.430	13.21
26	7.840	0.000	8.240	7.780 *	7.940	4.223	8.190	6.636	8.340	9.689	8.420	13.18
27	7.840	0.000	8.230	8.243	7.920	3.097	8.190	6.630 *	8.340	9.622	8.420	13.12
28	7.850	0.000	8.300	8.894	7.940	2.010 *	8.140	5.431	8.330	9.380	8.400	11.93
29	7.850	0.000	8.330	9.342	8.000	4.334	8.130	5.406	8.320	9.244	8.380	11.37 *
30	7.840	0.000	8.310	9.220			8.130	5.383	8.310	8.941	8.380	11.09
31	7.830	0.000	8.280	8.750 *			8.120	4.407			8.380	11.11
<u>Ten-Daily Mean</u>												
I Ten-Daily	8.378	10.44	7.787	0.000	8.313	9.404	8.185	6.664	8.234	7.474	8.353	10.28
II Ten-Daily	8.110	5.601	7.770	0.482	8.182	6.775	8.295	8.828	8.345	9.676	8.306	9.643
III Ten-Daily	7.842	0.000	8.257	8.031	8.056	4.308	8.168	6.175	8.346	9.778	8.416	12.55
<u>Monthly</u>												
Min.	7.830	0.000	7.720	0.000	7.920	2.010	8.070	4.361	8.070	4.247	7.980	3.938
Max.	8.420	11.93	8.330	9.342	8.360	11.06	8.340	9.804	8.380	10.83	8.480	14.64
Mean	8.101	5.176	7.948	3.212	8.188	6.916	8.215	7.189	8.308	8.976	8.360	10.88

Peak Computed Discharge = 71.73 cumecs on 20/09/2015 Corres. Water Level :9.80 m
Lowest Computed Discharge = 0.900 cumecs on 20/12/2015 Corres. Water Level :7.85 m

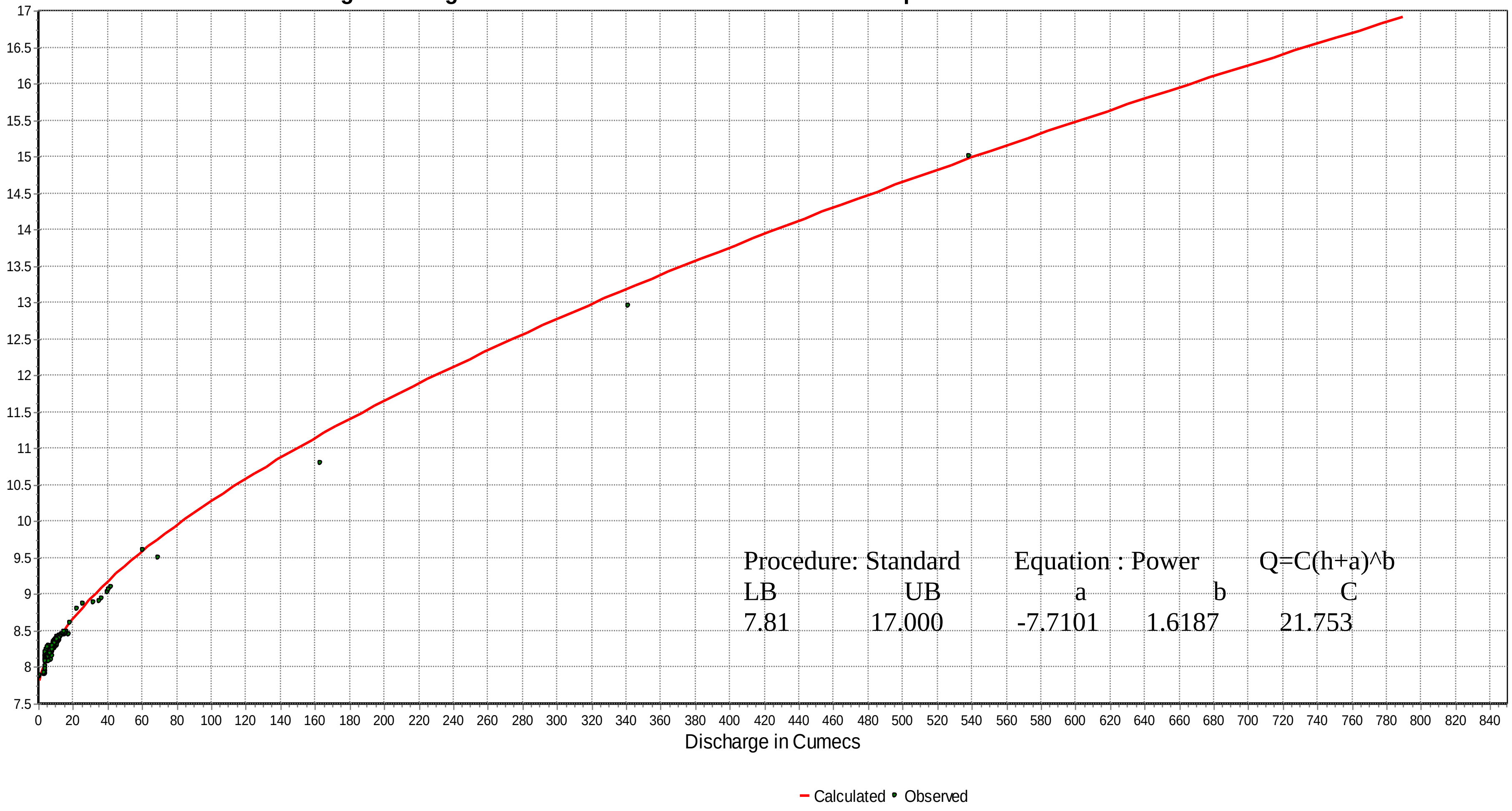
Q: Observed/Computed discharge in cumec WL: Corresponding Mean Water Level (m.s.l) in m * : Computed Discharge
#:Discarded Discharge (values changed as per rating curve)

Note: River in pooling or no flow condition on 21/12/15 to 18/01/16.

4.6.4 Stage Discharge Curve

Station Name: Kim at Motinaroli (01 02 16 001) Division : Tapi Division, Surat Local River: Kim Sub -Division : LNSD, CWC, Bharuch

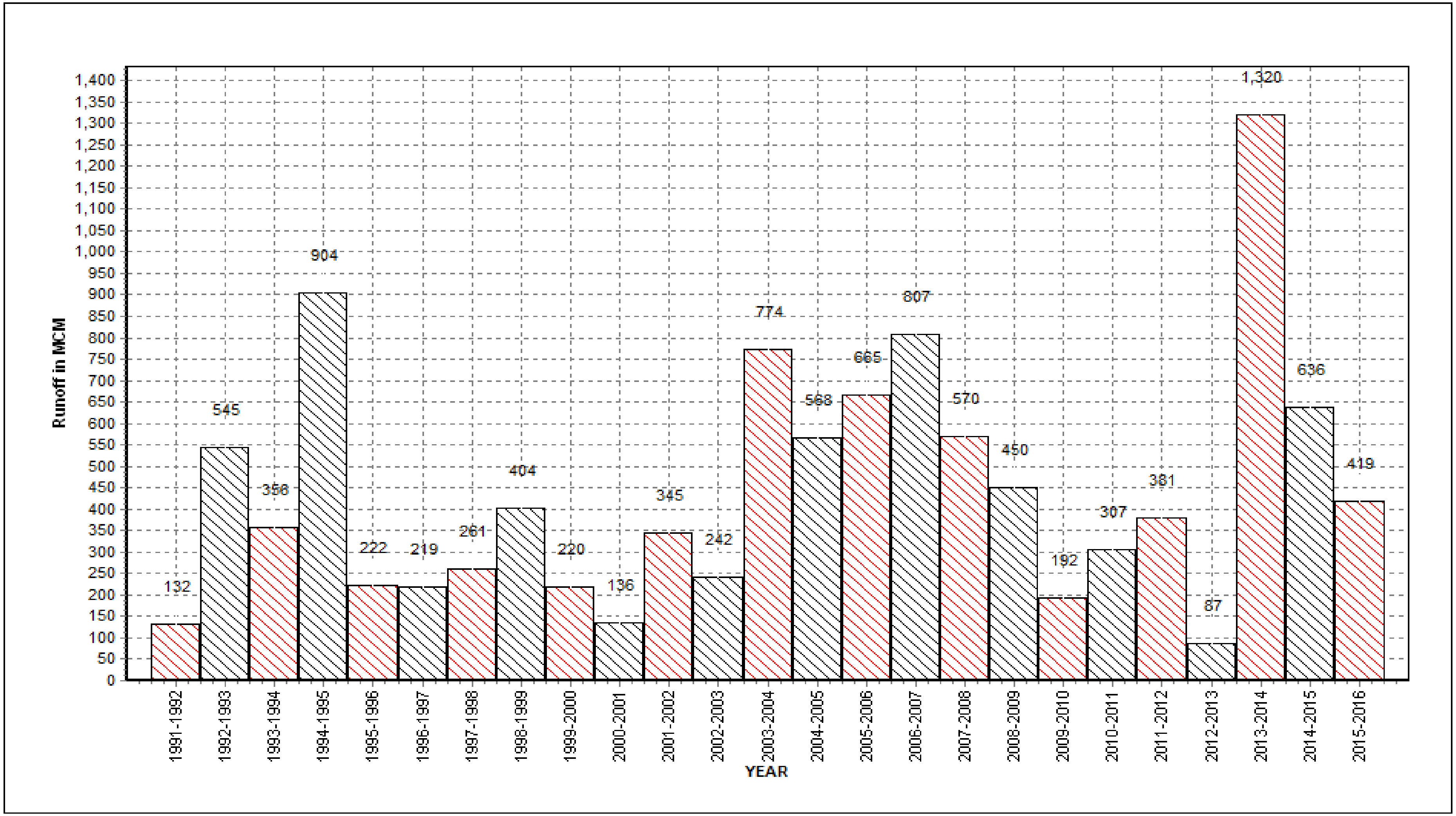
Stage Dischrge Curve of River Kim at Motinaroli for the period 01/06/15 to 31/05/16



4.6.5 Annual runoff

Annual Runoff values for the period 1991-2016

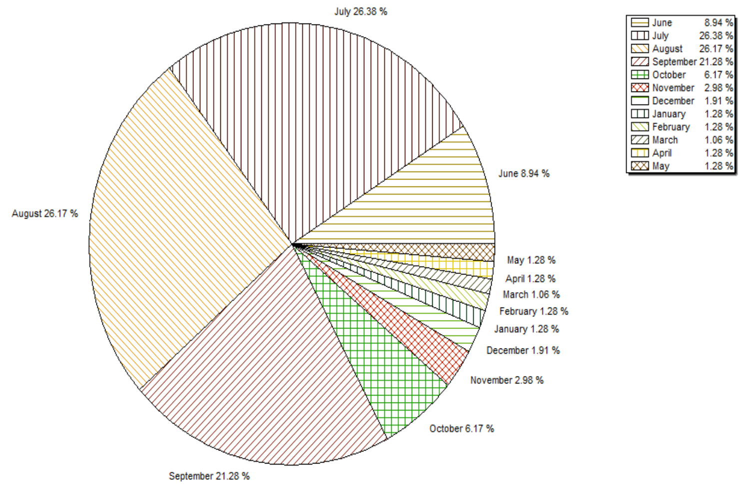
Station Name: Kim at Motinaroli (01 02 16 001) Division: Tapi Division, Surat Local River: Kim Sub -Division: LNSD, CWC, Bharuch



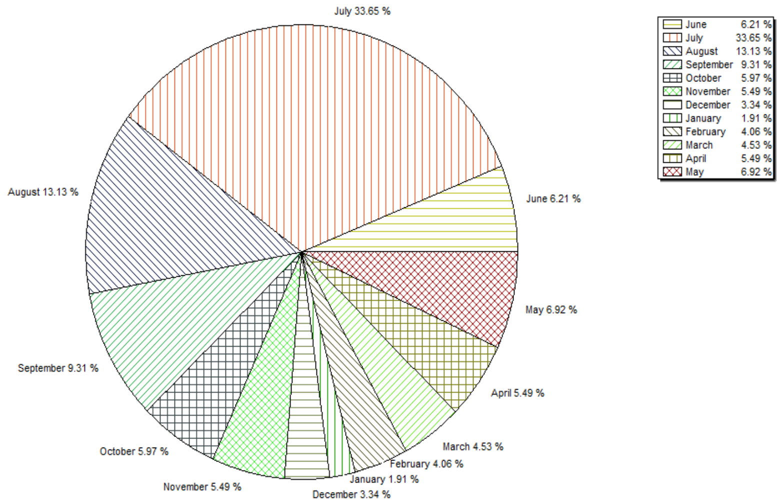
4.6.6 Monthly average Runoff

Station Name: Kim at Motinaroli (01 02 16 001) Division : Tapi Division, Surat Local River: Kim Sub -Division : LNSD, CWC, Bharuch

