IMPLEMENTATION OF FUTURE SALINITY CONTROL STRUCTURES AND ARTIFICIAL RECHARGE IN REGION OF MAHI ESTUARIAN AREA THROUGH GROUND WATER MODELLING

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Certificate

This is to certify that the thesis entitled **"Implementation of Future Salinity Control Structures and Artificial Recharge in Region of Mahi Estuarian Area through Ground Water Modelling"**, which is being submitted to The M.S. University of Baroda by **Patel Manharlal Bhagwanbhai** in fulfillment of the requirements for the degree of **Doctor of Philosophy in Civil Engineering** has been carried out by him under my supervision and guidance at the Faculty of Technology and Engineering, The Maharaja Sayajirao University of Baroda, Vadodara. The matter presented in this thesis has not been submitted for any other degree.

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EXECUTIVE SUMMARY

Water is vital to life and development in all parts of the world. Although water is very important key element for all activities related to life, it is scarce. In certain reaches, the surface water contributes to the subsurface water while in some other cases groundwater may emerge to surface as surface water. Surface water sources are limited in nature. Ground water is a precious and the most widely distributed resource of the earth. It is the largest source of fresh water on the planet excluding the polar icecaps and glaciers. The source of natural replenishment to groundwater is infiltration from precipitation.

The availability of fresh water is going to be the most pressing problem over the coming decades. Increasing demand and decreasing availability of fresh water is bound to result in water scarcity in near future. It is now widely accepted that the solution to the water scarcity lies only in efficient use of available water by good water management. Artificial recharge is necessary to save water in times of water surplus, for use in times of water shortage. Limited natural rainfall recharge and increased water usage calls for conservation as well as augmentation by artificial recharge.

An estuary is the tidal mouth of a river. In other words an estuary is the area in which mouth of river meets the ocean. Along the coastal line of India, numerous bays and gulfs are formed where big or small rivers meet, thereby forming estuarine zone. In many coastal areas, the ground water gets contaminated not only from sea to which one face of the aquifer is connected but also from the tidal water of the overlain estuary. The impoundments sited on the estuary reaches will create imbalance in both surface and ground water regimes. In coastal aquifer which is in contact with saline water from the sea on one side, a change in discharge of fresh water towards the sea from the land ward side and infiltration from the estuary, recharge from the rain or water body into the aquifer creates the complex problem

Construction of weir on river estuary provide a standing pool of water over radial collector wells and provide a surface barrier to prevent tidal water from entering collector well areas. The present study is related to groundwater fluctuations in Mahi estuarine area which is laying in part of three districts of Gujarat namely Anand, Vadodara, and Bharuch. The study area comprises an area of 2298.23 sq. km. The Mahi River is one of the major west flowing rivers, flowing through Central Gujarat and meeting Arabian Sea

in the Gulf of Khambhat near Kavi. Vadodara Mahanagar Seva Sadan and many industries near Vadodara are taking water from Mahi River for potable and industrial uses by constructing radial collector wells. The outflow of Mahi River in to the sea is being decreased due to construction of structures like Bajaj sagar, Kadana, Panam dams and Wanakbori weir. The tidal effect of sea in the Mahi estuary has increased the sea water intrusion in the land ward side. The groundwater has been contaminated over the period and the quality of the ground water is continuously deteriorating due to the increasing rate of withdrawal and the aquifer having not been recharged at the same rate on account of erratic rainfall pattern in Mahi estuarine area. Major portion of this area is comprises agricultural land. The groundwater system of this area is dynamic in nature because of monsoon recharge due to rain, irrigation return flow and groundwater pumping. The water level and water quality are also affected by natural recharge of surface water of River Mahi.

The present study attempts modeling of groundwater regime in the study area. The groundwater system of the study area is characterized by using inverse modeling and aquifer hydraulic conductivity values are obtained. The groundwater fluctuations are obtained during study period using model simulation. The software Groundwater Modeling System (GMS) 6.0 is used. Single layered unconfined aquifer is assumed. Mass balance of surface water and groundwater of unconfined aquifer is computed. The effect of fresh water pool, created by construction of weir, on adjoining groundwater table is investigated. Here an attempt is made to study the impacts of existing and future weir on artificial groundwater recharge in the region of Mahi estuarine area. The analysis has been carried out using Layer Property Flow (LPF) package of MODFLOW-2000 (based on Finite Difference Method) in GMS 6.0. Base map, fence diagram and longitudinal sections along Mahi River, along right as well as left bank have been prepared to study the geology of the study area. It is found that the general geology confirm to alluvial area consisting alternate layers of clay, sand, gravel, occasionally mixed with kankar.

The study area is divided in to 8 recharge zones, 23 Horizontal permeability and specific yield zones. 3D Grid created contains 75 columns and 75 rows is formed. The Groundwater model has been calibrated and validated. It is required to know the future behavior of the groundwater system in response to the applied hydrologic stresses. When the research was initiated there was a proposal to build a weir near Sindhrot. Sindhrot weir near Sindhrot village was constructed in the year 2007.The people on the downstream demands another weir to construct at Badalpur. So here a study of different following scenario is conducted. Scenario A-Without Weir, Scenario B-With Sindhrot Weir and Scenario C-With Sindhrot and Badalpur Weir

The top elevation of both weirs is given as RL 8.5 m considering high tide level as RL 6.95 m at weir location. The full reservoir level is kept as 8.0 m. For the above mentioned three scenarios model was run and results obtained are analyzed. To study the artificial recharge scenario, nature of water mound for Sindhrot weir and Badalpur weir on different dates are plotted.

Pre-monsoon and post-monsoon water mound nature is studied. Area of influence is more at Badalpur weir as compared to Sindhrot weir. The Badalpur weir is about 41.66 km downstream of Sindhrot weir. To study the effect at same point time series curves are plotted at 12 different locations. Reduced water levels are found to be showing rising trend with weir compared to without weir. Finally predictions are made for effect of alternative locations of weir on recharge of estuary area.

The relation between salinity and distance from sea are obtained. Water quality of unconfined aquifer is studied with reference to natural recharge from river. To establish relationship between Total Dissolved Solids of groundwater (to judge salinity) distance from the place Kavi (starting of sea) and Reduced groundwater level Multiple linear regression analysis has been carried out. Equations are established by taking average groundwater quality of 12 years.

Year wise Average Equation for left bank is $X_1 = 2582.76 - 27.52X_2 + 2.99X_3$.

Year wise Average Equation for right bank is X1 = 1382.95 - 14.20X2 + 5.75X3.

Year wise Average Equation for both bank is $X_1 = 1712.72 - 4.16X_2 - 20.27X_3$.

Where, X_1 = TDS in ppm, X_2 = Distances from sea (Kavi) in kms and X_3 = Reduced groundwater Level in m.

The analysis indicates that as the distance from sea increases the water quality improves. The regression analysis leads to conclusion that the correlation coefficient ‘r’ for multiple linear relations between TDS of groundwater and two parameters i. e. distance from sea (Kavi) and Reduced Water Level (RWL) for left bank, right bank and both banks are found well within the range.

Water samples of 36 wells parallel to Mahi river in May and Nov. 2003 collected and tested for important parameters like EC, PH, TDS, Ca, Mg, Na, CO3,HCO3, Cl,SO4, K and TH The results are graphically represented as TDS, Cl and TH v/s distances from sea (Kavi) and distances from centre line of river. The analysis indicates that the water quality improves as the distance from sea or river increases.

Same model can be applied for western India Rivers and other similar rivers in the world.

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ABBREVIATIONS

Abbreviation	Description
^0C	Degree Centigrade
2D	Two Dimensional
3D	Three Dimensional
A	Net suitable area for groundwater recharge
AICTE	All India Council for Technical Education
ASCE	American Society of Civil Engineers
b.g.l.	Below Ground Level
C. C. A.	Cultivable Command Area
CGWB	Central Ground Water Board
Cl	Chloride
Co_3	Carbonate
CRIV	Streambed hydraulic conductance
CSSRI	Central Soil Salinity Research Institute
Cumecs	Cubic meter per second
CWC	Central Water Commission
D/S	Down Stream
D_w	Gross Kharif draft
E	East
EC	Electrical Conductivity
ECP	Effluent Channel Project
ECPL	Effluent Channel Project Limited
EMRL	Environmental Modeling Research Laboratory
FEM	Finite Element Method
Fig	Figure
GACL	Gujarat Alkali and Chemicals Limited
GEC	Gujarat Ecology Commission
GERI	Gujarat Engineering Research Institute
GIDC	Gujarat Industrial Development Corporation

GIS	Geographical Information System
GMS	Groundwater Modeling System
GOG	Government of Gujarat
GPCB	Gujarat Pollution Control Board
GSFC	Gujarat State Fertilizer Corporation
GWRDC	Ground Water Resources Development Corporation
h	Potential head
$H\ Co_3$	Bi Carbonate
ha	Hectare
$h_{i,\ j,\ k}$	Head at the node in the cell (in the aquifer) corresponds to water table
Hk	Horizontal permeability
HRIV	Head at the stream
HWL	High Water Level
IARI	Indian Agricultural Research Institute
ICAR	Indian Council of Agriculture Research
IOCL	Indian Oil Corporation Limited
IPCL	Indian Petrochemical Corporation Limited
IS	Indian Standards
ISO-RWL	ISO-Reduced Water Level
ISTE	Indian Society for Technical Education
K	Hydraulic conductivity of the streambed material
Km	Kilo Meter
Km p. h.	Kilometer per hour
K_{xx}, K_{yy}, K_{zz}	Hydraulic conductivity along the x, y and z coordinate axes
L	Length of the conductance block is taken as the length of the stream
LPF	Layer Property Flow
m	Meter
M	Thickness of the streambed layer
m/day	Meter per day
m/s	Meter per second
m^2/hr	Square meter per hour

m^3/sec	Cubic meter per second
MCM	Million Cubic Meter
MCM/year	Million Cubic Meter per year
Mg	Magnesium
mg/l	Milligram per litre
MGD	Million Gallon per day
MIC	Mahi Irrigation Circle
MLD	Million Liter per day
mm	Millimeters
MRBC	Mahi Right Bank Canal
m.s.l.	Mean sea level
N	North
Na	Sodium
NEERI	National Environmental Engineering Research Institute
NF	Normalization factor
NIO	National Institute of Oceanography
N-W	North- West
ORG	Operations Research Group
ppm	Parts per million
ppt	Parts per thousand
QRIV	Flow between stream and the groundwater system(aquifer)
RBOT	Bottom of the stream bed
RCC	Reinforced Cement Concrete
RCW'S	Radial Collector Wells
Ri_{gw}	Recharge due to monsoon seepage from groundwater irrigation
R_{is}	Recharge due to monsoon seepage from surface water irrigation
RL	Reduced Level
RL's	Reduced Levels
R_s	Recharge due to monsoon seepage from canals and tanks
Rvr	River
RWL	Reduced Water Level

shp	Shape
So_4	Sulphate
Sq. km	Square kilometer
S_s	Specific storage of the porous material
SSNL	Sardar Sarovar Narmada Nigam
SUTRA	Saturated-Unsaturated Transport
SWDC	State Water Data Centre
Sy	Specific Yield
t	time
TDS	Total Dissolved Solids
TH	Total Hardness
TIN	Triangulated irregular Network
U/S	Up Stream
USA	United States of America
USDA	United States Department of Agriculture
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
VIC	Vadodara Irrigation Circle
VMSS	Vadodara Mahanagar Seva Sadan
W	Volumetric flux per unit volume representing sources and/or sinks of water
WL	Water Level
WRIC	Water Resources Investigation Circle
WTF	Groundwater table Fluctuation

1 INTRODUCTION

Water is vital to life and development in all parts of the world. Although water is very important key element for all activities related to life, it is scarce (Subramanya, 1994). To assess the total water storage on the Earth reliably is a complicated problem because water is so very dynamic. It is constantly changing from liquid to solid or gaseous phase and back again. Current estimates are that the Earth's hydrosphere contains a huge amount of water about 1386 million cubic kilometers. However, 97.5 % of these amounts are saline waters and only 2.5 % is fresh water. The greater portion of this fresh water (68.7 %) is in the form of ice and permanent snow cover in the Antarctic, the arctic, and in the mountainous regions. Next, 29.9 % exists as fresh ground waters. Only 0.26 % of the total amount of fresh waters on the Earth is concentrated in lakes, reservoirs and rivers systems where they are most easily accessible for our economic needs and absolutely vital for ecosystems (Patel and Shah, 2008). Dividing the water resources of a region into surface water and ground water is often artificial or questionable. The surface runoff, in certain cases contributes to the groundwater or in yet-some other cases ground water emerges at the ground surface becoming surface flow. The above considerations apply not only to water quantum of the region, but also to water quality. Contaminated surface water may easily reach and pollute ground water (Dalwadi, 1998). Surface water sources are limited in nature. Ground water is a precious and the most widely distributed resource of the earth. It is the largest source of fresh water on the planet excluding the polar icecaps and glaciers. It gets its annual replenishment from the meteoric precipitation (Raghunath, 1997). Ground water systems are dynamic in nature and adjust continually to short term and long term changes in climate, ground water withdrawal and land use (Mohapatra et al., 2006). India is endowed with substantial water resources. The basic source of water is precipitation (Water Technology Centre, IARI, 1983).

There is tremendous increase in the Global water usage in different sectors like agricultural, industrial and domestic. However there is considerable variety how these resources are used in different parts of the World. The availability of fresh water is going to be the most pressing problem over the coming decades. Water in India is not only a usable commodity but a very sentimental and religious value is attached to it, spiritual cultures of India have mushroomed on the banks of various holy rivers, abundance and greenery of India had attracted many invaders. Increasing demand and decreasing availability of fresh water is bound to result in water scarcity in near future. It is now widely accepted that the solution to the water scarcity lies only in efficient use of available water by good water management. The river runoff is one of the main sources of fresh water which meets various water demands. Though it is continuous and renewable by the hydrological cycle, river runoff represents the dynamic component of the total water resources, in contrast to the less mobile volumes of water contained in lakes and groundwater reservoirs.

1.1 Rivers of Gujarat

Gujarat popularly known as the "Garden State of India" is noted for the fertility of its soils and prosperity of its agricultural class. Gujarat is a land of rivers. Its land is fertile. Its agriculturists are diligent and resourceful (Directorate of Information, GOG, 1960).

The state of Gujarat is located on the northwestern shores of India, lying between N 20° 01' and 24° 07' latitudes and E 68° 10' and 74° 28' longitudes; covering a land area of 1, 95, 984 sq.km. The agricultural area of the state is 95, 000 sq.km. It has a coastline of 1663 km, which is the longest amongst all the states of the country and is 21.3% of the total Indian coastline of 7517 km. The coastline of Gujarat has two indentations, the Gulfs of Khambhat and Kachchh (Sen Gupta, 2000).

On the basis of geographical features, the Gujarat state is composed of four regions, viz. (i) North Gujarat region (ii) Central and South Gujarat (iii) Saurashtra peninsular region and (iv) Kachchh region. (Mistry, 1988).These zones have been characterized by their typical land forms and coastline. The present geomorphic configuration of the state is the result of the sub aerial geological processes that have given rise to a variety of erosion and depositional landforms.

From the water resources consideration the Gujarat state can be divided into four major physiographic regions. The Rivers of Gujarat are represented in figure 1.1. There are 185 river basins which can be distributed region wise as shown in table 1.1.

Table 1.1 Region Wise River Basins of Gujarat

Region	Nos. of River Basins
North Gujarat	05
Central and South Gujarat	12
Saurashtra	71
Kachchh	97
Total	185

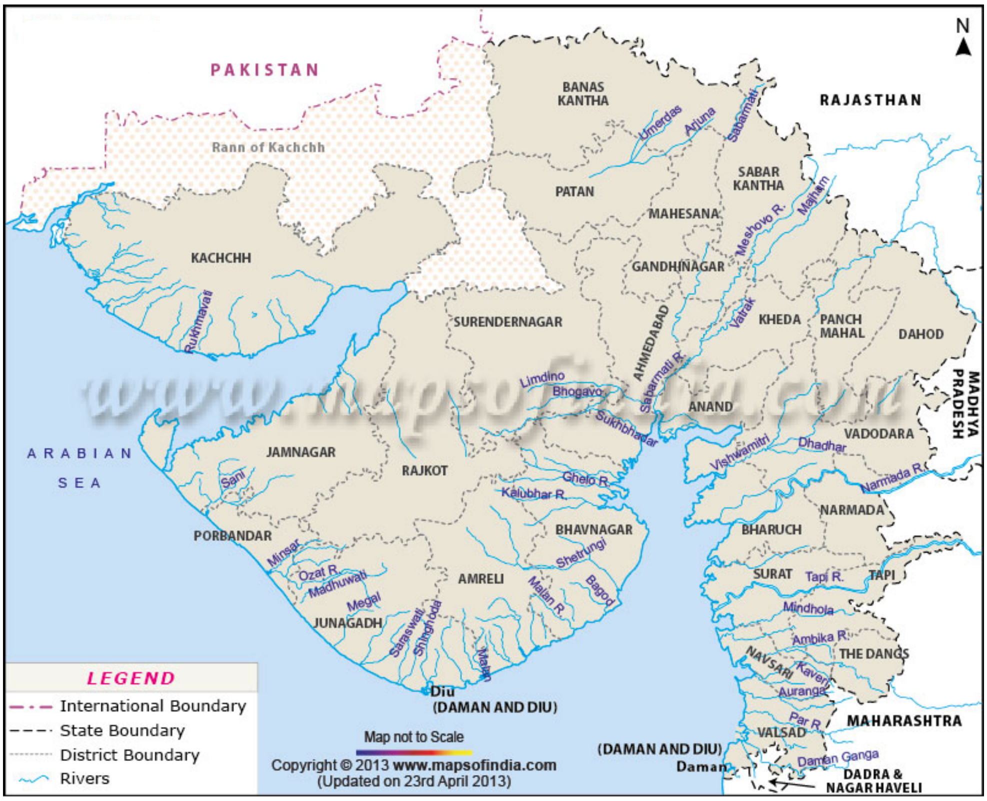


Figure 1.1 Gujarat River Map

Due to centrally elevated ridges in the Saurashtra and Kachchh regions, the rivers originate from central uplands. They are small, flashy and flow radially towards the Arabian Sea, Gulf of Khambhat, Gulf of Kachchh and Rann areas. In contrast to this, most of the rivers of Gujarat region are major rivers, viz., Banas, Sabarmati, Mahi, Narmada, Tapi and Damanganga which originate from the hilly regions in the adjoining states (Mistry, 1988).

Except Narmada, Tapi and Mahi rivers, all other rivers in the eastern part of the state, originate on the western slopes of the eastern hills. They flow in the direction almost at right angle to the boundary i.e. towards southwest (Sabarmati and Mahi rivers) in the northeastern part, towards almost West (Narmada, Tapi and Dhadhar) in the central region and towards Northwest (Kolak, Par, Ambica, etc.) in the southern part. Most of the rivers in the alluvial plain meander with very wide courses whereas those in rocky tracts have deep and narrow courses. Out of 185 river basins of Gujarat State only four basins i.e. Narmada, Mahi, Tapi and Damanganga have surplus water. Tapi, Narmada, Mahi and Sabarmati are the main perennial rivers of Gujarat. They are meeting Arabian Sea in Gulf of Khambhat.

1.2 Estuaries

Estuaries have been used for time immemorial. Estuaries are very important even though their area is only a small proportion of the world's surface. Because of their fertile waters, sheltered anchorages and the navigational access they provide to a broad hinterland. Estuaries have been the main centers of man's development (Dyer, 1979).

Historically estuaries in their upper ends have been used as sources of water in cities and industries and some times in the fields. The main uses of estuaries are for transportation, navigation harbors, national security, commercial, industrial sites, scientific research, natural beauty, fishing, cooling water and waste disposal. Waste disposal has started ever since man has started inhabiting the banks of the estuaries. The estuary with the beaches serves as great recreational and tourism spots-jolly boat-riding also. Estuaries are some of the most productive ecosystems in the world. They constitute a very complex environment with widely varying ecological conditions (Calcutta Metropolitan Development Authority, 1972). Most of the large cities in the world are located on them.

1.2.1 The Estuary Definitions

Estuaries around the world vary greatly in their characteristics and it is not easy to define one with absolute precision. Definitions of estuaries are very broad and include almost any body of water which joins the ocean at the coast. Estuaries are those bodies of water which are connected to the ocean at one end and fed by sources of fresh water as the water body's boundaries extend landward (Thatcher and Harleman, 1972).

An estuary is the tidal mouth of a river. In other words an estuary is the area in which mouth of a river meets the ocean. This unique environment mixes the fresh water of the river with salt water of the sea. The effects of the tides are typically strong in an estuary. The mouth of a river is the area in which the river enters a larger body of water.

Bowden has defined an estuary as “a partially enclosed body of water which has an influx of fresh water at one end and which is in free communication with the sea at the opposite end.”

An estuary can also be defined as a body of water in which river water mixes with and measurably dilutes sea water. It has also been described as the wide mouth of a river or arm of the sea where the tide meets the river currents, or flows and ebbs (Reid, 1961).

1.3 Sea Water Intrusion Problem in Coastal Aquifers

Due to increasing concentration of human settlement, agricultural development and economic activities, the shortage of fresh ground water for domestic, agricultural, and industrial purposes become more striking in these coastal zones (Parekh, 2009).

A sea water hydraulic gradient exists in the aquifer and excess fresh water from inland area flows to the ocean. Under the natural conditions a state of equilibrium is maintained when fresh water flows at a steady rate into the ocean. With reduction of fresh water flow and increased demand for groundwater, if the water table or piezometric surface is lowered below the potential of the adjacent sea water, the sea water moves inland. The process is known as sea water intrusion.

In some areas, water withdrawals are so high, relative to supply that surface water supplies are shrinking and ground water reserves are being depleted faster than they can be replenished by precipitation. Agriculture is by far the biggest user of water accounting for over 70 percent of water (Mohapatra et al., 2006).

1.3.1 Abrupt Interface Approach

More than 50 years ago two investigators (Ghyben and Herzberg), working independently along the European coast. They found that salt water occurred underground, not at sea level but at a depth below sea level of about 40 times the height of the fresh water above sea level. The equation derived to explain the phenomenon is generally referred to as the Ghyben-Herzberg relation after its originators (Todd, 1995). In this relationship the fresh water and saline water are considered to be immiscible fluids. An abrupt interface between fresh water and saline water regions is assumed to exist. This sharp interface approximation is valid where transition zone form fresh water to salt water is relatively limited in comparison with aquifer dimensions. This approximation, together with the equilibrium of pressure on the interface and Dupuit assumption of homogeneous horizontal flow, leads to an approximate solution of sea water intrusion problem. In fact both fluids are miscible and the sharp interface approach is not realistic when the width of the transition zone is considerable (Dalwadi, 1998).

1.3.2 Hydrodynamic Dispersion Approach

Under field conditions a brackish transition zone of finite thickness separates the two fluids. This zone develops from dispersion by flow of the fresh water plus unsteady displacements of the interface by external influences such as tides, recharge and pumping of wells. In general, greatest thicknesses of transition zones are found in highly permeable coastal aquifers subject to heavy pumping (Todd, 1995). Dispersion of the interface is the phenomenon that the fresh water-salt water interface is not sharp, but is represented by a narrower or wider transition zone in which the amount of total solids increases more or less rapidly from the landward to the seaward side. Calculations can be made for lines of equal total solids, say 1,500 or 2,000 ppm and this can be assumed as the interface (Raghunath, 1987).

1.3.3 Sea Water Intrusion Problem in Coastal Aquifer Overlain by an Estuary

The ever increasing demand of fresh water for various uses is a sufficient motivation for the exploration of additional sources of surface and subsurface water resources. In surface water resources in a coastal region the fresh water abstraction from the surface flow as rivers disturbs the equilibrium of fresh and salt water in the estuary.

In many coastal areas, the groundwater gets contaminated not only from sea to which one face of the aquifer connected but also from the tidal water of the overlain estuary. In normal condition, the dynamic equilibrium prevails between fresh water and salt water of these two surface and subsurface water systems. The impoundments sited on the estuary reaches will create imbalance in both surface and groundwater regimes. Coastal aquifer is in contact with saline water from the sea on one side. Changing discharge of fresh water towards the sea from the land ward side and infiltration from the estuary/recharge from the rain/water body into the coastal aquifer creates complex problem. This necessitates a detailed study about the sea water intrusion into the aquifer (Dalwadi, 1998).

1.4 Purpose of Artificial Recharge Structures in Estuarine Area

Artificial recharge is necessary to save water in times of water surplus, for use in times of water shortage. Limited natural rainfall recharge and increased water usage calls for conservation as well as augmentation by artificial recharge. Varieties of methods have been developed to recharge the groundwater (Mohapatra et al., 2006). Tidal water from Sea entering the river mouth imparts salinity to the river aquifers that are being tapped for water supply purposes. The discharge from radial collector well depends on static water level in river bed aquifer and induced recharge from nearby channel. Hence the presence of channel with sufficient water level increases the discharge from radial collector well. In non-monsoon season the water level in river is low. The construction of weir increases the water level in the vicinity of radial collector well and thus improves the flow.

Construction of a low weir on river estuary serves two purposes:

1) To provide a standing pool of water over radial collector wells.
2) To provide a surface barrier to prevent tidal water from entering collector well areas and also to provide a subsurface barrier to prevent subsurface saline water from entering radial collector well area.

1.5 Scope and Objectives of the Study

The present study is related to region of Mahi estuarine area which is laying in three districts of Gujarat namely Vadodara, Anand and Bharuch. The Mahi River is one of the major west flowing rivers and flowing through central Gujarat and meeting Arabian Sea in the Gulf of Khambhat near Kavi. Vadodara Mahanagar Seva Sadan and many industries near Vadodara are taking water from Mahi River for potable and industrial uses by constructing radial collector wells. The outflow of Mahi River in to the sea is being decreased due to construction of structures like Bajaj sagar, Kadana, Panam dams and Wanakbori weir. The tidal effect of sea in the estuary has increased the sea water intrusion in the land ward side.

The groundwater has been contaminated over the period and the quality of the ground water is continuously deteriorating due to the increasing rate of withdrawal and the aquifer having not been recharged at the same rate on account of erratic rainfall pattern in Mahi estuarine area.

The Mahi River is a tidal river. Mahi estuary joins the Arabian Sea at the northern part of the Gulf of Khambhat. The estuary is strongly influenced by the hydro dynamics of the Gulf of Khambhat. The limit for the daily tidal zone of Mahi estuary is up to the horse shoe bend downstream of Mahammadpura, 50 km upstream from the mouth. Sea water intrusion normally occurred up to Mahammadpura. The sill near Mahammadpura acts as a barrier between tidal flow and river discharge during the dry season. Further intrusion of sea water was obstructed by the sill at Mahammadpura. The tides were observed to cross the sill only during the high spring tides in summer and influenced the river segment up to Vasad on such occasions, the salinity of water increases and chloride concentration as high as 600-1000 mg/l has been reported at Vasad. The industries are, therefore, required to suspend operation on these days (NEERI and NIO, 1975). The fresh water regime of the river is limited to a few kilometers distance downstream below Vasad. Beyond this limit the water remains brackish throughout the dry weather conditions. The water is not suitable for drinking or agriculture.

The Gulf of Khambhat experiences semi-diurnal tides of high amplitude up to 10 m. The Mahi experiences a semi-diurnal tide. i. e. high waters occur daily twice at intervals averaging 12 to 12.4 hours.

Here an attempt is done to investigate the artificial recharge in the study area with salinity control cum artificial recharge structures.

Following are the objectives of the study:

1. Groundwater fluctuations study in Mahi estuarine area by using Groundwater Modeling System.
2. To study water quality and impacts of weir on artificial groundwater recharge.

1.6 Closure

A detailed literature review is described in chapter two. The study area is described in chapter three. Data collection and methodology are discussed in chapter four. Model simulation and regression analysis of water quality data are described in chapter five and six. Finally the results are discussed in chapter seven. Finally conclusions are listed in chapter eight.

2 LITERATURE REVIEW

Many estuarine areas are heavily urbanized and therefore require an adequate and sustained yield of water which is fit for various purposes. The increased use of groundwater in coastal areas upsets the existing dynamic balance between fresh water and sea water leading to intrusion of sea water in to the aquifer longitudinally and vertically.

Based on this the literature review is presented describing the different approaches. The work done by different persons in the field related to the estuarine area. Similar kinds of the work done and model's used for similar studies are also reviewed.

2.1 Estuaries and Related Problems

An estuary is the tidal mouth of a river. This unique environment mixes the fresh water of the river with the salt water of the sea.

2.1.1 Engineering Problems in Estuaries

One of the important factors contributing to the problems of estuaries has been the rapid growth of population and industrial activity in the surrounding area. In recent years engineering problems in tidal waters have received increased attention from the practitioner, the experimentalist, and the analyst in view of the important functions assigned to estuaries in the human environment. This is true not only for the United States but also for Europe, where most important contributions have been made, particularly in the Netherlands and in England. So it necessitates developing physical understanding of those processes of tidal flows in estuaries which are of primary importance in dealing with diffusion and sedimentation problems. The basic estuary problems of salinity intrusion, pollution by discharged wastes, shoaling and sediment transport are associated with diffusion processes in a stratified flow. Problems of estuarine pollution are significantly different from river or lake pollution. They are concerned with the temporal and spatial distribution of contaminants introduced into the estuary and with their effect on water quality (Ippen, 1966).

Problems of estuarine pollution are significantly different from river or lake pollution. These problems, originating essentially from human activity, are much greater in magnitude and far more widespread than ever before.

2.2 Estuary Dynamics

Estuarine processes are not simple. Estuaries are regions in which many factors like tidal flow from sea to land ward and fresh water flow from upland to sea interact. The estuaries are governed by the tidal action at the confluence with sea and upland river flow. The tidal characteristics are time and space variant. In the estuary salt is the dispersant and hydrodynamics is the transporting agent. The difference in density between fresh water and salt water modifies the hydrodynamics by bringing in the longitudinal circulation or stratified flow conditions (Dalwadi, 1998).

The mechanism of water flow in tidal estuaries is complex and incompletely understood yet. Two quite different operations take place at the opposite ends of an estuary. The lower end is a two way street where a heavier salt layer of water moves upstream near the bottom and a lighter layer of freshwater flows downstream at top. The mechanism for these two layer circulations is the input of fresh water from the catchment area of the river and the tidal movement from the bay. At the upper end of the estuary the entire flow is in one direction subject only to the stop and goes influence of the tide (Calcutta Metropolitan Development Authority, 1972).

The three most important factors operating to produce currents in estuaries are oceanic tides, stream flow and wind. Additionally, the morphology of the basin of the estuary and the channel of the stream modify and determine the stream and tidal dynamics. It should be borne in mind that these forces are not regular and constant. Stream flow varies seasonally with rainfall, while tide height and movement are correlated with lunar effects and wind (Reid, 1961).

The tidal currents in estuaries caused by rise and fall of the tide at the estuary entrance, in general, run “flood” during rising tide and “ebb” during falling tide. The magnitudes and durations of tidal currents in estuaries are functions of the tidal range at the entrance characteristics (semidiurnal and diurnal) of the Ocean tide at the entrance, and physical characteristics of estuary channels. The relationship between tide and current varies appreciably from estuary to estuary and from one location to another within a given estuary (Ippen, 1966).

2.2.1 Salinity Transport in Estuaries

Salinity transport in an estuary depends on the freshet discharge and tidal action. Increased tidal action increases mixing while enhanced freshet discharges will induce stratification during monsoon, the high freshet discharge may cause stratified condition in backwaters of estuary, but in dry season the well mixed conditions prevail to a great extent (Dalwadi, 1998).

The intrusion of salt water into the lower portions of tidal estuaries is of the greatest interest to engineers. The dynamic characteristics of tidal flow as well as with the diffusion processes which result from the discharge of fresh water under the tidal action into the saline reaches of the estuary are important. The diffusion process in estuaries is thus seen to depend on a combination of following three mechanisms (Ippen, 1966).

a. Turbulent diffusion as encountered in random-mixing.
b. The dispersion process inherent in the transient shear flows generated by the tides.
c. The internal circulation generated as a result of density differences.

Estuaries are either once or twice daily washed by the sea water. In fresh water the concentration of salts, or salinity, is nearly zero. The salinity of water in the ocean averages about 35 parts per thousand (ppt). The mixture of sea water and fresh water in estuaries is called brackish water and its salinity can range from 0.5 to 35 ppt. The salinity of estuarine water varies from estuary to estuary, and can change from one day to the next depending on the tides, weather, or other factors.

2.2.2 Estuary Mixing Types

The river discharge is mixed with the sea water by the action of tidal motion, by wind stress on the surface and by the river discharge forcing its way towards the sea (Dyer, 1979). Mixing of fresh water and sea water takes place through turbulent mixing and molecular diffusion.

Estuaries can be grouped in accordance with their mixing conditions which govern their vertical circulation patterns. Thus, three types of estuaries are identified with regard to their mixing conditions and consequent salinity variations.

1. Highly stratified type
2. Partially mixed type
3. Well-mixed type

2.2.2.1 Highly Stratified Type

Where the inflow of fresh water is large with respect to the tidal discharge, the fresh and salt water tend to remain separate with the fresh water (being less dense) flowing out to sea over the top of the salt water layer and the salt water layer intruding underneath the fresh water in a rough wedge shape. The extent to which the salt water wedge penetrates into the estuary is thus a function of the channel depth, the fresh water discharge, and the density differential between the salt and fresh water. In the highly stratified estuary, the ratio of fresh water discharge to tidal prism (the ratio of fresh water volume to the flood tide volume) is of the order of unity or more (figure: 2.1).

2.2.2.2 Partially Mixed Type

In the partially mixed estuary tidal currents are sufficient to produce appreciable vertical mixing of the salt and fresh water. Since the current normally flows both flood and ebb in the partly mixed type, the salt water advances and retreats with each rise or fall of the tide. The interface between the fresh water in the surface strata and the saltier water underneath is not so well defined as in the highly stratified type; however, the presence of the "interface" is indicated by a more or less pronounced transition in the vertical salinity profile or the vertical velocity profile. In the partly mixed estuary, the ratio of fresh water discharge to tidal prism is normally in the range of about0.2 to 0.5 (figure: 2.2).