Monthly Average Runoff on period 1991-2015

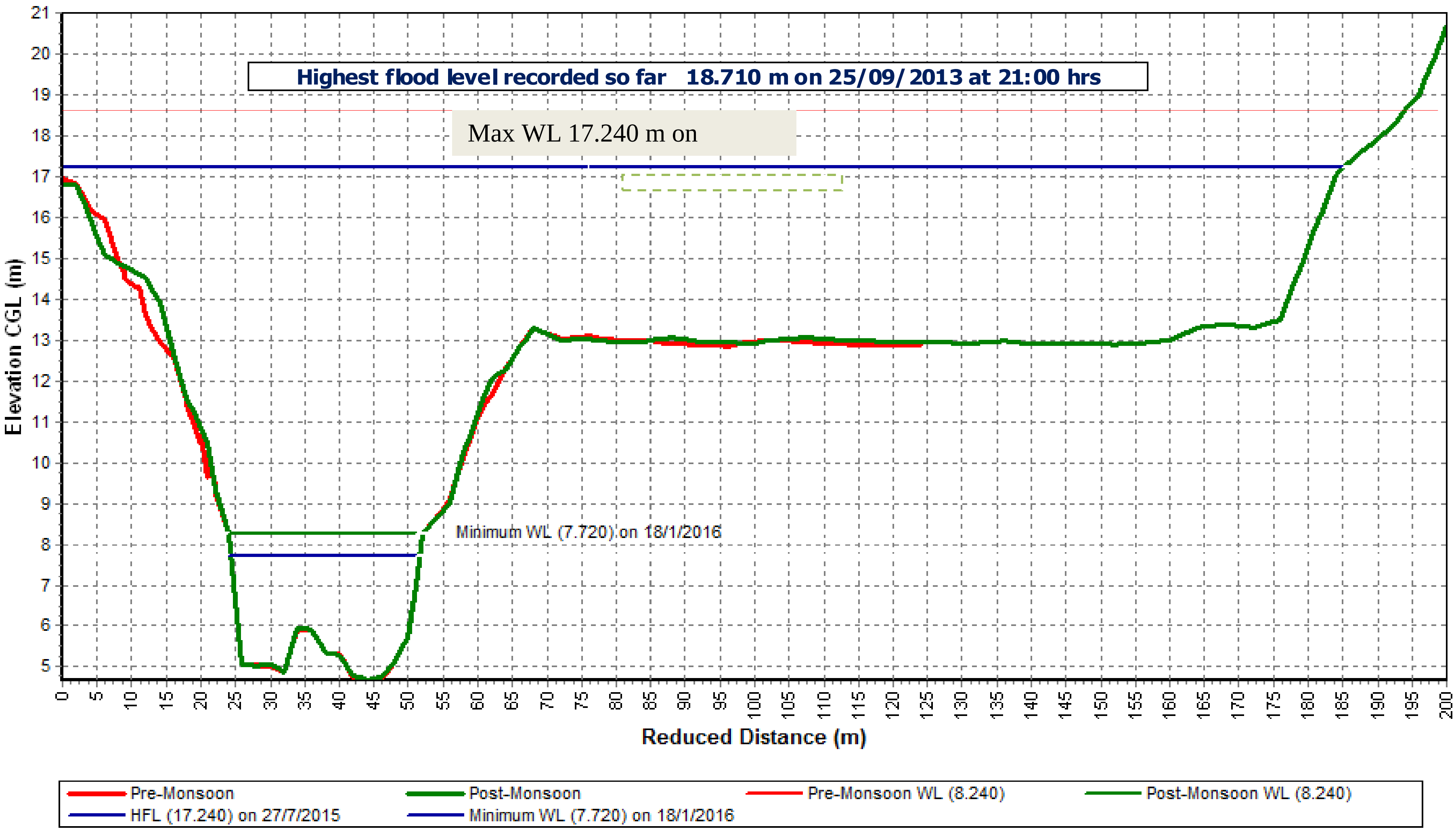


Monthly Average Runoff on period 2015-16



4.6.7 Superimposed cross section

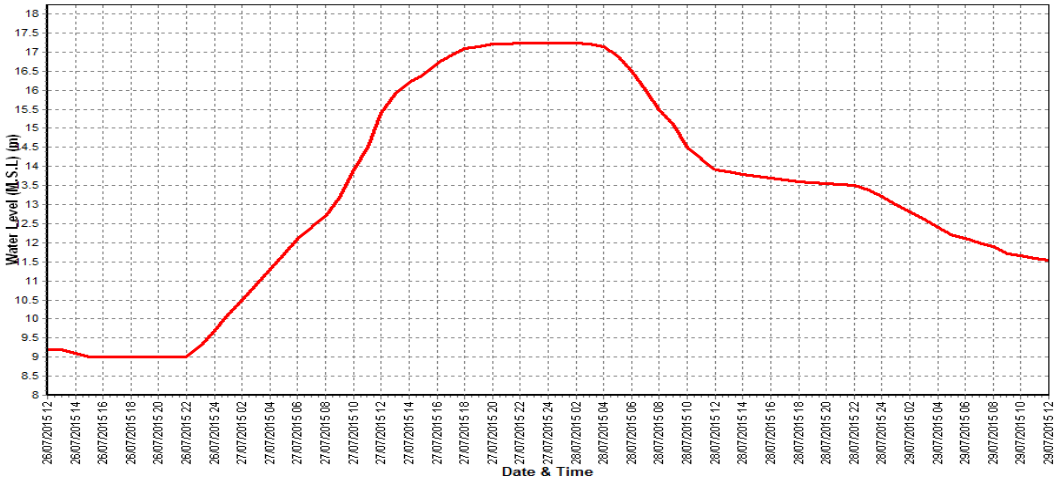
Station Name: Kim at Motinaroli (01 02 16 001) Division : Tapi Division, Surat Local River: Kim Sub -Division : LNSD, CWC, Bharuch



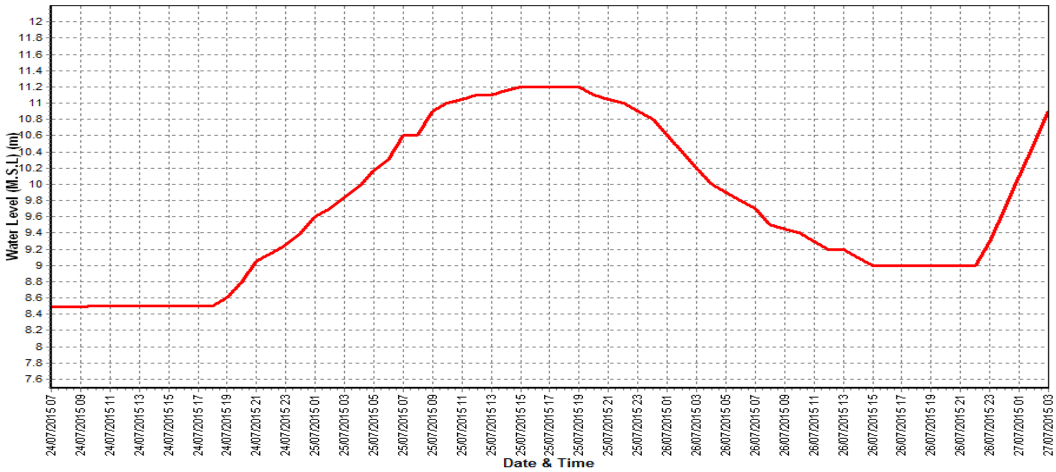
4.6.8 Water Level vs. Time Graph of highest flood peaks during 2015-16

Station Name: Kim at Motinaroli (01 02 16 001) Division : Tapi Division, Surat
Local River: Kim Sub -Division : LNSD, CWC, Bharuch

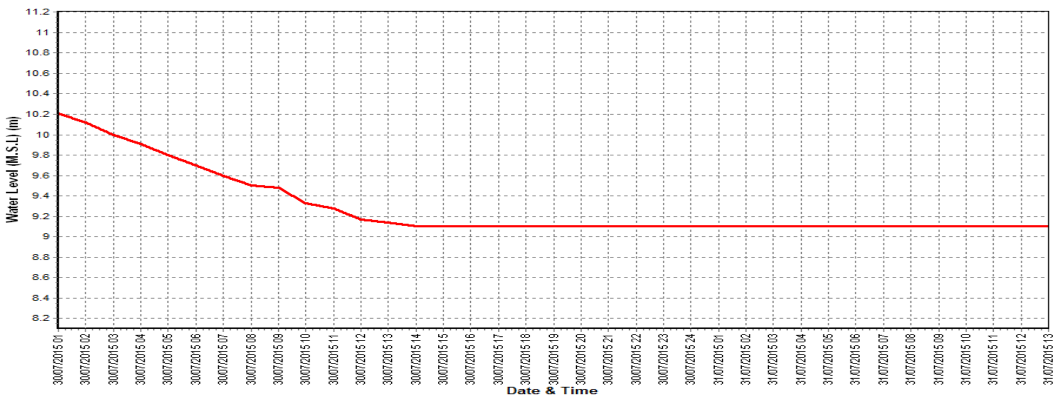
Water level vs. Time graph of 1st flood peak during the year 2015-16



Water level vs. Time graph of 2nd flood peak during the year 2015-16



Water level vs. Time graph of 3rd flood peak during the year 2015-16



5.0 Trend Analysis

5.1 Trend Analysis of Purna Basin

5.1.1 Introduction

Trends are important indicators of the temporal variability of runoff as computed from observed discharge at site. By analyzing the time sequence of the runoff, we assess the magnitude and significance of the temporal variability. The present surface runoff trend study involves analysis of the temporal variability of data sets on the observed discharges in Purna basin using available data of existing river gauging stations.

5.1.2 Methodology

In the analysis of the trends of runoff on Purna River at Mahuwa annual runoff is computed and analyzed. The analysis is carried out for one (1) river gauging station with sufficiently long and continuous data sets that are fairly representatively distributed across Purna river Basin.

Overall one station has been considered in this study. The length of the data sets of river gauging station is 45 years. Subsequently, time series are analysed on various statistical parameters, fitting of mathematical equations, observing moving means for various periods so as to find out if there are any trends in the annual runoff data.

5.1.2.1 Time series analysis

Time series is defined as a sequence of values arrayed in order of their occurrence which can be characterized by statistical properties. Time series analysis may be used to test the variability, homogeneity and trend of a stream flow series or simply to give an upright list the characteristics of the series as graphically displayed. Significant movements of time series are the secular, periodic, cyclic and irregular trends. A time series may display a tendency to increase or decrease, over a specified period. Such a series provides an interesting illustration because if the trend is usually predominant, virtually no other movements are discernible.

Various methods exist for analysis of time series such moving averages, residual series, residual mass curves and balance. Trends may also be revealed by determining if observed stream flow follows some mathematical equation as a function of time.

In this chapter, first statistical parameters have been computed for time series data of annual runoff in Purna basin. It is also ascertained if any mathematical equation can be fitted to the time series to assess predictability. Finally, the data is analysed by the method of moving means for various periods.

5.1.3 Availability of Data

There is a 1 G & D site in Purna Basin. Availability of annual runoff data for this site is summarized in **Table -5.1.1**

Table-5.1.1: Availability of Data

S. No.	Site	Period of Availability	Years
1.	Mahuwa on Purna River	1971-72 to 2015-16	45
The data is placed at Annexure-1 and shown in line diagram in **Fig- 5.1.1.**			

5.1.4 Analysis

5.1.4.1 Statistical Analysis

Various statistical parameters of the time series of available data are given below in **Table-5.1.2**

Table-5.1.2 Statistical parameters of Annual Runoff series at various sites in Purna Basin

River Gauging Station	Data length (years)	Mean (MCM)	Median (MCM)	standard deviation (MCM)	Co-efficient of variation
Mahuwa	45	1298	1116	849.355	0.655

5.1.4.2 Fit characteristics

In order to find out if any mathematical equation represents the time series as a function of time, fitting of various types of equations viz. linear, logarithmic, exponential and polynomial have been attempted. Results of such fits are given in the **Table- 5.1.3** and shown in **Fig 5.1.2**

Table-5.1.3: Fit Characteristics

S. No.	Station name	Standard Deviation σ (MCM)	Coefficient of variation C_v	Mathematical Fit		R^2
1.	Mahuwa	849.355	0.655	Linear	y = -3.6679x + 8607.735	0.0032
				Logarithmic	y = -7271.31ln(x) + 56540.48	0.0032
				Exponential	$y = 54441.6e^{-0.002x}$	0.0015
				Polynomial	y = -0.5754x2 + 2289.79.x – 2276724.38	0.0139

5.1.4.3 Moving Mean Analysis

In statistics, a moving mean (average), also called rolling average, rolling mean or running average, is a type of finite impulse response filter used to analyze a set of data points by creating a series of averages of different subsets of the full data set.

The first element of the moving average is obtained by taking the average of the initial fixed subset of the number series. Then the subset is modified by "shifting forward", that is excluding the first number of the series and including the next number following the original subset in the series. This creates a new subset of numbers, which is averaged. This process is repeated over the entire data series. The plot line connecting all the (fixed) averages is the moving average. A moving average is a set of numbers, each of which is the average of the corresponding subset of a larger set of data points. A moving average may also use unequal weights for each data value in the subset to emphasize particular values in the subset.

A moving average is commonly used with time series data to smooth out short-term fluctuations and highlight longer-term trends or cycles.

In the present analysis, moving means have been computed for 3, 5 and 7 year periods for various sites of Purna River Basin and shown in **Fig-5.1.3**.

5.1.5 Interpretation

5.1.5.1 Fitting of various statistical/mathematical models viz linear, logarithmic, exponential and polynomial reveals that values of R^2 range from 0.0139 to 0.0015 for Mahuwa. The values of R^2 are quite close to 0 indicating absence of any significant trend.

5.1.5.2 The curve for three year moving mean shows two bell shaled patterns at either end. However, as the period of moving mean is enlarges, smaller variations disappear and no trend is seen.

5.1.6 Conclusion

Statistically speaking, the average annual runoff of river Purna in general, appears to be a random variable A longer set of time series data may help identify trends in annual runoff, if any.

Annexure-I

Annual Runoff data at Site Mahuwa on Purna

Water Year	Annual runoff in MCM
1971-72	873
1972-73	403
1973-74	1471
1974-75	182
1975-76	1258
1976-77	4299
1977-78	2544
1978-79	1149
1979-80	1168
1980-81	835
1981-82	1595
1982-83	1052
1983-84	1928
1984-85	1246
1985-86	997
1986-87	502
1987-88	357
1988-89	2076
1989-90	1223
1990-91	1075
1991-92	618
1992-93	985
1993-94	1382
1994-95	2991
1995-96	711
1996-97	1162
1997-98	1027
1998-99	1534
1999-00	781
2000-01	379
2001-02	870
2002-03	1116
2003-04	1689
2004-05	2002
2005-06	3395
2006-07	2552
2007-08	1755
2008-09	2023
2009-10	571
2010-11	926
2011-12	858
2012-13	525
2013-14	1547
2014-15	512
2015-16	246

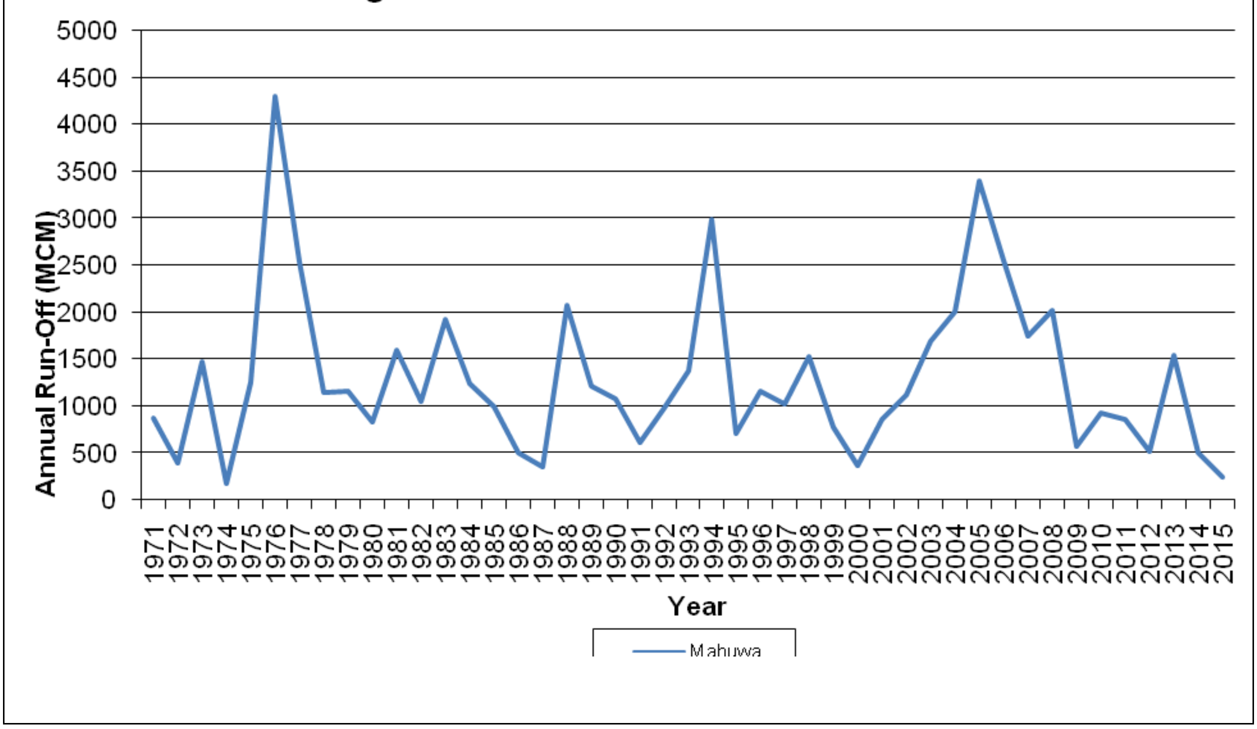


Fig. 5.1.1: Annual Run Off - Purna at Mahuwa Sites

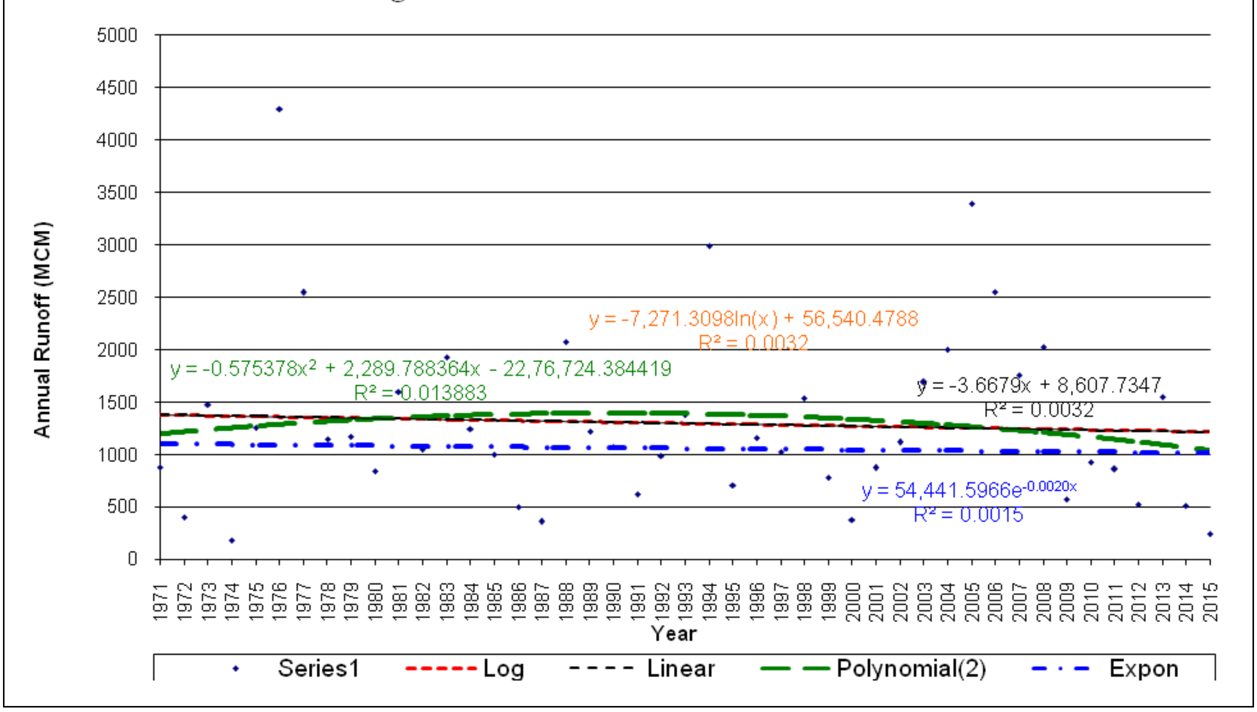


Fig.5.1.2 : Fit Characteistics- annual run off - Purna at Mahuwa

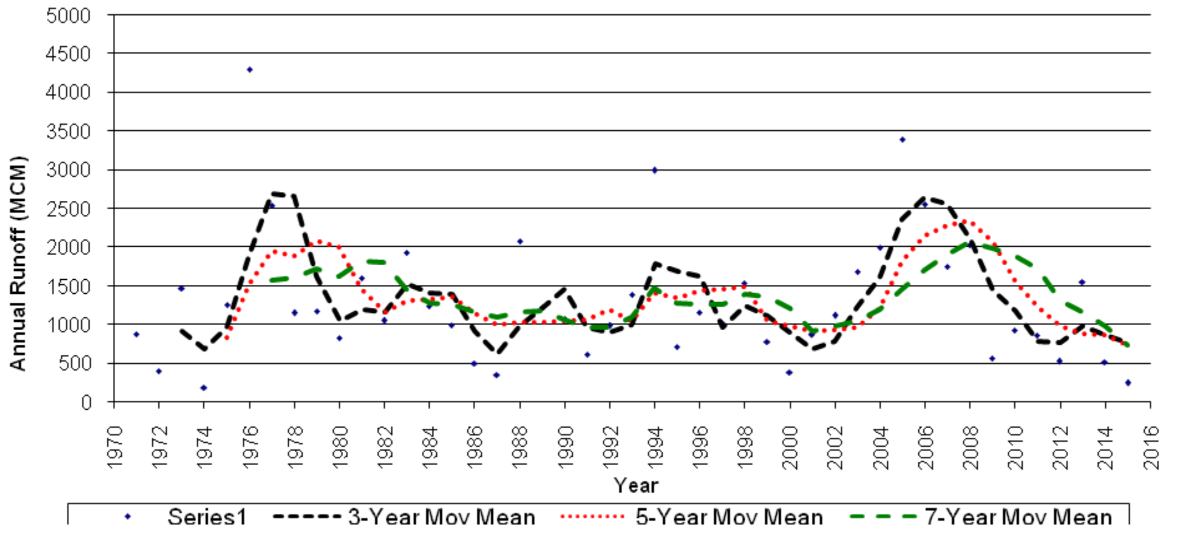


Fig.5.1.3: Moving Mean Analysis for annual run off - Purna at Mahuwa

5.2 Trend analysis of Ambica Basin

5.2.1 Introduction

Trends are important indicators of the temporal variability of runoff as computed from observed discharge at site. By analyzing the time sequence of the runoff, we assess the magnitude and significance of the temporal variability. The present surface runoff trend study involves analysis of the temporal variability of data sets on the observed discharges in Ambica basin using available data of existing river gauging stations.

5.2.2 Methodology

In the analysis of the trends of runoff on Ambica River at Gadat, annual runoff is computed and analyzed. The analysis is carried out for one (1) river gauging station with sufficiently long and continuous data sets that are fairly representatively distributed across Ambica river Basin.

Overall one station has been considered in this study. The length of the data sets of river gauging station is 37 years. Subsequently, time series are analysed on various statistical parameters, fitting of mathematical equations, observing moving means for various period so as to find out if there are any trends in the annual runoff data.

5.2.2.1 Time series analysis

Time series is defined as a sequence of values arrayed in order of their occurrence which can be characterized by statistical properties. Time series analysis may be used to test the variability, homogeneity and trend of a stream flow series or simply to give an upright list the characteristics of the series as graphically displayed. Significant movements of time series are the secular, periodic, cyclic and irregular trends. A time series may display a tendency to increase or decrease, over a specified period. Such a series provides an interesting illustration because if the trend is usually predominant, virtually no other movements are discernible.

Various methods exist for analysis of time series such moving averages, residual series, residual mass curves and balance. Trends may also be revealed by determining if observed stream flow follows some mathematical equation as a function of time.

In this chapter, first statistical parameters have been computed for time series data of annual runoff in Ambica basin. It is also ascertained if any mathematical equation can be fitted to the time series to assess predictability. Finally, the data is analysed by the method of moving means for various periods.

5.2.3 Availability of Data

There is a one G & D site in Ambica Basin. Availability of annual runoff data for this site is summarized in **Table -5.2.1**

Table-5.2.1 Availability of Data

S. no.	Site	Period of Availability	Years
1.	Gadat on Ambica River	1979-80 to 2015-16	37
The data is placed at Annexure-1 and shown in line diagram in **Fig- 5.2.1.**			

5.2.4 Analysis

5.2.4.1 Statistical Analysis

Various statistical parameters of the time series of available data are given below in

Table-5.2.2.

Table-5.2.2 Statistical parameters of Annual Runoff series at various sites in Ambica Basin

River Gauging Station	Data length (years)	Mean (MCM)	Median (MCM)	standard deviation (MCM)	Co-efficient of variation
Gadat	37	1446	1289	695.084	0.481

5.2.4.2 Fit characteristics

In order to find out if any mathematical equation represents the time series as a function of time, fitting of various types of equations viz. linear, logarithmic, exponential and polynomial have been attempted. Results of such fits are given in the **Table-5.2.3** and in **Fig 5.2 2**.

Table-5.2.3: Fit Characteristics

S. No.	Station name	Standard Deviation σ (MCM)	Coefficient of variation C_v	Mathematical Fit		R2
1.	Gadat	695.084	0.481	Linear	y = -2.059x – 5557.6	0.001
				Logarithmic	y = 2241.ln(x) - 15571	0.000
				Exponential	y = 210476.2e0.0025x	0.0033
				Polynomial	y = -1.2279x2 + 4902.09x – 4891090.43	0.0343

5.2.4.3 Moving Mean Analysis

In statistics, a moving mean (average), also called rolling average, rolling mean or running average, is a type of finite impulse response filter used to analyze a set of data points by creating a series of averages of different subsets of the full data set.

The first element of the moving average is obtained by taking the average of the initial fixed subset of the number series. Then the subset is modified by "shifting forward", that is excluding the first number of the series and including the next number following the original subset in the series. This creates a new subset of numbers, which is averaged. This process is repeated over the entire data series. The plot line connecting all the (fixed) averages is the moving average. A moving average is a set of numbers, each of which is the average of the corresponding subset of a larger set of data points. A moving average may also use unequal weights for each data value in the subset to emphasize particular values in the subset.

A moving average is commonly used with time series data to smooth out short-term fluctuations and highlight longer-term trends or cycles.

In the present analysis, moving means have been computed for 3, 5 and 7 year periods for Ambica River Basin and shown in **Fig-5.2.3.**

5.2.5 Interpretation

5.2.5.1 Fitting of various statistical/mathematical models viz linear, logarithmic, exponential and polynomial reveals that values of R^2 range from 0.000 to 0.0343 for Gadat. The values of R^2 are quite close to 0 indicating absence of any significant trend.

5.2.5.2 Patterns of gradually rising and then falling values of annual run off are seen in moving mean plots of different periods indicating elements of cyclical ness in the data. However, in view of the limited length of data series, it may be premature to conclude that there exists a definite cyclic trend in the average annual runoff data.

5.2.6 Conclusion

Statistically speaking, the average annual runoff of river Ambica, in general, appears to be a random variable; however elements of cyclicalness cannot be ruled out on the strength of moving mean analysis. A longer set of time series data may help identify trends in annual runoff, if any.