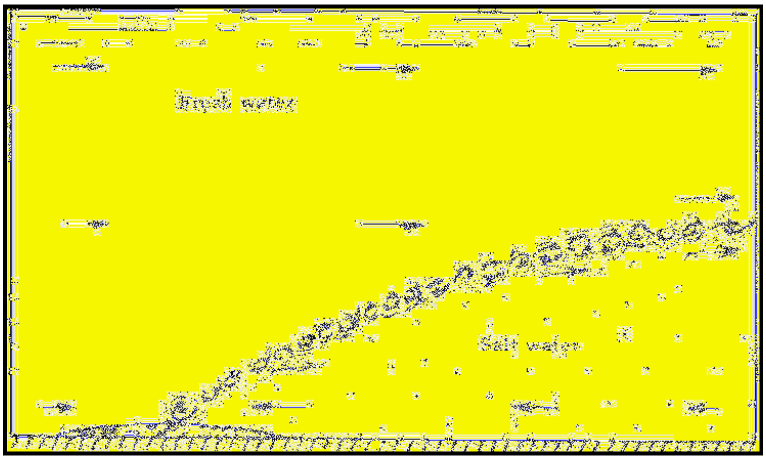


Figure 2.1 Conditions Typical of Highly Stratified Estuary

(Source: Ippen, (1966).

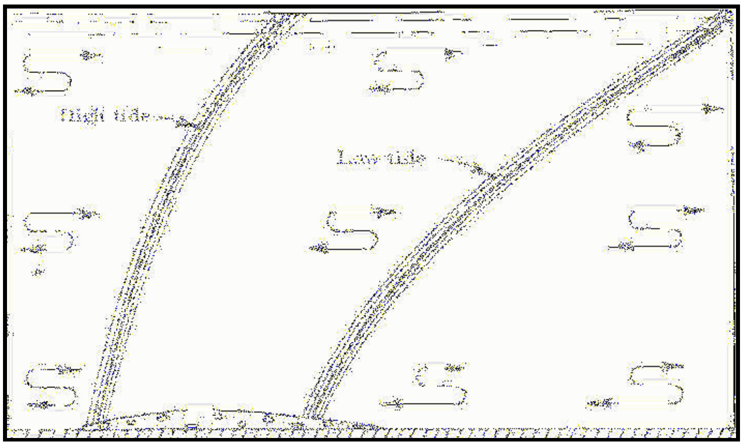


Figure 2.2 Conditions Typical of Partially Mixed Estuary

(Source: Ippen, (1966).

2.2.2.3 Well-Mixed Type

When the tidal range is very large there is sufficient energy available in the turbulence to break down completely the vertical salinity stratification.

In the well-mixed estuary, the tidal forces predominate over the fresh water inflow to such extent that the fresh and salt water are fairly well mixed throughout the vertical. Salinities decrease more or less progressively from sea water at the entrance to fresh water in the upper reaches and bottom salinities normally exceed those at the surface by

15 to 25 percent. In the well-mixed estuary, the ratio of fresh water discharge to tidal prism is normally of the order of 0.1 or less (Ippen, 1966). Refer figure: 2.3.

In this type of estuary there can be lateral variations in salinity and in velocity or, if the lateral mixing is also intense, the estuary can become sectionally homogeneous (also called a one-dimensional estuary) (Dyer, 1979).

Figure 2.3 Conditions Typical of Well - Mixed Estuary

(Source: Ippen, (1966).

Change in Mixing Type

An estuary may be changed from highly stratified to partly mixed or well mixed by reduction of the fresh water discharge; conversely, one may be changed from well mixed or partly mixed to partly mixed or highly stratified by increasing the fresh water discharge.

Minor changes in mixing types are being constantly effected by the deepening and other improvement of estuary channels for navigation (Ippen, 1966).

2.2.3 Estuarine Area's Problems of World

Estuaries represent one of the most sensitive and ecologically important habitats on earth. Due to their suitability to human settlement estuaries typically have a heavy human presence and of the 32 largest cities in the world, 22 are located on estuaries.

Estuaries have long been important as harbor sites and centers of commerce. Some of the oldest continuous civilizations have flourished in such estuarine environments as the lower region of the Tigris and Euphrates rivers, the Po Rivers delta region of Italy, the Nile delta, the Ganges delta, and the lower Huang He Valley. Developing civilizations soon discovered that the logical site for commercial seaports was the seaward most point of the major river systems. Such cities as London (Thames River), New York City (Hudson River), Montreal (St. Lawrence River), Hamburg (Elbe River) and Bordeaux (Gironde estuary) have developed on estuaries and have become important centers of commerce.

Since estuaries commonly provide excellent harbors, most of the large ports in the United States (New York, Philadelphia, Baltimore, Moblile, Galveston, Seattle, and San Francisco) are located in estuaries. However, the development of high-density population centers causes deleterious effects that can destroy the very properties of the estuary that made development of the region possible. Human impact on estuaries includes reclamation of tidal land by pollution from sewage, solid waste and industrial effluent. Not surprisingly human activities have led to a decline in the health of estuaries making them one of the most threatened ecosystems on Earth.

Among the countries engaged in estuarine water quality studies, USA ranks foremost as many of the estuaries in the country (near New York, Delaware, Potomac, Boston and others) had become/or are becoming virtually destroyed due to the indiscriminate and uncontrolled waste disposal. Similar studies have been done in U.K. also because they have a number of cities on the estuaries such as the Thames, Tee, Mersey (Calcutta Metropolitan Development Authority, 1972).

The occurrence of saline water intrusion is extensive and represents a special category of ground water pollution. The problem exists in localities of most parts of the United States. Sea water intrusion along coasts has received the most attention. In the United States the coastal States most severely affected include New York, Florida, Texas, California, and Hawaii. Internationally, the problem has received attention in populated coastal areas in England, Germany, the Netherlands, Israel and Japan, among others (Todd, 1995).

2.2.4 Estuarine Area's Problems of India

Along the coast line of India, numerous bays and gulfs are formed where big or small rivers meet, thereby forming estuarine zone. Along coastal line numerous brackish water lakes are in existences, which are joined with the sea during floods. A typical Indian estuary is highly productive, as its waters receive abundant qualities of nutrients from the connected fresh water systems and surrounding land areas. Most of the Indian estuaries are monsoon dominated. The abundant fresh water influx in them is more or less limited to the monsoon season extending from July to October. In the summer months of March to June very little fresh waters are added and the severity of pollution hazards comes into prominence at this phase.

The major estuarine systems of the country are: Hooghly-Metlah Estuarine system, Mahanadi Estuarine system, Krishna Estuary, Pulicat Lake, Cauvery Estuary, Vembanad Lake and Narmada-Tapti Estuary. All these water areas, along with a large number of small estuaries scattered throughout both the East and West coasts.

In Mahanadi Estuary, the tidal effect is felt only up to about 35 kms upstream of the mouth. In the Gautami which is the main component of the Godavari Estuarine system, the tidal inflow extends up to about 50km from the mouth. A general trend of increase in salinity has been observed in the rivers in recent years (Calcutta Metropolitan Development Authority, 1972).

2.3 Surface Water Models for Estuarine Area

Lung and O'Conner (1984) developed a simplified analytical model from the equations of momentum, continuity to compute two-dimensional estuarine transport. They applied this analysis to investigate transport and water quality problems in the Sacramento-San Joaquin estuary, the James River estuary, the Patuxent River estuary, and the Hudson River estuary (New York) throughout the country with satisfactory results. Roelfzema et al. (1987) developed a mathematical model system consisting of flow models morphological models and water quality models at Delft Hydraulics for the Rhine-Meuse estuary, the Netherlands.

Chandramohan and Joseph(1999) applied the two-dimensional finite element model FESWMS-2DH developed by USGS, USA for analyzing the dynamics of the Cochin estuary, influenced by seasonally varying sea water intrusion and fresh water discharge. They calibrated and validated the model using velocity measurement at eleven observed location. Senders and Piasecki (2000) optimized the fresh water diversion schedules from estuaries to mitigate the hazards of rising salinity levels further downstream. Liu et al. (2001) applied a real-time, two-dimensional, laterally averaged hydrodynamic mathematical model to analyze residual current and salinity distributions in the Tanshui River estuary in Taiwan.

Chau and Jiang (2001) developed a 3D numerical model and applied to the Pearl River estuary, which is the largest river system in South China, with Hong Kong and Macau at its entrance. Knowles (2002) studied the natural and management influences on fresh water inflows and salinity in the San Francisco estuary at monthly to interannual scales. Chatterjee (2003) used a 3D mathematical model for simulation of the circulation of an alluvial estuary. . He compared water surface elevations and currents from the model with those observed in the Hooghly estuary, Eastern India.

Liu et al. (2004) applied a vertical (laterally integrated) two-dimensional hydrodynamic and salt water intrusion numerical model to study the salt water intrusion in the Tanshui River estuarine system, Taiwan. Pinho and Vieira (2005) implemented the two dimensional hydrodynamic and mass transport model based on the finite element method to study salinity intrusion into the estuary of the river Lima in the north-western region of the Iberian Peninsula, Portugal. Brice et al. (2005) developed a numerical modal based on the finite volume MUSCL-Hancock method and used to simulate the saline intrusion within the Rio Maipo estuary, a well-mixed tidal river in central Chile.

Gross et al. (2005) performed three-dimensional simulations of circulation in the San Francisco Estuary with the three-dimensional hydrodynamic model, TRIM3D, using a generic length scale turbulence closure model. Cuthbertson et al (2006) studied the influence of submerged Tidal Barriers on estuarine mixing and exchange processes. Model studies have been undertaken by them to study the spatial and temporal development supplied by a fresh water inflow and bounded by an impermeable barrier that was overtopped periodically by a tidally generated saline water inflow. They demonstrated that the essential exchange mechanisms controlling the flow over a partially submerged tidal barrier can be simulated satisfactorily by an idealized laboratory model.

They also experimentally illustrate that the dimensions of the brackish pool reach equilibrium after a specific number of tidal cycles, with the normalized thickness of the pool being dependent on the strength of the fresh water inflow.

The above investigators have developed two dimensional and three dimensional mathematical or numerical hydrodynamic flow and mass transport models based on Finite Element Method, Finite Volume Method etc. They studied salinity intrusion into the estuary, circulation of fresh/saline water in the estuary, salinity distribution in estuary the fresh water diversion schedule in estuary, natural and management influences on fresh water inflows and salinity in estuary. Cutbertson et al. (2006) studied the influence of submerged Tidal barriers on estuarine mixing and exchange processes by an idealized laboratory model.

The studies are related to surface flow and salinity intrusion in surface water in estuarine regions of different rivers. They have not considered the infiltration from the estuary, recharge from the rain or water body into the aquifer. This mainly focuses on surface water so groundwater studies related to ground water fluctuations are required to be carried out for the study area.

2.4 Water Quality Studies in Estuarine Area

Patel et al. (1985) studied salinity distribution, pollution dispersion and tidal flushing in Mahi estuary. The tidal limit was observed to be at a distance of about 50 km upstream of the mouth during the summer months of May-June when the river discharge is the lowest. The salinity determination was carried out at the Kavi, J-point and Mahammadpura during pre monsoon (May-June). Linear equations, to determine distribution of salinity the least square method, were used for lower reach of estuary up to J-point. They found Mahi estuary is well mixed estuary. They also worked out dilution factors at Gangha, Kavi, J-point and Mahammadpura. The dispersion coefficients found for Mahi estuary at J-point and Kavi are 4.39 x 106 m^2/ hr and 2.45 x 106 m^2/ hr respectively.

Patel et al. (1986) also studied the effects of waste water discharges on Mahi estuary. The problems of pollution in estuaries are concerned with the temporal and spatial distribution of contaminants introduced into the estuary and with their effect on water quality. They conducted site survey for Mahi estuary, where partially treated effluent is discharged through 56 km long effluent channel from various industries. The effluent channel was commissioned in February-1983. They studied the physical characteristics of Mahi estuary such as tides, surface current speed and Bathymetry to decide the disposal point and to find dispersion coefficient. They found that estuarine channel up to Kavi gets exposed during the low tide. The ebb currents and flood currents in the left bank channel of the Mahi estuary are remarkably strong that is of the order of 0.5 m/s in neap and 1 m/s in spring. Since, the estuary drains nearly completely during low tide up to Kavi, the stretch of channel between J-point and Kavi will be merely, an effluent drain during low tide. It is, therefore, essential that the wastewater be released at certain stage of the high tide for effective dilution and dispersion. Keeping this in mind, the waste water effluent is collected in a lagoon near the shore for fifteen days and released for channel during high tide only. They concluded that to avoid the direct and the cross contamination, the release of the waste water should be carried out in the ebb cycle depending on the tidal phase. To obtain definite ambient dilution close to the slack periods of the tidal currents, the effluent discharge should be carried out through a multipore diffuser.

Nirmala et al. (1990) studied pollution in the coastal zone of Kerala, boarded by Western Ghats on the South West coast. Multi faceted activities like rapid industrialization, expanding population and agricultural activities have adversely affected the status of the environmental zone. Health hazard problems arising out of the contamination of the drinking water sources and recreational sites are noteworthy. This result in a situation where coastal environment is continuously changing and ecology is threatened. They found erratic rainfall and salinity intrusion problems in rivers and lakes are experienced in Kerala coast. They highlighted the major problems related to the coastal zone of Kerala, which would help the further developmental and management activities of the coast.

Patel et al. (1990) assessed river water quality of Mahi, Ambika, Kaveri, Par and Damanganga rivers in Gujarat. The study was started in the year 1979 and completed in 1985. Rivers get polluted by rapid urbanization and industrialization. They ultimately classified the river course as unpolluted, polluted and saline, based on five years test results of water samples collected regularly from the rivers. The waters of Mahi river classified in three zones as (i) Unpolluted zone from village Harod to 14 km d/s of Vasad bridge. (ii) Polluted water zone from D/S of Vasad Bridge to village Jaspur. (iii) Polluted-Saline water zone from Jaspur to Kavi.

They also assessed the contamination of underground water resources and the quality of ground water in wells situated along river course identified as polluted zones of some rivers. Samples were collected during 1981/1982 from wells along polluted and polluted-saline zone of Mahi river. Samples from wells at villages Vasad, Angadh, Jaspur and Dabka along the polluted zone are classified as good to moderate as per U. S. Salinity Diagram, while water samples collected from wells at villages Chamara, Bamangam, Gambhira, Badalpur and Dewan along the polluted-saline zone on right bank and those from Mujpur, Tithor, Kareli, Karkhadi and Kavi on the left bank are classified as bad on the basis of test results.

Yagnik et al. (2003) studied environmental impact assessment along the river Mahi due to industrialization and tidal effect in peripheral areas of Anand and Vadodara District, Gujarat. They assessed the present groundwater quality with the lateral and vertical extent in variation in groundwater quality with respect to space and time. They found groundwater quality largely affected due to man made changes. As compared to 1984, there is substantial increase in the affected area of surface water as well as groundwater pollution due to industrial and tidal water impact. They also concluded that as compared to right bank, left bank is more polluted.

Kumar et al. (2006) studied the sea water intrusion and its effects on water quality in Vasishta-Godavari estuary. The data, the saline water excursion and its variation under different river discharge conditions have been studied. They found practically no saline water intrusion into the estuary for river discharge > 4400 m^3/sec and as the river discharge decreases the saline water intrudes up to 30 km upstream. Under nil discharge condition the saline water extends beyond 30 km upstream. Diurnal variation in saline water excursion indicates increase in salinity during tide and decrease in salinity during falling tide. Under high river discharge conditions the saline water enter into the estuary only in the bottom layers and during ebb period the entire estuary is occupied with fresh water from surface to bottom. During moderate and nil discharge conditions the salinity variations over a tidal cycle are small.

Patel (2006) studied the problems in the tail reaches of the rivers, where the strategy for protection and improvement of groundwater quality in the coastal area near a river are not discussed. The tail ends of rivers are subjected to tides, which create the problem of salt water intrusion and deterioration of groundwater quality. The strategy included the construction of a specially designed weir across the river near the tail end. He also presented a case study of Surat city (India) In the case study the problem of groundwater pollution due to tide water entering into the river Tapi and measures for the improvement of groundwater quality in the study area. It included effect of construction of a weir cum causeway across river Tapi and effect of artificial recharge of the groundwater (either in the existing tube wells and open wells) or by constructing new groundwater recharge wells using rainwater in the affected area. To solve the problem of groundwater deterioration in the area on both sides of downstream of river Tapi, he recommended a specially designed weir near tail end of the river and a network of groundwater recharge wells in the affected area.

Shah and Patel (2010) developed linear regression equations to predict the concentration of water quality constituents having significant correlation coefficient with electrical conductivity of Anand district, Gujarat. Groundwater samples from Anand district were collected by grab sampling method during pre monsoon (May 2008) and post monsoon seasons (October 2008). Physicochemical analysis was conducted following standard methods (IS: 10500:1983). The linear regression analysis between electrical conductivity and strongly correlated TDS and Cl in water showed that these constituents can be estimated from electrical conductivity values in Anand district.

Varadaraj (2010) studied the status of salt water intrusion in parts of Tamil Nadu coast bounded by the Bay of Bengal on the east. The hydro geological conditions and aquifer geometry of various porous and fractured rock media in Tamil Nadu has indicated the presence of multi layered/multi-quality aquifer system. The over exploitation of few fresh water bearing aquifer in Minjur area, Tiruvanmiyar coast, Marakanam-Cuddalore coast, Ramanathapuram Island and Tiruchendur-Udangudi belt resulted in sea water ingress due to human interference while the ‘insitu’ salinity is existing for few thousand years. He concluded that the interface between fresh water and saline water with marked transition zone is prevalent at different depths in different position with reference to present day coast. Some of the sea water - fresh water interface movement towards land due to over exploitation of groundwater was identified. The sea water ingress due to depleting pressure head and reversal of gradient towards land is observed / predicted in many parts of Tamil Nadu coast. It was also predicted that climatic changes and resulting rise in sea level will also influence the water quality of aquifer system in coming years. He recommended the large scale flood water diversion to the surface water bodies and recharge to ground by injection through tube wells parallel to coast to minimize the problem.

Dhar et al. (2010) investigated the salt water intrusion phenomenon in the Piyali River aquifer located in the South of West Bengal, India. They mentioned that the sluice gate is connected to the Matla River which in turn connected to the Bay of Bengal. So at different distances from sluice gate the samples were collected and by analyzed variation of TDS, EC, and PH etc. They also discussed the variation of chloride content of soil samples. They concluded that maximum values of salinity occurred near the sluice gate of Piyali River. Values reduced a distance of ten km away from the sluice gate. For the coastal community of Piyali River salt water intrusion is a significant concern. The values of PH decrease as the distance from the sluice gate increases.

The above investigators have studied salinity distribution, pollution dispersion, tidal flushing and the effects of waste water discharge on Mahi estuary. They assessed river water quality, contamination of under-ground water resources and quality of groundwater in wells situated along river course of Mahi, Ambica, Kaveri, Par and Damanganga rivers in Gujarat. They also studied environmental impact assessment along the River Mahi due to industrialization and tidal effect in peripherial areas of Anand and Vadodara District, Gujarat, pollution in the coastal zone of Kerala, bordered by Western Ghats on the South West cost, the seawater intrusion and its effects on water quality in Vasista-Godavari estuary and the problems in the tail reaches of the rivers. They developed linear regression equations between electrical conductivity, TDS and cl of Anand district, Gujarat.

These investigators have not considered the effect of distances from sea and from centre line of river on groundwater quality. So this type of investigations by Graphical analysis of field data, development of linear and multiple regression equations are required to be carried out for the study area.

2.5 Coastal Groundwater Models

Sugio et al. (1987) analyzed the problem of sea water intrusion in an unconfined coastal aquifer caused by groundwater withdrawal in the dry season numerically using the assumptions of an abrupt interface, the Darcy equation and the Dupuit approximations. The model employed finite difference numerical Techniques. This model provides a practical design and management tool for predicting the likelihood of sea water intrusion through a semi pervious subsurface barrier in an unconfined coastal aquifer. The movements of both the water table and the fresh water-saltwater interface are numerically simulated in the unsteady state. The computed results are validated with observations obtained from a vertical two-dimensional sand box model. The computer model applied for a proposed subsurface barrier location in a lime stone coastal aquifer on Okinawa-Jima Island in the Western Pacific Ocean. They found that the semi pervious subsurface barrier is able to delay sea water intrusions under critical conditions of continual pumping of the aquifer without recharge. The subsurface barrier is technically feasible and is a viable solution to the problem of sea water intrusion in coastal aquifers.

Rechards and Jones (1997) described research and development in paper “A conceptual model approach for modeling groundwater with GMS”. It has been implemented in department of Defence Groundwater Modeling System (GMS). This new approach of handling human interaction with GMS is based on the engineer or scientist visualizing the hydrogeologic conceptual model on the computer screen and then having the computer developed numerical model. A single conceptual model is used to generate a variety of groundwater models, both finite-element and finite- difference. They found that focusing on high level representations of the site rather than on a discretized representation of the site. Simplifies data entry greatly and overall modelling process is enhanced.

Rastogi and Sulekha (2000) developed a coupled groundwater flow and solute transport model to ascertain spread of pollutants in the irrigated area of the Mahi Right Bank Canal (MRBC) command area, Kheda Dist.; Gujarat. The FEM based groundwater flow model is coupled with the transport model by passing the values of groundwater flow velocity to the transport model. Initial concentration and head distribution contour maps were used to linearly interpolate data at the finite element grid nodes. They found that predicted solute concentration in the form of EC values for a period of one year agrees reasonably with the data obtained from the field office.

Cheng and Chen (2001) developed a three–dimensional, density dependent model to study salt water intrusion in multilayered coastal aquifers of Jahe river basin, Shandong Province, China. A coupled Eulerian- Lagrangian method is applied to solve the transport equation, in which the advection part is calculated by a hybrid method of characteristics. They found the reasons for salt water intrusion as excessive groundwater exploitation and improper arrangement of pumping wells in the lower reaches of the Jahe River Basin as well as the tidal affected river. Some of the important reviews are described here.

Kumar (2001) simulated sea water intrusion in Nauru Island which is a Coral Island in the central Pacific Ocean, very near to equator under steady state conditions through Saturated-Unsaturated Transport (SUTRA) model. The application of this model is very useful in those cases where a two-dimensional vertical cross-section adequately represents the groundwater system. The simulation results highlight the importance of tidal forcing for islands and coastal groundwater studies.

Kumar (2002) presented the salient features of available numerical models to enable selection of appropriate code for the specific sea water intrusion problem. He found that the selection of an appropriate modeling code for a particular study is a matter of ensuring that the code has the capability to adequately represent the essential features and flow processes of the groundwater system being studied. It is also important to ensure that the selected code has been verified and benchmarked against standard test problems. Most of the commercially available codes have been verified. No model can replace a comprehensive field program which provides the required data. If reasonably good data is available, numerical model can be employed to provide an important means for guiding management decisions.

Ravi (2003) enumerated the simple and applicable models for various ecosystems. SUTRA a two- dimensional model for Saturated-Unsaturated Transport has been used for analyzing the two-dimensional flow of salt water intrusion under steady-state condition for unconfined aquifer using vertical section concept. He found that the hydraulic gradient and the interface movement are inversely proportional and this interface movement is non-linear. The systems are found to be very sensitive to hydraulic gradient

Senthilkumar and Elango (2004) used a three dimensional mathematical model to simulate groundwater flow in the lower Palar River basin, Southern India. A two layered finite- difference flow model was used. There are three major pumping stations on the riverbed apart from a number of wells distributed over the area. The model simulated for a transient state condition. The transient models run to forecast groundwater flow under various scenarios of over pumping and less recharge. They shown that the aquifer system is stable at the present rate of pumping, excepting for a few locations along the coast where sea water would intrude up to 50-100 m inland. The model predicted that an increase of pumping would lower the groundwater head.

Shoemaker (2004) presented important observations and parameters for a salt water intrusion model. A sensitivity analysis with a density-dependent groundwater flow simulator was conducted to produce insight and understanding of salt water intrusion calibration problems. Five simple experimental simulations presented. He found that dispersivity is a very important parameter for reproducing a steady-state distribution of hydraulic head, salinity and flow in the transition zone between fresh water and salt water in a coastal aquifer system. When estimating dispersivity, observation locations and data types are likely to be most effective. Results are expected to be directly applicable to many complex situations.

Mane et al. (2005) developed Geographic Information System (GIS) interface for groundwater model-MODFLOW. An attempt has made to develop an interface for generating all data files where spatial and temporal variability in rainfall, irrigation, soil, crop and weather are needed. GIS was interfaced with a groundwater model to prepare the input files and process the output of the model. For generating input files, an Arc Info interface program Con2grid for groundwater flow model PMWIN (processing-MODFLOW for Windows) was developed in Arc Macro language as an extension for facilitating modeling. The efficient pre processing capabilities of Con2grid were demonstrated for predicting water table in the command of Dadupur distributary under Ganga canal System of Utter Pradesh in India.

Langevin and Guo (2006) presented the approach for coupling MODFLOW and MT3DMS into a single computer program (SEAWAT) for the simulation of variable-density groundwater flow. The approach consists of formulating the groundwater flow equation in terms of equivalent fresh water head and fluid density, which is calculated from solute concentrations using a linear equation of state.

Elango and Senthilkumar (2006) simulated groundwater head in the part of lower Palar River basin, Tamilnadu, India, for studying the effect of construction of sub-surface barrier across the Palar River on the groundwater flow regime in the aquifer system. The Finite-Difference computer code MODFLOW (McDonald and Harbaugh, 1998) was used to simulate the groundwater flow in the study. Groundwater Modelling System (GMS) was used to give input data and process the model output. The model predicted the effect of the sub-surface barrier on the groundwater system. They found that there would be an increase in groundwater level by about 0.1 to 0.3 m extending up to a radius of about 1.5-2 km along the upstream side of the sub-surface barrier while on the downstream side the groundwater head would lower by 0.1 to 0.2 m.

Ranjan et al. (2006) simulated salt water intrusion in the lower part of Walawe River basin located in the southern coastal aquifer in Sri Lanka through a numerical model based on the sharp interface approach. They found that in arid areas, the fresh groundwater loss increases as the percentage of forest cover increases. With respect to groundwater recharge, agricultural lands are the best land use pattern in arid and semi-arid areas. The combined effects of deforestation and aridity index on fresh groundwater loss indicated that deforestation causes an increase in the recharge and existing fresh groundwater resource in areas having less precipitation and high temperature (arid climates).

Elango (2009) used Groundwater modeling technique to assess the feasibility of pumping seawater from a beach well for Chennai desalination plant. The study was carried out in Nemmili village located 25 km south of Chennai along the coast of Bay of Bengal. The finite-difference computer code MODFLOW was used to simulate the groundwater flow in the study area .Solute transport modeling was carried out using the MT3D code. The pre and post processor, developed by the United States Department of Defence Groundwater Modelling System version 6.0 (GMS), was used to give input data and process the model output, various scenarios with different pumping strategies were modeled. From the results it was concluded that Groundwater occurs as a ridge with flow towards the sea in the east and the Buckingham canal in the west, hence, it is not advisable to go for a beach well to meet the larger requirements, as this will affect the groundwater resources in the vicinity. Further, pumping at higher rate will eventually make the fresh groundwater of this region saline.

Some of the above investigators have analyzed the problem of sea water intrusion in an unconfined coastal aquifer by finite difference numerical techniques using the abrupt interface approach. They described a conceptual model approach for modeling groundwater with GMS and presented the salient features of available numerical models to enable selection of appropriate code and enumerated the simple and applicable models for various ecosystems. They also presented important observations and parameters for a saltwater intrusion model and approach for coupling MODFLOW and MT3DMS into a single computer program (SEAWAT) for the simulation of variable density groundwater flow. They developed a coupled groundwater flow and solute transport model to ascertain spread of pollutants in the irrigated area of the MRBC command area Kheda district, Gujarat. It is a three-dimensional density dependent model to study salt water intrusion in coastal aquifers and GIS interface for groundwater model- MODFLOW to prepare the input files and process the output of the model. They simulated seawater intrusion under steady state conditions through SUTRA model. They used a three dimensional mathematical model based on finite difference to forecast groundwater flow under various scenarios of over pumping and less recharge. They used MODFLOW (McDonald and Harbaugh 1998) as well as GMS to give input data and process the model output to simulate groundwater head for studying the effect of construction of subsurface barrier across the Palar River, Tamilnadu, India on the groundwater flow regime in the aquifer system. They also used MODFLOW to simulate the groundwater flow in the study area, MT3D code for solute transport modeling and GMS version 6.0, to assess the feasibility of pumping sea water from a beach well for Chennai desalination plant.

They have not considered the effects of impoundment of water due to construction of tidal regulator cum recharge structures located on the estuary in influencing the underlying groundwater regime. So this type of groundwater modelling is required to be carried out for the study area. The software GMS is used for this study.

The literature reviewed in this chapter indicates that the problems of Mahi estuarine area can be investigated by applying modelling and other analysis suggested by various researchers.

In order to consider infiltration from the estuary, recharge from the rain or water body into the aquifer, groundwater studies are required to be carried out in the study area. Similarly to include the effect of distances from sea and from centre line of river on groundwater quality, graphical analysis of field data, development of linear and multiple regression equations are required to be carried out for the study area. Also to consider the effects of impoundment of water due to construction of tidal regulator cum recharge structures located on the estuary in influencing the underlying groundwater regime, the groundwater modelling is required to be carried out for the study area. The software GMS is used for this study.

3 CASE STUDY AREA AND DETAILS

The State of Gujarat is located on the north-western shores of India, lying between 20° 01' and 24° 07' North latitudes and 68° 10' and 74° 28' East longitudes. It covers a total geographical area of 1, 95,984 sq.km (Directorate of Economics and Statistics, 1987). Out of the total area nearly 1, 09,314 sq. km is occupied by rocky formations and 86,670 sq. km is by alluvium; of which 34,625 sq. km is saline area. The State has the longest coastline in the country measuring about 1,663 km along the Western part of India, extending from Lakhpat in the North to Valsad in the South. Gujarat State has common borders with Rajasthan, Madhya Pradesh and Maharashtra States in North, East and South respectively and with Pakistan in North-West.

The drainage in all areas of Gujarat has a distinct manifestation of the topographical features and physical characteristics of the rock formations. The flow directions of some of the major rivers are controlled by the major tectonic activities, which occurred during geological times. Except Narmada, Tapi and Mahi rivers, all other rivers in the eastern part of the state originate on the western slopes of eastern hills. They flow in the direction almost at right angle to the boundary i. e. towards South-West (Sabarmati and Mahi rivers) in the North-Eastern part, towards almost west (Narmada, Tapi and Dhadhar) in the central region and towards North-West (Kolak, Par, Ambica, etc.) in the Southern part. Most of the rivers in the alluvial plain meander with very wide courses whereas those in rocky tracts have deep and narrow courses. The rivers in Saurashtra and Kachchh originate from the central uplands and represent a radial drainage pattern.

Gujarat falls in the sub-tropical climatic zone and a large part of the state lies between 35° C and 45° C isotherms. The rainfall in the state is moderate. It forms a transitional zone between the heavy monsoon area of Kokan in the South and arid areas of Rajasthan in the north. Climatic conditions vary greatly in the state. The climate in general has three main seasons i.e. summer, monsoon and winter. The monsoon breaks by middle of June, reaches its peak in July and starts retreating by end of September. The overall climate is humid, sub-humid and semi-arid to arid. The relative humidity in the all parts of the state, except the coastal strip, is low (being about 50 % between October and May). Average annual relative humidity figures for different regions are South Gujarat 71 %, North Gujarat 64 %, Saurashtra and Kutch Uplands 56% to 67% and Coastal Saurashtra 69 % to 77 %. Wind velocities are generally moderate except during the period prior to onset of monsoon and during the monsoon period. Winds blow from West or South-West during monsoon whereas they blow from North-East during winter.

3.1 STUDY AREA

The present study is related to region of Mahi estuarine area. The location map of Mahi estuarine area in country, state and district shown in figure no 3.1

3.1.1 Geographical Location of Study Area

Geographic location of the study area is shown in Location map. Physiographically, it's northern and southern limits are marked by catchment boundary of Mahi basin. Mahi River meets Gulf of Khambhat near Kavi town. The western limit is determined by the Gulf of Khambhat and in the East the area stretches up to Khanpur between catchment boundaries of Mahi basin. The study area comprises an area of 2298.23 sq.km and is enclosed within the North latitude 22°05'06" to 22°33'36" and East longitude 72°27'18" to 73°13'57" covering Survey of India, toposheets nos. 46 B/14 to 16 and 46 F/2 to 4. (Survey of India, 1975)

Administratively, the study area is shared by the districts of Vadodara, Bharuch and Anand. In Vadodara district, it covers three talukas Padra, Vadodara and Savali, while in Bharuch district, it covers one taluka Jambusar and in Anand district, it covers five talukas Anand, Anklav, Borsad, Khambhat (Cambay) and Petlad. Vadodara and Bharuch districts are on left bank while Anand district on right bank of Mahi River. The Mahi River forms the boundary between Vadodara and Anand districts. The area between Wanakbori to Gulf of Khambhat is gently sloping to almost flat near the Gulf and is a fully developed and fertile alluvial tract. The location map of study area is shown in figure no 3.2(a) and (b).