Annexure-I

Annual Runoff data of Site Gadat on Ambika

Water Year	Annual runoff in MCM
1979-80	1089
1980-81	1189
1981-82	2052
1982-83	943
1983-84	2298
1984-85	1801
1985-86	1073
1986-87	890
1987-88	369
1988-89	2266
1989-90	1265
1990-91	1097
1991-92	943
1992-93	1389
1993-94	1704
1994-95	3859
1995-96	940
1996-97	1374
1997-98	1206
1998-99	1627
1999-00	1652
2000-01	688
2001-02	1289
2002-03	1063
2003-04	1580
2004-05	1598
2005-06	3010
2006-07	2126
2007-08	1733
2008-09	1794
2009-10	704
2010-11	1199
2011-12	1299
2012-13	635
2013-14	2152
2014-15	1161
2015-16	453

Fig.5.2.1 Annual Run off - Ambika at Gadat

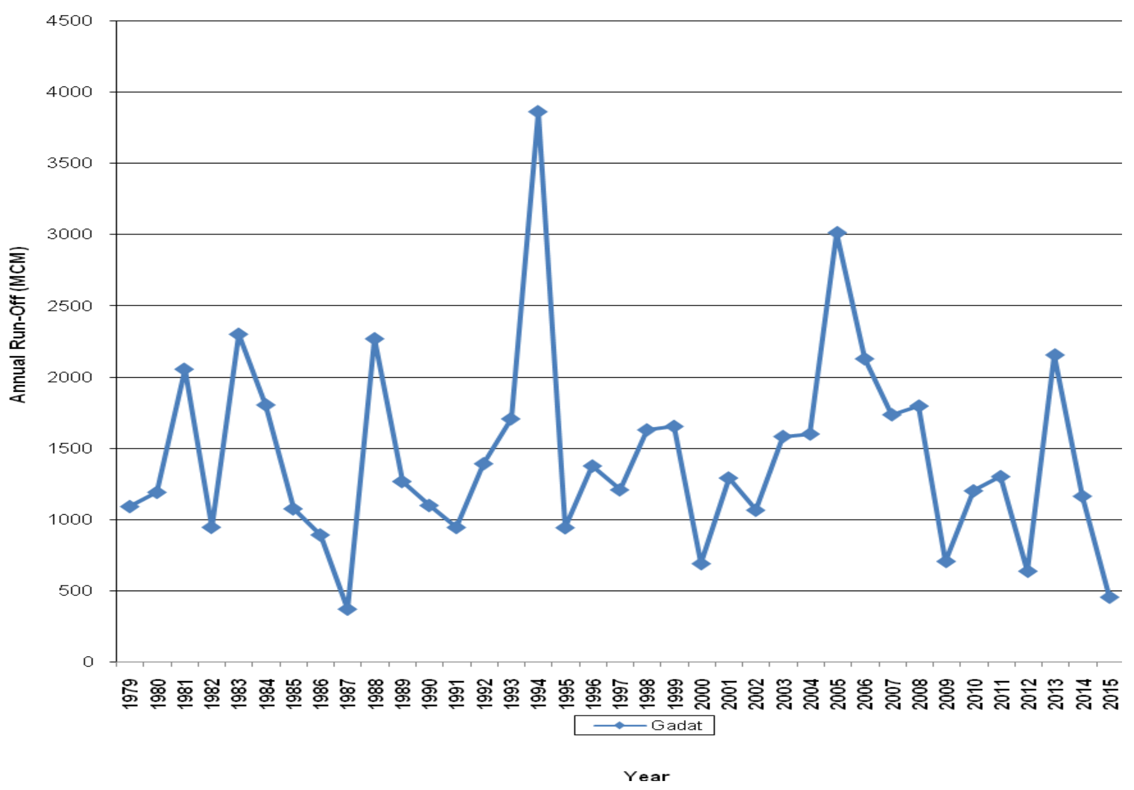
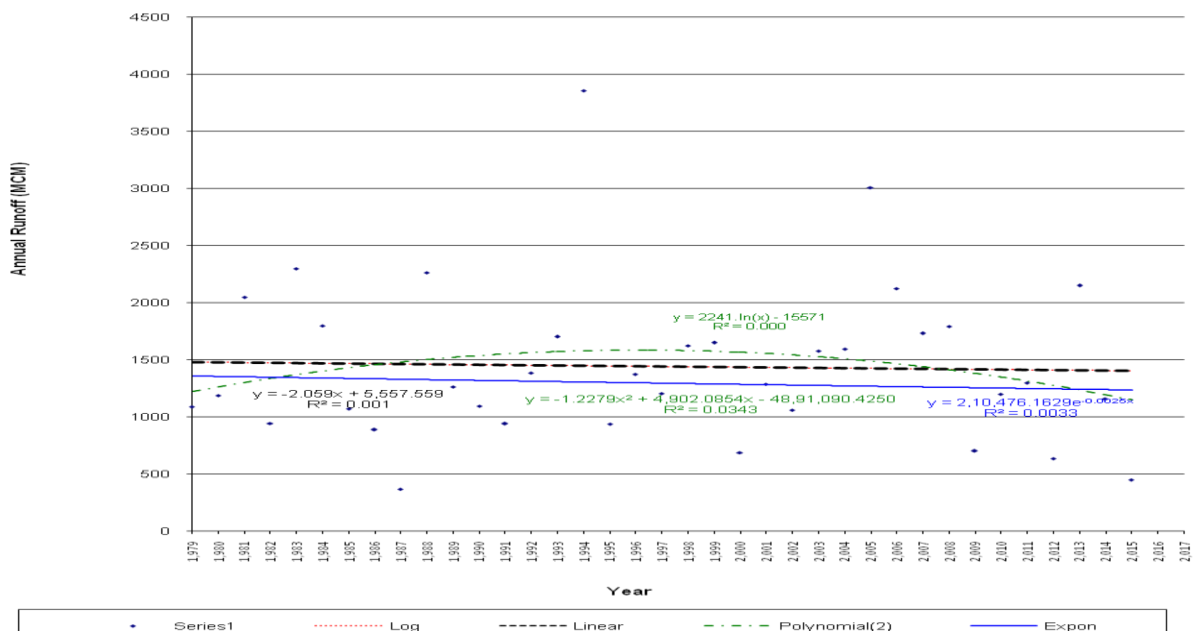


Fig.5.2.2 Fit Characteistics -Annual run off- Ambica at Gadat



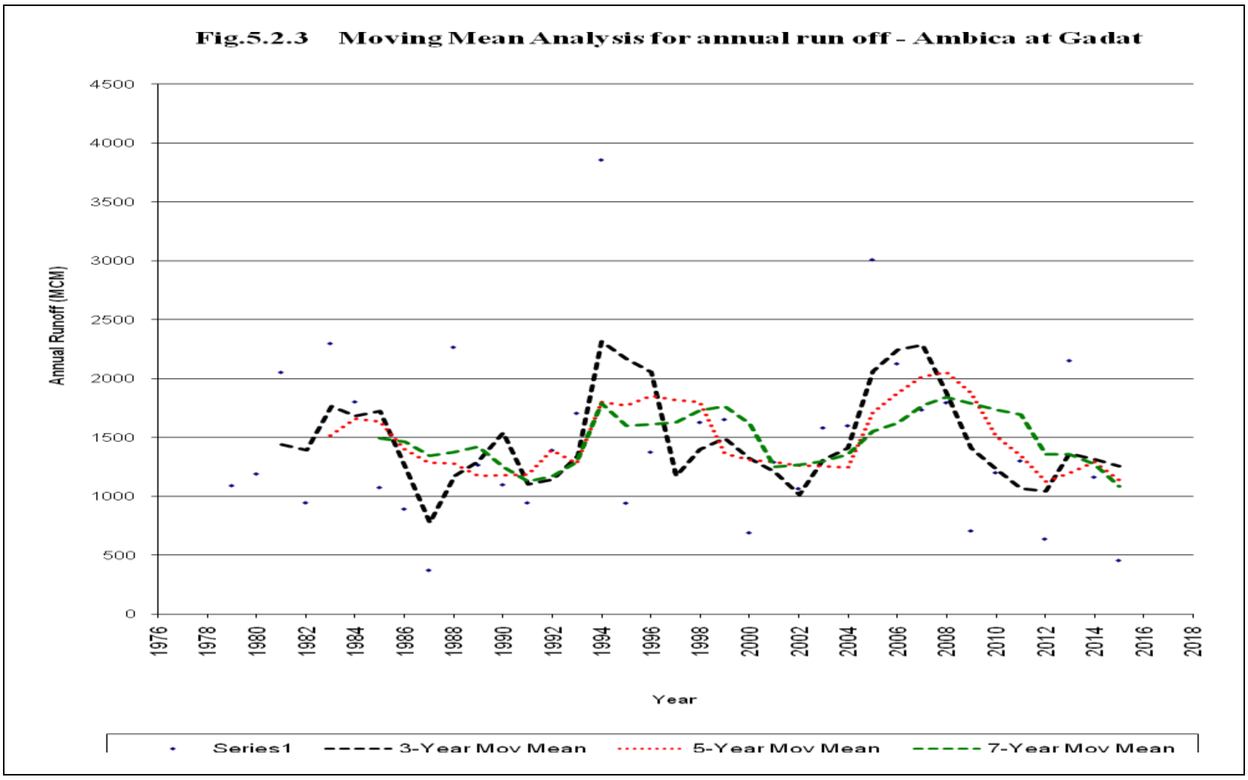


Fig.5.2.3 Moving Mean Analysis for annual run off - Ambica at Gadat
Annual Runoff (MCM)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
Year
Series1
3-Year Mov Mean
5-Year Mov Mean
7-Year Mov Mean

5.3 Trend Analysis of Vaitarna Basin

5.3.1 Introduction

Trends are important indicators of the temporal variability of runoff as computed from observed discharge at site. By analyzing the time sequence of the runoff, we assess the magnitude and significance of the temporal variability. The present surface runoff trend study involves analysis of the temporal variability of data sets on the observed discharges in Vaitarna basin using available data of existing river gauging stations.

5.3.2 Methodology

In the analysis of the trends of runoff on Vaitarna River at Durvesh, annual runoff is computed and analyzed. The analysis is carried out for one (1) river gauging station with sufficiently long and continuous data sets that are fairly representatively distributed across Vaitarna river Basin.

Overall one station has been considered in this study. The length of the data sets of river gauging station is 45 years. Subsequently, time series are analysed on various statistical parameters, fitting of mathematical equations, observing moving means for various period so as to find out if there are any trends in the annual runoff data.

5.3.2.1 Time series analysis

Time series is defined as a sequence of values arrayed in order of their occurrence which can be characterized by statistical properties. Time series analysis may be used to test the variability, homogeneity and trend of a stream flow series or simply to give an upright list the characteristics of the series as graphically displayed. Significant movements of time series are the secular, periodic, cyclic and irregular trends. A time series may display a tendency to increase or decrease, over a specified period. Such a series provides an interesting illustration because if the trend is usually predominant, virtually no other movements are discernible.

Various methods exist for analysis of time series such moving averages, residual series, residual mass curves and balance. Trends may also be revealed by determining if observed stream flow follows some mathematical equation as a function of time.

In this chapter, first statistical parameters have been computed for time series data of annual runoff in Vaitarna basin. It is also ascertained if any mathematical equation can be fitted to the time series to assess predictability. Finally, the data is analysed by the method of moving means for various periods.

5.3.3 Availability of Data

There is a 1 G & D site in Vaitarna Basin. Availability of annual runoff data for this site is summarized in **Table -5.3.1**

Table-5.3.1 Availability of Data

S. no.	Site	Period of Availability	Years
1.	Durvesh on Vaitarna River	1971-72 to 2015-16	45
The data is placed at Annexure-1 and shown in line diagram in **Fig-5.3.1.**			

5.3.4 Analysis

5.3.4.1 Statistical Analysis

Various statistical parameters of the time series of available data are given below in

Table-5.3.2.

Table-5.3.2 Statistical parameters of Annual Runoff series at various sites in Vaitarna Basin

River Gauging Station	Data length (years)	Mean (MCM)	Median (MCM)	standard deviation (MCM)	Co-efficient of variation
Durvesh	45	3141	3058	1214.685	0.387

5.3.4.2 Fit characteristics

In order to find out if any mathematical equation represents the time series as a function of time, fitting of various types of equations viz. linear, logarithmic, exponential and polynomial have been attempted. Results of such fits are given in the **Table-5.3.3** and shown in **Fig 5.3.2**.

Table-5.3.3 Fit Characteristics

S. No	Station name	Standard Deviation σ (MCM)	Coefficient of variation C_v	Mathematical Fit		R^2
1.	Durvesh	1214.685	0.387	Linear	y = -0.57851x + 4294.44	0.00004
				Logarithmic	y = 1258.78ln(x) – 12704.8	0.00005
				Exponential	$y = 1320.19e^{0.0004x}$	0.00018
				Polynomial	y = 1.5616x2 – 6225.2x + 6206878.65	0.03845

5.3.4.3 Moving Mean Analysis

In statistics, a moving mean (average), also called rolling average, rolling mean or running average, is a type of finite impulse response filter used to analyze a set of data points by creating a series of averages of different subsets of the full data set.

The first element of the moving average is obtained by taking the average of the initial fixed subset of the number series. Then the subset is modified by "shifting forward", that is excluding the first number of the series and including the next number following the original subset in the series. This creates a new subset of numbers, which is averaged. This process is repeated over the entire data series. The plot line connecting all the (fixed) averages is the moving average. A moving average is a set of numbers, each of which is the average of the corresponding subset of a larger set of data points. A moving average may also use unequal weights for each data value in the subset to emphasize particular values in the subset.

A moving average is commonly used with time series data to smooth out short-term fluctuations and highlight longer-term trends or cycles.

In the present analysis, moving means have been computed for 3, 5 and 7 year periods for various sites of Vaitarna River Basin and shown in **Fig-5.3.3**

5.3.5 Interpretation

5.3.5.1 Fitting of various statistical/mathematical models viz linear, logarithmic, exponential and polynomial reveals that values of R^2 range from 0.00004 to 0.03845 for Durvesh. The values of R^2 are quite close to 0 indicating absence of any significant trend.

5.3.5.2 It is seen at site Durvesh from the plot of moving mean averages that after a period of high annual runoff about mid 1970's ,the annual runoff has gradually reduced and subsequently again shows gradual rise peaking about 2005. It may or may not be part of a larger trend. With the current length of data set, conclusions cannot be drawn regarding cyclical trend.

5.3.6 Conclusion

Statistically speaking, the average annual runoff of river Vaitarna at Durvesh in general, appears to be a random variable. A longer set of time series data may help identify trends in annual runoff, if any.