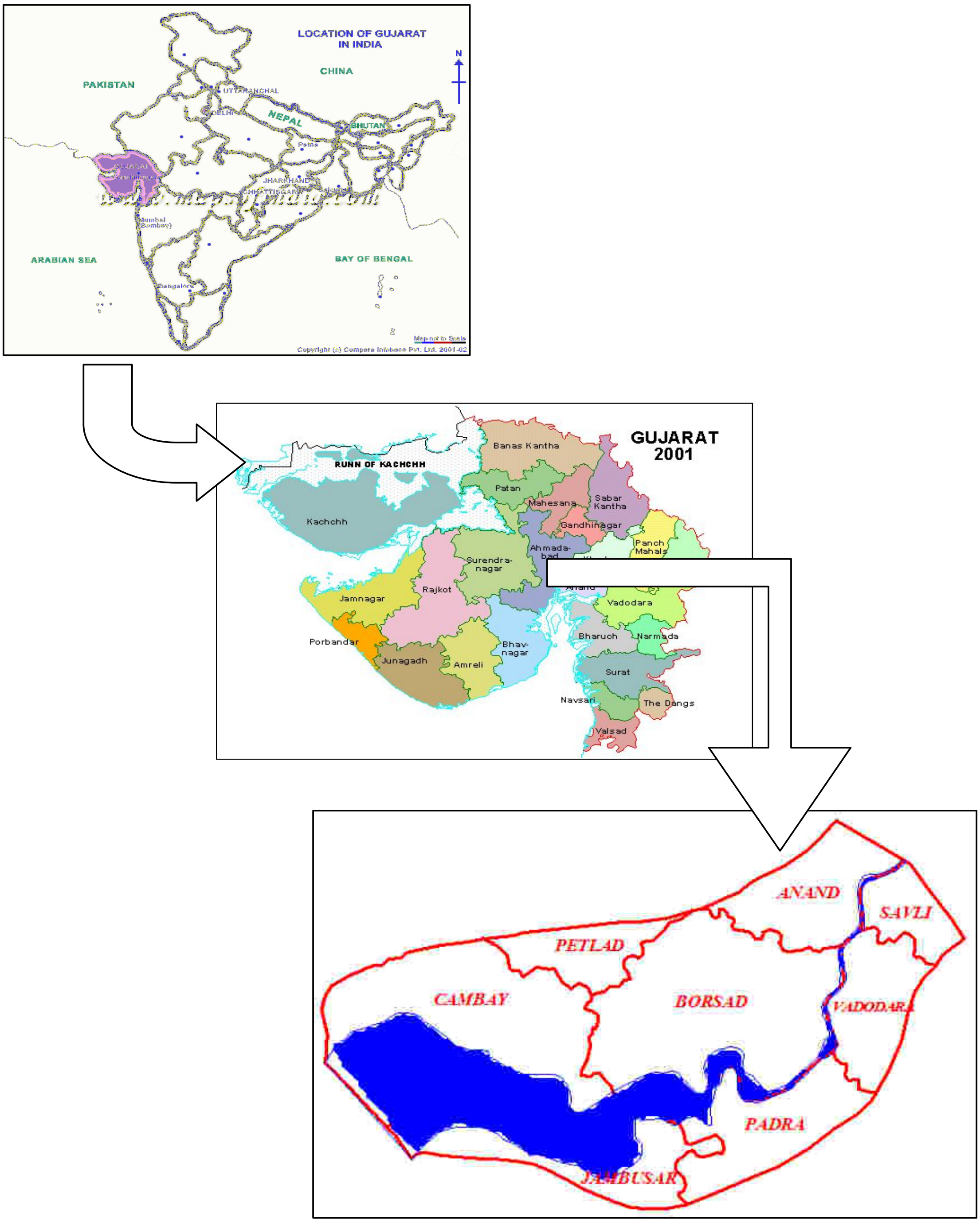


Figure 3.1 Location Map of Mahi Estuarine Area in Country, State and District

Scale 1:250000

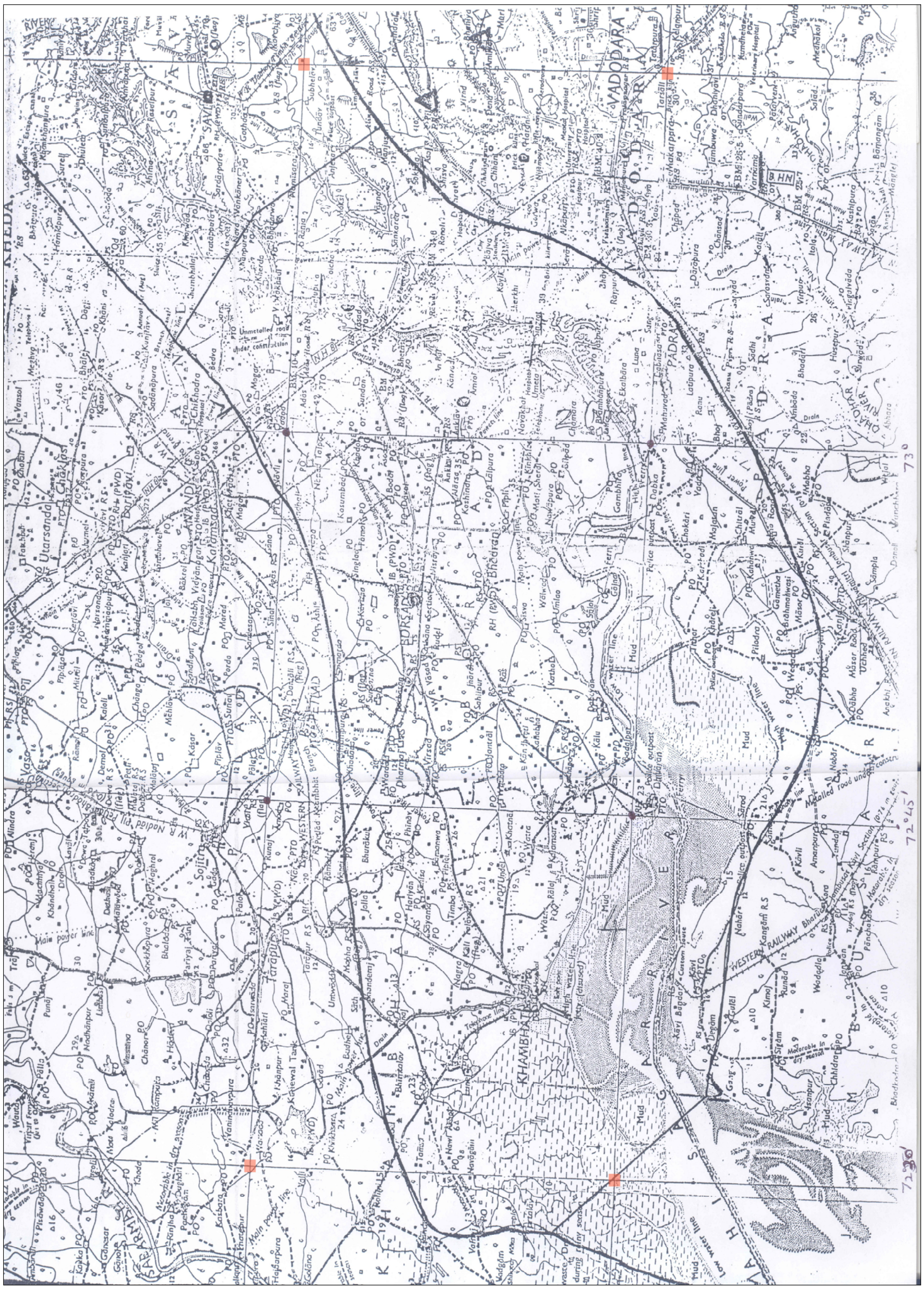
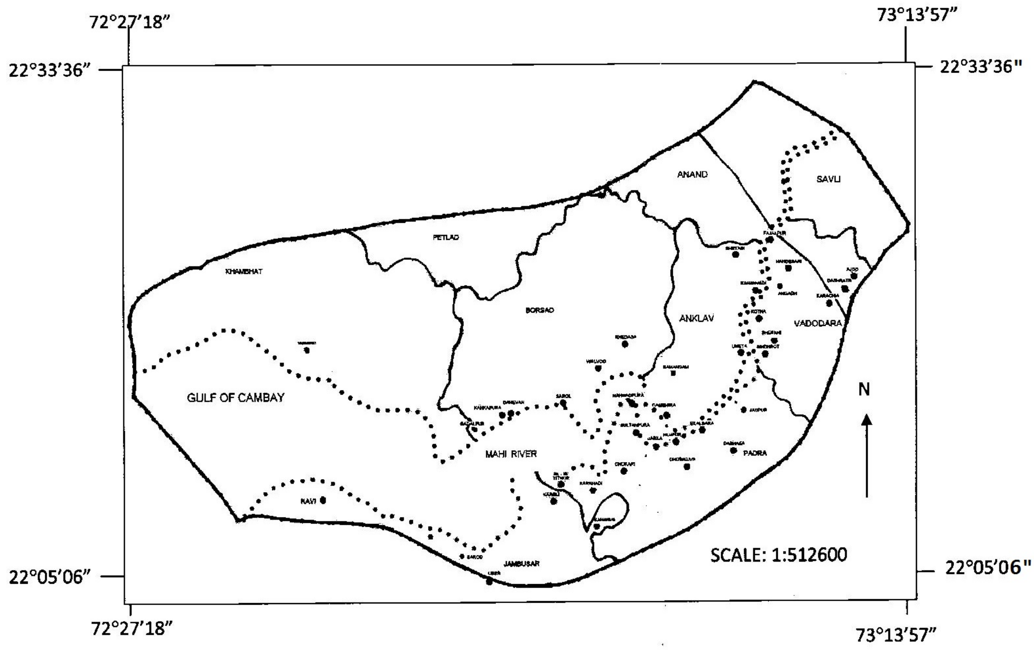


Figure-3.2 (a) Location Map of Study Area



LEGEND

- ● Village
- …… River boundary
- Taluka boundary
- ——— Study area boundary

Figure 3.2 (b) Location Map of Study Area

3.2 Mahi River

The river Mahi is third major west flowing interstate river of India, draining into the Gulf of Khambhat. It is one of the four major perennial rivers in Gujarat (Directorate of information G.O.G., 1960). It originates in the northern slopes of Vindhyas mountain ranges at an elevation of 500 m. above mean sea level (Rao, 1975). At about 22° 35' N and 74 ° 15' E near the village Sardarpur in Dhar district of Madhya Pradesh (Narmada Water Resources And Water Supply Department, 1999). Its total length is 583 km, traversing 167 km. in Madhya Pradesh, 174 km. in Rajasthan and remaining 242 km. in Gujarat. It flows initially in North-West direction through Dhar and Jhabua districts of Madhya Pradesh. Thereafter, it takes turn to the left and flows South-West direction through Banswara district of Rajasthan. It enters the Gujarat State near Bhukia village in Rajasthan and runs through the Panchmahal and Anand districts of Gujarat State before joining the Arabian Sea in the Gulf of Khambhat (Water Technology and centre of IARI, 1983). In the Vadodara district the river passes through three talukas, viz., Savli, Vadodara and Padra. In the Savli taluka the Mahi flows past Jambu Goral, Varsada, Kanoda and Pincha villages. Thereafter it enters Vadodara taluka and passes by Anagadh and Sindhrot villages. Lastly the river enters the Padra taluka and passes near the villages of Jaspur, Ekalbara, Mujpur, Dabka, Karkhadi and Tithor. After traversing a course of about 115 km., in this district; the river enters the Anand district and merges into Gulf of Khambhat (Cambay) (Government of Gujarat, 1979).The course of the river is well defined and has steep banks in most of its reaches. (Narmada Water Resources and Water supply Department, 1999).

3.2.1 Mahi Basin

The total catchment area of Mahi basin up to the point of its confluence in the Gulf of Khambhat is 34,842 sq. km of which 19% lies in Madhya Pradesh, 47% in Rajasthan and 34% in Gujarat (Rao, 1975). The basin lies between the geographical co- ordinates of 73° 00’ to 74° 20’ East longitudes and 22° 30’ to 24° 20’ North latitudes. The catchment area within Gujarat is 11,694 sq. km

The catchment of the river is mostly hilly and its shape is double fanned, which gives rise to high intensity flash floods (Water Technology Centre of IARI, 1983). The basin is bounded by the Aravalli hills in North and North-West, by the ridge separating it from Chambal basin in the East, by the Vindhya hill range in the South and finally by Arabian Sea in the West (Narmada Water Resources and water Supply Department, 1999). The upper basin lying in Madhya Pradesh has undulating terrain crisis crossed by ridges and valleys. In Rajasthan, the basin consists of hills, forests and eroded terrain. In Gujarat up to the confluence of Mahi and Panam, the basin comprises semi-developed lands. Below Wanakbori weir and up to the mouth, the basin is flat, fertile and well developed alluvial tract. The Plan showing the rivers of Mahi basin is shown in the figure 3.3 (Narmada Water Resources and Water Supply Department, 1999).

3.2.2 Tributaries of Mahi

The Mahi River receives several tributaries on both banks out of which the main tributaries are Som, Anas and Panam. The Som River joins the main river Mahi on the right Bank in Rajasthan (basin area 8,707 sq. km). The Anas (basin area 5,604 sq. km) and Panam (basin area 2,470 sq. km) join the main river on the left bank in the Rajasthan and Gujarat respectively (Rao, 1975).

The other major tributaries of Mahi River are Bageri and Pumpavati in Madhya Pradesh and Bhadar, Karad as well as Goma in Gujarat. The Mini River is a minor tributary of the Mahi. It originates near village Nani Bhedol of the Savli taluka of the Vadodara district. It flows through Savli and Vadodara talukas. After traversing the course of 50 km, it merges in Mahi near the village Sindhrot of the Vadodara taluka (Government of Gujarat, 1979).

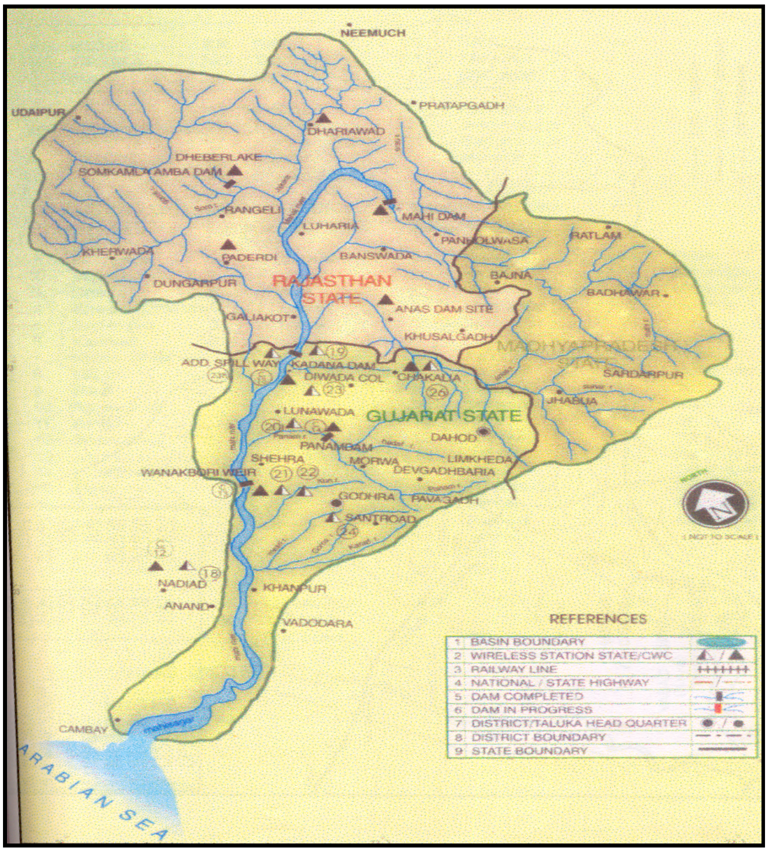


Figure 3.3 Plan Showing the Rivers of Mahi Basin
Source: Narmada Water Resources and Water Supply Department, (1999).

3.2.2.1 Mini River

The Mini River is a minor tributary of the river Mahi. It originates at a distance of about 30 km North- East of Vadodara district. Its course of 50 km is almost parallel to that of the Mahi River and flows towards West before it joins the Mahi River between the villages of Jaspur and Sindhrot at a distance of about 9 km towards North-West of Padra and 15 km downstream from Vasad. Sindhrot village is 1 km upstream of the confluence of Mini with Mahi near Jaspur and Dabka. The mini river crosses the National Highway and the Railway line to Ahmedabad at a distance of about 16 km North of Vadodara. This river remains dry almost all throughout the year except during the monsoon and is not of much use to the local people (NEERI and NIO, 1975).

Prior to the commissioning of effluent channel (1983) many industries around Vadodara used to release their waste waters (effluents) in the Mini rivulet and converted river Mini into an open uncontrolled gutter which can pollute surface as well as sub- surface water of river Mahi. The Mini River meets the Mahi River in the fresh water zone at Jaspur. The major findings of the field investigation during 1973-74 in the Mahi River stretch between Vasad and Gangua by NIO is that the river stretch between Jaspur and Mahammadpura was severely polluted during dry season as the sea water crossed the sill at Mahammadpura only occasionally (NIO, 2005). It was therefore planned to collect the effluent from different industries and transport through a channel to a site downstream of Mahammadpura for effective flushing to the Gulf of Khambhat. So after commissioning of the 56 km long effluent channel by the ECPL in 1983, the fresh water zone of the Mahi River was free from the polluted load (NIO, 2005).

3.2.3 Water Resources Projects on River Mahi

There are three projects on river Mahi, out of which the Mahi Bajajsagar dam is in Rajasthan state and the Kadana dam and Wanakbori weir are in Gujarat State. Mahi Bajajsagar dam is located in Banswara district in southern part of Rajasthan bordering the States of Madhya Pradesh and Gujarat. Major part of catchment and submergence is in the Madhya Pradesh state. Its gross storage capacity is 2067.17 MCM. Kadana dam (Mahi stage- II) is constructed 3 km upstream of Kadana village of Kadana taluka in Panchmahal district in Gujarat state, which is moderating the flood in Mahi River. The Kadana dam provides irrigation, generates hydropower and acts as flood protective reservoir. Its catchment area is 25520 sq. km and gross storage capacity is 1249.26 MCM. Wanakbori weir (Mahi stage-I) is a pick up weir across river Mahi near Wanakbori village of Balasinor taluka in Kheda district. Its catchment area is 30665 sq. km and gross storage capacity is 67.372 MCM.

3.2.3.1 Mahi Right Bank Canal Project

The Mahi Kadana Irrigation Project has been developed in two stages. The first stage comprised the construction of a diversion weir across the river Mahi near village Wanakbori in Balasinor taluka of district Kheda in Gujarat state. The weir was completed in the year 1958. It facilitated the diversion of the river flow to the canal system with negligible storage in the upstream of the weir.

The second stage of irrigation development comprised the construction of a major reservoir near Diwada colony 3 km upstream of Kadana in Kadana taluka of Panchmahals district of Gujarat. It is located 70 km upstream of Wanakbori weir. The Kadana reservoir, known as Mahi stage-II, was constructed in the year 1979 with the primary objective of augmenting the supply of water to the Mahi Right Bank Canal Command area. While the Wanakbori weir system was built primarily to provide supplemental irrigation for monsoon crop, the Kadana reservoir system was designed to store and supply irrigation water for the winter and summer crops in the same areas served by the Wanakbori weir system. After the completion of the Kadana reservoir, assured water supply has been made available in the MRBC command area and an irrigation potential of 2, 63,000 ha has been created.

The water from the Kadana reservoir is released into the Mahi river and is carried downstream to the Wanakbori weir. The natural course of the river itself is used for the conveyance of the releases.

3.2.3.2 Mahi Right Bank Canal Command Area

The MRBC irrigation project is one of the major irrigation projects of Gujarat State, in western central India provides irrigation waters in two stages through Kadana Reservoir and Wanakbori weir. The head works of the system comprise the Kadana reservoir and the Wanakbori weir, both of which are located on the river Mahi. The MRBC Command is bounded by rivers Shedhi and Watrak (Tributaries of Sabarmati) in North, Sabarmati

River in North-West and West, whereas Mahi river provides southern and eastern boundaries of the command area. The plan to harness Mahi river to irrigate the lands bounded by Mahi and Sabarmati rivers in Anand and Kheda district was first conceived after the devastating famine of 1900-1901.The command area served by MRBC, covers eleven talukas namely, Anand, Umreth, Anklav, Borsad, Petlad, Khambhat (Cambay), Sojitra, Tarapur of Anand district and Thasara, Matar and Nadiad of Kheda districts.

The irrigation command area of MRBC lies between the North latitudes 22°26’ and 22° 55’ and East longitudes 72° 49’ and 73° 23’ (CSSRI, 1993). With the help of its nearly about 2362 kms canal networks, provides irrigation water in the gross command of 3, 15,790 ha and culturable command area 2, 12,694 ha in Anand district and major part of Kheda district of Gujarat State. The water distribution system of MRBC project comprises of main canal of design discharge capacity of 198.10 cumecs and having a length of 73.6 km. Due to additional requirement of irrigation and non agriculture purpose (water supply scheme for Saurashtra area and Ahmedabad Municipal Corporation).

3.2.3.3 Radial Collector Wells

There are thirteen Radial collector wells and one intake well upstream of Mahi Weir site permitted to draw 5.2 cumecs water. Government of Gujarat has guaranteed Vadodara Mahanagar Seva Sadan and industrial companies like Gujarat Refinery (Indian Oil Corporation), Indian Petrochemicals Corporation Ltd., Gujarat State Fertilizer Corporation to maintain a flow of 5.2 cumecs at NH-8 Bridge at Vasad 11.5 km upstream of Mahi weir site. Any deficit in river flow is to be met by releasing flow from Panam dam. For drinking water supply and industrial requirements, these thirteen Radial Collector wells in river Mahi U/S and D/S of NH-8 bridge at Vasad constructed by VMSS and big industries. There is also one Intake well of Nirma located near Bhadarva. The locations of collector wells in Mahi River are shown in figure 3.4 and also given in table 3.1.

All Radial Collector Wells draw ground water from below river bed being recharged by river flow, as ground water source does not need filtration plant. The average discharge drawn by all RCW’s has not exceeded 5.2 cumecs. Even though Government of Gujarat has guaranteed to release water from Panam dam to maintain base flow of 5.2 cumecs at Vasad, there has hardly been any need to release water from Panam dam till now, as river base flow and incidental leakage and flow from Wanakbori weir maintains sufficient flow to 13 RCW's even in driest months of March to June (Multimedia Consulting Engineers, 1997).

Table 3.1 Locations of Radial Collector Wells in River Mahi

Sr.	Owner of Well	Village	Distance from Umeta Bridge (m)
1	GACL/GIPCL	Kahanwadi	7000
2	Gujarat Refinery (IOCL) B	Fajalpur	10200
3	Gujarat Refinery (IOCL) A	Fajalpur	10550
4	Gujarat Refinery (IOCL) C	Fajalpur	11000
5	Vadodara Municipal Corporation-1	Fajalpur	12000
6	Gujarat Refinery (IOCL) D	Raika	13500
7	Vadodara Municipal Corporation-3	Raika	14500
8	Vadodara Municipal Corporation-4	Dodka	15500
9	Vadodara Municipal Corporation-2	Poicha	15700
10	IPCL –I	Khandi	16750
11	IPCL –II	Jalampura	18070
12	GSFC – I	Jalampura	19650
13	GSFC – II	Parthampura	20765
14	Nirma (Intake Well)	Bhadarva	24500

Source: Shah, (2000).

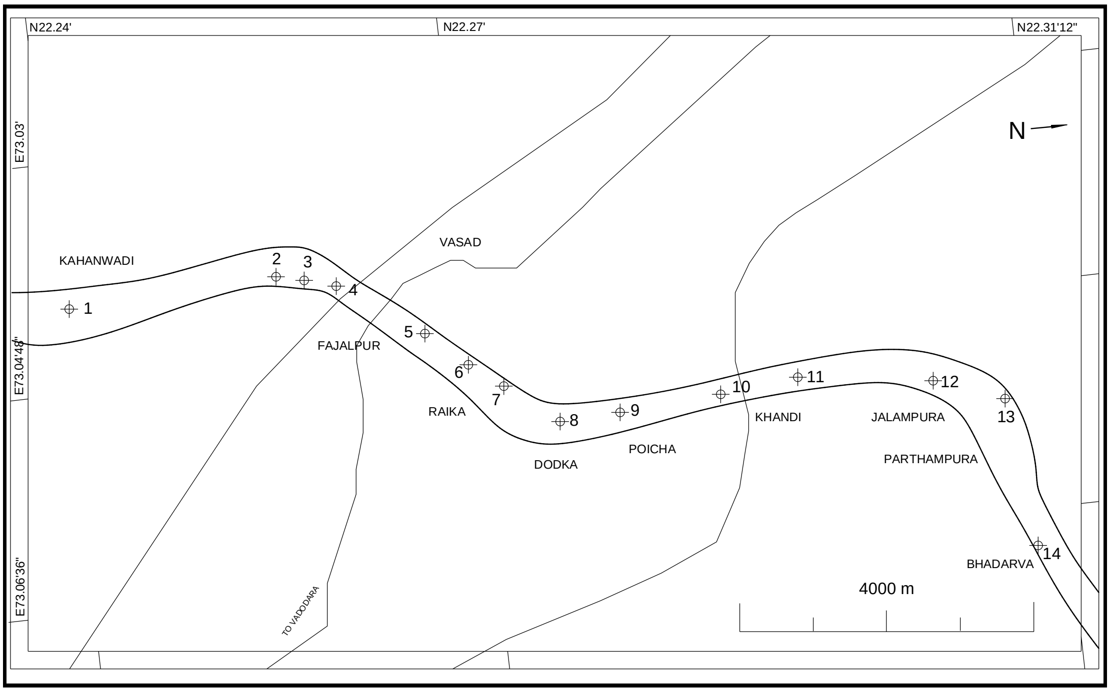


Figure 3.4 Map of Mahi River with Locations of Collector Wells
Source: Shah, (2000).

3.2.3.4 Mahi Tidal Regulator cum Recharge Scheme

Mahi tidal regulator cum recharge scheme envisages Sindhrot- Umeta of Vadodara district. The main purpose of the scheme is to prevent surface salinity ingress as well as to recharge the surrounding land. Three alternative sites were suggested. After further sub soil investigation by Gujarat Engineering Research Institute, Vadodara for the weir location was finalized at 1350 m downstream of Umeta Bridge. The Vadodara Irrigation Circle constructed a 540 m long weir on Mahi River near Sindhrot - Umeta. As a result of construction of this Weir, reservoir of fresh water is created on upstream side and automatically artificial recharge is done. The sea water intrusion to land ward side will be decreased because of this.

The weir structure would be resting on permeable foundation; therefore, pore pressure distribution beneath the structure has been determined using Khosla’s theory. Based on this, the upstream cut off has been provided up to RL (+) 1.00 m in form of 1.0 m thick RCC key, as a monolith with the U/S concrete floor. Lesser concentration of discharge is considered as the weir is located on straight reach and without any feature like silt excluder or pier etc. On the downstream 0.6 m thick M-20 grade RCC diaphragm has been provided as cut-off.

3.2.4 Water Resources Projects on Tributaries of River Mahi

Anas dam site (on upper catchment) situated in Rajasthan State on Anas River, which is a tributary of Mahi River. Panam irrigation scheme is a medium irrigation scheme. Panam dam is situated in Gujarat State on Panam River (a tributary of Mahi River meeting on the downstream of Kadana dam) near village Kel-Dezar on the border of Lunawada and Santrampur taluka of Panchmahal district. Panam reservoir on this river also helps in moderating the floods in Mahi River. Area of catchment is 2314 sq. km Panam irrigation scheme is a medium irrigation scheme. The dam impounds gross storage of 735.8 MCM of water, which irrigates 41116 ha of land through left bank main canal having length 99.725 km in Santrampur, Lunawada, Shehera, Godhra and Kalol taluka of Panchmahal district and Savli taluka of Vadodara district.

3.3 Mahi Estuary

Mahi estuary is well-mixed estuary as there is gentle salinity gradient or homogeneous i.e. small salinity difference during the flood and ebb cycle. The estuary was vertically well-mixed. The advective river flow was appreciable during monsoon and for a few months thereafter subject to release of water from the Wanakbori weir upstream of Vasad. The stretch between Jaspur and Dabka remained nearly stagnant in the dry season. In an estuarine habitate salinity provides information on the intrusion of sea water which varies with the tidal stage and riverine flow. Normally sea water salinity is 35.5 ppt which may vary depending on competition between evaporation and precipitation and fresh water addition. The estuary experienced high river runoff during July-October effecting excellent annual flushing. The fresh water flow in the estuary decreased considerably with the withdrawal of monsoon and the estuary was sea water dominated after October (NIO, 2005).

The Mahi River is a tidal river. Mahi estuary joins the Arabian Sea at the northern part of the Gulf of Khambhat. The estuary is strongly influenced by the hydro dynamics of the Gulf of Khambhat. The mouth of estuary was considered at Gangua (Patel, 1983). The limit for the daily tidal zone of Mahi estuary is up to the horse shoe bend downstream of Mahammadpura, 50 km upstream from the mouth where a rocky sill on the river bed is formed by the deposition of silt carried by the river and tidal waters. Sea water intrusion normally occurred up to Mahammadpura. The sill near Mahammadpura acts as a barrier between tidal flow and river discharge during the dry season. Thus, on downstream of Mahammadpura the estuary is practically dominated by the tides while on upstream of Mahammadpura the influence is mainly of riverine flow. Further intrusion of sea water was obstructed by the sill at Mahammadpura. The tides were observed to cross the sill only during the high spring tides in summer and influenced the river segment up to Vasad on such occasions, the salinity of water increases and chloride concentration as high as 600-1000 mg/l has been reported at Vasad. The industries are, therefore, required to suspend operation on these days (NEERI and NIO, 1975). The fresh water regime of the river is limited to a few kilometers distance downstream below Vasad. Beyond this limit the water remains brackish throughout the dry weather conditions. The water is not suitable for drinking or agriculture.

3.3.1 Tidal Range in Mahi Estuary

The Gulf of Khambhat experiences semi-diurnal tides of high amplitude up to 10 m. Tidal bores are formed at the head due to typical ‘v’ shape of the Gulf of Khambhat. The Mahi estuary exhibited certain unique hydrographic features. The tidal range was less than 0.3 m at low tide periods and up to 6 m at high tide periods. The period between ebbing tide and flooding tide (called low slack period) was substantial in this estuary at and near point ‘J’ the two slack periods amounted to about 12 hours in a day. The Mahi experiences a semi-diurnal tide. i. e. high waters occur daily twice at intervals averaging 12 to 12.4 hours. The low slack period is about 6 hours and the water continues to ebb through the tidal channels between point ‘J’ and Shiv Mandir. The tidal range during neap and spring tides has been given in Table 3.2

Table 3.2 Tidal Range and High Water Level

Tide	Kavi Range	Shiv Mandir Range	Shiv Mandir HWL	Point 'J' Range	Point 'J' HWL	Sarod Range
	m.	m.	m.	m.	m.	m.
Spring tide	8.5	6.8	8.0	5.9	6.9	4.5
Neap tide	3.7	2.4	3.6	1.8	2.8	Nil

The tidal range at Gangua 3 days after the spring tide was 6.8 m (Source: NEERI And NIO, 1975).

3.4 DETAILS OF STUDY AREA

The more details of study area are described as follows.

3.4.1 Topography of Study Area

The overall topography of the area is more or less plain, except river courses where the topography is undulating. In general, the Mahi Right Bank canal command area is sloping south-west, towards the Gulf of Khambhat (Cambay). The land slopes from north-east to South-West with an average gradient of about 1 to 1600. The South-West region of the MRBC command area comprises a relatively flat land locally referred to as Bhal area (Water Technology Centre, IARI, 1983). The area between Narmada and Mahi covered by Jambusar, Padra and Vadodara talukas forms a part of the Vadodara-Bharuch plains. The area between Mahi and Sabarmati covered by Khambhat, Borsad and Petlad talukas forms a part of the Charotar plain. It is located on the lower reaches of canal irrigation system of the MRBC. The ground elevation of major part of the area is below 30 m above mean Sea level (GEC, 1997). The alluvial plain is a product of the age long processes of erosion and deposition carried out by the major rivers of southern and Central Gujarat flowing westwards to the Gulf of Khambhat (Cambay) (GOG, 1961).

3.4.2 Climate of Study Area

The study area in general experiences a semi arid (moist) to sub-humid climate. Aridity indicates status of climate in relation to moisture conditions. The climate of this area is characterized by a hot summer and general dryness, except during the south-west monsoon season which experiences heavy rain (GOG, 1979). The year may be divided into four seasons in the area. The cold season is from December to February. This is followed by the hot summer season from March to the middle of June. The period from mid-June to September is the South-West monsoon season where July is the rainiest month. October and November constitute the post-monsoon season characterized by moderate temperature and scanty rain (Water Technology Centre, IARI, 1983).

3.4.3 Temperature of Study Area

It may be seen that the period from March to May is one of continuous increase in temperatures. May is generally the hottest month, the mean daily maximum temperature being about 41°C and mean daily minimum temperature about 26°C. The weather is intensely hot in summer and during the same period the day temperature occasionally reaches 47°C or more. With the onset of monsoon in the area, there is an appreciable drop in the day temperature but nights are as warm as during the summer. With the withdrawal of the monsoon from the area by about the end of September, there is a slight increase in day temperature and a secondary maximum of day temperature is reached during October. However, the night temperature decreases after the withdrawals of the monsoon. After mid-November both day and night temperatures decrease rapidly till January which is the coldest month. The mean daily maximum temperature in January is about 30.1°C and the mean daily minimum is about 10.6°C. The area is sometimes affected by cold waves in association with western disturbances passing across north India and the minimum temperature may reach the freezing point of water. The highest maximum temperature recorded at Vadodara was 46.7°C on 20th May, 1955. The lowest minimum temperature recorded was 1.1°C on 15th January, 1935. Average temperature during winter and monsoon is 30°C and during summer is 43°C (GOG, 1979 and Water Technology Centre, IARI, 1983).

3.4.4 Humidity

During the South-West monsoon season the humidity is high, generally exceeding 70 percent. In the rest of the year the air is dry. Humidity decreases during the post monsoon months. The driest part of the year is the period from February to April with relative humidity’s less than 30 percent mainly in the afternoons. Relative humidity is maximum in the early morning and minimum in the afternoon. Humidity in the morning varies from about 60 % in the winter months to about 85 to 90 % during the monsoon months. On individual days in the monsoon months it may be even 100 %. In the afternoon it varies from 20 to 25 % in the months November to March and is about 70 % in July and August. It is lowest in the winter months (GOG, 1961; GOG, 1979 and Water Technology Centre, IARI, 1983).

3.4.5 Cloudiness

During the South-West monsoon season, the Skies are generally heavily clouded or overcast. Cloudiness rapidly decreases in the post-monsoon season. Skies are mostly clear or lightly clouded during the period December to May (GOG, 1979).

3.4.6 Winds

Winds are generally light during most of the months in the year, ranging from 2.6 km p. h. to 9.8 km p. h. However, the summer months experience comparatively strong winds. Winds blow mostly from the South-Westerly and Westerly directions during the period from May to September. Winds blow from the North or North-East during the post-monsoon and early winter months. In the latter half of the cold season and the first two months of summer winds are mostly from directions between South-West and North-West (GOG, 1979 and Water Technology Centre, IARI, 1983).

3.4.7 Rainfall

About 90 to 96 percent of the normal annual rainfall in the study area is received during the South-West monsoon months mid of June to mid of September, July being the rainiest month. Most of rainfall during the monsoon season is generally associated with movement West or North- West wards towards Gujarat of the depressions from the North Bay of Bengal. There is no regular rainfall during monsoon months. Winter rains are not significant and seldom exceed 50mm. The variation in the annual rainfall from year to year is large. The range of annual rainfall is found to be 661 to 1009 mm for districts of Anand, Vadodara and Bharuch. The range of rainy days is found to be 45-31 days in a year in the area. The heaviest rainfall in 24 hours recorded at any station in the Vadodara district was 460.3 mm at Vadodara on 24th September, 1945. The annual rainfall in the study area shows wide variation in its spatial distribution. The average and extreme values for rainfall and rainy days have increased in recent years. It indicates the increasing trend of erratic character of rainfall in recent years (GOG, 1979; GOG, 1961 and GEC, 1997).

3.4.8 Special Weather Phenomena in Study Area

A special weather phenomenon experienced is the occurrence of occasional cyclonic storm originating from the Arabian Sea in the late summer season, and in the post-monsoon season, which may affect the weather over the area causing heavy rain (Water Technology Centre, IARI, 1983 and GOG, 1979).

3.4.9 Geology

The area around Gulf of Khambhat is covered by the alluvial deposits of Quaternary period (1.5 million years). During Quaternary, the sea level has fluctuated in the range of about plus 50 m to minus 150 m with reference to present level. Majority of the present sediments of this area around Gulf of Khambhat comprising raised mud flats and stabilized coastal and inland ridges represent the last marine transgression when the Sea had risen up to about 10 m around six thousand years ago and which is now regressed to the present level (GEC, 1997).

The present study area is a part of Cambay basin and consists of recent to sub-recent thick alluvial deposits of ‘aeolian’, ‘fluviatile’, and ‘estuarine’ which range in geological time scale from Holocene to Pleistocene. These alluvial deposits consisting of river laid and windblown sands and clays, overlying older sediments consisting of blue shales and sandstones of Tertiary age. The alluvial deposits overly the Deccan trap basements.

Alluvial deposits are mainly consisting of alternate layers of silt, clay, sand, gravel, pebbles and kankars in various proportions. The clay beds are generally yellowish in colour. Such strata are suitable for artificial recharge of groundwater. The blue clay formation is a marker horizon for tertiaries formation which is noticed at a depth varying from 65 to 130 m below ground level at the villages: Mokshi, Kunpad, Natwarnagar, Rania, Jalampur (taluka Savli), Fajalpur, Dashrath, Nandesari, Angadh (taluka Vadodara), Kanwadi, Bhanpura, Amrol (taluka Borsad), etc. The sand layers are yellowish to dark brown in colour and consisting of fine to coarse grained particles mainly of quartz. The lateral and vertical extents of clay and sand layers are non-uniform, which in general, is the characteristic feature of estuarine alluvial deposits. As compared to sand layers (beds), the clay layers are thin and oriented almost horizontally. The clay layers (beds) are found to be varying in its thickness and thin in the North East part (upstream) but in south-west part (downstream) of study area, its thickness increasing as much as 20m. The thickness of sand and clay layers is non-uniform.

Based on the study of the data of exploratory tube well drilled earlier by CGWB and others, it is reveled that the maximum alluvium thickness is about 300m below ground level. Within this depth there are about 12 distinguishing layers consisting of sand and clay (GOG, 1979, GWRDC, 1987, Yagnik et al. 2003).

3.4.10 Soils in the Study Area

The soils of the study area are formed through alluvial deposits carried by rivers. The Vadodara taluka is mainly covered by black cotton soil, except a small area along river Mahi in N-W parts, where soils are predominantly sandy type. The soils are generally dark brown to black in colour as the name black cotton soil indicates. However in some parts sandy soils are yellowish to brownish yellow in colour. Soils in the Anand, Borsad, Anklav and Petlad talukas are ranging from sandy loam to clay. The type of the soil is deep black coastal alluvium in Bharuch district and medium black in Vadodara and Anand districts. These soils lie on a comparatively higher elevation and are inherently porous and permeable.

The area is predominantly derived from rocks like phyllites, schists and quartzites. The phyllites and schists give rise to medium to heavy soils, varying from sandy loam to clay, where as the quartzites from the coarse material in the flood plains giving rise to loamy sand to sandy loam soils. Soils are of recent and sub-recent origin. During the process of alluvial formation, the coarse and heavy material are deposited near the source whereas the fine materials are carried away towards the Gulf of Cambay and form the clay soil deposits in the flat region near the Coastal-estuaries(GWRDC, 98-99 and Water Technology Centre, IARI, 1983).

The soil map of study area from Gujarat soil map by National Bureau of soil survey and land use planning (ICAR) Nagpur is shown in the figure 3.5. The brief description highlighting soil depth, texture, drainage, slope, erosion, salinity etc. of the dominant and associated subdominant mapped soils are given in Legend. Legend also provides taxonomy of soils as per USDA system of classification for national and international understanding.

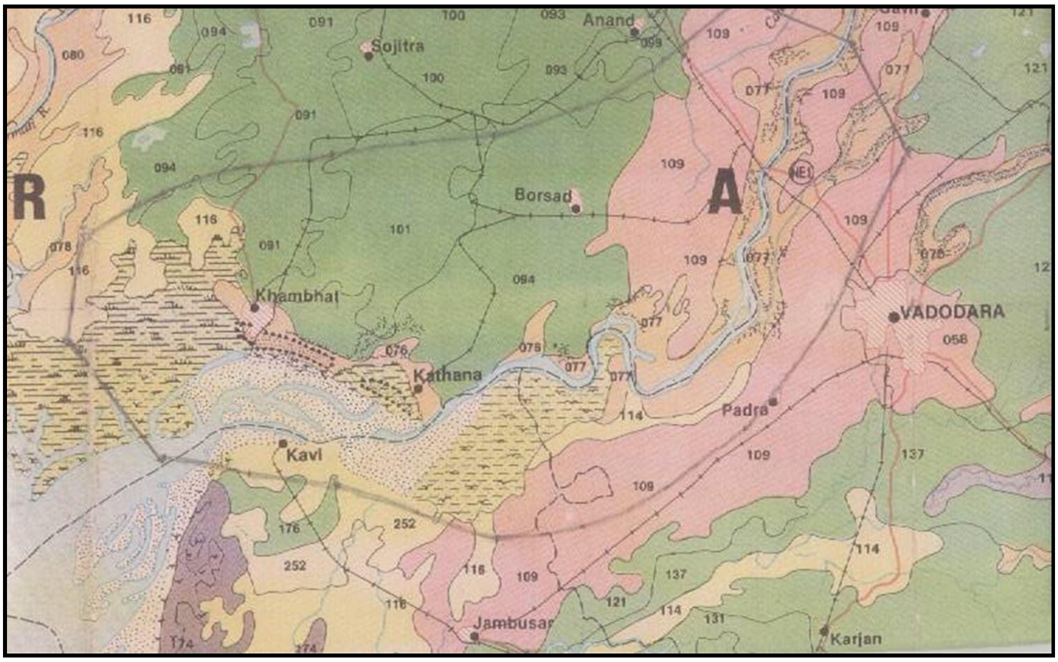


Figure 3.5 Soil Map of Study Area from Gujarat Soil Map by National Bureau of Soil Survey and Land Use Planning (ICAR) Nagpur

Table 3.3 Legend (Soil Map of Study Area)

Sr. No.	Identity color / Mapping symbol	Description	Taxonomy
Soils of Alluvial Plains			
1	- 076	SOILS OF ALLUVIAL PLAINS. This deep, 'drained, calcareous, coarse-loamy soils on very gently sloping dissected flood plain with moderate erosion and	o Coarse-loamy, mixed (calcareous), hyper-thermic Typic ustifluvents. o Fine-loamy, mixed (calcareous),

		strong salinity; associated with very deep well drained, calcareous, fine-loamy soils with slight erosion and moderate salinity.	hyper-thermic Fluventic usto-chrepts.
2	- 077	Very deep, well drained, calcareous coarse-loamy soils on very gently sloping dissected flood plain with very severe erosion; associated with very deep, well drained, calcareous, fine-loamy soils with severe erosion.	o Coarse-loamy mixed (calcareous), hyper-thermic Typic ustifluvents. o Fine-loamy, mixed (calcareous), hyper-thermic Fluventic ustochrepts.
3	- 091	Deep, well drained, calcareous, fine-loamy soils on very gently sloping alluvial plain with slight sloping alluvial plain with slight erosion and moderate salinity; associated with deep moderately well drained, calcareous, fine soils with slight erosion.	o Fine-loamy, mixed (calcareous), hyper-thermic Typic ustochrepts. o Fine, mixed (calcareous), hyper-thermic Typic ustochrepts
4	- 093	Deep, well drained, fine-loamy soils on very gently sloping alluvial plain with slight erosion; associated with deep, somewhat excessively drained, coarse-loamy soil with slight erosion.	o Fine-loamy, mixed, hyper-thermic Typic ustochrepts o Coarse-loamy mixed, hyper-thermic Typic ustifluvents
5	-094	Deep, well drained, fine-loamy soils on very gently sloping alluvial plain with slight erosion and moderate salinity associated with deep, somewhat excessively drained, coarse-loamy soil with slight erosion and slight salinity.	o Fine-loamy, mixed, hyper-thermic Typic ustochrepts o Coarse-loamy mixed, hyper-thermic Typic ustifluvents

6	- 099	Deep, well drained, fine-loamy soils on very gently sloping alluvial plain with slight erosion; associated with deep, moderately well drained, calcareous, fine soils on gently sloping lands with moderate erosion.	o Fine-loamy, mixed, hyper-thermic Typic ustochrepts o Fine, modntmorillonitic (calcareous), hyperthermic vertic ustocharepts
7	-101	Deep, well drained, fine-loamy soils on very gently sloping alluvial plain with slight erosion and moderate salinity associated with deep, moderately well drained, calcareous, fine soils on gently sloping lands with moderate erosion.	o Fine-loamy, mixed, hyper-thermic Typic ustochrepts o Fine, modntmorillonitic (calcareous), hyperthermic vertic ustocharepts
8	- 109	Very deep, well drained, fine-loamy soils on very gently sloping alluvial plain with slight erosion; associated with very deep, well drained, fine soils on nearly level lands with slight erosion.	o Fine-loamy, mixed, hyperthermic Fluventic ustochrepts o Fine, mixed, hyperthremic Fluventic ustochrepts
9	-114	Moderately deep, well drained, calcareous, fine soils on nearly level alluvial plain with slight erosion and slight salinity; associated with deep, moderately well drained, calcareous, fine soils with slight erosion.	o Fine, montmorillonitic (calcareous), hyperthermic Veric Ustochrepts o Fine, montmorillonitic (calcarious), hyperthermic Typic chromusterts
10	- 116	Moderately deep, well drained, calcareous, fine soils on very gently sloping alluvial plain with slight erosion and moderate salinity; associated with	o Fine, montmorillonitic (calcareous), hyperthermic Veric Ustochrepts o Fine,

		deep, moderately well drained, calcareous, fine soils with moderate erosion.	montmorillonitic (calcarious), hyperthermic Typic chromusterts
Soils of Coastal Plains			
11	- 176	SOILS OF COASTAL PLAINS. Deep, moderately, well drained, calcareous, fine soils on nearly level costal plain with slight erosion and moderate salinity; associated with moderately shallow, moderately well drained, calcareous, fine soils with slight erosion and moderate salinity.	o Fine, montmorillonitic (calcarious), hyperthermic Typic chromusterts o Fine, montmorillonitic (calcareous), hyperthermic Veric Ustochrepts
Soils of Piedmont Plains			
12	- 252	Moderately shallow, well drained, calcareous, fine soils on very gently sloping piedmont plain (with narrow Vlleys) with slight erosion and slight salinity; associated with moderately shallow, well drained, calcareous, fine soils with slight erosion and slight salinity.	o Fine, montmorillonitic (calcareous), hyperthermic Veric Ustochrepts o Fine, montmorillonitic (calcarious), hyperthermic Typic chromusterts

3.4.11 Vadodara Branch Canal

Vadodara branch canal having length of 115.09 km and design discharge of 76.04 cumecs at head and 2.142 cumecs at tail is one of the major branch canal off taking at Chainage 81.834 km of Narmada main canal near village Rameshara, district Vadodara runs Whaghodia, Vadodara , Savli, Padra and Jambusar talukas and caters C.C.A. of 80228 ha. in Vadodara district.

3.4.12 Effluent Channel Project, Vadodara (ECP)

Vadodara the second largest city in the State of Gujarat is one of the forcal points for industrial growth in Western India. The industrial complex near Vadodara comprises of many large and medium industrial units, most of these industries and even a part of Vadodara city draw their fresh water supply from the Mahi River through French type infiltration wells. Further prior to the commissioning of the effluent channel all the large industries and many other chemical industries round about, discharge their effluent in river Mini, a tributary of river Mahi that meets the Mahi river at Jaspur in the fresh water zone.

It was felt that with further industrialization of the region, the sweet water resources of river Mahi would be completely polluted and there would be a serious, threat to the environment of Vadodara city and villages depending upon river Mahi for their fresh water requirement. In order to protect these fresh water requirements, it was necessary to prevent the discharge of industrial effluents into the river. To achieve this objective, the State government decided a project to intercept the industrial effluents from industries in this area and arrange for efficient transportation of the same to a distinct safe disposal point into the Sea on Gulf of Cambay. Thus GIDC earned the distinction of providing India's first effluent disposal channel on co-operative basis (Mitun, 2003)

The Effluent Channel Project (ECP) is a pioneering project in India for providing effluent disposal facility through effluent channel. The common Effluent Disposal Channel in Gujarat is managed by ECPL.

Effluent Channel Project Limited (ECPL), Vadodara has constructed a 55.3 km long channel for conveying treated effluent from 31 large and medium scale industries and about 270 small scale industries in clusters at Nandesari and Umraya comprising Indian Petrochemical Corporation Limited (IPCL), Indian Oil Corporation Limited (IOCL) or Gujarat Refinery, Gujarat State Fertilizer Corporation (GSFC), Gujarat Alkali and Chemicals Limited (GACL), etc. in 1980. The purpose of the channel was to carry treated combined effluents for release in the Mahi estuary thereby protecting fresh waters of Mahi River from industrial pollution.

Based on detailed ecological and hydrographic studies in the Mahi estuary in 1973-74 conducted jointly by the National Institute of Oceanography (NIO) and the National Environmental Engineering Research Institute (NEERI), the J point near the Sarod village of taluka Jambusar, district Bharuch was selected by a committee comprising of the representatives from the Gujarat Pollution Control Board (GPCB), Government of Gujarat (GOG), NIO and NEERI. The gravity flow effluent channel was commissioned in 1983 originating from Dhanora and Terminating at J-point near Sarod village, where treated effluent is discharged in estuarine region of Mahi through diffuser out fall arrangement. Based on the study by NIO, six hours tidal cycle was established. To match the cycle, two lagoons of 4 MGD capacity were constructed at the disposal point to hold the effluent during high tide and discharge the effluent during low tide to achieve efficient dispersion.

The channel is constructed in the form of 'U' shape brick masonry conduit covered with RCC slab. The channel is designed to carry an average discharge of 145 MLD (32 MGD) and peak discharge of 218 MLD (48 MGD) taking peak factor as 1.5. Capacity of channel including free board is 65 MGD. Depth of flow is 1.65 m at a peak discharge of 48 MGD. The conveyance of effluent is by gravity only with a bed gradient of 1 in 3000 (NIO, 2005). The channel is provided with 139 cross drainage works to ensure free passage of natural waterways. Number of falls provided is 6. The channel passes through land admeasuring 15 m width, which is in possession of ECPL. The manholes and vent holes are also constructed on the channel. Though the channel capacity was designed for 32 MGD, the initial maximum discharge of 22 MGD was only flowing through the channel. This has however progressively reduced to10 MGD as a result of recycling and reuse practices followed by a majority of the industries contributing to the channel.

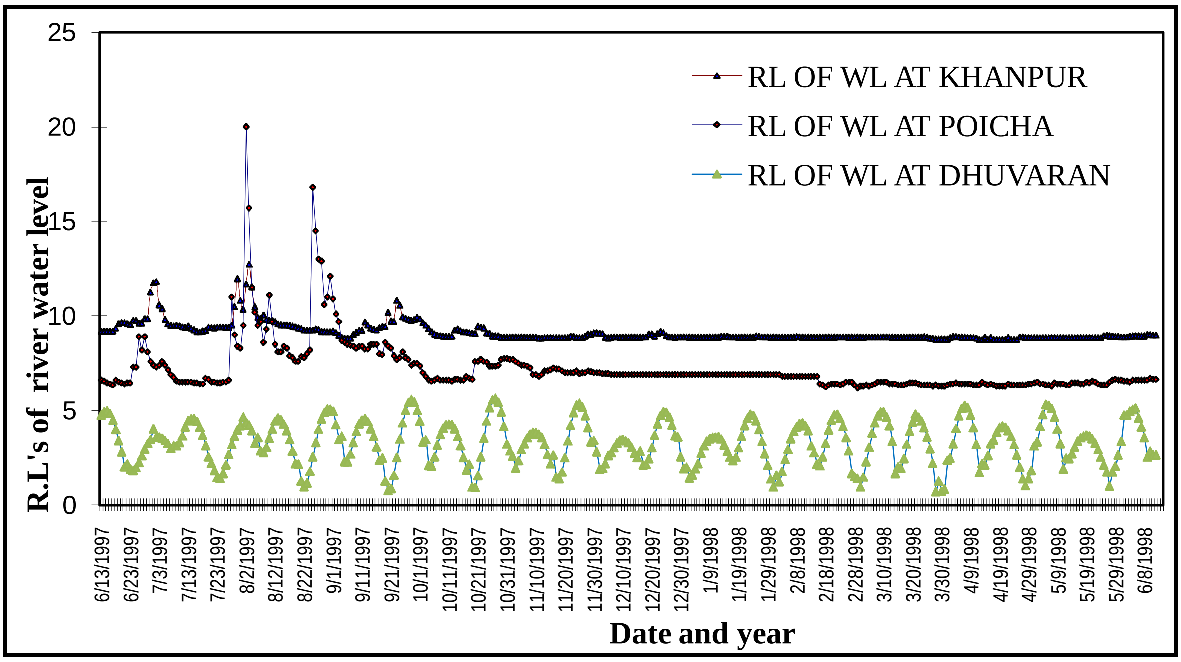
The channel presently passes through about 29 villages. Due to shortage of fresh water in the region through which the channel crosses the channel is being tampered by farmers enroute and utilize the channel effluent for irrigation purpose. This unauthorized indiscriminate use of partially treated effluent can cause adverse impact on the water, land and biological environment since the effluent does not conform to the discharge standards (NEERI, 2005).

4 DATA COLLECTION & METHODOLOGY

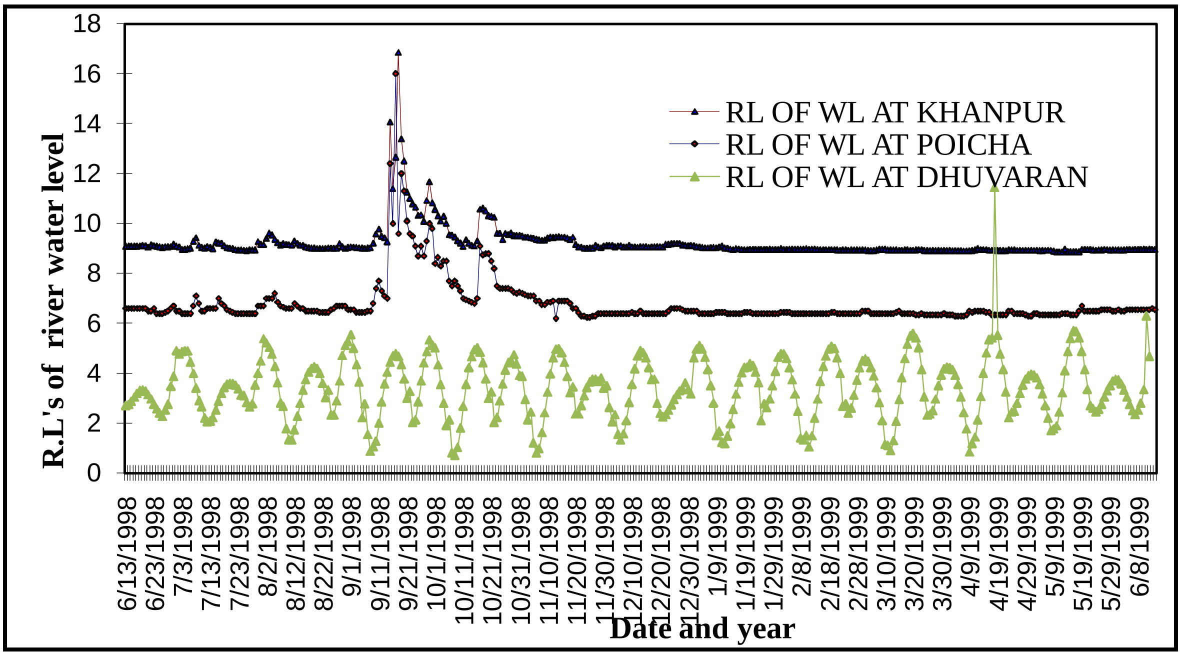
Data has been collected from Gujarat Water Resources Development Corporation Ltd. (GWRDC), Central Ground Water Board (CGWB), State Water Data Centre (SWDC), Vadodara Mahanagar Seva Sadan (VMSS), Central Water Commission (CWC), Water Resources Investigation Circle (WRIC), Vadodara Irrigation Circle (VIC), Mahi Irrigation Circle (MIC), Gujarat Engineering Research Institute (GERI), Sardar Sarovar Narmada Nigam Limited (SSNL) and Gujarat Electricity Corporation Ltd etc. are compiled and enlisted. The data to be used for model study as an input are prepared. In this chapter the model boundary is identified and construction of the model using GMS software is discussed.

4.1 RL’s of Mahi River Water Level

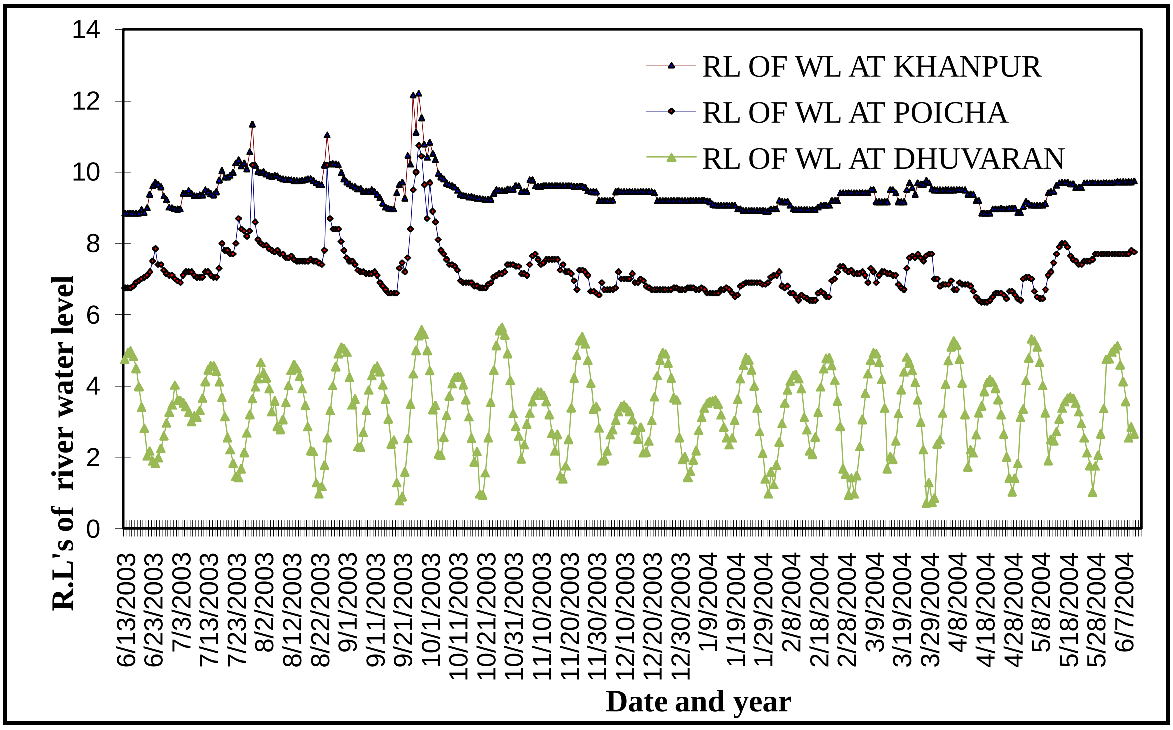
Daily RL’s of Mahi water levels are collected at three sites namely Khanpur, Poicha and Dhuvaran for the duration June 1997 to June 1999, June 2003 to June 2005 and June 2005 to June 2007. RL’s at Khanpur are collected from the Central Water Commission (CWC), Gandhinagar, RL’s at Poicha are collected from Vadodara Mahanagar Seva Sadan (VMSS), Vadodara and RL’s at Dhuvaran are collected from Gujarat Electricity Corporation Ltd. This data is presented in Annexure-I and graphically plotted viz. graphs 4.1 to 4.6.



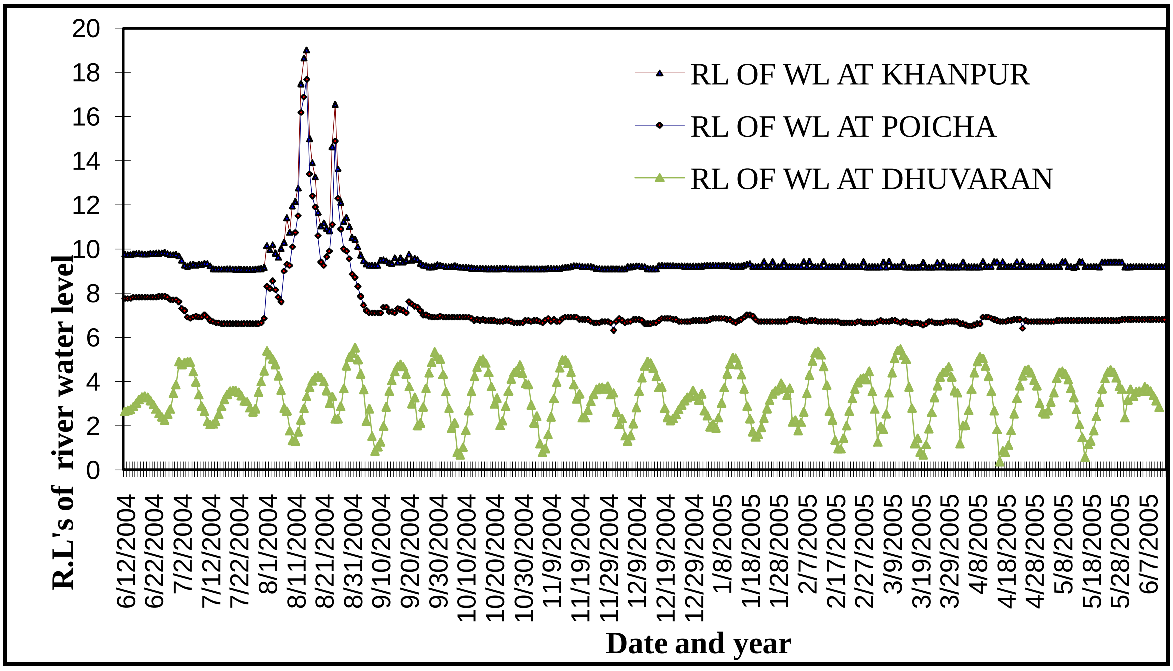
Graph 4.1 River Water Levels in m from m.s.l for Year June 1997 to June 1998



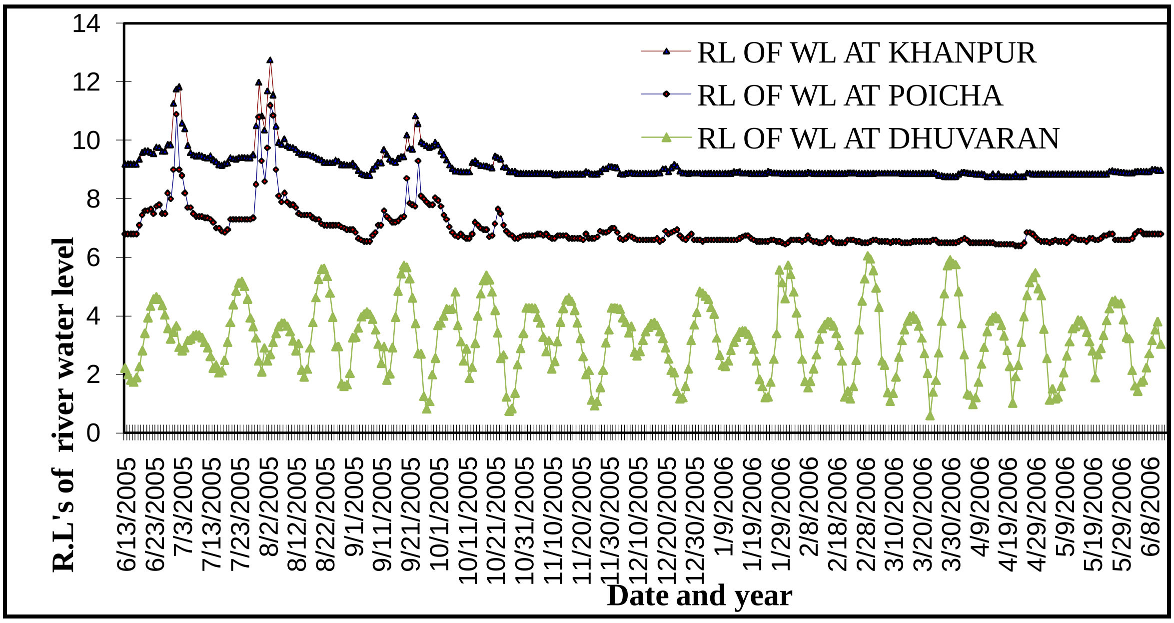
Graph 4.2 River Water Levels in m from m.s.l for Year June 1998 to June 1999



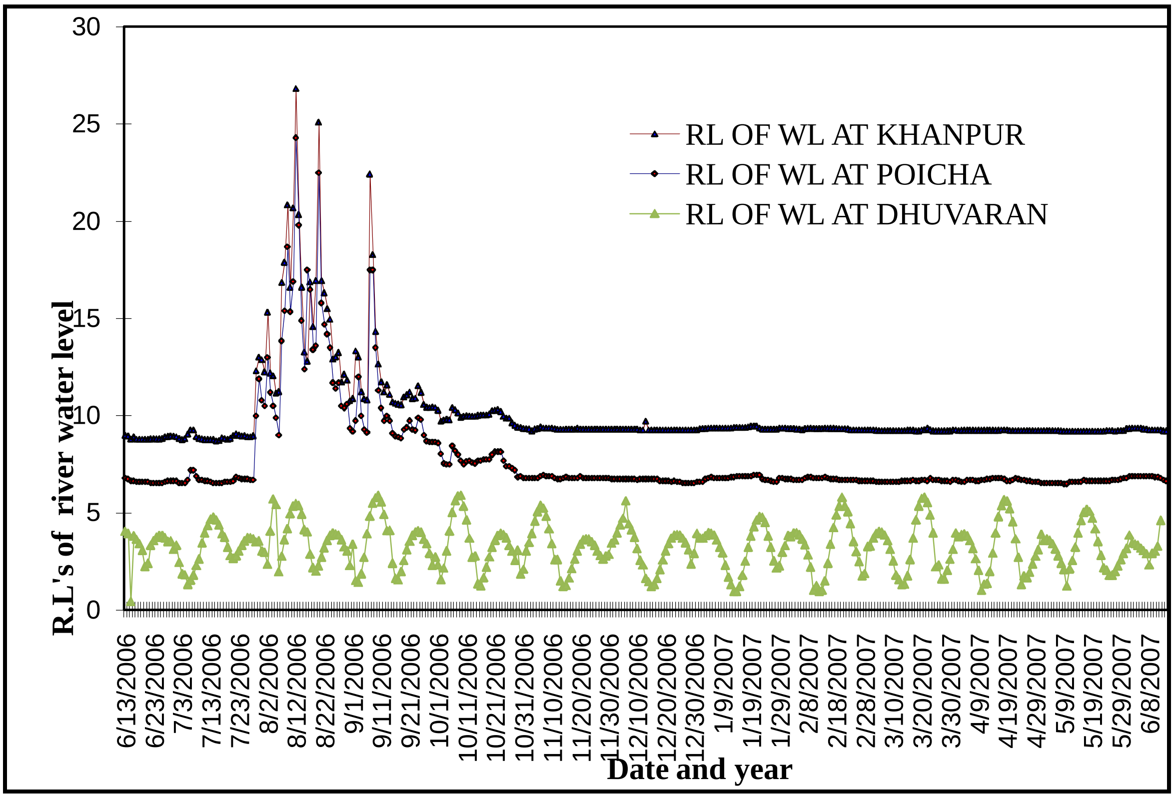
Graph 4.3 River Water Levels in m from m.s.l for Year June 2003 to June 2004



Graph 4.4 River Water Levels in m from m.s.l for Year June 2004 to June 2005



Graph 4.5 River Water Levels in m from m.s.l for Year June 2005 to June 2006



Graph 4.6 River water levels in m from m.s.l for year June 2006 to June 2007

4.2 RL's of Ground Level of Wells and River Bed

Reduced levels of ground levels of wells, piezometers, villages, river banks, river bed etc are collected from agencies like GWRDC, WRIC, VIC, CGWB and CWC. The river bed data have been completed by interpolating intermediate values in software surfer. These data have been contained in Annexure-II.