Annexure-I

Annual Runoff data of Site Durvesh on Vaitarna

Water Year	Annual runoff in MCM
1971-72	3605
1972-73	1594
1973-74	3951
1974-75	2822
1975-76	5025
1976-77	7379
1977-78	4092
1978-79	2312
1979-80	2995
1980-81	3543
1981-82	3240
1982-83	2006
1983-84	3689
1984-85	2738
1985-86	1517
1986-87	1677
1987-88	1415
1988-89	3065
1989-90	2004
1990-91	3502
1991-92	2265
1992-93	1910
1993-94	2496
1994-95	3995
1995-96	1661
1996-97	2226
1997-98	2842
1998-99	3674
1999-00	2673
2000-01	2334
2001-02	3058
2002-03	3180
2003-04	4193
2004-05	3994
2005-06	5338
2006-07	5038
2007-08	4082
2008-09	4360
2009-10	2078
2010-11	3829
2011-12	3701
2012-13	2466
2013-14	3745
2014-15	2970
2015-16	1089

Fig.5.3.1 Annual Run off- Vaitarna at Durvesh

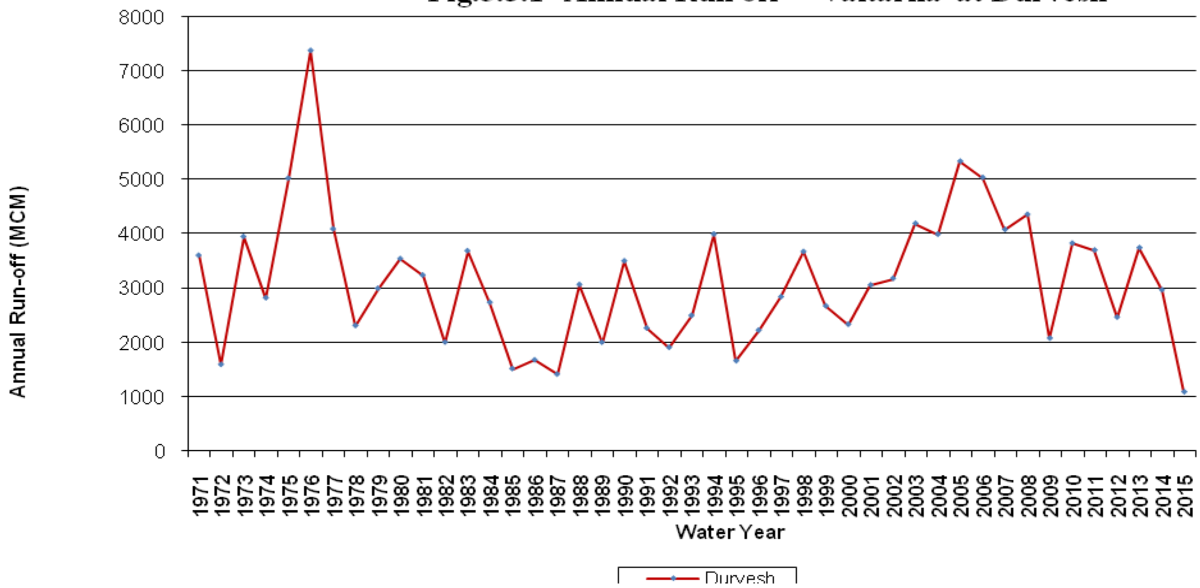
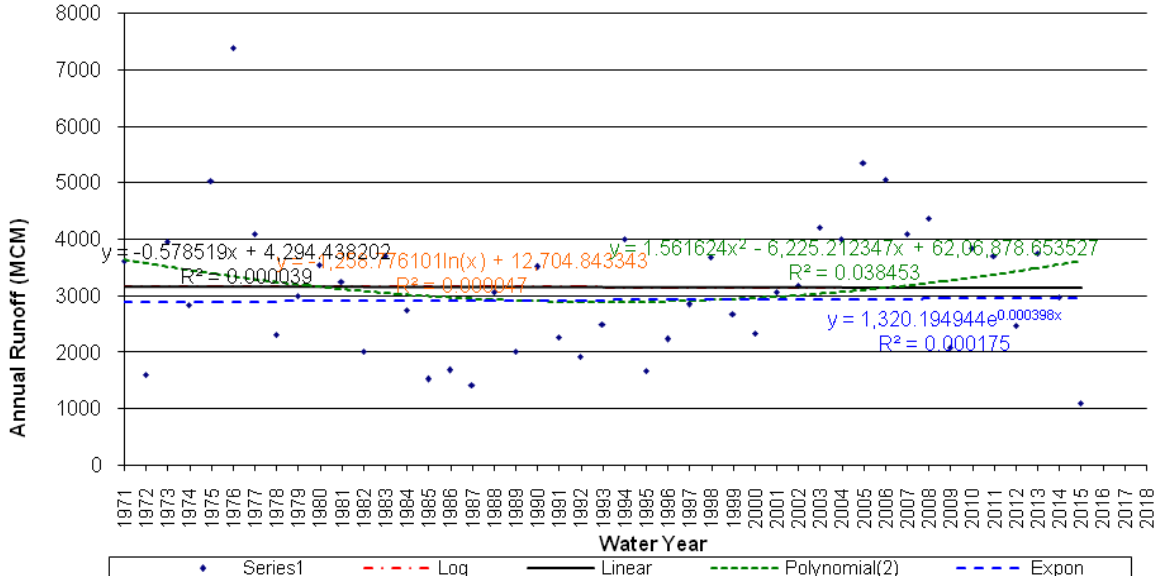


Fig.5.3.2: Fit Characteistics -Annual runoff -Vaitarna at Durvesh



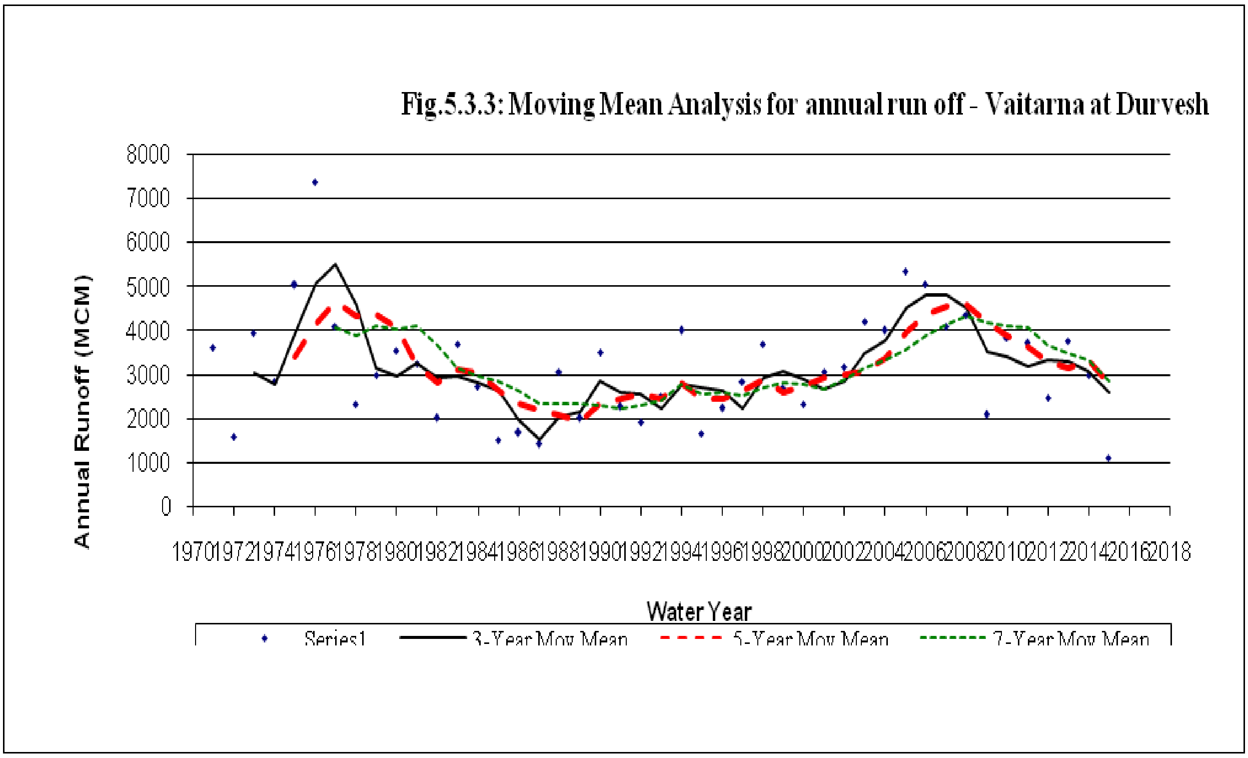


Fig.5.3.3: Moving Mean Analysis for annual run off - Vaitarna at Durvesh
Annual Runoff (MCM)
8000
7000
6000
5000
4000
3000
2000
1000
0
1970 1972 1974 1976 1978 1980 1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018
Water Year
Series1
3-Year Mov Mean
5-Year Mov Mean
7-Year Mov Mean

5.4 Trend Analysis of Dhadar basin

5.4.1 Introduction

Trends are important indicators of the temporal variability of runoff as computed from observed discharge at site. By analyzing the time sequence of the runoff, we assess the magnitude and significance of the temporal variability. The present surface runoff trend study involves analysis of the temporal variability of data sets on the observed discharges in Dhadhar basin using available data of existing river gauging stations.

5.4.2 Methodology

In the analysis of the trends of runoff on Dhadhar River is computed and analyzed. The analysis is carried out for one (1) river gauging station with sufficiently long and continuous data sets that are fairly representatively distributed across Dhadhar river Basin.

Overall one station has been considered in this study. The length of the data sets of river gauging station is 26 years. Subsequently, time series are analysed on various statistical parameters, fitting of mathematical equations, observing moving means for various period so as to find out if there are any trends in the annual runoff data.

5.4.2.1 Time series analysis

Time series is defined as a sequence of values arrayed in order of their occurrence which can be characterized by statistical properties. Time series analysis may be used to test the variability, homogeneity and trend of a stream flow series or simply to give an upright list the characteristics of the series as graphically displayed. Significant movements of time series are the secular, periodic, cyclic and irregular trends. A time series may display a tendency to increase or decrease, over a specified period. Such a series provides an interesting illustration because if the trend is usually predominant, virtually no other movements are discernible.

Various methods exist for analysis of time series such moving averages, residual series, residual mass curves and balance. Trends may also be revealed by determining if observed stream flow follows some mathematical equation as a function of time.

In this chapter, first statistical parameters have been computed for time series data of annual runoff in Dhadhar basin. It is also ascertained if any mathematical equation can be fitted to the time series to assess predictability. Finally, the data is analysed by the method of moving means for various periods.

5.4.3 Availability of Data

There is a 1 G & D site in Dhadhar Basin. Availability of annual runoff data for this site is summarized in **Table -5.4.1**

Table-5.4.1 Availability of Data

S. no.	Site	Period of Availability	Years
1.	Dhadhar at Pingalwada	1989-90 to 2015-16	27
The data is placed at Annexure-1 and shown in line diagram in **Fig- 5.4.1.**			

5.4.4 Analysis

5.4.4.1 Statistical Analysis

Various statistical parameters of the time series of available data are given below in

Table-5.4.2.

Table-5.4.2 Statistical parameters of Annual Runoff series at various sites in Dhadhar Basin

River Gauging Station	Data length (years)	Mean (MCM)	Median (MCM)	Standard deviation (MCM)	Co-efficient of variation
Pingalwada	27	494	452	288.928	0.585

5.4.4.2 Fit characteristics

In order to find out if any mathematical equation represents the time series as a function of time, fitting of various types of equations viz. linear, logarithmic, exponential and polynomial have been attempted. Results of such fits are given in **Table-5.4.3** and in **Fig 5.4.2**.

Table-5.4.3 Fit Characteristics

S. No.	Station name	Standard Deviation σ (MCM)	Coefficient of variation C_v	Mathematical Fit		R^2
1.	Pingalwada	288.928	0.585	Linear	y = 7.416x - 14374	0.037
				Logarithmic	y = 14881ln(x) - 11264	0.037
				Exponential	y = 0.000000000002 e0.016535287129x	0.027
				Polynomial	y = -1.24519x2 + 4,995.66375x - 5,010,039.22780	0.081

5.4.4.3 Moving Mean Analysis

In statistics, a moving mean (average), also called rolling average, rolling mean or running average, is a type of finite impulse response filter used to analyze a set of data points by creating a series of averages of different subsets of the full data set.

The first element of the moving average is obtained by taking the average of the initial fixed subset of the number series. Then the subset is modified by "shifting forward", that is excluding the first number of the series and including the next number following the original subset in the series. This creates a new subset of numbers, which is averaged. This process is repeated over the entire data series. The plot line connecting all the (fixed) averages is the moving average. A moving average is a set of numbers, each of which is the average of the corresponding subset of a larger set of data points. A moving average may also use unequal weights for each data value in the subset to emphasize particular values in the subset.

A moving average is commonly used with time series data to smooth out short-term fluctuations and highlight longer-term trends or cycles.

In the present analysis, moving means have been computed for 3, 5 and 7 year periods for Dhadhar River Basin and shown in **Fig-5.4.3.**

5.4.5 Interpretation

5.4.5.1 Fitting of various statistical/mathematical models viz linear, logarithmic, exponential and polynomial reveals that values of R^2 range from 0.027 to 0.081 for Pingalwada. The values of R^2 are quite close to 0 indicating absence of any significant trend.

5.4.5.2 No significant trend is seen at site Pingalwada from the plot of moving mean averages except that it shows signs of rising by 2005-06 & 2006-07. However, in view of the limited length of data series, it may be premature to conclude that there exists a definite trend in the annual runoff data.

5.4.6 Conclusion

Statistically speaking, the average annual runoff of river Dhadhar at Pingalwada, in general, appears to be a random variable. A longer set of time series data may help identify trends in annual runoff, if any.