4.3 RL's of Bottom of Wells in Unconfined Aquifer

Contours of bottom of unconfined aquifer in Sardar Sarovar Command area (Source: Wallingford and Shah, (1994) "Data for Groundwater Model of Sardar Sarovar Command Area" Sponsored by Narmada Planning Group, Gandhinagar. Vol. III- Plates) have been transferred to base map of study area. They are used to work out RL's of bottom of wells by interpolation. They are presented in Annexure-III.

4.4 Horizontal Permeability 'HK' of Wells in an Unconfined Aquifer

Horizontal permeability of aquifer is estimated by superimposing figure of aquifer permeability zones of Sardar Sarovar Command area given in EX3183: Main Report, November 1995, Wallingford, by interpolation. They are represented in table 4.1

Table 4.1 Horizontal Permeability 'HK' of Wells

Zone Id	Taluka	Village	Well No.	X Latitude	Y Longitude	Hk m/day
552	Anand	Bedva	KR-08	298338.2188	2495240.50	50
553	Anand	Sarsa	KR-06	301609.5625	2494433.75	50
771	Anand	Vasad	KR-07	303395.9375	2488507.50	50
881	Savli	Anjesar	NCCA-14	311864.938	2486740.50	50
551	Borsad	Borsad	KR-19	283767.25	2479632.25	50
115	Petlad	Danteli	KR-70	268272.9	2482068.61	20
882	Savli	Manjusar	BD-48	313994.4063	2483237.25	50
661	Anklav	Anklav	KR-16	294427.55	2475901.85	50
114	Khambhat	Kanisha	KR-20	261564.14	2477128.29	10
772	Vadodara	Sokhda	BD-06	311648.4375	2480807.00	50
111	Khambhat	Gudel	KR-25	244895.8125	2478585.00	10
773	Vadodara	Dashrath	BD-05	309398.6563	2477047.00	50
112	Khambhat	Kansari	KR-23	256803.69	2471326.90	10
332	Borsad	Bhadran	KR-17	283689.9063	2474095.00	50
221	Khambhat	Bhuvel	KR-21	264060.8125	2468621.00	10
222	Khambhat	Haripura	KR-22	270508.31	2463701.40	20
662	Padra	Jaspur	NCCA-43	299932.24	2465442.61	50
334	Padra	Dabka	NCCA-44	289541.875	2461919.50	50
333	Borsad	Gajna	KR-18	283803.5625	2465232.25	50
113	Jambusar	Kavi	NCCA-48	256865.3	2456700.75	10
335	Padra	Karankuva	NCCA-45	291753.25	245608.25	50
331	Jambusar	Sarod	BR-14	280113.4375	2453554.00	20
441	Padra	Masar Road	BD-34	287036.875	2450600.50	50

4.5 Specific Yield 'S_y' of Wells in an Unconfined Aquifer

Specific yields have been approximated by critically studying aquifer characteristics of study area and various reference studies, reports and manuals on this area. This data is presented in table 4.2

Table-4.2 Specific Yield of Wells

Zone Id	Taluka	Village	Well no	X Latitude	Y Longitude	Specific Yield Sy (fraction)
112	Khambhat	Kansari	KR-23	256803.69	2471326.90	0.11
221	Khambhat	Bhuvel	KR-21	264060.8125	2468621.00	0.09
111	Khambhat	Gudel	KR-25	244895.8125	2478585.00	0.113
115	Petlad	Danteli	KR-70	268272.9	2482068.61	0.097
114	Khambhat	Kanisha	KR-20	261564.14	2477128.29	0.106
222	Khambhat	Haripura	KR-22	270508.31	2463701.40	0.10
551	Borsad	Borsad	KR-19	283767.25	2479632.25	0.097
332	Borsad	Bhadran	KR-17	283689.9063	2474095.00	0.068
333	Borsad	Gajna	KR-18	283803.5625	2465232.25	0.079
661	Anklav	Anklav	KR-16	294427.55	2475901.85	0.091
771	Anand	Vasad	KR-07	303395.9375	2488507.50	0.087
552	Anand	Bedva	KR-08	298338.2188	2495240.50	0.093
553	Anand	Sarsa	KR-06	301609.5625	2494433.75	0.094
331	Jambusar	Sarod	BR-14	280113.4375	2453554.00	0.095
334	Padra	Dabka	NCCA-44	289541.875	2461919.50	0.086
441	Padra	Masar Road	BD-34	287036.875	2450600.50	0.094
773	Vadodara	Dashrath	BD-05	309398.6563	2477047.00	0.117
772	Vadodara	Sokhda	BD-06	311648.4375	2480807.00	0.098
882	Savli	Manjusar	BD-48	313994.4063	2483237.25	0.091
662	Padra	Jaspur	NCCA-43	299932.24	2465442.61	0.15
881	Savli	Anjesar	NCCA-14	311864.938	2486740.50	0.091
335	Padra	Karankuva	NCCA-45	291753.25	245608.25	0.091
113	Jambusar	Kavi	NCCA-48	256865.3	2456700.75	0.092

4.6 Lithology Data

The lithology data of wells, tube wells and piezometers of study area i.e. Anand, Borsad, Petlad, Khambhat talukas of Anand District; Savli, Vadodara and Padra talukas of Vadodara District and Jambusar taluka of Bharuch District have been collected from agencies like GWRDC,CGWB and GWSSB. From these 26 wells data have been tabulated viz Annexure-IV.

4.7 Reduced Water Level of Wells

The Reduced Water Levels of Wells are collected from GWRDC. These data have been tabulated viz table 4.3.

Table-4.3 Reduced Water Level of Wells in m from m.s.l.

Well no	X (Latitude)	Y (Longitude)	Pre monsoon 1995	Post monsoon 1995	Pre monsoon 1996	Post monsoon 1996	Pre monsoon 1997
KR-23	256803.69	2471326.90	9.17	12.17	9.52	12.57	9.77
KR-21	264060.81	2468621.00	4.28	4.78	4.28	5.18	3.98
KR-25	244895.81	2478585.00	13.35	15.65	13.85	15.60	14.4
KR-70	268272.9	2482068.61	13.75	14.35	13.05	15.10	13.3
KR-20	261564.14	2477128.29	11.36	13.06	11.66	12.71	11.76
KR-22	270508.31	2463701.40	6.53	6.68	4.93	5.38	4.58
KR-19	283767.25	2479632.25	28.10	28.30	27.90	29.40	27.4
KR-17	283689.91	2474095.00	19.22	19.92	17.52	20.12	20.02
KR-18	283803.56	2465232.25	-2.40	-1.70	-2.40	-2.20	-2.8
KR-16	294427.55	2475901.85	12.50	13.90	13.40	NA	13.55
KR-07	303395.94	2488507.50	32.42	32.62	31.47	32.22	31.62
KR-08	298338.22	2495240.50	37.69	38.09	36.84	38.59	36.99
KR-06	301609.56	2494433.75	30.27	00.77	30.62	30.47	27.97
NCCA-47	280030.91	2453555.00	1.69	2.29	1.13	1.85	0.39
BR-14	280113.44	2453554.00	-5.95	-5.40	-7.05	-6.70	-7.9
NCCA-44	289541.88	2461919.50	6.70	6.86	6.12	7.68	6.16
BD-34	287036.88	2450600.50	3.34	3.34	3.14	3.39	2.99
BD-05	309398.66	2477047.00	15.32	15.17	14.97	19.07	17.62
BD-06	311648.44	2480807.00	23.24	23.44	19.79	29.29	22.82
BD-48	313994.41	2483237.25	16.55	19.55	15.60	25.05	16.62
NCCA-43	299932.24	2465442.61	-5.68	-4.67	-5.32	-4.87	-5.9
NCCA-14	311864.94	2486740.50	3.06	3.03	0.50	6.05	2.56
NCCA-13	305511.11	2486551.80	NA	NA	NA	NA	NA
NCCA-45	291753.25	245608.25	-2.36	-2.62	NA	-1.57	-2.35
NCCA-48	256865.3	2456700.75	3.51	4.91	NA	0.12	0.69
NCCA-50	273528.22	2444055.18	-7.61	-7.81	-8.44	-7.14	-8.54

NA= Not Available

Well no	X (Latitude)	Y (Longitude)	Post monsoon 1997	Pre monsoon 1998	Post monsoon 1998	Pre monsoon 1999	Post monsoon 1999
KR-23	256803.69	2471326.90	13.77	10.07	14.07	11.47	10.92
KR-21	264060.81	2468621.00	7.68	5.68	9.08	8.48	6.18
KR-25	244895.81	2478585.00	15.55	13.55	15.6	14.6	15.65
KR-70	268272.9	2482068.61	18	14.1	15.6	14.75	15.60
KR-20	261564.14	2477128.29	13.66	11.86	13.26	12.61	13.46
KR-22	270508.31	2463701.40	8.23	4.03	9.63	7.23	4.53
KR-19	283767.25	2479632.25	31.05	28.2	31.4	28.9	30.00
KR-17	283689.91	2474095.00	21.72	20.42	23.37	21.67	21.12
KR-18	283803.56	2465232.25	-0.5	-1.9	-0.75	-1.6	-1.70
KR-16	294427.55	2475901.85	17.7	12.95	18.8	17.2	16.70
KR-07	303395.94	2488507.50	33.42	32.52	34.52	32.82	32.72
KR-08	298338.22	2495240.50	39.79	36.89	38.99	37.99	39.09
KR-06	301609.56	2494433.75	31.27	30.07	31.07	30.57	30.07
NCCA-47	280030.91	2453555.00	1.94	-0.66	2.51	2.74	2.22
BR-14	280113.44	2453554.00	-6.85	-7.6	-7.05	-7.45	-7.30
NCCA-44	289541.88	2461919.50	7.53	6.9	9.12	5.28	NA
BD-34	287036.88	2450600.50	3.79	8.14	5.99	8.14	8.24
BD-05	309398.66	2477047.00	19.97	18.22	20.27	18.37	18.27
BD-06	311648.44	2480807.00	29.09	23.89	30.39	23.64	23.99
BD-48	313994.41	2483237.25	22.2	17.5	25.6	16.7	22.70
NCCA-43	299932.24	2465442.61	-4.32	-2.62	-1.38	-4.82	NA
NCCA-14	311864.94	2486740.50	9.38	NA	NA	NA	NA
NCCA-13	305511.11	2486551.80	7.07	NA	NA	NA	NA
NCCA-45	291753.25	245608.25	-3.05	-1.5	-4.95	-1.7	-4.75
NCCA-48	256865.3	2456700.75	2.86	2.19	4.06	3.06	3.59
NCCA-50	273528.22	2444055.18	-5.86	-7.48	-5.06	-6.96	-5.54

Well no	X (Latitude)	Y (Longitude)	Pre monsoon 2000	Post monsoon 2000	Pre monsoon 2001	Post monsoon 2001	Pre monsoon 2002
KR-23	256803.69	2471326.90	8.25	10.87	9.87	9.97	8.22
KR-21	264060.81	2468621.00	2.38	2.18	1.18	0.88	0.08
KR-25	244895.81	2478585.00	12.85	13.75	11.75	13.75	12.05
KR-70	268272.9	2482068.61	NA	NA	NA	NA	NA
KR-20	261564.14	2477128.29	11.36	NA	7.26	7.96	4.96
KR-22	270508.31	2463701.40	2.83	1.73	2.03	2.53	NA
KR-19	283767.25	2479632.25	26.25	26.10	NA	NA	NA
KR-17	283689.91	2474095.00	16.92	15.32	13.72	14.32	11.82
KR-18	283803.56	2465232.25	-2.40	-3.10	-4.10	-3.60	-5.30
KR-16	294427.55	2475901.85	13.40	11.60	9.20	13.70	NA
KR-07	303395.94	2488507.50	NA	NA	NA	NA	NA
KR-08	298338.22	2495240.50	35.09	34.99	32.19	29.39	27.69
KR-06	301609.56	2494433.75	28.17	26.77	25.07	23.07	20.87
NCCA-47	280030.91	2453555.00	0.97	1.87	0.22	0.72	-0.33
BR-14	280113.44	2453554.00	-8.60	-9.20	-9.10	-7.45	NA
NCCA-44	289541.88	2461919.50	NA	NA	3.14	NA	NA
BD-34	287036.88	2450600.50	3.24	3.24	18.27	4.14	4.14
BD-05	309398.66	2477047.00	17.77	18.07	17.00	17.97	18.77
BD-06	311648.44	2480807.00	18.99	18.89	NA	22.19	NA
BD-48	313994.41	2483237.25	15.40	18.90	-3.30	17.30	16.10
NCCA-43	299932.24	2465442.61	-6.78	NA	1.90	-9.98	-12.18
NCCA-14	311864.94	2486740.50	NA	NA	NA	0.98	-5.75
NCCA-13	305511.11	2486551.80	NA	NA	1.89	NA	-0.26
NCCA-45	291753.25	245608.25	NA	NA	-10.00	NA	NA
NCCA-48	256865.3	2456700.75	NA	NA	NA	2.59	2.39
NCCA-50	273528.22	2444055.18	-8.84	-0.09	NA	-9.23	NA

Well no	X (Latitude)	Y (Longitude)	Post monsoon 2002	Pre monsoon 2003	Post monsoon 2003	Pre monsoon 2004	Post monsoon 2004
KR-23	256803.69	2471326.90	9.87	7.67	10.47	8.72	10.57
KR-21	264060.81	2468621.00	2.38	2.38	8.18	5.48	7.38
KR-25	244895.81	2478585.00	13.95	10.5	14.85	14.55	15.65
KR-70	268272.9	2482068.61	NA	NA	NA	NA	NA
KR-20	261564.14	2477128.29	7.76	5.06	12.06	8.51	12.36
KR-22	270508.31	2463701.40	2.03	0.33	4.53	2.48	1.33
KR-19	283767.25	2479632.25	NA	NA	NA	NA	NA
KR-17	283689.91	2474095.00	12.42	10.02	11.12	10.92	12.02
KR-18	283803.56	2465232.25	-3.80	-7.9	-1.6	-3.3	-1.5
KR-16	294427.55	2475901.85	NA	NA	NA	NA	NA
KR-07	303395.94	2488507.50	NA	NA	NA	NA	NA
KR-08	298338.22	2495240.50	28.39	27.19	29.59	29.34	31.39
KR-06	301609.56	2494433.75	22.47	21.37	24.97	24.27	27.97
NCCA-47	280030.91	2453555.00	0.39	-0.88	2.1	2.12	2.62
BR-14	280113.44	2453554.00	-8.85	NA	-8.6	-9.1	-9.1
NCCA-44	289541.88	2461919.50	NA	NA	NA	NA	NA
BD-34	287036.88	2450600.50	4.34	5.89	3.24	3.14	4.44
BD-05	309398.66	2477047.00	17.97	15.97	19.17	17.47	19.57
BD-06	311648.44	2480807.00	NA	16.79	23.19	21.64	30.29
BD-48	313994.41	2483237.25	20.70	16.8	19.5	17.2	23.9
NCCA-43	299932.24	2465442.61	-11.14	-16.75	-10.38	-11.08	-9.08
NCCA-14	311864.94	2486740.50	2.75	-4.82	7.42	-2.58	6.72
NCCA-13	305511.11	2486551.80	0.00	-10.03	-2.58	-3.33	-1.78
NCCA-45	291753.25	245608.25	NA	NA	NA	NA	NA
NCCA-48	256865.3	2456700.75	2.72	1.94	3.09	2.74	3.24
NCCA-50	273528.22	2444055.18	NA	NA	NA	NA	NA

Well no	X (Latitude)	Y (Longitude)	Pre monsoon 2005	Post monsoon 2005	Pre monsoon 2006	Post monsoon 2006	Pre monsoon 2007
KR-23	256803.69	2471326.90	8.17	13.27	10.17	13.57	NA
KR-21	264060.81	2468621.00	2.78	7.23	5.08	8.38	NA
KR-25	244895.81	2478585.00	13.95	15.45	14.4	15.15	NA
KR-70	268272.9	2482068.61	NA	NA	NA	NA	NA
KR-20	261564.14	2477128.29	8.36	12.91	10.71	12.61	NA
KR-22	270508.31	2463701.40	0.43	4.93	3.43	7.53	NA
KR-19	283767.25	2479632.25	NA	NA	NA	NA	NA
KR-17	283689.91	2474095.00	12.52	15.52	15.32	19.02	NA
KR-18	283803.56	2465232.25	-3.5	-1	-2.5	-2.1	NA
KR-16	294427.55	2475901.85	NA	NA	13.7	17.7	NA
KR-07	303395.94	2488507.50	NA	NA	NA	NA	NA
KR-08	298338.22	2495240.50	29.09	34.84	33.64	38.19	NA
KR-06	301609.56	2494433.75	23.57	31.02	28.57	33.07	NA
NCCA-47	280030.91	2453555.00	2.87	4.12	4.02	4.77	4.28
BR-14	280113.44	2453554.00	-9.55	-9.65	NA	NA	-0.9
NCCA-44	289541.88	2461919.50	NA	NA	NA	NA	NA
BD-34	287036.88	2450600.50	5.49	3.59	5.74	5.44	4.74
BD-05	309398.66	2477047.00	15.47	20.27	19.67	21.27	18.42
BD-06	311648.44	2480807.00	25.79	27.89	23.79	28.04	23.24
BD-48	313994.41	2483237.25	16.5	26.9	17.5	28.4	16.5
NCCA-43	299932.24	2465442.61	-9.12	-2.62	-4.23	2.42	-0.26
NCCA-14	311864.94	2486740.50	-4.38	11.22	0.07	11.22	3.4
NCCA-13	305511.11	2486551.80	-2.88	-0.33	0.07	2.57	2.74
NCCA-45	291753.25	245608.25	NA	NA	NA	NA	NA
NCCA-48	256865.3	2456700.75	NA	NA	NA	NA	NA
NCCA-50	273528.22	2444055.18	NA	NA	NA	NA	NA

4.8 Water Quality Data of Wells

The Water quality data of Wells such as TDS, EC, PH, Cl, CO3, HCO3, SO4, Mg, Na and K are collected from GWRDC. Using the Topographical sheet of the study area the distances from Kavi and from river of wells have been found out. The Year wise TDS of different wells etc are given in table 4.4.

Table-4.4 Water Quality Data of Wells

WELL	Village	Dist. from Kavi in km	Dist. from River in km	1995 Pre monsoon TDS in ppm	1996 Pre monsoon TDS in ppm	1997 Pre monsoon TDS in ppm	1998 Pre monsoon TDS in ppm
NCCA-48	Kavi	6.50	5.90	930	N A	2250	980
KR-23	Kansari	8.05	7.60	1110	1180	1350	1070
KR-21	Bhuval	10.60	10.50	750	1180	1040	1020
NCCA-47	Sarod	14.25	3.20	14720	13740	20870	14820
KR-22	Haripura	14.35	6.90	2710	2640	2270	2650
KR-20	Kanisha	15.00	15.00	810	940	820	970
KR-25	Gudel	18.40	18.40	720	700	540	860
KR-18	Gajna	26.50	2.45	450	660	720	540
NCCA-50	Piludra	24.40	6.55	2470	2830	3790	2480
KR-17	Bhadran	28.60	7.50	1160	1550	1360	1430
BD-34	Masar Road	29.65	11.45	2120	2020	2120	2660
KR-70	Danteli	30.00	22.50	850	980	920	1060
KR-19	Borsad	30.95	12.40	740	1000	740	830
NCCA-44	Dabka	32.75	1.80	2040	1960	2110	1680
NCCA-45	Karankuva	35.75	7.10	910	N A	1810	1770
KR-16	Anklav	38.75	5.65	980	1130	1390	1080
NCCA-43	Jaspur	42.50	2.30	1580	900	1850	1240
KR-07	Vasad	47.70	1.85	570	920	940	450
KR-08	Bedva	51.00	7.30	930	1240	1040	1060
BD-05	Dashrath	53.10	7.50	2510	1960	2180	1990
KR-06	Sarsa	53.25	4.20	690	720	550	451
BD-06	Sokhda	56.75	8.65	890	830	1230	810
NCCA-14	Anjesar	59.00	6.25	950	950	1420	N A
BD-48	Manjusar	59.45	10.55	270	220	250	240

NA- Not Available

WELL	Village	Dist. from Kavi in km	Dist. from River in km	1999	2000	2001	2002
				Pre monsoon	Pre monsoon	Pre monsoon	Pre monsoon
				TDS in ppm	TDS in ppm	TDS in ppm	TDS in ppm
NCCA-48	Kavi	6.50	5.90	2340	N A	1950	1340
KR-23	Kansari	8.05	7.60	1050	1040	1370	1600
KR-21	Bhuval	10.60	10.50	1640	820	900	1080
NCCA-47	Sarod	14.25	3.20	18310	17150	15970	18140
KR-22	Haripura	14.35	6.90	2790	2070	2280	1990
KR-20	Kanisha	15.00	15.00	1720	1540	1130	1460
KR-25	Gudel	18.40	18.40	990	820	830	1180
KR-18	Gajna	26.50	2.45	720	690	1180	900
NCCA-50	Piludra	24.40	6.55	2630	3400	3620	N A
KR-17	Bhadran	28.60	7.50	1760	1470	1540	1300
BD-34	Masar Road	29.65	11.45	2210	2160	2000	1830
KR-70	Danteli	30.00	22.50	1360	N A	N A	N A
KR-19	Borsad	30.95	12.40	1090	830	N A	N A
NCCA-44	Dabka	32.75	1.80	1560	1800	N A	N A
NCCA-45	Karankuva	35.75	7.10	1070	N A	N A	N A
KR-16	Anklav	38.75	5.65	1640	1080	1180	N A
NCCA-43	Jaspur	42.50	2.30	1440	1520	N A	1350
KR-07	Vasad	47.70	1.85	970	N A	N A	N A
KR-08	Bedva	51.00	7.30	1310	1000	1140	1240
BD-05	Dashrath	53.10	7.50	1600	1830	1930	N A
KR-06	Sarsa	53.25	4.20	640	590	660	680
BD-06	Sokhda	56.75	8.65	520	1130	N A	N A
NCCA-14	Anjesar	59.00	6.25	N A	N A	600	710
BD-48	Manjusar	59.45	10.55	290	360	340	830

WELL	Village	Dist. from Kavi in km	Dist. from River in km	2003	2004	2005	2006
				Pre monsoon	Pre monsoon	Pre monsoon	Pre monsoon
				TDS in ppm	TDS in ppm	TDS in ppm	TDS in ppm
NCCA-48	Kavi	6.50	5.90	1170	N A	N A	N A
KR-23	Kansari	8.05	7.60	1460	1820	1420	1190
KR-21	Bhuval	10.60	10.50	1080	1360	1080	970
NCCA-47	Sarod	14.25	3.20	17890	20130	15970	18110
KR-22	Haripura	14.35	6.90	1760	1490	2260	2150
KR-20	Kanisha	15.00	15.00	1470	2080	1290	1070
KR-25	Gudel	18.40	18.40	1850	630	1040	860
KR-18	Gajna	26.50	2.45	1310	740	1080	930
NCCA-50	Piludra	24.40	6.55	N A	N A	N A	N A
KR-17	Bhadran	28.60	7.50	1330	1600	1570	1690
BD-34	Masar Road	29.65	11.45	2340	2080	2150	3200
KR-70	Danteli	30.00	22.50	N A	N A	N A	N A
KR-19	Borsad	30.95	12.40	N A	N A	N A	N A
NCCA-44	Dabka	32.75	1.80	N A	N A	N A	N A
NCCA-45	Karankuva	35.75	7.10	N A	N A	N A	N A
KR-16	Anklav	38.75	5.65	N A	N A	N A	1160
NCCA-43	Jaspur	42.50	2.30	930	960	950	N A
KR-07	Vasad	47.70	1.85	N A	N A	N A	N A
KR-08	Bedva	51.00	7.30	1000	1030	1190	1380
BD-05	Dashrath	53.10	7.50	2170	400	1830	2010
KR-06	Sarsa	53.25	4.20	440	740	750	630
BD-06	Sokhda	56.75	8.65	990	790	870	600
NCCA-14	Anjesar	59.00	6.25	470	590	510	370
BD-48	Manjusar	59.45	10.55	N A	350	320	250

4.9 Rainfall Data

The average annual rainfall data have been collected from State Water Data Center (SWDC) and GWRDC for Anand, Borsad, Petlad, Khambhat talukas of Anand District; Savli, Vadodara and Padra talukas of Vadodara District and Jambusar taluka of Bharuch district from year 1994 to 2006. Talukawise rainfalls are as shown in table 4.5.

Table-4.5 Talukawise Rainfalls in mm

TALUKA/YEAR	Khambhat	BORSAD	ANAND	PETLAD
1994	935	819	1250	1288
1995	454	496	535	757
1996	262	331	377	508
1997	1068	1052	1330	1306
1998	896	937	704	606
1999	340	380	398	455
2000	340	365	370	190
2001	416	517	525	466
2002	573	362	545	425
2003	1122	1086	923	1073
2004	956	773	821	815
2005	2130	1733	1312	1440
2006	1707	1049	1379	997

TALUKA/YEAR	VADODARA	PADRA	SAVLI	JAMBUSAR
1994	1130	927	1205	975
1995	631	442	485	507
1996	1003	810	1590	400
1997	1170	849	1164	571
1998	1134	469	1199	776
1999	377	291	533	252
2000	835	255	610	262
2001	826	489	775	437
2002	835	378	661	616
2003	952	438	1102	613
2004	1153	445	770	559
2005	1755	1691	1346	539
2006	1790	1799	1441	825

4.10 Recharge Data

The norms provided by the Ground water Resources Estimation Committee, Ministry of Irrigation,(Ministry of Irrigation,1984 ; Ministry of Water Resources,1997) and the Indian Agricultural Research Institute (IARI,1983) are adopted to estimate the net annual recharge in the study area. The net annual recharges during (June to May) in study area for different talukas were estimated by the water table fluctuation approach.

For calculating the annual recharge during monsoon, the formula indicated below is adopted.

Monsoon recharge (in MCM/year) =

$$\left[\left\{\left(\mathbf{A} * \mathbf{WTF} * \mathbf{S_y}\right) + \mathbf{D_w} - \left(\mathbf{R_s} + \mathbf{R_{igw}} + \mathbf{R_{is}}\right)\right\} * \mathbf{NF}\right] + \mathbf{R_s} + \mathbf{R_{is}} \quad \ldots\ldots.. \quad \mathbf{(4.1)}$$

Where

$\mathbf{A} * \mathbf{WTF} * \mathbf{S_y}$ = Rainfall recharge by WTF.

A= Net suitable area for groundwater recharge (sq.km.)

WTF= Groundwater table rise

$\mathbf{S_y}$**=** Specific yield (fraction)

$\mathbf{D_w}$= Gross kharif draft (MCM/Year)

$\mathbf{R_s}$ **=** Recharge due to monsoon seepage from canals and tanks (MCM/Year)

$\mathbf{R_{igw}}$ = Recharge due to monsoon seepage from groundwater irrigation (MCM/Year)

$\mathbf{R_{is}}$ = Recharge due to monsoon seepage from surface water irrigation (MCM/Year)

NF=Normalization factor.

The sample calculations of Vadodara taluka for the year 2003 are contained in Annexure-V.

Calculated values of all the talukas are adjusted by subsequent field checks of the study area and the Talukawise recharge in m/day are represented in table 4.6

Table-4.6 Talukawise Recharge in m/day

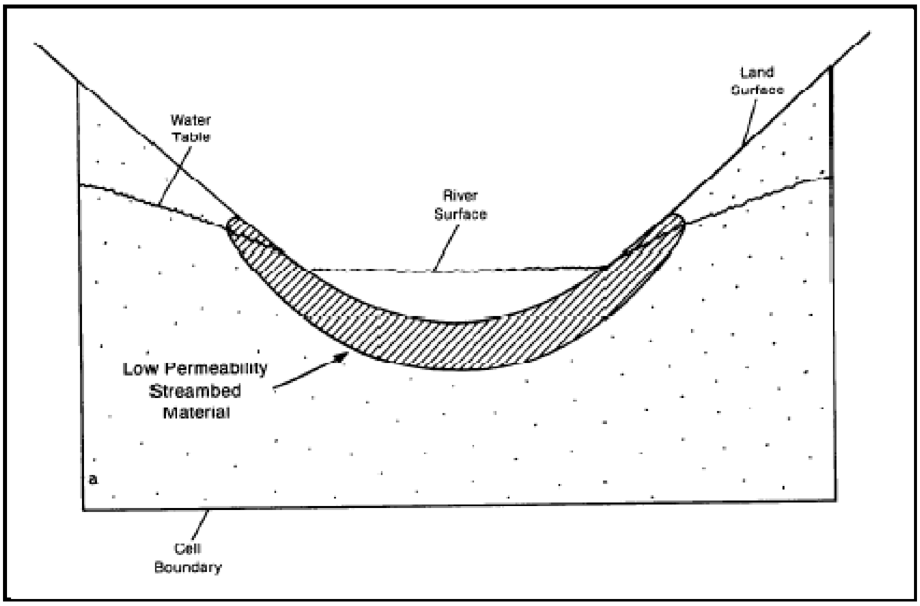
year	Season	Vadodara	Savli	Padra	Jambusar
1997	Monsoon	0.0015403	0.0015549	0.0017	0.0012
	Non monsoon	-0.0003772	-0.0003985	-0.0003	-0.00018
1998	Monsoon	0.0014921	0.0014921	0.0014	0.0011
	Non monsoon	-0.0003783	-0.0003996	-0.00035	-0.00018
2003	Monsoon	0.001638	0.0019867	0.0009153	0.0009546
	monsoon	-0.0004723	-0.000255	-0.0003776	-0.0003776
2004	Monsoon	0.0011575	0.0013959	0.0009396	0.0008705
	Non monsoon	-0.0005296	-0.000402	-0.0003809	-0.0003809
2005	Monsoon	0.0016081	0.00209627	0.0013403	0.0009525
	Non monsoon	-0.0005870	-0.0005480	-0.0003843	-0.0003843
2006	Monsoon	0.0013517	0.0020559	0.0013646	0.0010875
	Non monsoon	-0.0006444	-0.0006936	-0.0003876	-0.0003876

year	season	Khambhat	Borsad	Anand	Petlad
1997	Monsoon	0.001286	0.001286	0.00204	0.0015966
	Non monsoon	-0.00015	-0.00015	-0.000095	-0.0001
1998	Monsoon	0.0011568	0.0011568	0.0011	0.001
	Non monsoon	-0.0002	-0.00022	-0.00013	-0.00015
2003	Monsoon	0.002357	0.002357	0.0019979	0.0022286
	monsoon	-0.0002595	-0.0002595	-0.0000706	-0.0001043
2004	Monsoon	0.0015311	0.0015311	0.0018151	0.0018145
	Non monsoon	-0.0002926	-0.0002926	-0.0000967	-0.000132
2005	Monsoon	0.0011683	0.0023683	0.0023408	0.0024276
	Non monsoon	-0.0003056	-0.0003056	-0.0001229	-0.0001595
2006	Monsoon	0.0012287	0.0022287	0.002335	0.0021549
	Non monsoon	-0.0003186	-0.00031860	-0.0001490	-0.0001873

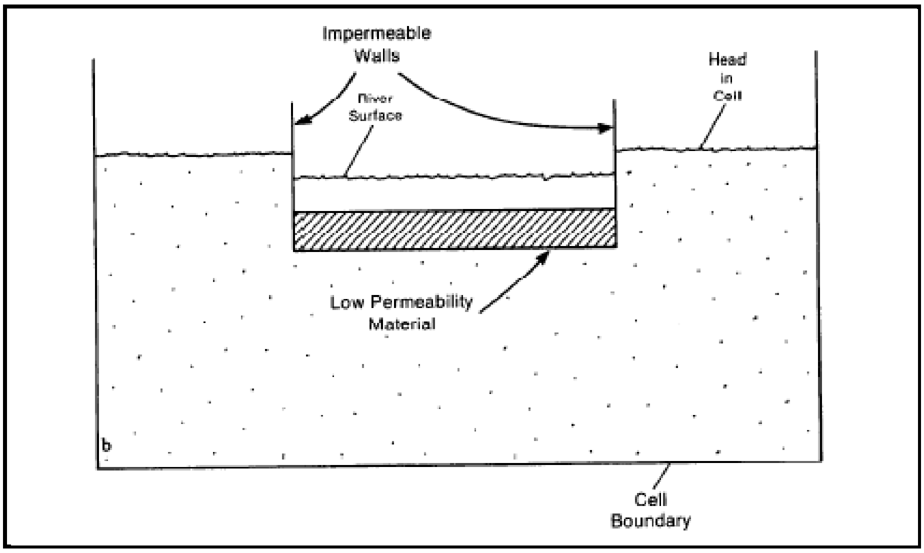
Note: Monsoon season from 15th June to 14th October

4.11 Conductance for the River

Rivers and streams contribute water to the groundwater system or drain water from it depending on the head gradient between the stream and the groundwater regime. The purpose of the river package is to simulate the effects of flow between surface water features and groundwater systems. The river package adequately represents most surface- groundwater systems.



(a)

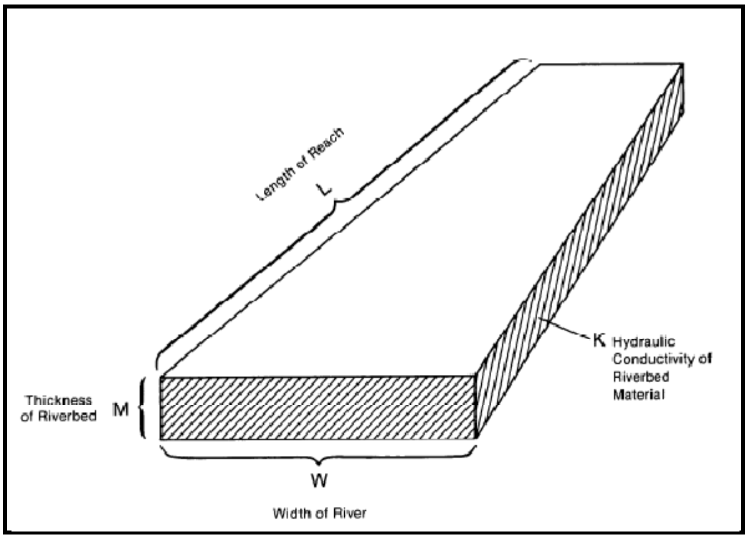


(b)

Figure 4.1 (a) Cross section of an aquifer containing a stream and

(b) Conceptual representation of stream-aquifer interconnection in simulation

Source: McDonald, and Harbaugh, (1988).



Streambed conductance = KLW/M

Figure 4.2 Idealization of streambed conductance in an individual cell

Source: McDonald and Harbaugh, (1988).

Figure 4.1 (a) shows cross section of an aquifer containing a stream which represents a situation in which the open water of a stream is separated from the groundwater system by a layer of low permeability streambed material. Figure 4.1 (b) shows an idealization of this system in which the stream-aquifer interconnection is represented in simulation as a simple conductance through which one-dimensional flow occurs.

Figure 4.2 shows an isolated view of the idealized streambed conductance of figure 4.1 (b), as it crosses an individual cell. The length of the conductance block is taken as the length of the stream, L, as it crosses the node; the width is taken as the stream width, W; the distance of flow is taken as the thickness, M, of the streambed layer; and the hydraulic conductivity (vertical) of the streambed material is designated K. The river package uses the streambed conductance (CRIV) which is given by

Streambed conductance (CRIV) = KLW/M ………………………………… (4.2)

Flow (rate of leakage) between the stream and the groundwater system or aquifer is given by

$$QRIV = CRIV\ (HRIV - h_{i,j,k}) \qquad h_{i,j,k} > RBOT \quad \ldots\ldots\ldots\ldots (4.3)$$

Where QRIV is the flow between the stream and the aquifer, taken positive if it is directed into the aquifer; HRIV is the head in the stream; CRIV is the hydraulic conductance of the stream-aquifer interconnection (KLW/M), $h_{i,}$ j, k is the head at the node in the cell (in the aquifer) directly underlying the stream reach which corresponds to water table and RBOT is the bottom of the streambed.

Sometimes the water level (table) in the aquifer has fallen below the bottom of the streambed layer, leaving an unsaturated interval beneath that layer; if it is assumed that the streambed layer itself remains saturated, the head at its base will simply be the elevation at that point. If this elevation is designated RBOT, leakage stabilizes and the flow through the streambed (QRIV) is given by QRIV = CRIV (HRIV- RBOT), $h_{i,j,k} \leq$ RBOT ….. (4.4)

If reliable field measurements of stream seepage and associated head difference are available, they may be used to calculate an effective conductance. Otherwise, a conductance value must be chosen more or less arbitrarily and adjusted during model calibration (McDonald and Harbaugh, 1988).

The river reach from Khanpur to Kavi (Sea) is divided into three arcs, namely upper, middle and lower arcs as shown in Figure 4.3. The initial conductance of 50, 60 and 20 per unit length (m) is estimated and given to upper, middle and lower arcs respectively. GMS automatically computes the appropriate cell conductance value when the river is assigned to the grid cells.

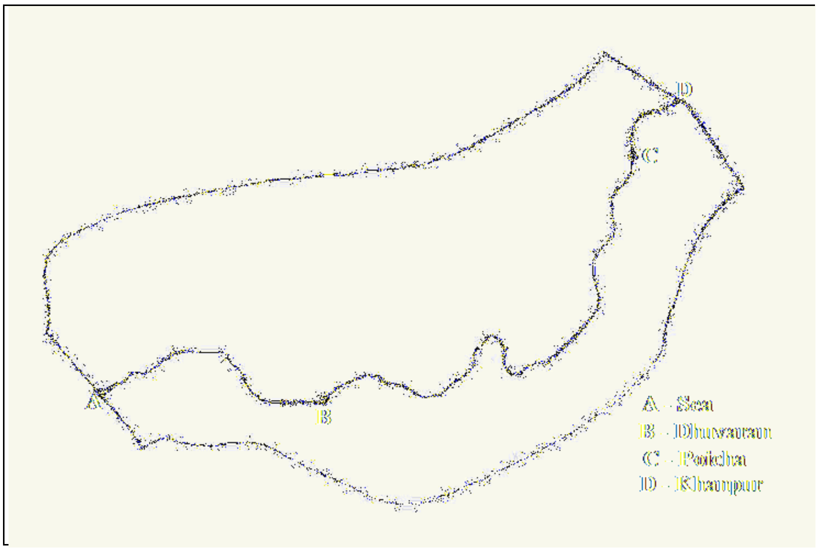


Figure 4.3 Locations of Arcs of River for Conductance

4.12 GMS 6.0 Software

The Department of Defense Groundwater Modeling System (GMS) is a comprehensive graphical user environment for performing groundwater simulations. The entire GMS system consists of a graphical user interface for ground water modeling (the GMS program) and a number of pre and post processor of multiple groundwater flow and contaminant transport analysis codes like MODFLOW, MT3DMS, RT3D, SEAM3D, MODPATH, MODAEM, SEEP2D, FEMWATER, WASH123D, UTCHEM (Goyal, R. 2003). The GMS interface was developed by the Environmental Modeling Research Laboratory of Brigham Young University in partnership with the U.S. Army Engineer Waterways Experiment Station. GMS was designed as a comprehensive modeling environment. Several types of models are supported and facilities are provided to share information between different models and data types. Tools are provided for site characterization, model conceptualization, mesh and grid generation, geostatistics, and post-processing.

GMS includes a powerful graphical interface to the MODFLOW 2000 model. Most popular MODFLOW packages are supported. Models can be constructed using either the grid approach or the conceptual model approach. Numerous options are provided for visualizing MODFLOW simulation results.

4.12.1 MODFLOW

MODFLOW is a finite-difference modeling program, which simulates groundwater flow in three dimensions. The code or computer program is written in FORTRAN 77. The program has a modular format, and consists of a ‘main’ program and a series of highly independent subroutines called ‘modules’. The modules are grouped into ‘packages’. Each package deals with a specific feature of the hydrologic system which is to be simulated, such as flow of rivers or flow into drains, or with a specific method of solving linear equations which describe the flow system. The division of the program into modules facilitates examination of each hydrologic feature in the model independently. Another advantage of having the modular structure is that new options/features could be added to the program without much change to the existing code.

4.12.2 The Conceptual Model Approach

A MODFLOW model can be created in GMS using one of two methods: assigning and editing values directly to the cells of a grid (the grid approach), or by constructing a high level representation of the model using feature objects in the Map module and allowing GMS to automatically assign the values to the cells (the conceptual model approach). Except for simple problems, the conceptual model approach is typically the most effective.

In GMS, the term conceptual model is used in two different ways. In the generic sense, a conceptual model is a simplified representation of the site to be modeled including the model domain, boundary conditions, sources, sinks, and material zones. GMS also has a conceptual model object, that can be defined in the map module using points, arcs, and polygons. Once the conceptual model object is defined, a grid can be automatically generated and the boundary conditions and model parameters are computed and assigned to the proper cells. This approach to modeling fully automates the majority of the data entry and eliminates the need for most or all of the tedious cell-by-cell editing traditionally associated with MODFLOW modeling.

A complete conceptual model object consists of several coverages. One coverage is typically used to define the sources and sinks such as wells, rivers, lakes, and drains. Coverage (or the same coverage) is used to define the recharge zones. Other coverages can be used to define the zones of hydraulic conductivity within each layer. Any number of coverages may be used, or all these attributes may exist in the same coverage. In addition to the feature data, a conceptual model may include other data (scatter points, boreholes, solids) to define the layer elevations. A specialized set of tools for manipulating layer elevation data is provided in GMS.

4.12.3 Advantages of the Conceptual Model Approach

There are numerous benefits to the conceptual model approach. First of all, the model can be defined independently of the grid resolution. The modeler does not need to waste valuable time computing the appropriate conductance to assign to a river cell based on the length of the river reach within the cell. This type of computation is performed automatically. Furthermore, transient parameters such as pumping rates for wells can also be assigned independently of model discretization. Transient parameters are entered as a curve of the stress vs. time. When the conceptual model is converted to the numerical model, the transient values of the stresses are automatically assigned to the appropriate stress periods. Since the conceptual model is defined independently of the spatial and temporal discretization of the numerical model, the conceptual model can be quickly and easily changed and a new numerical model can be generated in seconds. This allows the modeler to evaluate numerous alternative conceptual models in the space of time normally required to evaluate one, resulting in a more accurate and efficient modeling process.

A further advantage of storing attributes with feature objects is that the method of applying the boundary conditions to the grid cells reduces some of the instability that is inherent in finite difference models such as MODFLOW and MT3DMS. When the user enters individual values for heads and elevations, entering cell values one cell at a time can be tedious. It is also difficult to determine the correct elevation along a river segment at each cell that it crosses. The temptation is to select small groups of cells in series and apply the same values to all of the cells in the group. This results in an extreme stair-step condition that can slow or even prevent convergence of the numerical solver. By using GMS to interpolate values at locations along a linear boundary condition such as a river, the user insures that there will be no abrupt changes from cell to cell-thus minimizing the stair-step effect. It also produces a model with boundary conditions that more accurately represent real world conditions.

4.12.4 Groundwater Flow Equation Used In MODFLOW

The simultaneous equations used by MODFLOW for each finite difference cell is derived using Darcy's Law and the law of conservation of mass. The derivation gives a partial differential equation, which is used by MODFLOW. This partial-differential equation of groundwater flow used in MODFLOW-2000 is

$$\frac{\partial}{\partial X}\left[K_{XX}\frac{\partial h}{\partial X}\right] + \frac{\partial}{\partial Y}\left[K_{YY}\frac{\partial h}{\partial Y}\right] + \frac{\partial}{\partial Z}\left[K_{ZZ}\frac{\partial h}{\partial Z}\right] + W = S_s\frac{\partial h}{\partial t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (4.5)$$

Where,

Kxx, Kyy, and Kzz are values of hydraulic conductivity along the x, y, and z coordinate axes, which are assumed to be parallel to the major axes of hydraulic conductivity (L/T);

h is the potentiometric head (L);

W is a volumetric flux per unit volume representing sources and/or sinks of water, with W<0.0 for flow out of the ground-water system, and W>0.0 for flow in (T^{-1});

S_s is the specific storage of the porous material (L^{-1}); and

t is time (T).

Above Equation, when combined with boundary and initial conditions, describes transient three-dimensional ground-water flow in a heterogeneous and anisotropic medium, provided that the principal axes of hydraulic conductivity are aligned with the coordinate directions.

The Ground-Water Flow Process solves above equation using the finite-difference method in which the groundwater flow system is divided into a grid of cells (fig. 4.4). For each cell, there is a single point, called a node, at which head is calculated. The finite-difference equation for a cell is (Harbaugh et al. 2000)

$$\begin{aligned} & CR_{i,j-1/2,k}\left(h^m_{i,j-1,k} - h^m_{i,j,k}\right) + CR_{i,j+1/2,k}\left(h^m_{i,j+1,k} - h^m_{i,j,k}\right) \\ & \quad + CC_{i-1/2,j,k}\left(h^m_{i-1,j,k} - h^m_{i,j,k}\right) + CC_{i+1/2,j,k}\left(h^m_{i+1,j,k} - h^m_{i,j,k}\right) \\ & \quad + CV_{i,j,k-1/2}\left(h^m_{i,j,k-1} - h^m_{i,j,k}\right) + CV_{i,j,k+1/2}\left(h^m_{i,j,k+1} - h^m_{i,j,k}\right) + P_{i,j,k}h^m_{i,j,k} + Q_{i,j,k} \\ & \quad = SS_{i,j,k}\left(DELR_j \times DELC_i \times THICK_{i,j,k}\right)\frac{h^m_{i,j,k} - h^{m-1}_{i,j,k}}{t^m - t^{m-1}} \end{aligned} \quad \text{.............................. (4.6)}$$

Where

$h^m_{i,j,k}$ is head at cell i, j, k at time step m(L);

CV, CR and CC are hydraulic conductances, or branch conductances, between node i, j, k and a neighboring node (L^2/T);

$P_{i,j,k}$ is the sum of coefficients of head from source and sink terms (L^2/T);

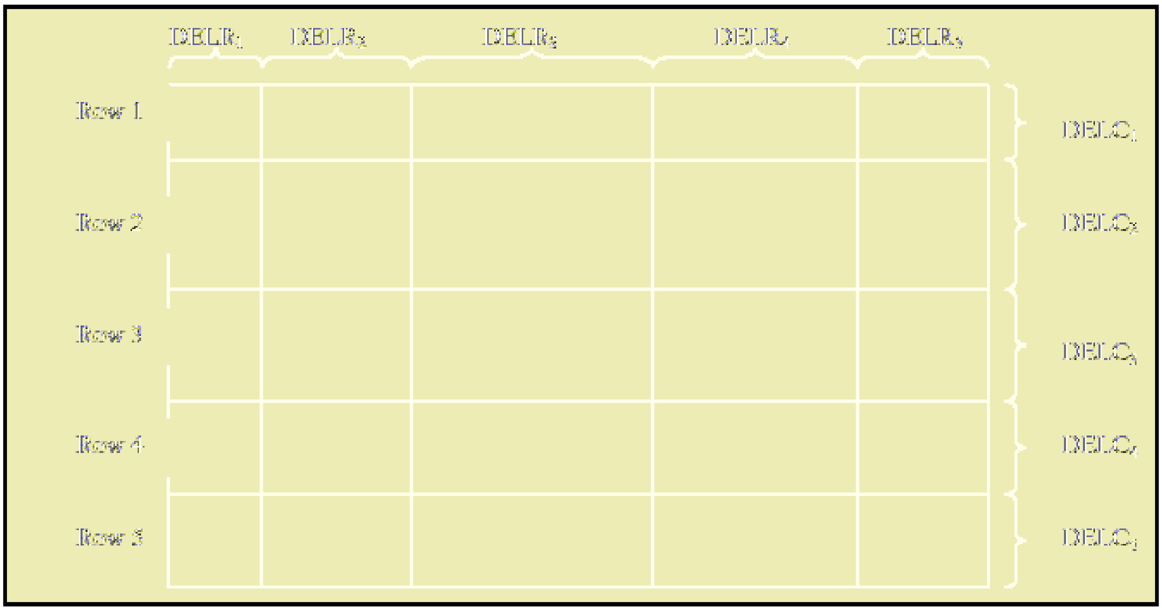
$Q_{i,j,k}$ is the sum of constants from source and sink terms, with $Q_{i,j,k} < 0.0$ *for flow out of the ground − water system*, *and* $Q_{i,j,k} > 0.0$ *for flow in* $\left(\frac{L^3}{T}\right)$;

$SS_{i,j,k}$ is the specific storage(L^{-1});

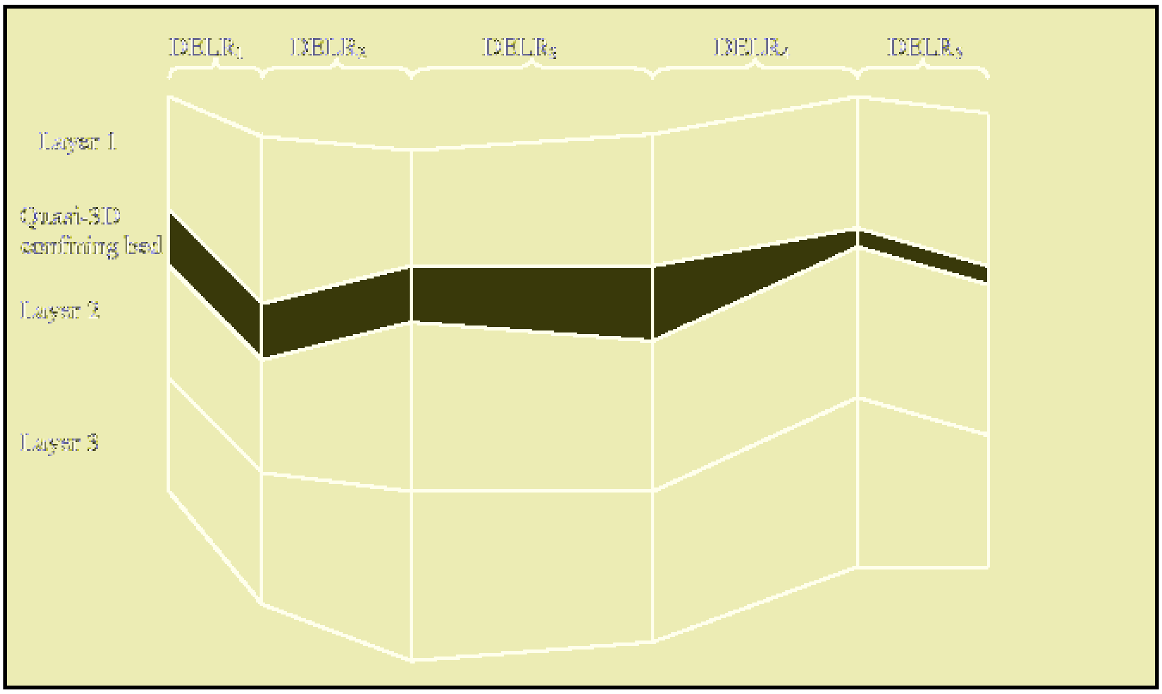
$DELR_j$ is the cell width of column j in all rows (L);

$DELC_i$ is the cell width of row i in all columns (L);

$THICK_{i,j,k}$ is the vertical thickness of cell i, j, k (L); and t^m is the time at time step m (T)



(A)



(B)

Figure 4.4 Finite-Difference Grid with (A) Plan View and (B) Cross-Section view.

Source: Harbaugh et al., MODFLOW-2000.

4.13 Groundwater Modeling

Groundwater modeling is a powerful management tool which can serve multiple purposes such as providing a framework for organizing hydrological data, quantifying the properties and behavior of the systems and allowing quantitative prediction of the responses of those systems to externally applied stresses. No other numerical groundwater management tool is as effective as a 3-dimensional groundwater model. A number of groundwater modeling studies have been carried out around the World for effective groundwater management. A digital groundwater model is an idealized representation of a groundwater system and describes in mathematical language, how the basin would function under various conditions. It considers relationship among parts of the system and stresses on the system simultaneously and describes the system studied in concise quantitative terms (ORG, 1982).

Conceptual models describe how water enters an aquifer system, flows through the aquifer system and leaves the aquifer system. Conceptual models start with simple sketches although in their final form they may be detailed three dimensional diagrams. Developing a conceptual model is not straightforward. It is necessary to examine all available data, other information, visit the area under different climatic conditions and talk to those who have used the aquifer. Insights can be gained from case studies in similar areas, but there will be always be new features to identify since every aquifer system has unique features. The conceptual model is put into a form suitable for modeling. The step includes design of the grid, selecting time steps, setting boundary, and initial conditions and preliminary selection of values for aquifer parameters and hydrologic stress.

Perhaps the most demanding task in preparing a numerical model from a conceptual model is the selection of appropriate values of the aquifer parameters. Inevitably there is insufficient information. Even if additional fieldwork is carried out, the selection of suitable parameter values requires skill, experience and judgment. Furthermore, the selection of parameter values is a time consuming task. Unless it is carried out systematically and thoroughly, a great deal of rethinking may required in later stages of model refinement. For each parameter it is advisable to quote the best estimate and arrange which represents the uncertainty. Numerical models should not have unnecessary complexity in terms of number of layers, number of mesh divisions and size of time steps. Another issue which requires careful attention is that there are some features which are not conveniently represented in certain numerical model codes. Refinement of numerical groundwater models when the model code is run for the first time there are likely to be many differences between field and modeled values of groundwater heads and flows. First of all there will be differences because of mistakes in preparing the input data; very careful checks must be made to ensure that the model boundaries parameter values, inflow and outflow are correctly included in the numerical model (Rushton, 2003).

A protocol for modeling includes code selection and verification, model design, calibration, sensitivity analysis and finally prediction (Anderson, 1992).

4.13.1 Assumptions and Considerations in Model Analysis

1. Basin is a single layered unconfined aquifer.
2. An impermeable basement boundary (either the basement is complex or the tertiary clays) exists at the bottom of aquifer.
3. The storage coefficient (specific yield) is constant with time.
4. Vertical flow components are negligible compared to horizontal flow components.

4.13.2 Construction of the Model for the Study Area

Study area's Northern and Southern limits are marked by catchment boundary of Mahi basin. The western limit is determined by the Gulf of Khambhat and in the east the area stretches up to Khanpur between catchment boundaries of Mahi basin. The study area comprises an area of 2298.23 sq. km and is enclosed within the North latitude 22°05'06" to 22°33'36" and East longitude 72°27'18" to 73°13'57".

The selection of MODFLOW is widely accepted model all over the world and many regional groundwater modeling studies based on MODFLOW are reported in the literature (Elango and Senthilkumar (2006), Elango (2009)). It has capabilities to handle unsteady, three dimensional groundwater flow problems with complex hydrogeogical features. Integration of MODFLOW in GMS provides calibration utility. Hence GMS software is selected for present study. Using the software Groundwater Modeling System (GMS 6.0) the Mahi estuarine area has been modeled. The analysis has been carried out using Layer Property Flow (LPF) package of MODFLOW-2000 (based on Finite Difference Method) in GMS6.0.

4.13.2.1 Base Map Preparation

For base map, a scanned image of study area has been registered in appropriate co-ordinate system (UTM co-ordinate system) using Arc view software (GIS) and shape (shp) file of this Mahi estuarine area is established. This shape file is imported to GMS and a base map for three dimensional groundwater flow model is obtained. Top elevation of Ground Level data modeling have been taken from Annexure-II.

The top elevation data are imported from database in GMS as a 2D scatter point data set and the top elevation TIN have been established using TIN Module in GMS using 2D scatter data set as shown in figure 4.5

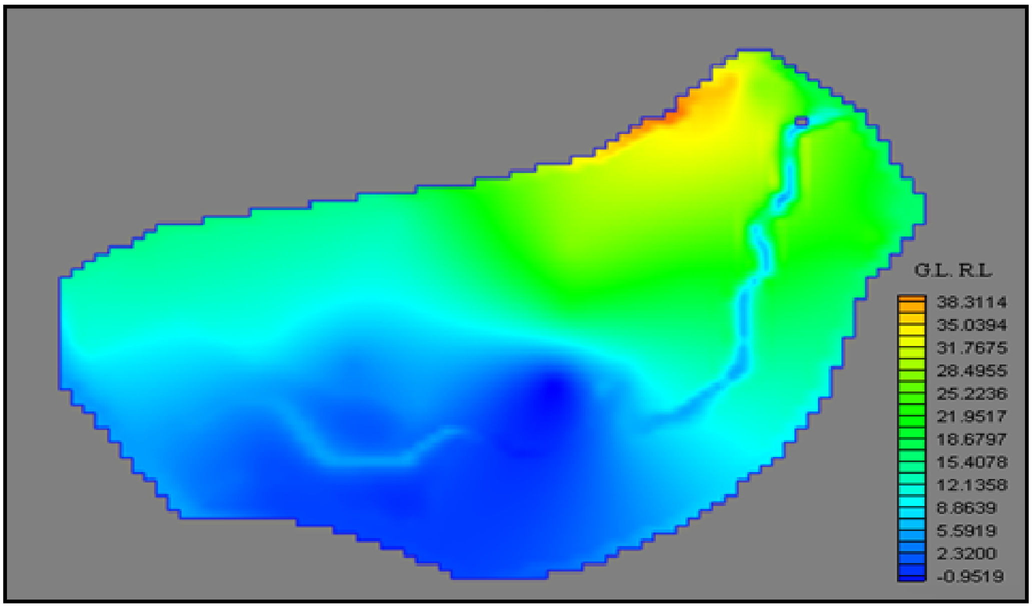


Figure 4.5 Top Elevation TIN

4.14 Conceptual Model of the Aquifer System

The model area is bounded by the catchment boundary of Mahi River Basin in the North and South. The Western limit is determined by the Gulf of Khambhat and in the East the area stretches up to Khanpur between catchment boundaries of Mahi River Basin.

The aquifer system of the model area is typical alluvial. Recharge to the aquifer system is mainly by infiltration of rainfall, seepage from rivers and the drainable surplus from irrigation. At present the most important discharge component is pumpage from wells for irrigation. It includes net groundwater recharge zones and other boundaries which can be represented as head dependent flow boundaries.

4.14.1 Fence Diagram, Solids and Longitudinal Sections

Fence Diagram has been prepared / developed by using the Lithology data of wells. The Lithology data of wells have been imported from database as a borehole data set using 2D scatter point module in GMS. Annexure-IV shows Lithology (borehole) data set which are imported to GMS.

From the above data set, GMS auto assigns Horizon IDs of material, and from these Horizon IDs, GMS auto creates cross sections of different wells and from these cross sections, GMS auto fill these cross sections using same horizon IDs of material (Environmental Modeling Research Laboratory, 2005) as shown in figure 4.6.

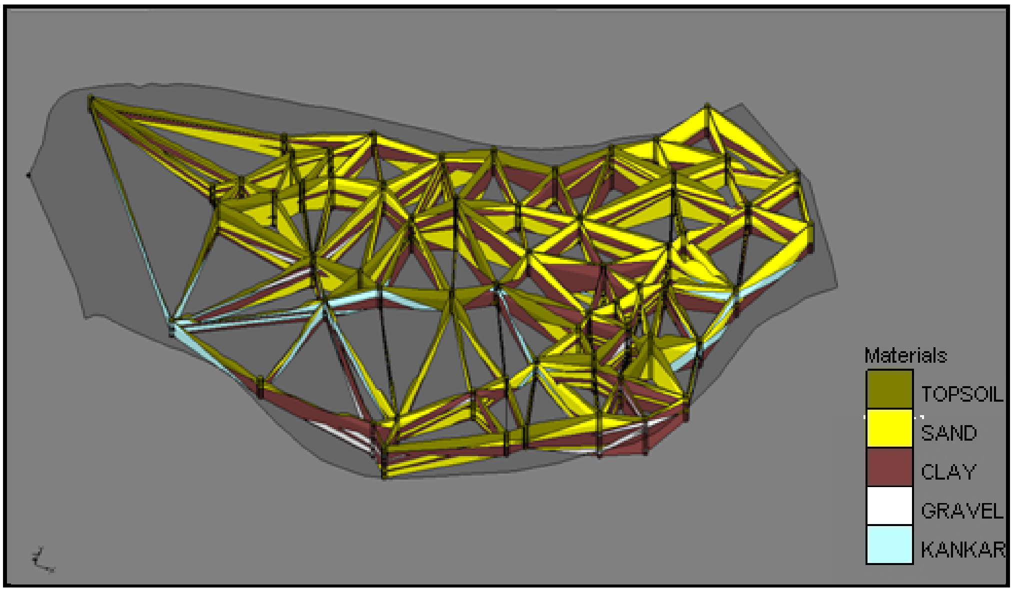


Figure 4.6 Fence Diagram of Study Area

From the above cross sections of different wells, The Solid module of GMS is used to construct three-dimensional models of stratigraphy using solids of study area created is shown in figure 4.7.

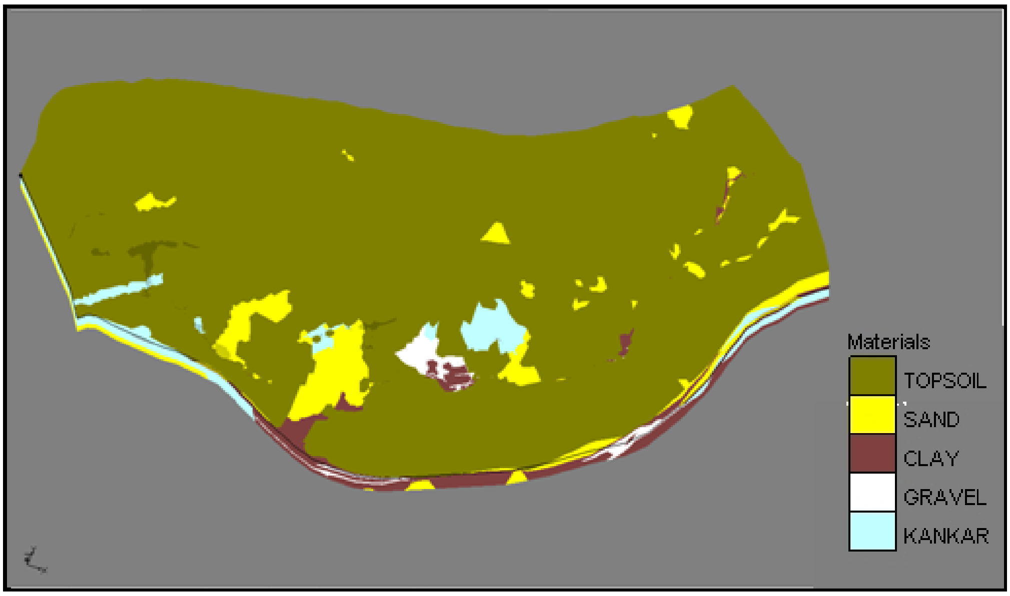


Figure 4.7 Solids of Study Area

Once the three-dimensional model (Solids) is created, cross sections can be cut anywhere on the model to create Longitudinal Sections. Fig 4.8 shows the three location of longitudinal sections i.e. along right bank (A-A'), along River (B-B') and along left bank (C-C') that have been cut for longitudinal sections as shown in figure 4.9 to 4.11.

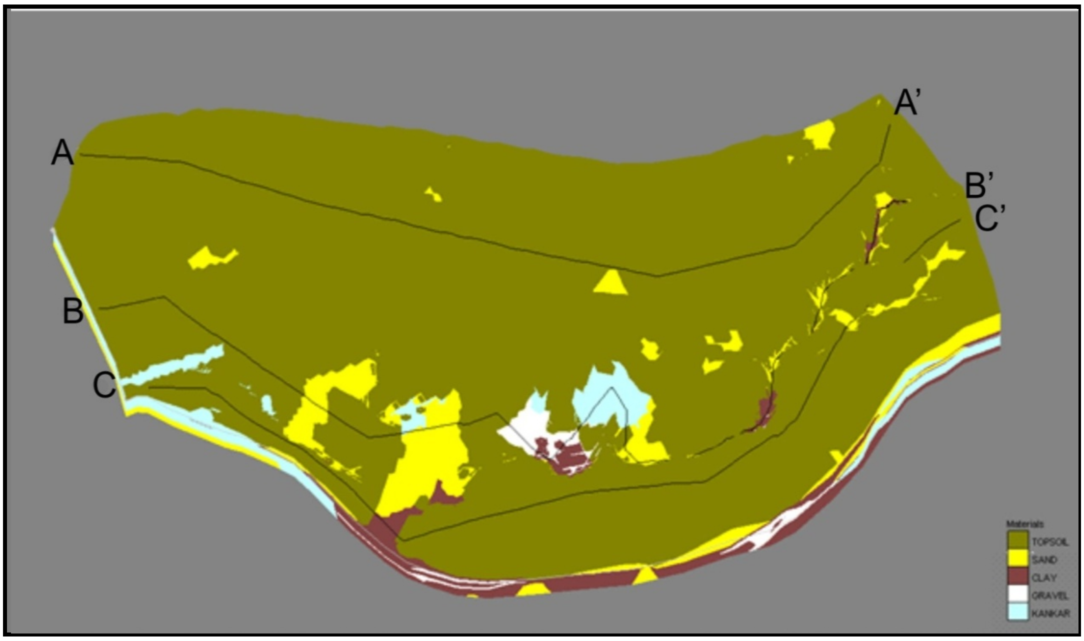


Figure 4.8 Three Locations of Longitudinal Section

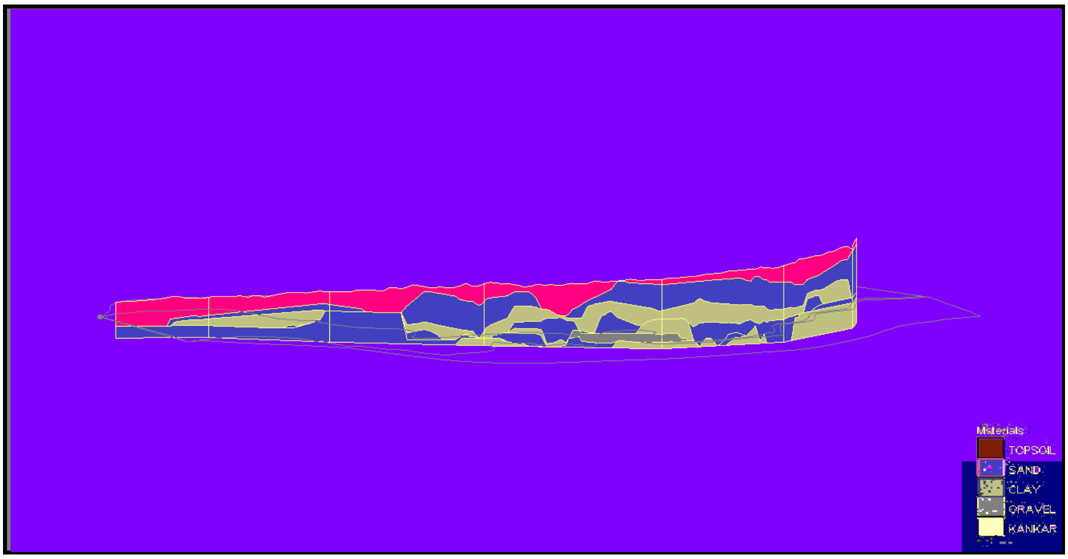


Figure 4.9 Longitudinal Section Along Right Bank (Section A-A')

From Kavi (sea) to Khanpur about 85 km U/S of Kavi

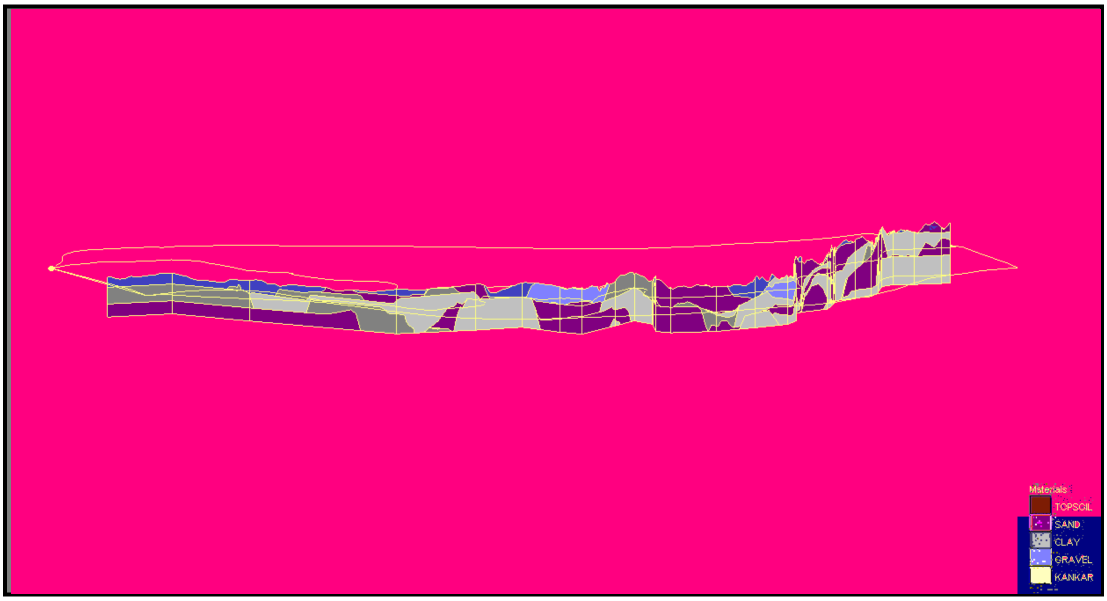


Figure 4.10 Longitudinal Section Along Mahi River (Section B-B')

From Kavi (sea) to Khanpur about 85 km U/S of Kavi

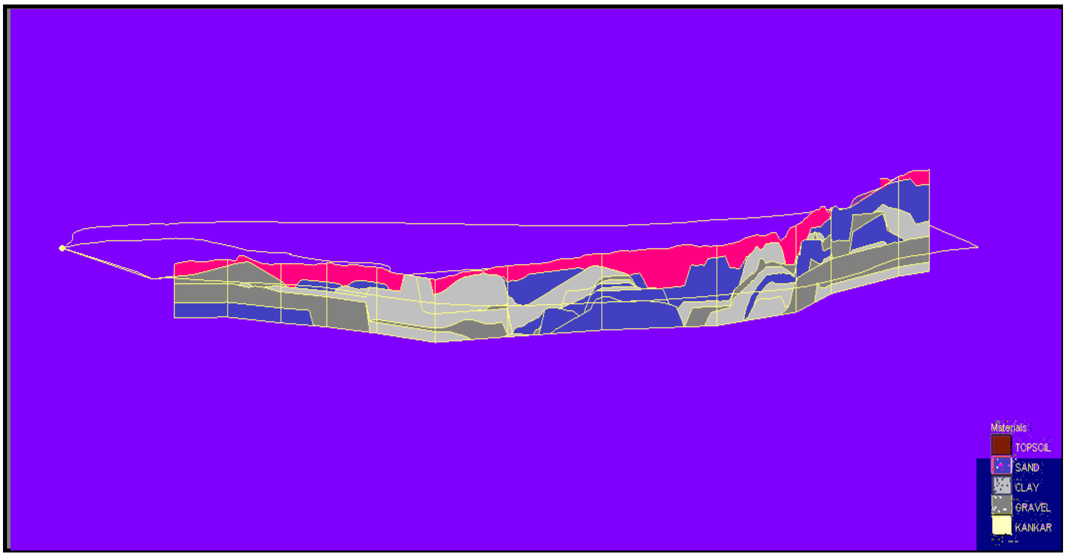


Figure 4.11 Longitudinal Section Along Left Bank (Section C-C')

From Kavi (sea) to Khanpur about 85 km U/S of Kavi

From above it is found that general geology confirm to alluvial area consisting alternate layers of clay, sand, gravel, occasionally mixed with kankar. Such strata are suitable for artificial recharge of groundwater.