Annexure-I

Annual Runoff data at Pingalwada in Dhadhar Basin

Water Year	Annual runoff in MCM
1989-90	346
1990-91	963
1991-92	304
1992-93	140
1993-94	428
1994-95	638
1995-96	345
1996-97	566
1997-98	722
1998-99	452
1999-00	47
2000-01	157
2001-02	416
2002-03	267
2003-04	487
2004-05	556
2005-06	1009
2006-07	1239
2007-08	646
2008-09	526
2009-10	116
2010-11	699
2011-12	341
2012-13	293
2013-14	628
2014-15	795
2015-16	204

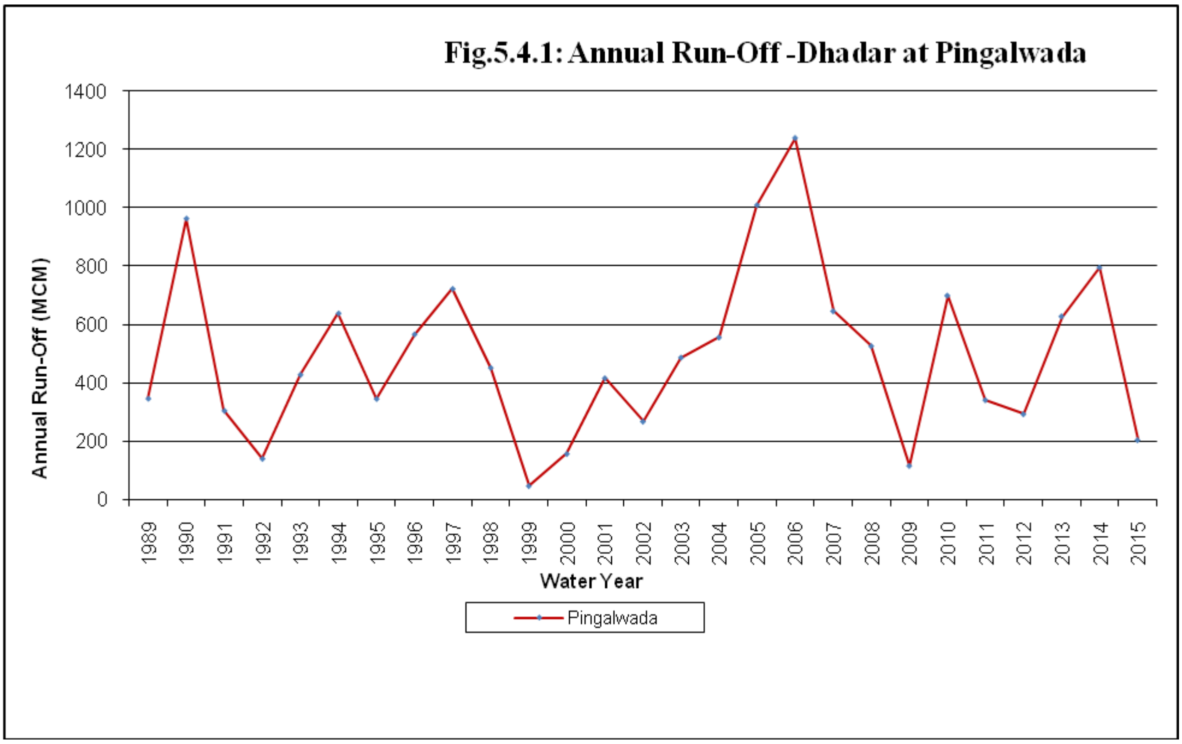


Fig.5.4.1: Annual Run-Off -Dhadar at Pingalwada
Annual Run-Off (MCM)
Water Year
Pingalwada

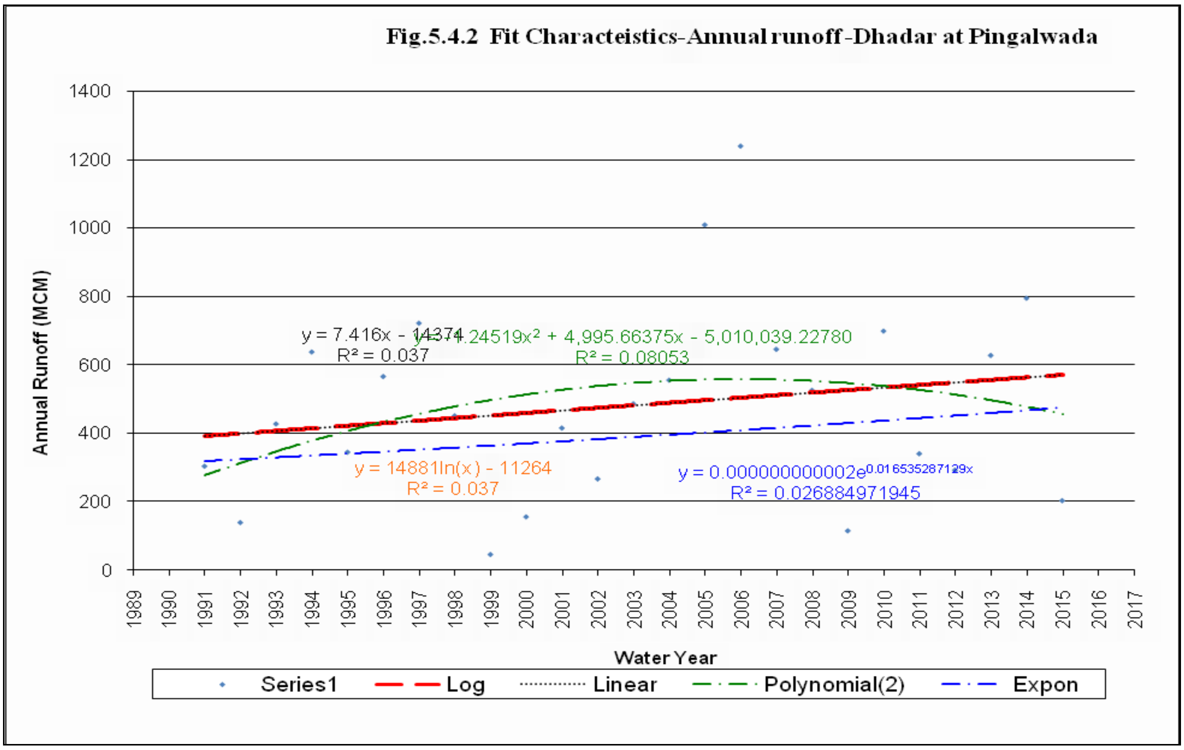


Fig.5.4.2 Fit Characteistics-Annual runoff-Dhadar at Pingalwada
Annual Runoff (MCM)
y = 7.416x - 14374
R² = 0.037
R² = 0.08053
y = 14881ln(x) - 11264
R² = 0.037
R² = 0.026884971945
Water Year
Series1
Log
Linear
Polynomial(2)
Expon

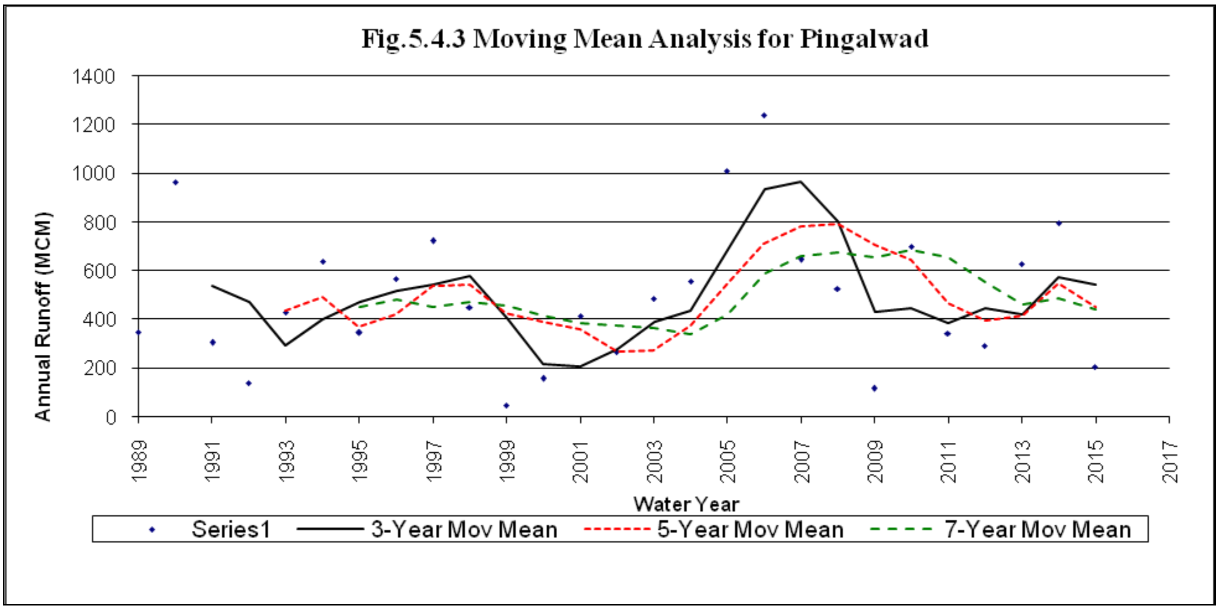


Fig.5.4.3 Moving Mean Analysis for Pingalwad
1400
1200
1000
800
600
400
200
0
Annual Runoff (MCM)
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
Water Year
Series1
3-Year Mov Mean
5-Year Mov Mean
7-Year Mov Mean

5.5 Trend Analysis of Damanganga basin

5.5.1 Introduction

Trends are important indicators of the temporal variability of runoff as computed from observed discharge at site. By analyzing the time sequence of the runoff, we assess the magnitude and significance of the temporal variability. The present surface runoff trend study involves analysis of the temporal variability of data sets on the observed discharges in Damanganga basin using available data of existing river gauging stations.

5.5.2 Methodology

In the analysis of the trends of runoff on Damanganga River and its major tributary Wagh, annual runoff is computed and analyzed. The analysis is carried out for two (2) river gauging station with sufficiently long and continuous data sets that are fairly representatively distributed across Damanganga river Basin.

Overall two stations have been considered in this study. The length of the data sets of river gauging station is 24 years. Subsequently, time series are analysed on various statistical parameters, fitting of mathematical equations, observing moving means for various period so as to find out if there are any trends in the annual runoff data.

5.5.2.1 Time series analysis

Time series is defined as a sequence of values arrayed in order of their occurrence which can be characterized by statistical properties. Time series analysis may be used to test the variability, homogeneity and trend of a stream flow series or simply to give an upright list the characteristics of the series as graphically displayed. Significant movements of time series are the secular, periodic, cyclic and irregular trends. A time series may display a tendency to increase or decrease, over a specified period. Such a series provides an interesting illustration because if the trend is usually predominant, virtually no other movements are discernible.

Various methods exist for analysis of time series such moving averages, residual series, residual mass curves and balance. Trends may also be revealed by determining if observed stream flow follows some mathematical equation as a function of time.

In this chapter, first statistical parameters have been computed for time series data of annual runoff in Damanganga basin. It is also ascertained if any mathematical equation can be fitted to the time series to assess predictability. Finally, the data is analysed by the method of moving means for various periods.

5.5.3 Availability of Data

There are 2 G & D sites in Damanganga Basin. Availability of annual runoff data for this site is summarized in **Table -5.5.1.**

Table-5.5.1 Availability of Data

S. no.	Site	Period of Availability	Years
1.	Nanipalsan on Damanganga River	1991-92 to 2015-16	25
2	Ozerkheda on Wagh River	1991-92 to 2015-16	25
The data is placed at Annexure-1 and shown in line diagram in Fig- 5.5.1 & 5.5.2			

5.5.4 Analysis

5.5.4.1 Statistical Analysis

Various statistical parameters of the time series of available data are given below in

Table-5.5.2.

Table-5.5.2: Statistical parameters of Annual Runoff series at various sites in Damanganga Basin

River Gauging Station	Data length (years)	Mean (MCM)	Median (MCM)	Standard deviation (MCM)	Co-efficient of variation
Nanipalsan	25	897.0	880.0	385.212	0.429
Ozerkheda	25	1028	988.0	347.446	0.338

5.5.4.2 Fit characteristics

In order to find out if any mathematical equation represents the time series as a function of time, fitting of various types of equations viz. linear, logarithmic, exponential and polynomial have been attempted. Results of such fits are given in the Table-5.5. 3 and shown in Fig 5.5.2A & 5.5.2B

Table-5.5.3: Fit Characteristics

S. No.	Station name	Standard Deviation σ (MCM)	Coefficient of variation C_v	Mathematical Fit		R^2
1	Nanipalsan	385.212	0.429	Linear	y =12.52x – 24145.49	0.057
				Logarithmic	y = 25106.5ln(x) – 189936.12	0.057
				Exponential	$y = 0.000000014e^{0.01354x}$	0.066
				Polynomial	y = -1.354x2 + 5438.6x – 5458340.5	0.085
2	Ozerkheda	349.562	0.341	Linear	y = 5.1986 x – 9384.84	0.012
				Logarithmic	y = 10424.87ln(x) – 78226.01	0.012
				Exponential	$y = 0.010e^{0.005x}$	0.015
				Polynomial	y = -0.5913x2 +2373.8 x – 2381476.8	0.018

5.5.4.3 Moving Mean Analysis

In statistics, a moving mean (average), also called rolling average, rolling mean or running average, is a type of finite impulse response filter used to analyze a set of data points by creating a series of averages of different subsets of the full data set.

The first element of the moving average is obtained by taking the average of the initial fixed subset of the number series. Then the subset is modified by "shifting forward", that is excluding the first number of the series and including the next number following the original subset in the series. This creates a new subset of numbers, which is averaged. This process is repeated over the entire data series. The plot line connecting all the (fixed) averages is the moving average. A moving average is a set of numbers, each of which is the average of the corresponding subset of a larger set of data points. A moving average may also use unequal weights for each data value in the subset to emphasize particular values in the subset. A moving average is commonly used with time series data to smooth out short-term fluctuations and highlight longer-term trends or cycles.

In the present analysis, moving means have been computed for 3, 5 and 7 year periods for various sites of Damanganga River Basin and shown in **Fig-5.5.3A & 5.5.3B**.

5.5.5. Interpretation

5.5.5.1 Fitting of various statistical/mathematical models viz linear, logarithmic, exponential and polynomial reveals that values of R^2 range from 0.057to 0.085 for Nanipalsan. Similarly, fitting of various statistical/mathematical models viz linear, logarithmic, exponential and polynomial reveals that values of R^2 range from 0.012 to 0.018 for Waugh (a tributary of Damanganga) at Ozerkheda. It is observed that in both the cases, the values of R^2 are quite very small, indicating absence of any significant trend.

5.5.5.2 No significant trend is seen at site Nanipalsan from the plot of moving mean averages except that it shows signs of gradual rise by 2003-04 & 2004-05. Similarly, the moving mean plot for Wagh at Ozerkheda does not indicate any trend except a gradual rise by mid – 2000s. Therefore, in view of the limited length of data series, it may be premature to conclude that there exists a definite cyclic trend in the average annual runoff data

5.5.6 Conclusion

Statistically speaking, the average annual runoff of river Damanganga and its tributary Wagh, in general, appear to be a random variable. A longer set of time series data may help identify trends in annual runoff, if any.

Annual Runoff data at Sites in Damanganga Basin **Annexure-I**

Site / Water Year	Nanipalsan on Damanganga	Ozerkheda on Wagh
1991-92	1042	1017
1992-93	635	654
1993-94	935	944
1994-95	1230	1746
1995-96	439	889
1996-97	513	719
1997-98	467	1120
1998-99	814	988
1999-00	669	917
2000-01	841	459
2001-02	898	592
2002-03	674	859
2003-04	808	1058
2004-05	1032	1576
2005-06	1734	1701
2006-07	2040	1436
2007-08	947	904
2008-09	1319	1051
2009-10	658	595
2010-11	880	842
2011-12	1081	1466
2012-13	758	1328
2013-14	1417	1026
2014-15	978	1112
2015-16	526	700

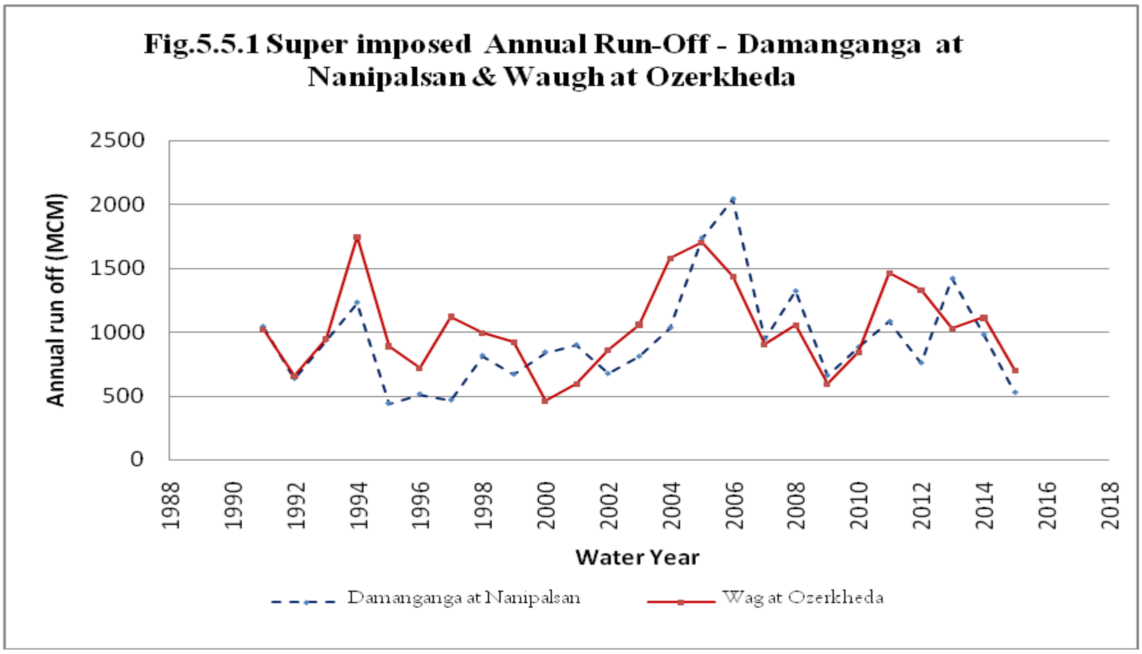


Fig5.5.2.A: Fit Characteistics-Annual runoff- Damanganga at Nanipalsan

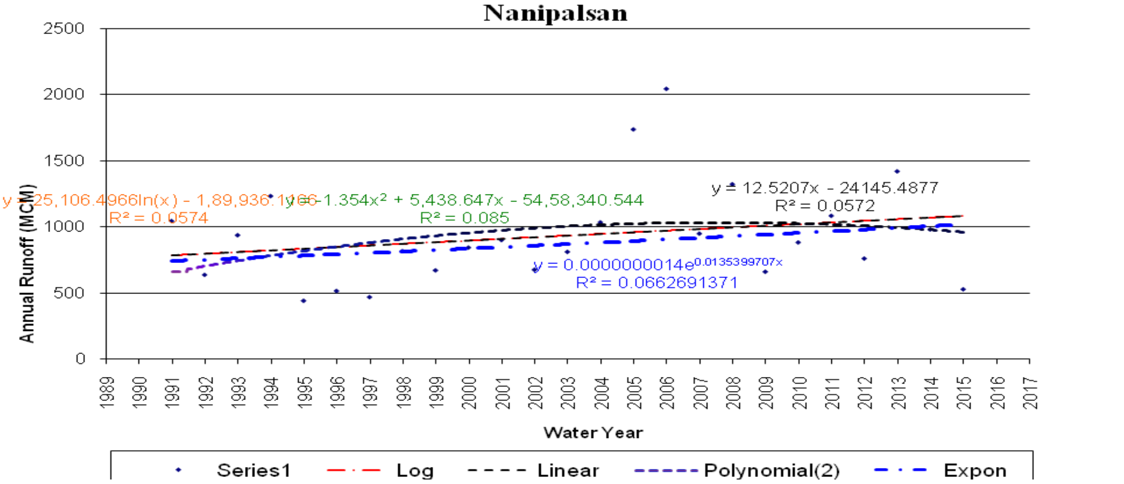
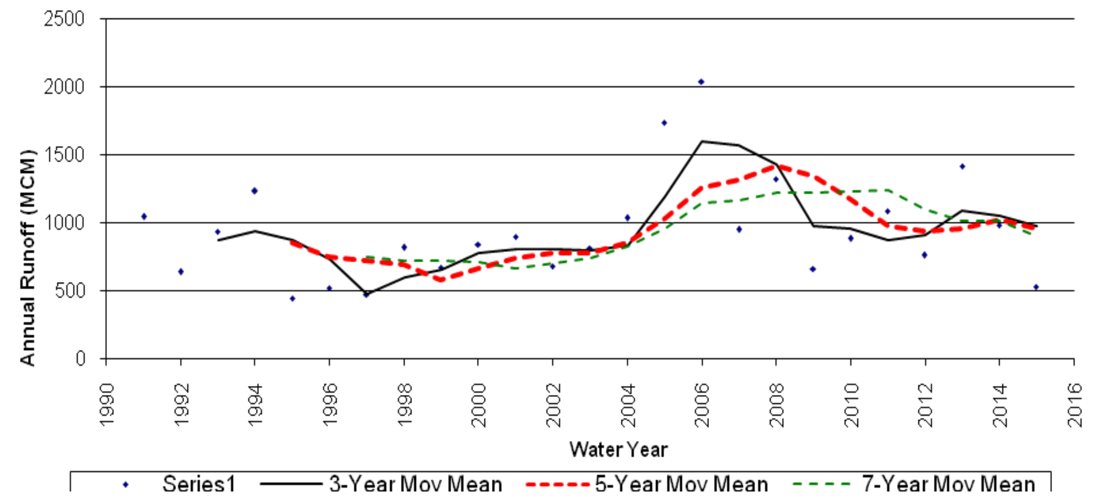


Fig.5.5.3A Moving Mean Analysis for Damanganga at Nanipalsan



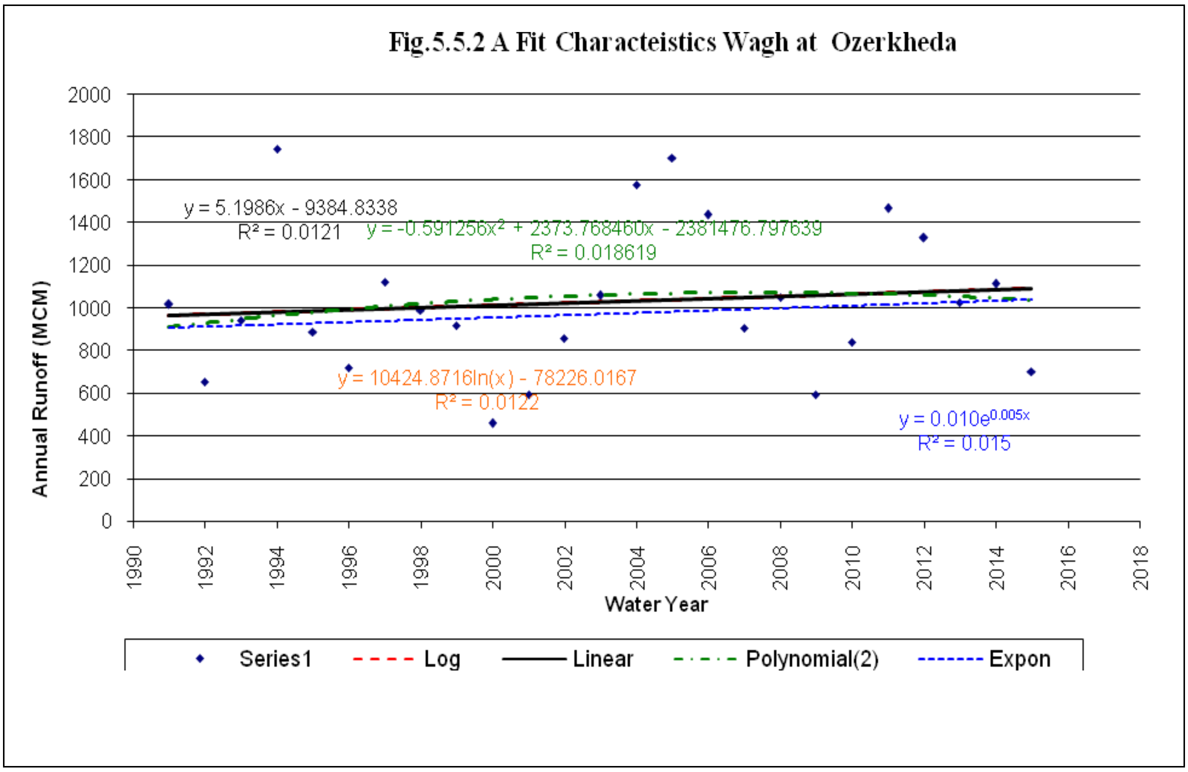


Fig.5.5.2 A Fit Characteistics Wagh at Ozerkheda
y = 5.1986x - 9384.8338
R² = 0.0121
y = -0.591256x² + 2373.768460x - 2381476.797639
R² = 0.018619
y = 10424.8716ln(x) - 78226.0167
R² = 0.0122
y = 0.010e^0.005x
R² = 0.015
Annual Runoff (MCM)
Water Year
Series1
Log
Linear
Polynomial(2)
Expon

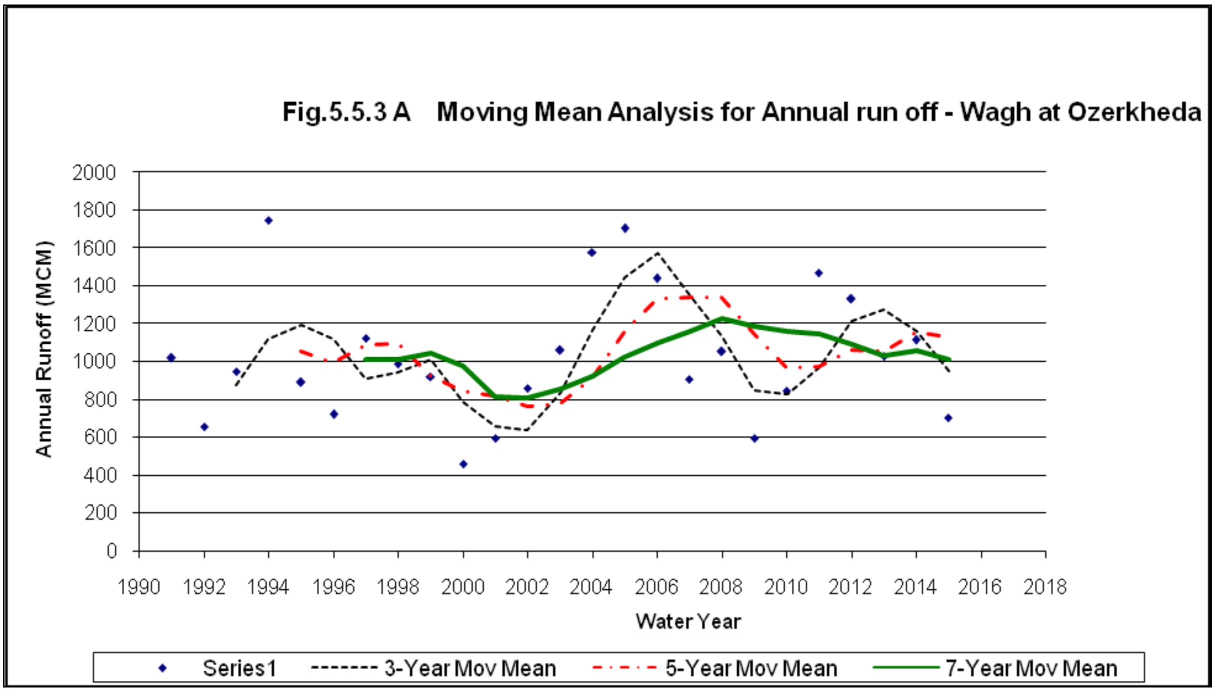


Fig.5.5.3 A Moving Mean Analysis for Annual run off - Wagh at Ozerkheda
Annual Runoff (MCM)
Water Year
Series1
3-Year Mov Mean
5-Year Mov Mean
7-Year Mov Mean

5.6 Trend Analysis of Kim Basin

5.6.1 Introduction

Trends are important indicators of the temporal variability of runoff as computed from observed discharge at site. By analyzing the time sequence of the runoff, we assess the magnitude and significance of the temporal variability. The present surface runoff trend study involves analysis of the temporal variability of data sets on the observed discharges in Kim basin using available data of existing river gauging stations.