4.15 Three Dimensional Model for Present Study

From the detailed study of lithology of wells and previous study reports the aquifer is considered as unconfined aquifer. As the thickness of unconfined aquifer is very less as compared to extent of study area (2298.23sq.km), the consideration of single layer unconfined aquifer in model to be appropriate for study of recharge. Using top elevation TIN and bottom elevation from Reduced Levels of bottom of wells in unconfined aquifer Annexure-III the three- dimensional groundwater model (solids) is created for present study.

4.15.1 Setting up the Recharge Zones

The study area is divided in to eight talukas and these polygons are considered as recharge zones as shown in figure 4.12.

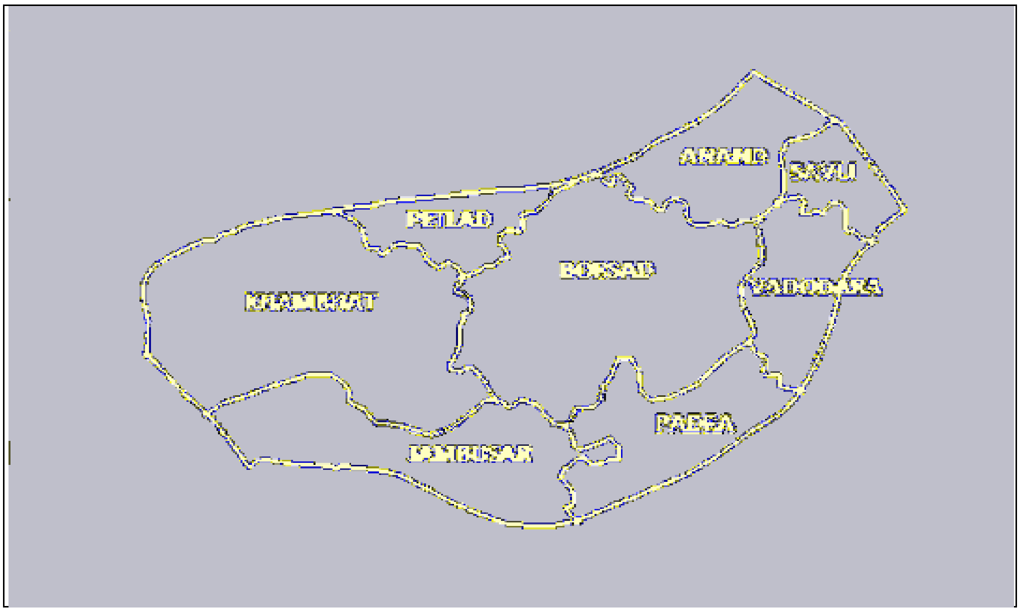


Figure 4.12 Recharge Zones of Study Area

4.15.2 Setting up the Horizontal Permeability Zones

On the basis of Horizontal permeability from pumping tests the model area has been divided into twenty three areal zones (polygons) as shown in figure 4.13.

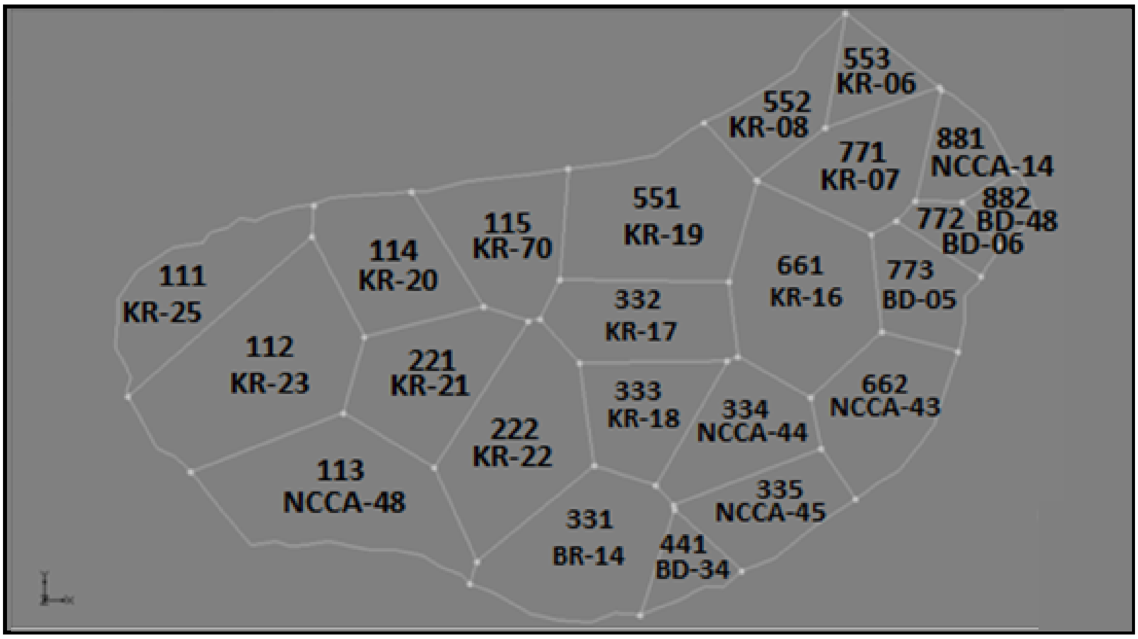


Figure 4.13 Zones of Study Area for Horizontal Permeability/Specific Yield

4.15.3 Setting up the Specific Yield Zones

Storage in the unconfined aquifer (or more correctly the specific yield of the alluvial material in the water table zone) is difficult to calculate accurately from pumping tests. It was recommended that the value of specific yield adopted for the modeled area is about 10 percent. For specific yield, the aquifer zones of study area were taken as coincident with the Horizontal Permeability zones i. e. 23 polygons as shown in figure 4.13. In conceptual model number of zones considered for horizontal permeability and specific yield are considered 23 which may be adequate to represent the variation in aquifer characteristics in the study area.

4.15.4 Setting up the Location of River Mahi

The Mahi River originates in the northern slopes of Vindhyas mountain ranges at an elevation of 500 m. above mean sea level at about 22° 35’ N and 74 °15’ E near the village Sardarpur in Dhar district of Madhya Pradesh. Its total length is 583 km, traversing 167 km. in Madhya Pradesh, 174 km. in Rajasthan remaining 242 km. in Gujarat. It flows initially in North-West direction through Dhar and Jhabua districts of Madhya Pradesh. Thereafter, it takes turn to the left and flow South-West direction through Banswara district of Rajasthan.

It enters the Gujarat State near Bhukia village in Rajasthan and runs through the Panchmahal and Anand districts of Gujarat State before joining the Arabian Sea in the Gulf of Khambhat. The Mahi River was explicitly represented in the model. The location is in figure 4.14. Based on field inspection this deep River is considered to be the only river in the modeled area which currently has major impact on groundwater level.

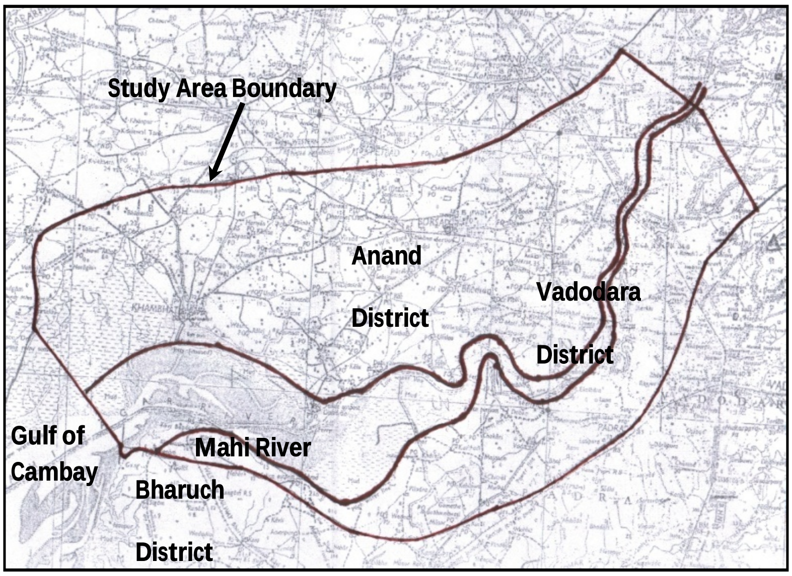


Figure 4.14 Location of River Mahi

4.16 Creating the 3D Grid

Before building a MODFLOW simulation, a 3D grid must be created which covers the area to be modeled. A grid can be created by selecting the Create Grid command in the Grid menu. A suite of tools and commands for editing grids (inserting rows, changing column widths, etc.) are also provided in the 3D Grid Module. If the conceptual model approach is used to construct a MODFLOW model, the grid can be automatically constructed from the conceptual model data using the Grid Frame and the Map -> 3D Grid command in the Feature Objects menu. The grid can be automatically refined around wells and cells outside the model domain can be inactivated. This 3D Grid contains 75 cells in X direction (75 columns), 75 cells in Y direction (75 rows) and 1 cell in Z direction i.e. this model is single layer. The Grid is cell centered type. The grid is shown in figure 4.15.

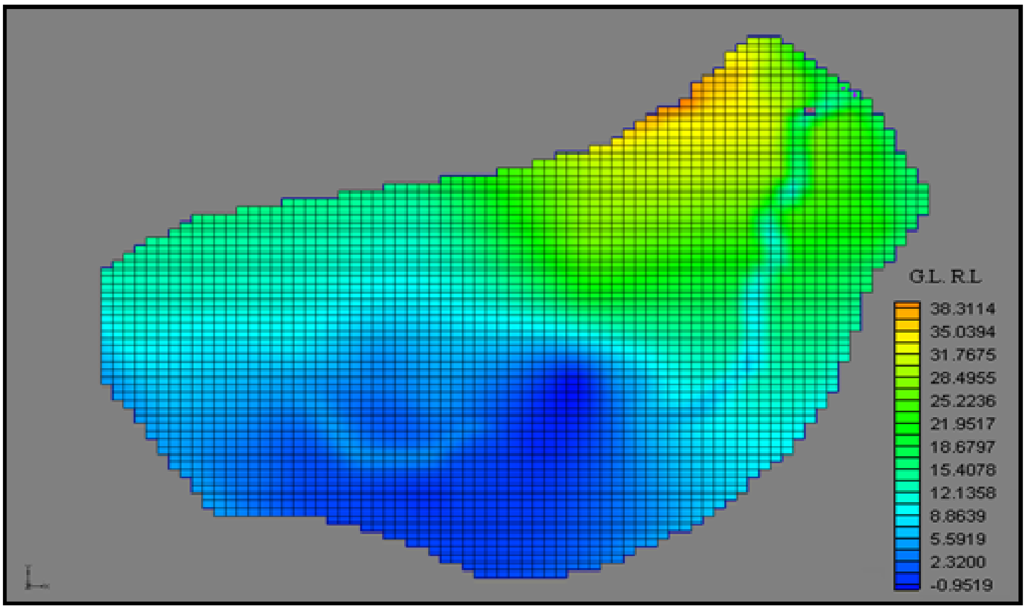


Figure 4.15 3D Grid of Study Area

4.17 Starting Heads to the Model

For Starting heads, ISO-RWL map is prepared using Surfer 6.0 software. From the ISO-RWL starting head values are stored in the database in the form of x coordinate, y coordinate, function value at different nodes. The starting head data obtained from Surfer have been imported from database in GMS as a 2D scatter point data set and RWL TIN has been established using TIN Module in GMS using 2D scatter data set as shown in fig 4.16.

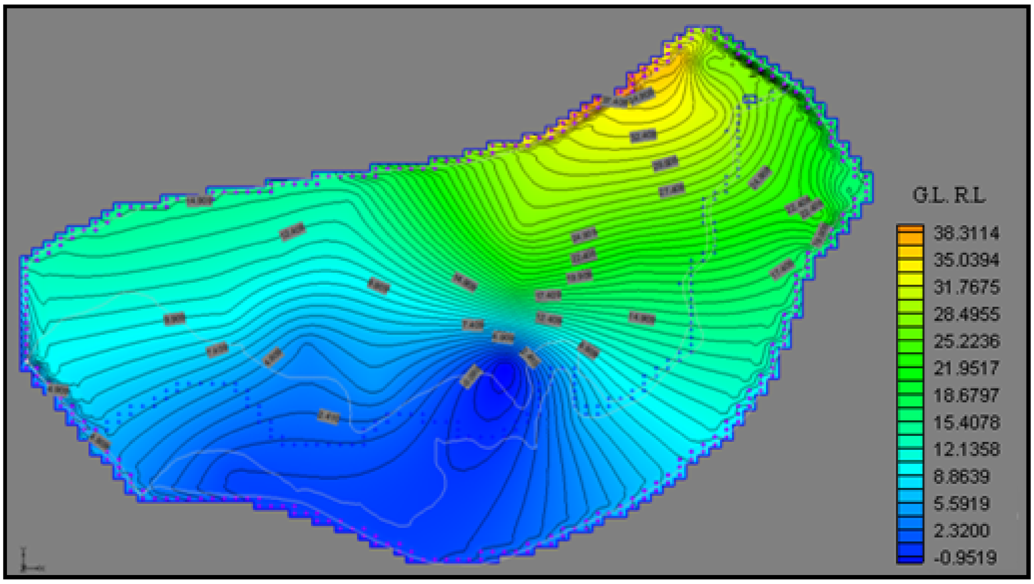


Figure 4.16 Starting Heads (Pre Monsoon 1997)

4.18 Boundary Conditions

The boundary is located along the catchment boundary of the Mahi Basin. The boundary of the study area is divided into number of segments. Twenty four points are selected on the perimeter of the study area as shown in figure 4.17. Heads on these points are obtained using available reduced water level of wells for pre monsoon and post monsoon periods of years 1997, 1998, 1999, 2003, 2004, 2005, 2006 and 2007.The Iso-RWL contour maps are prepared using surfer 6.0 Software and head at boundary points are interpolated or extrapolated. The heads on the South-West and North-East boundary of the study area are estimated using the RL's of Mahi River water levels at Khanpur and at Dhuvaran respectively. The flow domain is bounded by head-dependent flow (Transient head) boundary conditions. The transient heads on the boundary points are presented in table 4.7.

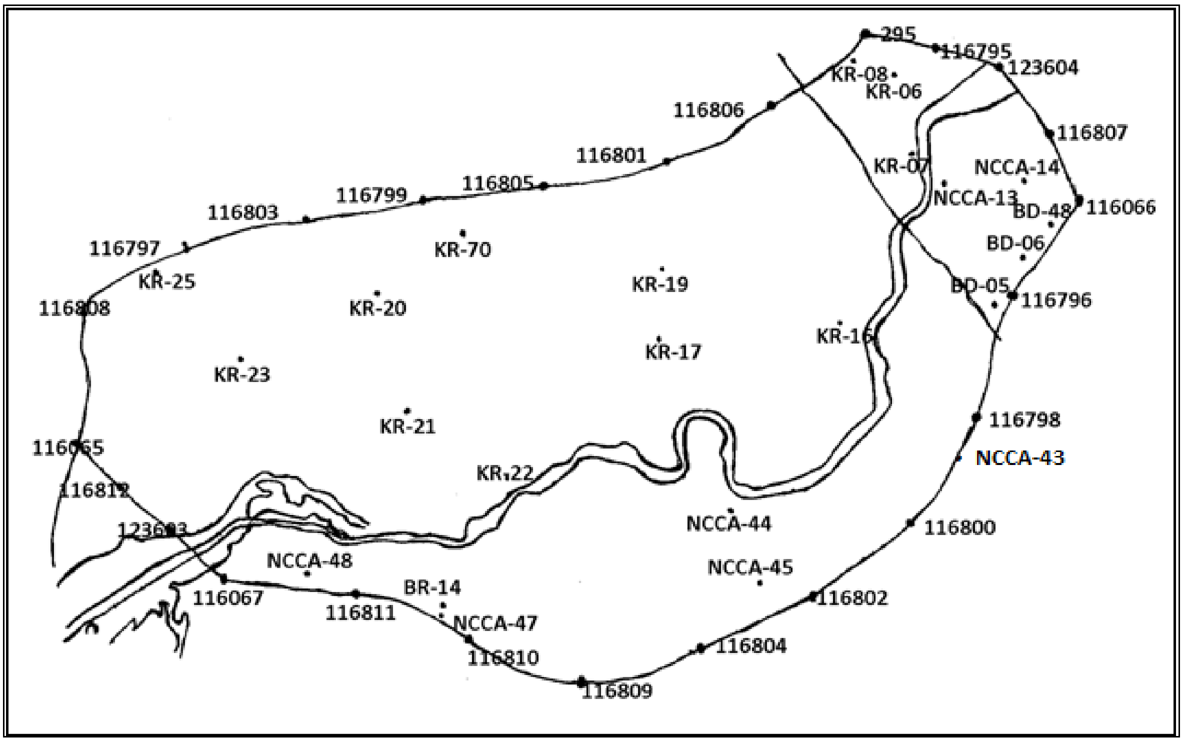


Figure 4.17 Location of Boundary points on the Study Area

Table-4.7 Transient Heads on the Boundary Points in m from m.s.l.

Boundary point id	X (Latitude)	Y (Longitude)	Pre monsoon 1997	Post monsoon 1997	Pre monsoon 1998	Post monsoon 1998	Pre monsoon 19 99
295	300487.6	2498279	29.6395	33.97558	32.17443	34.32598	32.93105
116806	293269.6	2492123	40.19563	45.44183	38.27858	41.26279	39.79873
116801	284935.2	2487628	33.1939	38.18979	32.8857	35.9767	33.86554
116805	275752.7	2485371	23.40196	28.2116	24.19556	26.36832	24.64922
116799	266341.2	2484208	14.43361	18.81532	14.97834	16.30085	15.48506
116803	256967.1	2482761	15.13609	17.18011	14.743	16.16428	15.23859
116797	247405.5	2481309	15.33259	16.10677	14.50044	16.42821	15.42935
116808	238644.4	2476772	13.3927	14.34984	12.75693	14.60397	13.76003
116065	238230.7	2467029	4.93	3.62	2.74	4.66	5.4
116812	241994.2	2462846	4.93	3.62	2.74	4.66	5.4
123603	245731	2458640	4.93	3.62	2.74	4.66	5.4
116067	248715.2	2454500	4.93	3.62	2.74	4.66	5.4
116811	257926	2454533	0.68	2.85	2.18	4.05	3.05
116810	267016.3	2452145	0.45	2	1.4	2.57	2.8
116809	275720.2	2448303	0.6	2.19	1.5	2.82	3.525964
116804	284982.4	2449798	3	3.8	8.15	6	8.15
116802	293675.9	2453759	6.444857	7.538505	10.37881	9.241808	8.784163
116800	301473.8	2459259	8.921953	11.08266	10.03031	10.60975	8.849905
116798	307199.5	2466670	10.94709	13.85149	10.09559	11.1281	9.91564
116796	309987.7	2475788	16.49044	19.81869	16.10677	17.7485	16.12328
116066	316048.3	2483030	16.41865	22.31932	14.19657	22.35152	13.16545
116807	312704.1	2488088	17.28	22.38	19.22411	25.72261	18.39045
123604	309579.7	2492724	18.18	22.45	23.19297	26.74786	22.60819
116795	304794.6	2495612	19.08337	22.50934	26.07027	27.38917	26.06337

Boundary point id	X (Latitude)	Y (Longitude)	Pre monsoon 2003	Post monsoon 2003	Pre monsoon 2004	Post monsoon 2004	Pre monsoon 2005
295	300487.6	2498279	19.58398	23.35236	22.06037	24.964	21.49521
116806	293269.6	2492123	22.99191	24.61112	25.36117	25.44177	25.85141
116801	284935.2	2487628	19.16735	20.78119	21.0171	21.54977	22.22657
116805	275752.7	2485371	15.34406	18.97043	17.58384	19.66712	18.63109
116799	266341.2	2484208	10.23106	16.5933	13.6889	17.15136	14.15016
116803	256967.1	2482761	9.069472	15.41206	12.75745	16.04943	12.89251
116797	247405.5	2481309	10.74959	15.69234	14.85976	15.47	14.31708
116808	238644.4	2476772	10.44662	14.24572	14.37572	15.16034	14.1221
116065	238230.7	2467029	4.93	3.62	2.74	4.66	1.99
116812	241994.2	2462846	4.93	3.62	2.74	4.66	1.99
123603	245731	2458640	4.93	3.62	2.74	4.66	1.99
116067	248715.2	2454500	4.93	3.62	2.74	4.66	1.99
116811	257926	2454533	1.513632	2.529131	2.300917	2.633886	4.604895
116810	267016.3	2452145	0.556495	2.350819	2.078263	1.644467	3.139967
116809	275720.2	2448303	1.723394	2.757459	3.08422	3.205629	4.604725
116804	284982.4	2449798	5.155396	3.216163	3.28827	4.445082	5.628322
116802	293675.9	2453759	6.617126	4.031621	3.601473	4.509408	4.313165
116800	301473.8	2459259	10.26745	7.881263	7.349482	6.951638	5.091483
116798	307199.5	2466670	15.38833	13.3559	12.57422	11.07234	7.58207
116796	309987.7	2475788	18.14591	19.81791	18.26859	19.37174	14.90551
116066	316048.3	2483030	21.88247	21.06157	19.87599	24.82737	16.98158
116807	312704.1	2488088	19.98	21.41	19.5	24.75	17.02
123604	309579.7	2492724	18.08	21.75	19.13	24.62	17.06
116795	304794.6	2495612	16.17604	22.0936	18.75957	24.48623	17.13901

Boundary point id	X (Latitude)	Y (Longitude)	Pre monsoon 2005	Post monsoon 2005	Pre monsoon 2006	Post monsoon 2006	Pre monsoon 2007
295	300487.6	2498279	21.49521	25.25	25.4	27.9	24.45
116806	293269.6	2492123	25.85141	28.73	29.94	33.81	32.8
116801	284935.2	2487628	22.22657	24.84	25.95	29.92	28.8
116805	275752.7	2485371	18.63109	22.15	21.65	24.1	23.06
116799	266341.2	2484208	14.15016	18.16	16.73	18.91	15.9
116803	256967.1	2482761	12.89251	16.63	14.8	16.28	13.1
116797	247405.5	2481309	14.31708	16.28	15.07	15.92	14.77
116808	238644.4	2476772	14.1221	15.22	14.34	15.04	14
116065	238230.7	2467029	1.99	3.06	3.93	2.77	4.33
116812	241994.2	2462846	1.99	3.06	3.93	2.77	4.33
123603	245731	2458640	1.99	3.06	3.93	2.77	4.33
116067	248715.2	2454500	1.99	3.06	3.93	2.77	4.33
116811	257926	2454533	4.604895	7.77	6.31	9.44	8.4
116810	267016.3	2452145	3.139967	5.94	5.03	7.85	8.1
116809	275720.2	2448303	4.604725	5.65	5.77	7.09	7.85
116804	284982.4	2449798	5.628322	6.68	5.91	7.15	7.3
116802	293675.9	2453759	4.313165	3.87	5.84	7.3	7
116800	301473.8	2459259	5.091483	7.94	7.5	9.5	7.6
116798	307199.5	2466670	7.58207	13.7	13	15.6	12.1
116796	309987.7	2475788	14.90551	20.95	20.08	21.1	16.7
116066	316048.3	2483030	16.98158	23.45	21.25	29.3	21.45
116807	312704.1	2488088	17.02	23.8	22.3	28.1	20.4
123604	309579.7	2492724	17.06	24.1	23.3	28.6	21
116795	304794.6	2495612	17.13901	24.5	22.87	29.15	21.8

In the present study, the groundwater model was calibrated and validated. The validated model was used for predictive simulation and is presented in chapter-5.

4.19 Regression Analysis

Water quality data of wells in unconfined aquifer collected from offices have been used to establish the average equations for linear relations between TDS and distance from Kavi. Similarly water quality data of wells used for establishing the average equations for linear relation between TDS and distance from centre line of river. The graphs have been prepared for this.

The Multiple Linear Regression Analysis has been carried out for establishing the linear relationships between three parameters such as TDS, Distance from Kavi and RWL. TDS has been taken as dependent variable because the analysis has been carried out to study the variation of salinity in Mahi estuarine area and other two have been taken as independent variables.

The effect of recharge due to Mahi Right Bank Canal (MRBC) irrigation have been observed in the area on right bank of the river, while in the area on the left bank of the river, the recharge due to irrigation is not observed as there is no left bank irrigation canal in past. So, the analysis for left bank, right bank and for both bank have been carried out separately.
Similarly the Multiple Linear Regression Analysis has been carried out for establishing the linear relationships between four parameters such as TDS, Distances from Kavi and RWL and rainfall.

4.19.1 Year Wise Variation in TDS With Reference to Rainfall and Lab Analysis for Water Quality

Another analysis which shows the year wise variation in TDS with reference to Rainfall for different wells in Anand, Borsad, Khambhat (Cambay), Savli, Vadodara and Padra talukas have been done.

Water samples of 36 wells parallel to Mahi river in May and Nov. 2003 collected and tested for important parameters like EC, PH, TDS, Ca, Mg, Na, CO3,HCO3, Cl,SO4, K and TH The results are graphically represented as TDS, Cl and TH v/s distances from Kavi and distances from centre line of river.

5 MODEL SIMULATION

In this chapter details of calibration, validation of groundwater model for the study area and use of the validated model for predictive simulation to evaluate the impact of the implementation of future salinity control structures on artificial recharge are described.

5. 1 Calibration of Groundwater Model

The ultimate purpose of the model is to predict changes in water levels in the aquifer caused by changes in stresses on the system. Before the model can be used for prediction, it must be calibrated, that is, water levels simulated by the model, when the stress regime of the past is imposed on it, must match measured water levels at any chosen time (ORG, 1982).

The process of model calibration is a complex one. An important part of any groundwater modeling exercise is the model calibration process. Calibration is a process wherein certain parameters of the model are varied (altered) within physically reasonable bounds in a systematic fashion in order to improve/achieve the best overall agreement between the simulated and observed groundwater levels. The main parameter adjusted during model calibration is hydraulic conductivity/transmissivity.

The objective of this calibration procedure is to minimize difference between the observed data and calculated values. Usually, the model is considered calibrated when it represents historical data within some acceptable level of accuracy. The level of acceptability is, of course, determined subjectively. Even when the match to historical data is good, the model may still fail to predict future responses accurately, especially under a newer or more extended set of stresses than were experienced during the calibration period (Delleur, 1999). Many problems always arise during the calibration phase and generally relate to inadequate and/or inaccurate data (ORG, 1993).

Usually model calibration proceeds in two sequential phases, firstly, there is steady state calibration, and, secondly, transient calibration. Model calibration can be performed to steady state or transient data sets.

Steady state calibration involves matching simulated groundwater levels with those observed under steady state or dynamic equilibrium conditions. During steady state calibration, non time varying parameters are altered within physically reasonable bounds in order to improve the agreement between the simulated and observed groundwater levels. The main parameters adjusted during steady state calibration are the hydraulic conductivity/ transmissivity. These parameters are varied within physically reasonable bounds. Aquifer recharge and abstraction is not normally varied during steady state calibration (Wallingford, 1995).

In some hydrogeologic settings it may be inappropriate to assume steady state conditions owing to large seasonal fluctuations in the water levels, or a steady state data set may not be available. In this case, the model may be calibrated to transient conditions. The most common type of transient calibration begins the simulation from the calibrated steady-state solution. The model is then calibrated to a time series of water level changes caused by pumping. The initial conditions are set arbitrarily and the model is run until the solution hits the calibration targets. It is assumed that the effect of the initial conditions do not influences the solution.

There are basically two ways of finding model parameters to achieve calibration, i. e. of solving the inverse problem:

(1) Manual trial-and-error adjustment of parameters and

(2) Automated parameter estimation. (Anderson, 1992)

A general rule which must be taken into account during model calibration is that the conditions which exist during calibration should be similar to those which will exist during the predictive simulations. Transient calibration should be carried out over a period similar in length to that proposed for the predictive simulations (Wallingford, 1995).

GMS provides a suit of options for model calibration including calibration targets and plots of calibration statistics'. Both point and flux observations are supported. GMS also supports automated parameter estimation.

5.1.1 Automated Parameter Estimation

In many cases, calibration can be achieved much more rapidly with an inverse model. GMS contains an interface to inverse model: PEST. An inverse model is an internal process or an external utility that automates the parameter estimation process. The inverse model systematically adjusts user-defined set of input parameters until the difference between the computed and observed values.

Transient-state model calibration was attempted. Out of all the input parameters, the hydraulic conductivity value is the only poorly known one, as less pumping tests in unconfined aquifer have been carried out in the study area. Based on these data it was decided to vary hydraulic conductivity of unconfined aquifer in order to get a good match of the computed and observed heads.

The automated parameter estimation process by which calibration of the transient model was achieved by PEST as inverse model contained in GMS 6.0. Zonal approach for parameterization was used. This involves indentifying polygonal zones of hydraulic conductivity, marking the zones as parameters and assigning a starting value for each zone.

The PEST process will then adjust the hydraulic conductivity values assigned to the zones as it attempts to minimize the residual error between computed vs. observed heads.

5.1.2 Period of Calibration Simulation

In the present study, data were available for the periods June 1997 to June1999. For this period water table elevation, rainfall and river stage data were available. Therefore, the Groundwater model was calibrated using the data of the period June1997 to June 1999(732 days).

5.1.3 Input Parameters for Calibration

Condition- Transient

Calibration interval or target is selected = 1m. (The interval or target represents the estimated error (±) in the observed value. Calibration is achieved when the error is within the estimated error interval of observed value.

The confidence selected is 95 % (The confidence value represents the confidence in the error estimate)

Maximum number of iterations limited to twenty in the interest of time.

Anisotropy Horizontal =1

Anisotropy vertical =3

Porosity =30 %

Specific storage S_s =0.00001 m^{-1}

The specific yield of wells s_y for each zone given is as shown in table 4.2 and specific yield zones are shown in figure 4.13

River conductances given to the upper, middle and lower arc of river are 50, 60 and 20 per unit length respectively. It is as shown in section 4.11 of chapter 4.

Daily Mahi river water level's given to model for the period June1997 to June 1999 (732 days) are as shown in Annexure 1 and graph 4.1 to 4.2 (Note: River water levels at Kavi/Sea is considered same as at Dhuvaran)

Starting heads given to the model (pre-monsoon 1997) is as shown in table 4.3 (Reduced Water Levels of wells) and in figure 4.16

Observation points (active) for calibration are as shown in table 5.2(Initially 23 observation wells considered and finally 17 0bservation wells kept active)

Reduced water levels of wells for pre monsoon and post monsoon for calibration period given to the model are as shown in table 4.3.

Transient heads (head dependent flow) on boundary point's pre monsoon and post monsoon for calibration period given to the model are as shown in table 4.7

Taluka wise transient net recharges monsoon and non monsoon for the calibration period given to the model are as shown in table 4.6 and the detail dates and time of Vadodara taluka is shown below (table 5.1) and similarly recharges given to all talukas.