5.6.2 Methodology

In the analysis of the trends of runoff on Kim River, annual runoff is computed and analyzed. The analysis is carried out for one (1) river gauging station with sufficiently long and continuous data sets that are fairly representatively distributed across Kim river Basin.

Overall one station has been considered in this study. The length of the data sets of river gauging station is 23 years. Subsequently, time series are analysed on various statistical parameters, fitting of mathematical equations, observing moving means for various period so as to find out if there are any trends in the annual runoff data.

5.6.2.1 Time series analysis

Time series is defined as a sequence of values arrayed in order of their occurrence which can be characterized by statistical properties. Time series analysis may be used to test the variability, homogeneity and trend of a stream flow series or simply to give an upright list the characteristics of the series as graphically displayed. Significant movements of time series are the secular, periodic, cyclic and irregular trends. A time series may display a tendency to increase or decrease, over a specified period. Such a series provides an interesting illustration because if the trend is usually predominant, virtually no other movements are discernible.

Various methods exist for analysis of time series such moving averages, residual series, residual mass curves and balance. Trends may also be revealed by determining if observed stream flow follows some mathematical equation as a function of time.

In this chapter, first statistical parameters have been computed for time series data of annual runoff in Kim basin. It is also ascertained if any mathematical equation can be fitted to the time series to assess predictability. Finally, the data is analysed by the method of moving means for various periods.

5.6.3 Availability of Data

There is a 1 G & D site in Kim Basin. Availability of annual runoff data for this site is summarized in **Table -5.6.1**

Table-5.6.1 Availability of Data

S. no.	Site	Period of Availability	Years
1.	Motinaroli on Kim River	1991-92 to 2015-16	25
The data is placed at Annexure-1 and shown in line diagram in **Fig- 5.6.1.**			

5.6.4 Analysis

5.6.4.1 Statistical Analysis

Various statistical parameters of the time series of available data are given below in

Table-5.6.2.

Table-5.6.2: Statistical parameters of Annual Runoff series at various sites in Kim Basin.

River Gauging Station	Data length (years)	Mean (MCM)	Median (MCM)	Standard deviation (MCM)	Co-efficient of variation
Motinaroli	25	446	381	288.441	0.646

5.6.4.2 Fit characteristics

In order to find out if any mathematical equation represents the time series as a function of time, fitting of various types of equations viz. linear, logarithmic, exponential and polynomial have been attempted. Results of such fits are given in the **Table- 5.6.3** and shown in **Fig 5.6.2.**

Table-5.6.3: Fit Characteristics

S. No.	Station name	Standard Deviation σ (MCM)	Coefficient of variation C_v	Mathematical Fit		R^2
1.	Motinaroli	294.587	0.658	Linear	y = 9.861x - 19307	0.063
				Logarithmic	y = 19746ln(x) - 14967	0.063
				Exponential	y = 2E-14e0.018x	0.043
				Polynomial	y = 0.328609x2 - 1,306.5449x + 1,299,057.387104	0.066

5.6.4.3 Moving Mean Analysis

In statistics, a moving mean (average), also called rolling average, rolling mean or running average, is a type of finite impulse response filter used to analyze a set of data points by creating a series of averages of different subsets of the full data set.

The first element of the moving average is obtained by taking the average of the initial fixed subset of the number series. Then the subset is modified by "shifting forward", that is excluding the first number of the series and including the next number following the original subset in the series. This creates a new subset of numbers, which is averaged. This process is repeated over the entire data series. The plot line connecting all the (fixed) averages is the moving average. A moving average is a set of numbers, each of which is the average of the corresponding subset of a larger set of data points. A moving average may also use unequal weights for each data value in the subset to emphasize particular values in the subset.

A moving average is commonly used with time series data to smooth out short-term fluctuations and highlight longer-term trends or cycles.

In the present analysis, moving means have been computed for 3, 5 and 7 year periods for Kim River Basin and shown in **Fig-5.6.3**.

5.6.5 Interpretation

5.6.5.1 Fitting of various statistical/mathematical models viz linear, logarithmic, exponential and polynomial reveals that values of R^2 range from 0.043 to 0.066 for Motinaroli. The values of R^2 are quite close to 0 indicating absence of any significant trend.

5.15.5.2 Gradually decreasing values of annual run off are seen at site Motinaroli beginning from 1997 to about 2001 after which a gradual rise is seen from the moving mean plot of 7 year moving mean. After reaching a peak value in about 2007, elements of decrease in values are again visible from the 7 year moving mean plot. Thus, as we prolong the period of mean, elementary cyclicalness or periodicity begins to appear. However, in view of the limited length of data series, it may be premature to conclude that there exists a definite cyclic trend in the average annual runoff data.

5.6.6 Conclusion

Statistically speaking, the average annual runoff of river Kim in general, appears to be a random variable; however elements of cyclicalness cannot be ruled out on the strength of moving mean analysis. A longer set of time series data may help identify trends in annual runoff, if any.

Annexure-I

Annual Runoff data of Kim at Motinaroli

Water Year	Annual Runoff in MCM
1991-92	132
1992-93	545
1993-94	356
1994-95	904
1995-96	222
1996-97	219
1997-98	261
1998-99	404
1999-00	220
2000-01	136
2001-02	345
2002-03	242
2003-04	774
2004-05	568
2005-06	665
2006-07	807
2007-08	570
2008-09	450
2009-10	192
2010-11	307
2011-12	381
2012-13	87
2013-14	1320
2014-15	636
2015-16	419

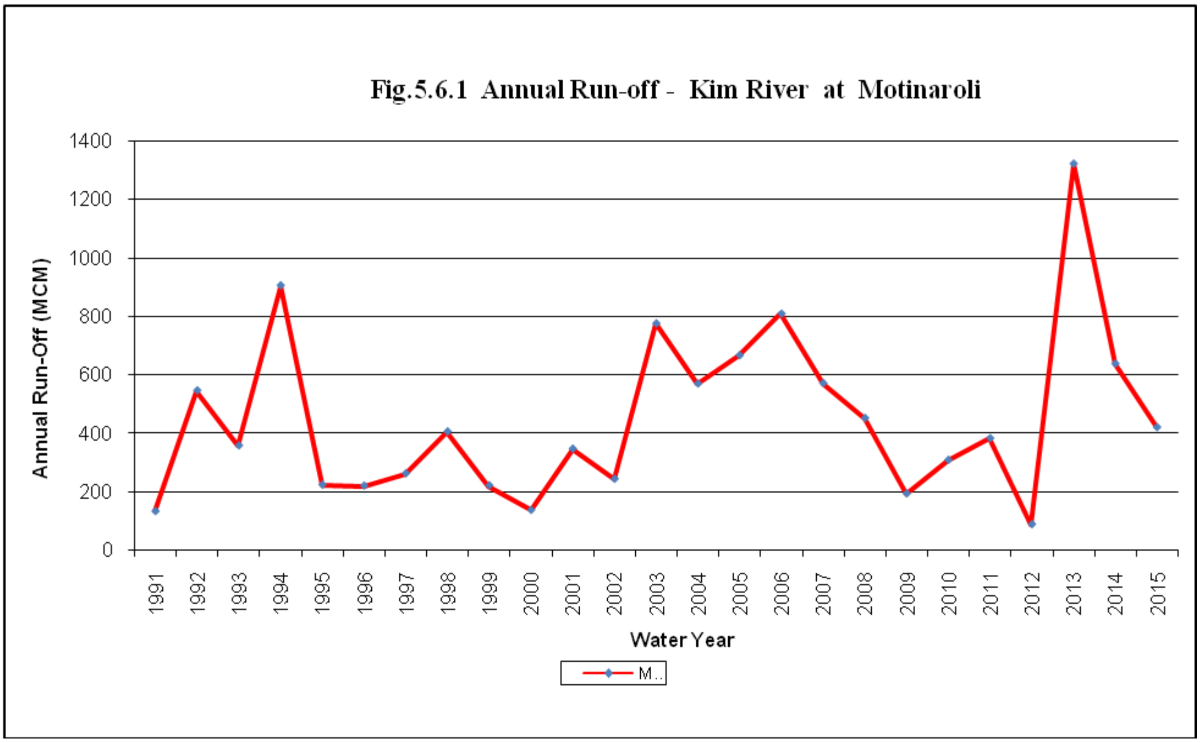


Fig.5.6.1 Annual Run-off - Kim River at Motinaroli
Annual Run-Off (MCM)
Water Year
M..

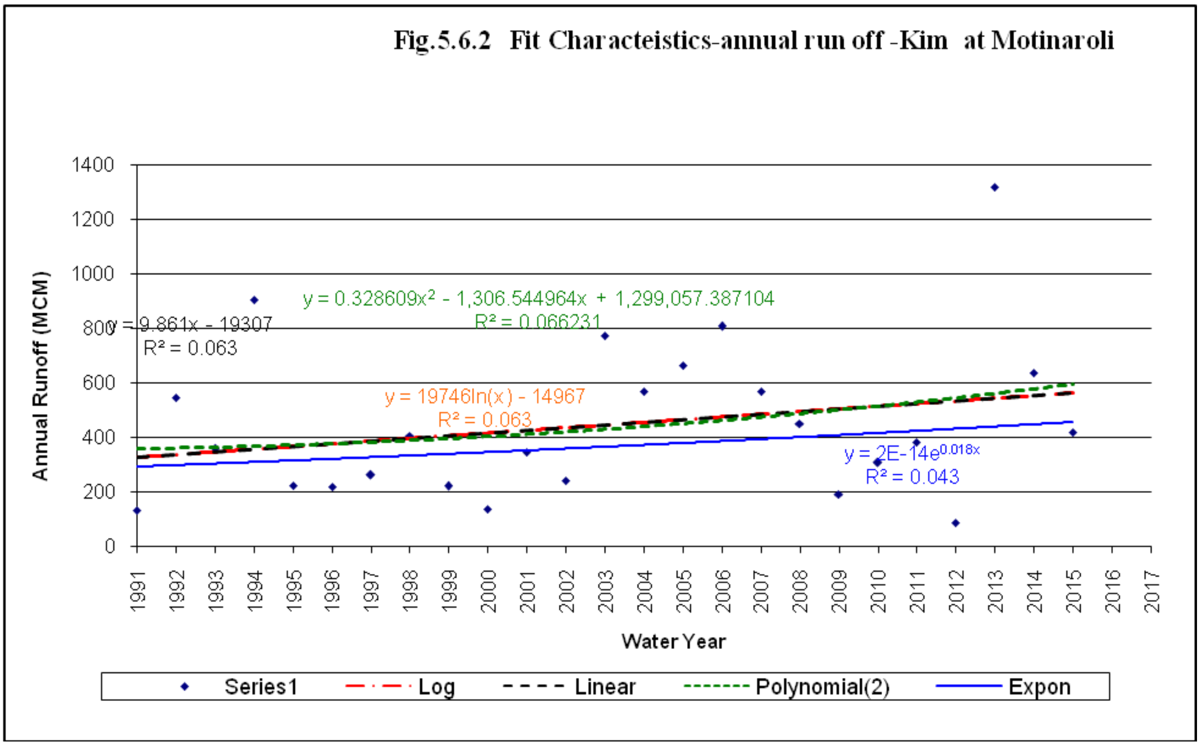


Fig.5.6.2 Fit Characteistics-annual run off -Kim at Motinaroli
Annual Runoff (MCM)
Water Year
y = 0.328609x² - 1,306.544964x + 1,299,057.387104
R² = 0.066231
y = 9.861x - 19307
R² = 0.063
y = 19746ln(x) - 14967
R² = 0.063
y = 2E-14e0.018x
R² = 0.043
Series1
Log
Linear
Polynomial(2)
Expon

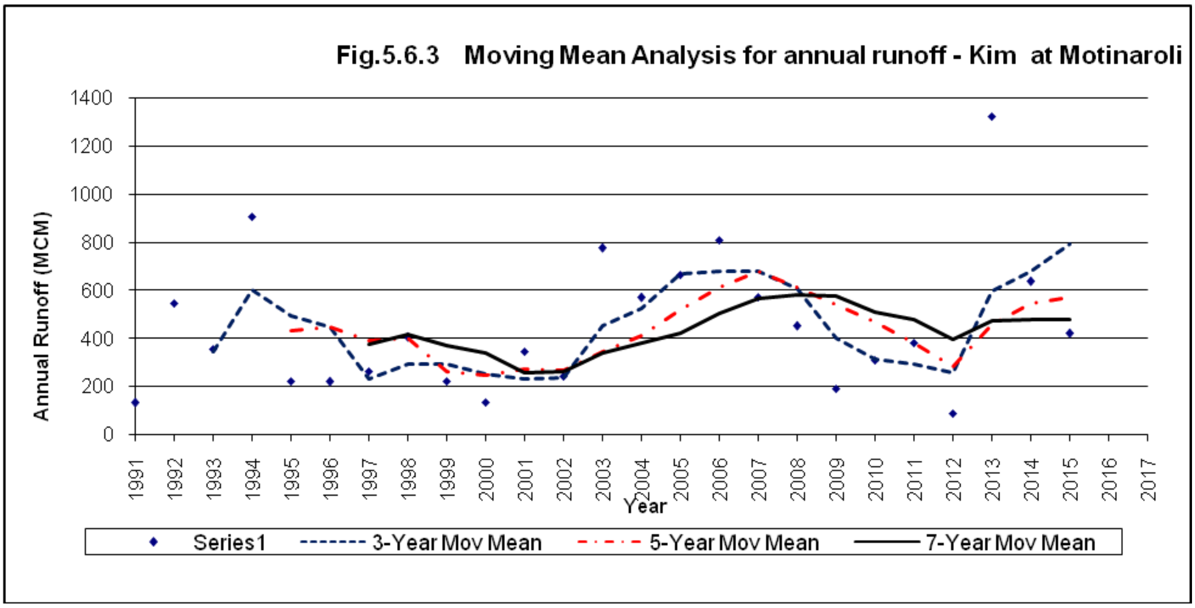


Fig.5.6.3 Moving Mean Analysis for annual runoff - Kim at Motinaroli
Annual Runoff (MCM)
0
200
400
600
800
1000
1200
1400
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
Year
Series1
3-Year Mov Mean
5-Year Mov Mean
7-Year Mov Mean