Taluka: Vadodara

Table 5.1 Detail Dates and Time for Net Recharge of Vadodara taluka for Calibration

Sr. No.	Date and time	Recharge rate in m/day
1	6/14/1997 12:00:00 AM	-0.0003772
2	6/15/1997 12:00:00 AM	0.0015403
3	10/14/1997 12:00:00 AM	0.0015403
4	10/15/1997 12:00:00 AM	-0.0003772
5	6/14/1998 12:00:00 AM	-0.0003772
6	6/15/1998 12:00:00 AM	0.0014921
7	10/14/1998 12:00:00 AM	0.0014921
8	10/15/1998 12:00:00 AM	-0.0003783
9	6/14/1999 12:00:00 AM	-0.0003783

Times and Time Steps for the Stress Periods (For Transient Calibration**)**

Time steps and stress periods in transient calibration given to model are as shown in table 5.3.

The starting horizontal permeability Hk of wells for each zone in unconfined aquifer given to model are as shown in table 4.1 and horizontal permeability zones are shown in figure 4.13

The range of horizontal permeability given to model is 5 to 50 m/day for the calibration.

Table 5.2 Observation Points for Model Calibration

Taluka	Village	Obs.Point	X Latitude	Y Longitude	Pre monsoon 1997 RWL in m from m.s.l.
Khambhat	Kansari	KR-23	256803.69	2471326.90	9.77
Jambusar	Kavi	NCCA-48	256865.3	2456700.75	0.69
Khambhat	Bhuvel	KR-21	264060.8125	2468621.00	3.98
Khambhat	Gudel	KR-25	244895.8125	2478585.00	14.4
Petlad	Danteli	KR-70	268272.9	2482068.61	13.30
Khambhat	Kanisha	KR-20	261564.14	2477128.29	11.76
Khambhat	Haripura	KR-22	270508.31	2463701.40	4.58
Borsad	Borsad	KR-19	283767.25	2479632.25	27.40
Borsad	Bhadran	KR-17	283689.9063	2474095.00	20.02
Borsad	Gajna	KR-18	283803.5625	2465232.25	-2.8
Anklav	Anklav	KR-16	294427.55	2475901.85	19.60
Anand	Vasad	KR-07	303395.9375	2488507.50	31.62
Anand	Sarsa	KR-06	301609.5625	2494433.75	27.97
Padra	Dabka	NCCA-44	289541.875	2461919.50	6.16
Padra	Masar Road	BD-34	287036.875	2450600.50	2.99
Vadodara	Dashrath	BD-05	309398.6563	2477047.00	17.62
Jambusar	Sarod	NCCA-47	280030.9063	2453555.00	0.39

5.1.4 Setting up the Stress Periods

The date/time format is used to display time values such as the time step values when post-processing. We want the stress periods to match the times where our input data in map module changes. For example, the value for recharge changes at different dates. Therefore, we need to make sure that we have stress periods that start at those times and at the time corresponding to changes in the net recharge schedules(Environmental Modeling Research Laboratory, 2005) The times and time steps for the stress periods used in transient calibration is shown in the table 5.3. The number of stress periods used is 18.

Table 5.3 Times and Time Steps for the Stress Periods (For Transient Calibration)

Stress periods	Start(date and time)	Time step(days)	Num. of time steps	Total days
1	6/13/1997 12:00:00 AM	1	1	1
2	6/14/1997 12:00:00 AM	1	1	1
3	6/15/1997 12:00:00 AM	1	4	4
4	6/19/1997 12:00:00 AM	2	1	2
5	6/21/1997 12:00:00 AM	3	1	3
6	6/24/1997 12:00:00 AM	5	1	5
7	6/29/1997 12:00:00 AM	7	1	7
8	7/6/1997 12:00:00 AM	10	1	10
9	7/16/1997 12:00:00 AM	10	9	90
10	10/14/1997 12:00:00 AM	1	1	1
11	10/15/1997 12:00:00 AM	1	2	2
12	10/17/1997 12:00:00 AM	10	24	240
13	6/14/1998 12:00:00 AM	1	1	1
14	6/15/1998 12:00:00 AM	1	1	1
15	6/16/1998 12:00:00 AM	10	12	120
16	10/14/1998 12:00:00 AM	1	1	1
17	10/15/1998 12:00:00 AM	1	2	2
18	10/17/1998 12:00:00 AM	10	24	240
End	6/14/1999 12:00:00 AM End	1	1	1
	Total			732

5.1.5 Results of Calibration

Manual trial and error method can be used to iteratively adjust model parameters until the model computed values match the field observed values to an acceptable level of agreement. The level of acceptability is, of course, determined subjectively. Because a large number of interrelated factors affect the output trial and error adjustment may become a highly subjective and inefficient procedure. It is not uncommon to make numerous trial and error simulations before an acceptable calibration is achieved. So, more time is required in trial and error method. Solution obtained by this method may not be an optimal solution.

Calibration is really a way of solving the inverse problem. Automated parameter estimation techniques improve the efficiency of model calibration and calculate the best fit. Calibration can be achieved much more rapidly with an inverse model. GMS contains an interface to inverse model: PEST. The PEST interface in GMS can be used to perform automated parameter estimation for MODFLOW. An inverse model is an internal process or an external utility that automates the parameter estimation process. The inverse model systematically adjusts a used- defined set of input parameters until the difference between the computed and observed values is minimized.

With the above data as input, the inverse model PEST was run to calibrate transient condition through several iterations adjusting horizontal permeability values until a good match achieved between computed and observed heads.

The model is calibrated. The computed horizontal permeability Hk of wells for each zone in unconfined aquifer are as shown in table 5.4.

In conceptual model number of zones considered for horizontal permeability and specific yield are considered 23 which may be adequate to represent the variation in aquifer characteristics in the study area.

Table-5.4 Computed Horizontal permeability 'HK' of wells

Zone Id	Taluka	Village	Well No.	X Latitude	Y Longitude	Hk m/day
552	Anand	Bedva	KR-08	298338.2188	2495240.50	28.86
553	Anand	Sarsa	KR-06	301609.5625	2494433.75	50
771	Anand	Vasad	KR-07	303395.9375	2488507.50	50
881	Savli	Anjesar	NCCA-14	311864.938	2486740.50	9.6857
551	Borsad	Borsad	KR-19	283767.25	2479632.25	5.1637
115	Petlad	Danteli	KR-70	268272.9	2482068.61	5
882	Savli	Manjusar	BD-48	313994.4063	2483237.25	36.144
661	Anklav	Anklav	KR-16	294427.55	2475901.85	43.497
114	Khambhat	Kanisha	KR-20	261564.14	2477128.29	32.56
772	Vadodara	Sokhda	BD-06	311648.4375	2480807.00	7.3208
111	Khambhat	Gudel	KR-25	244895.8125	2478585.00	49.572
773	Vadodara	Dashrath	BD-05	309398.6563	2477047.00	41.485
112	Khambhat	Kansari	KR-23	256803.69	2471326.90	22.077
332	Borsad	Bhadran	KR-17	283689.9063	2474095.00	5.9989
221	Khambhat	Bhuvel	KR-21	264060.8125	2468621.00	22.322
222	Khambhat	Haripura	KR-22	270508.31	2463701.40	15.74
662	Padra	Jaspur	NCCA-43	299932.24	2465442.61	49.503
334	Padra	Dabka	NCCA-44	289541.875	2461919.50	16.478
333	Borsad	Gajna	KR-18	283803.5625	2465232.25	8.9196
113	Jambusar	Kavi	NCCA-48	256865.3	2456700.75	32.193
335	Padra	Karankuva	NCCA-45	291753.25	245608.25	5
331	Jambusar	Sarod	BR-14	280113.4375	2453554.00	50
441	Padra	Masar Road	BD-34	287036.875	2450600.50	11.18

The calibration of model is carried out using data from the period June 1997 to June 1999 and the horizontal permeability is found to be in the range of 5 to 50 m/day.

The figure 5.1 indicates that there is a very good match between the computed and observed heads in most of wells of the study area under calibration.

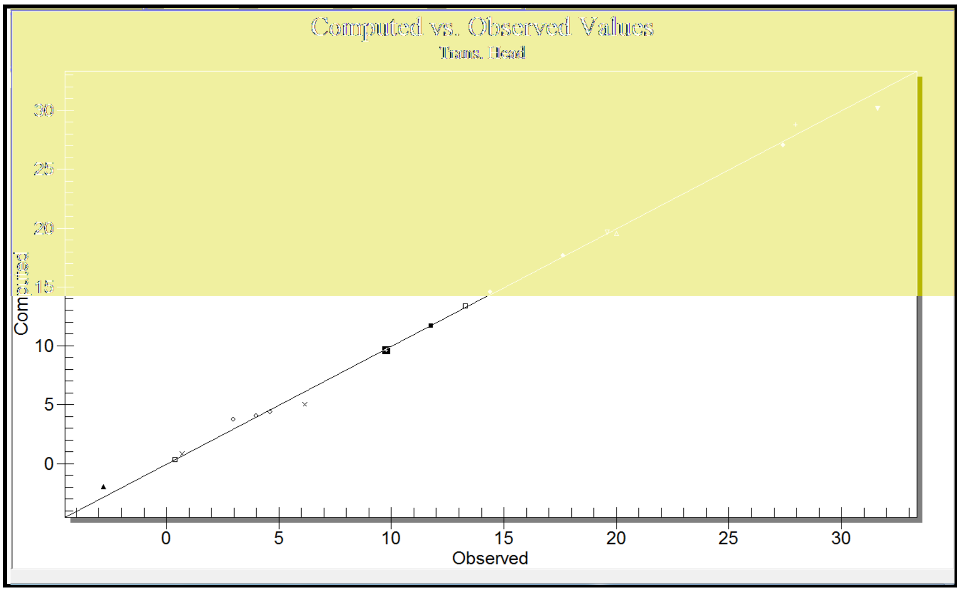
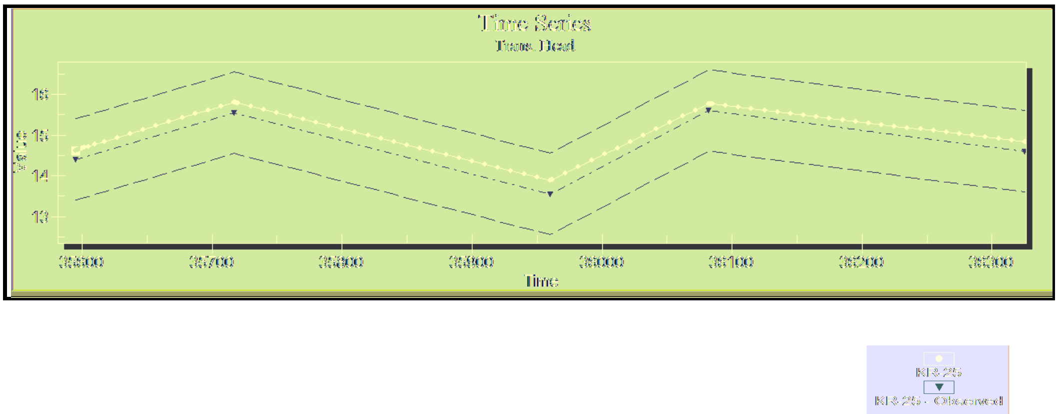


Figure 5.1 Comparisons of Computed and Observed Groundwater Heads (m) Under Calibration.

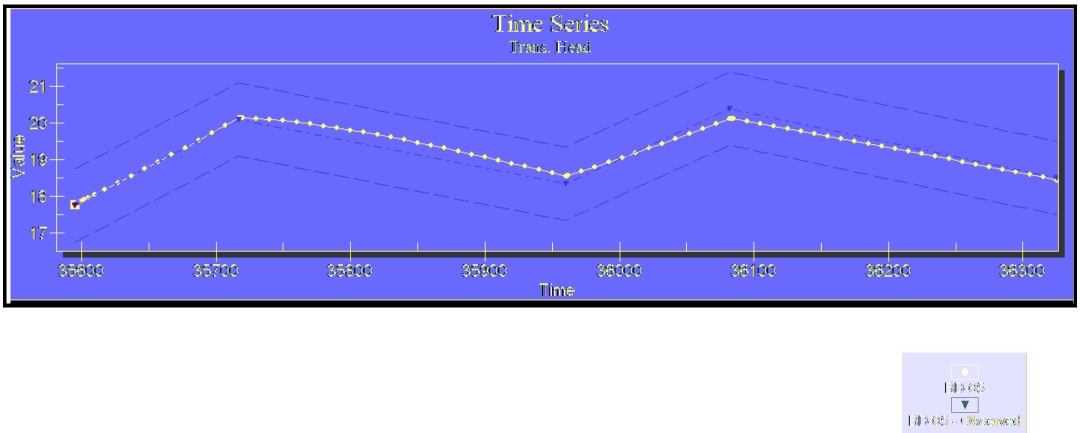
The figure 5.2 (a) and (b) show temporal variation of groundwater table elevation at wells KR- 25 and BD- 05 under calibration.

The mean error, mean absolute error and root mean squared error under calibration are as follows.

Calibration Criterion	Error in m
Mean Error (ME)	0.085
Mean Absolute Error (MAE)	1.137
Root Mean Squared (RMS) Error	1.472



(a)



(b)

Figure 5.2 Temporal Variation of Groundwater Table Elevation at Wells KR-25 and BD-05 Under Calibration.

5.2 Validation of Groundwater Model

The goal of validation is to demonstrate that the model is capable of simulating some historical hydrologic event for which field data are available. For example, one might attempt to simulate drawdown during pumping test or water level declines during a drought. Generally, some additional refinement of parameters will be necessary during validation (Wang, 1982)

Owing to uncertainties in the calibration, the set of parameter values used in the calibrated model may not accurately represent field values. Consequently, the calibrated parameters may not accurately represent the system under a different set of boundary conditions or hydrologic stresses. Model verification will help establish greater confidence in calibration (Anderson, 1992).

Once a model has been calibrated, it should be verified against an entirely independent set of data. Verification is carried out to confirm that a calibrated model and all the parameters contained therein, remains valid under different, but physically similar, conditions to those for which it was calibrated.

The calibrated model should be used to simulate the revised conditions and the results compared with the observations. This process will verify the acceptability of the model calibration. If there is poor agreement between the predicted groundwater levels and those in the verification data set the model should be re-calibrated. This re-calibration should not include the verification data. Once re-calibration has been completed a second verification exercise should be carried out (Wallingford, 1995).

5.2.1 Period of Validation Simulation

In present study, the calibrated Model was validated using the data of the period June2003 to June 2005(733 days).

5.2.2 Input Parameters for Validation

Condition- Transient

Porosity =30 %

Specific storage S_s =0.00001 m^{-1}

The specific yield of wells s_y for each zone given is as shown in table 4.2. Specific yield zones are shown in figure 4.13

River conductances given to the upper, middle and lower arc of river are 50, 60 and 20 per unit length respectively. It is as shown in section 4.11 of chapter 4.

Daily Mahi river water level's given to model for the period June2003 to June 2005(733 days) are as shown in Annexure 1 and graph 4.3 to 4.4. (Note: River water levels at Kavi/Sea is considered same as at Dhuvaran)

Starting heads given to the model (pre-monsoon 2003) is as shown in table 4.3 (Reduced Water Levels of wells).

Reduced water levels of wells for pre monsoon and post monsoon for validation period given to the model are as shown in table 4.3

Transient heads (head dependent flow) on boundary point’s pre monsoon and post monsoon for validation period given to the model are as shown in table 4.7

Taluka wise transient net recharges monsoon and non monsoon for the validation period given to the model are as shown in table 4.6 and the detail dates and time of Vadodara taluka is shown below (table5.5) and similarly recharges given to all talukas.

Taluka: Vadodara

Table 5.5 Detail Dates and Time for Net Recharge of Vadodara taluka for Validation

Sr. No.	**Date and time**	**Recharge rate in m/day**
1	6/14/2003 12:00:00 AM	-0.0004723
2	6/15/2003 12:00:00 AM	0.001638
3	10/14/2003 12:00:00 AM	0.001638
4	10/15/2003 12:00:00 AM	-0.0004723
5	6/14/2004 12:00:00 AM	-0.0004723
6	6/15/2004 12:00:00 AM	0.0011575
7	10/14/2004 12:00:00 AM	0.0011575
8	10/15/2004 12:00:00 AM	-0.0005296
9	6/14/2005 12:00:00 AM	-0.0005296

Times And Time Steps for the Stress Periods (For Validation), time steps and stress periods in validation given to model are as shown in table 5.6.

The computed horizontal permeability Hk of wells for each zone in unconfined aquifer from calibration of model given to model are as shown in table 5.4 and horizontal permeability zones are shown in figure 4.13

5.2.3 Setting up the Stress Periods

The times and time steps for the stress periods used in validation is shown in the table 5. 6 The number of stress periods used is18.

Table 5.6 Times and Time Steps for the Stress Periods (For Validation)

Stress periods	Start(date and time)	Time step(days)	Num. of time steps	Total days
1	6/13/2003 12:00:00 AM	1	1	1
2	6/14/2003 12:00:00 AM	1	1	1
3	6/15/2003 12:00:00 AM	1	4	4
4	6/19/2003 12:00:00 AM	2	1	2
5	6/21/2003 12:00:00 AM	3	1	3
6	6/24/2003 12:00:00 AM	5	1	5
7	6/29/2003 12:00:00 AM	7	1	7
8	7/6/2003 12:00:00 AM	10	1	10
9	7/16/2003 12:00:00 AM	10	9	90
10	10/14/2003 12:00:00 AM	1	1	1
11	10/15/2003 12:00:00 AM	1	2	2
12	10/17/2003 12:00:00 AM	10.042	24	241
13	6/14/2004 12:00:00 AM	1	1	1
14	6/15/2004 12:00:00 AM	1	1	1
15	6/16/2004 12:00:00 AM	10	12	120
16	10/14/2004 12:00:00 AM	1	1	1
17	10/15/2004 12:00:00 AM	1	2	2
18	10/17/2004 12:00:00 AM	10	24	240
End	6/14/2005 12:00:00 AM	1	1	1
	Total			733

5.2.4 Results of Validation

With the above data as input, the model was run forward in MODFLOW to validate in transient condition. The figure 5.3 indicates that there is a very good match between the computed and observed heads in most of wells of the study area under validation.

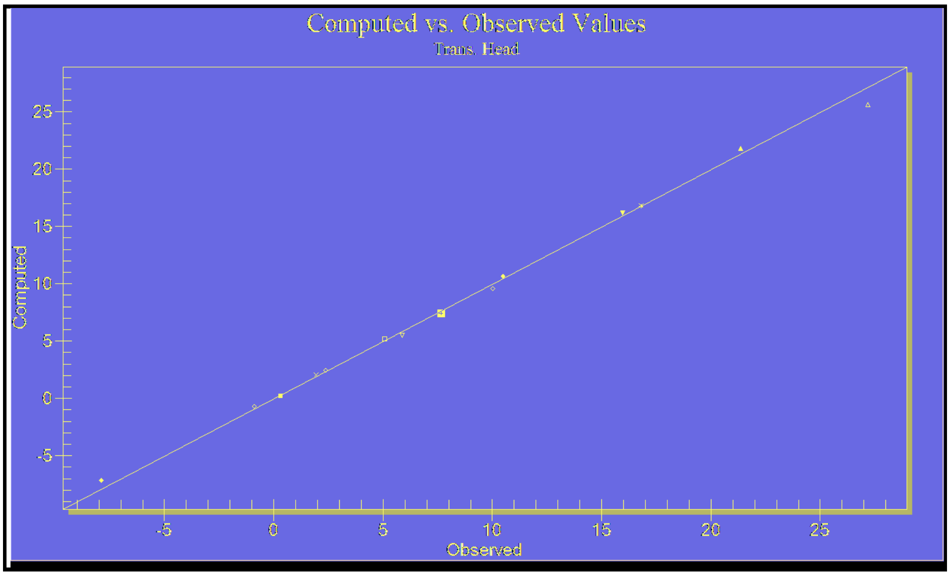
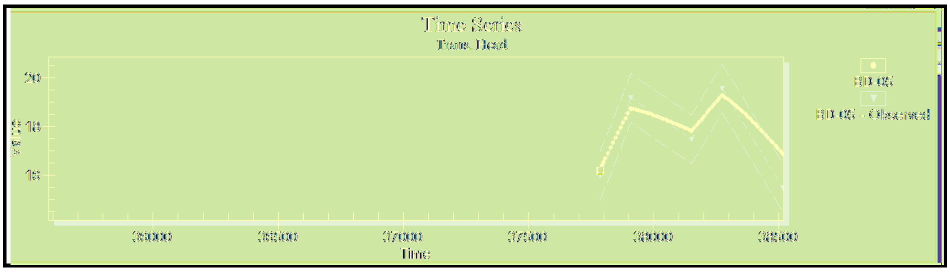


Figure 5.3 Comparison of computed and observed groundwater heads (m) under validation.

The figure 5.4 (a) and (b) show temporal variation of groundwater table elevation at wells KR-25 and BD-05 under validation.

(a)



(b)

Figure 5.4 Temporal variation of groundwater table elevation at wells KR-25 and BD-05 under validation.

5.3 Predictive Groundwater Modeling

Groundwater models are usually prepared for two reasons, firstly to assist in developing an understanding of the groundwater system and secondly to predict the future behavior of the aquifer system under changed conditions (Rushton, 2003).

In a predictive simulation, the parameters determined during calibration and verification is used to predict the response of the system to future events. Once a calibration of a model is satisfactory, the model can be used for predictive simulation (Anderson, 1992).

Some environmental problems require predicting the system response many years. An important task in predictive modeling is to determine the length of time for which the model will accurately predict the future. The modeler must consider the extent to which the model has been validated.

Faust et al. 1981, Suggest that a predictive simulation not to be extended into the future more than twice the period for which calibration data are available, but this may not be possible if regulations require longer simulations.

Predictive simulation provides the information regarding response of the aquifer to a variety of scenarios of possible management options such as effects of number, location and spacing of wells, rates of pumping and artificial recharge, and rate of movement of leachate from hazardous wastes dumps, sanitary landfills and other sources of pollution etc. (Sarma, 2008). The outputs provide the appropriate basis for the decision making process for the optimal management of the aquifer on a sustainable basis. This process obviates the need for expensive and long term field studies and experiments.

The reliability of the predictive simulation is based on the conceptual model, information and reliability of the inputs, the parameters of the model accuracy of calibration and a clear understanding of the assumptions and limitations of the model. The confidence to be placed in model predictions depends largely on the results of the calibration, sensitivity analysis and verification tests.

Uncertainty in a predictive simulation arises from uncertainty in the calibrated model and inability to estimate accurate values for the magnitude and timing of future stresses. Two major pitfalls are involved in making predictions uncertainty in the calibrated model and uncertainty about future hydrologic stresses. Each of these requires a different type of sensitivity analysis.

It should be kept in mind that calibration of a model is done with respect to a set of observations of field data and conditions prevailing in the field. There may be changes in the conditions during the simulation. Hence use of models for predictive simulation must be done with caution and clear understanding of the conditions under calibration and simulation.

Even though the set of calibrated parameters may give close agreement during calibration and verification the model may not accurately reflect system behavior when the model is stressed in some new way. Furthermore, many predictive simulations require guesses the likelihood and magnitude of future hydrologic or human-regulated events such as future recharge events or pumping rates. Because such information is known only with uncertainty, new errors are introduced into the simulation.

Even with a well calibrated model, if the prediction is based on inadequate data and over simplifications, errors and uncertainties occur in the model predictions. Other type of the error associated with numerical model is data errors. Data errors are the result of inadequate or incorrect data being used in the model study. Data errors are difficult to assess since true description of the aquifer is never known. Unreliable predictions have also occurred due to the failure to use appropriate values for assumed future stresses. Predictive simulations should be planned and assessed by a group of people with a range of expertise to ensure that the best estimates of future stresses are included.

5.3.1 Period of Predictive Simulation

In present study, the validated Model was used for predictive groundwater modeling to study the impacts of existing and future weir on artificial groundwater recharge for the period June 2005 to June 2007(732 days).

5.3.2 Operational Runs

It is required to know the future behavior of the groundwater system in response to the applied hydrologic stresses. When the research was initiated there was a proposal to build a weir near Sindhrot. Sindhrot weir near Sindhrot village was constructed in the year 2007.The people on the downstream demand another weir to be constructed at Badalpur.

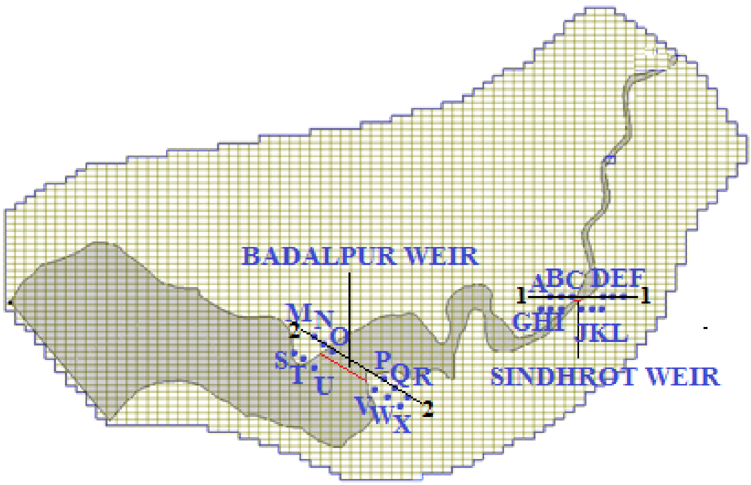
So here following three scenarios are conducted to study the impacts of existing and future weir on artificial groundwater recharge in the Mahi estuarine area.

Scenario A-Without Weir

Scenario B-With Sindhrot Weir

Scenario C-With Sindhrot and Badalpur Weir

Weir is represented in model by giving very low permeability of aquifer ($1*10^{-6}$ m/day) along the weir location. The top elevation of weir is given as RL 8.5 m considering high tide level as RL 6.95 m at weir location. The full reservoir level is kept as 8.0 m by giving river stage data input in the upstream of weir. The Sindhrot weir is having length about 540 m, average river bed RL is 6 m and deepest river bed RL is 3.51. The Badalpur weir is about 41.66 km downstream of Sindhrot weir. The Badalpur weir is having more length about 7 km, average river bed RL is 3.5 m and deepest river bed RL 0.97. The locations of imaginary observation wells for Sindhrot and Badalpur weir are shown in figure 5.5



A,B,C,D,E,F,G,H,I,J,K,L,O,P,Q,R,S,T,U,V,W and X are Imaginary Observation Wells.

Figure 5.5 Locations of Imaginary Observation Wells for Sindhrot and Badalpur Weir

5.3.3 Input Parameters for Predictive Simulation

Condition- Transient

Porosity =30 %

Specific storage S_s =0.00001 m^{-1}

The specific yield of wells s_y for each zone given is as shown in table 4.2 and specific Yield zones are shown in figure 4.13

River conductances given to the upper, middle and lower arc of river are 50, 60 and 20 per unit length respectively. It is as shown in section 4.11 of chapter 4.

Daily Mahi river water level's given to model for the period June 2005 to June 2007(732 days) are as shown in Annexure 1 and graph 4.5 to 4.6. (Note: River water levels at Kavi/Sea is considered same as at Dhuvaran)

Stating heads given to the model (pre-monsoon 2005) is as shown in table 4.3 (Reduced Water Levels of wells).

Transient heads (head dependent flow) on boundary point's pre monsoon and post monsoon for Predictive Simulations period given to the model are as shown in table 4.7

Taluka wise transient net recharges monsoon and non monsoon for the Predictive Simulations period given to the model are as shown in table 4.6 and the detail dates and time of Vadodara taluka is shown below (table5.7) and similarly recharges given to all talukas.

Taluka: Vadodara

Table 5.7 Detail Dates and Time for Net Recharge of Vadodara Taluka for Predictive Simulation

Sr. No.	Date and time	Recharge rate in m/day
1	6/14/2005 12:00:00 AM	-0.0005870
2	6/15/2005 12:00:00 AM	0.0016081
3	10/14/2005 12:00:00 AM	0.0016081
4	10/15/2005 12:00:00 AM	-0.0005870
5	6/14/2006 12:00:00 AM	-0.0005870
6	6/15/2006 12:00:00 AM	0.0013517
7	10/14/2006 12:00:00 AM	0.0013517
8	10/15/2006 12:00:00 AM	-0.0006444
9	6/14/2007 12:00:00 AM	-0.0006444

Times and Time Steps for the Stress Periods (For Predictive Simulations), time steps and stress periods in validation given to model are as shown in table 5.8

The computed horizontal permeability Hk of wells for each zone in unconfined aquifer from calibration of model given to model are as shown in table 5.4 and horizontal permeability zones are shown in figure 4.13

5.3.4 The Stress Periods

The times and time steps for the stress periods used in Predictive simulations is shown in the table 5.8. The number of stress periods used is18.

Table 5.8 Times and Time Steps for the Stress Periods (For Predictive Simulations)

Stress periods	Start(date and time)	Time step(days)	Num. of time steps	Total days
1	6/13/2005 12:00:00 AM	1	1	1
2	6/14/2005 12:00:00 AM	1	1	1
3	6/15/2005 12:00:00 AM	1	4	4
4	6/19/2005 12:00:00 AM	2	1	2
5	6/21/2005 12:00:00 AM	3	1	3
6	6/24/2005 12:00:00 AM	5	1	5
7	6/29/2005 12:00:00 AM	7	1	7
8	7/6/2005 12:00:00 AM	10	1	10
9	7/16/2005 12:00:00 AM	10	9	90
10	10/14/2005 12:00:00 AM	1	1	1
11	10/15/2005 12:00:00 AM	1	2	2
12	10/17/2005 12:00:00 AM	10	24	240
13	6/14/2006 12:00:00 AM	1	1	1
14	6/15/2006 12:00:00 AM	1	1	1
15	6/16/2006 12:00:00 AM	10	12	120
16	10/14/2006 12:00:00 AM	1	1	1
17	10/15/2006 12:00:00 AM	1	2	2
18	10/17/2006 12:00:00 AM	10	24	240
End	6/14/2007 12:00:00 AM	1	1	1
	Total			732

5.3.5 Results of Prediction Scenarios

With the above data as input, the model was run forward in MODFLOW for all the above three scenarios and results obtained are analyzed. The RWL of water table at different locations for respective scenarios are shown in table 5.9. To study the artificial recharge scenario, nature of water mound development graphs for Sindhrot weir and Badalpur weir on different dates are plotted. They are shown in figures 5.6 to 5.15. To study the effect at same point time series curves are plotted at A, B, C, D, E, F, M, N, O, P,Q and R surrounding locations of weirs. They are shown in figures 5.16 to 5.27.

Based on this predicted water table conditions of groundwater model operation under Scenario A-Without Weir, Scenario B-With Sindhrot Weir and Scenario C-With Sindhrot and Badalpur Weir, the water table contours (meters), post-monsoon and pre-monsoon respectively for years 2006 - 2007 are shown in Figures 5.28 to 5.33.

Table 5.9 RWL of Water Table in m at Different Locations

(From Predictive Simulations)

Location /Date	14/6/2005			15/10/2005			16/6/2006		
	Without Weir	With Sindhrot Weir	With Sindhrot & Badalpur weir	Without Weir	With Sindhrot Weir	With Sindhrot & Badalpur weir	Without Weir	With Sindhrot Weir	With Sindhrot & Badalpur weir
A	3.11	3.12	3.13	4.83	4.93	4.94	4.4	4.8	4.8
B	2.94	2.94	2.96	4.79	5.03	5.05	4.47	4.89	4.9
C	2.83	2.83	2.85	4.95	5.48	5.48	4.7	5.4	5.35
D	2.66	2.64	2.65	5.13	5.5	5.49	4.43	5.2	5.18
E	2.67	2.66	2.66	4.91	5	4.99	4.18	4.45	4.47
F	2.95	2.94	2.95	5.19	5.22	5.2	4.57	4.7	4.67
M	2.19		2.21	2.6		3.31	2.08		2.6
N	2.04		2.06	2.32		3	1.92		2.55
O	1.97		2	2.46		3.1	2.23		2.8
P	1.32		1.37	1.82		2.77	1.58		2.2
Q	1.33		1.39	1.63		2.35	1.23		1.85
R	1.4		1.47	1.95		2.6	1.4		1.92

Location /Date	16/10/2006			15/6/2007		
	Without Weir	With Sindhrot Weir	With Sindhrot & Badalpur weir	Without Weir	With Sindhrot Weir	With Sindhrot & Badalpur weir
A	5.6	6.1	6.12	5	5.74	5.77
B	5.7	6.52	6.47	5.07	6.13	6.12
C	5.92	7.11	6.9	5.2	6.6	6.53
D	5.87	6.93	6.66	4.65	5.77	5.69
E	5.64	6.1	6.02	4.74	5.34	5.27
F	6.1	6.28	6.25	5.22	5.71	5.67
M	2.45		2.9	1.88		2.35
N	2.3		3.15	1.89		2.85
O	2.75		3.4	2.4		3.15
P	2		2.65	1.65		2.35
Q	1.66		2.75	1.25		2.2
R	2		3.1	1.5		2.75

Location /Date	14/6/2005			15/10/2005			16/6/2006		
	Without Weir	With Sindhrot Weir	With Sindhrot & Badalpur weir	Without Weir	With Sindhrot Weir	With Sindhrot & Badalpur weir	Without Weir	With Sindhrot Weir	With Sindhrot & Badalpur weir
G	3.19	3.21	3.22	4.76	4.81	4.82	4.24	4.48	4.57
H	2.97	2.99	3	4.65	4.8	4.84	4.28	4.7	4.72
I	2.79	2.81	2.81	5	5.69	5.84	4.6	5.28	5.43
J	2.41	2.4	2.39	4.75	5.4	5.45	4.15	5	5.1
K	2.305	2.3	2.29	4.69	4.9	4.93	4.1	4.67	4.67
L	2.23	2.23	2.22	4.38	4.45	4.48	4.01	4.26	4.25
S	1.75		1.74	2.4		3.1	1.9		2.42
T	1.5		1.45	2.11		2.8	1.7		2.3
U	1.36		1.32	2.08		2.78	1.82		2.45
V	1.2		1.21	1.7		2.6	1.5		2.15
W	1.31		1.35	1.6		2.3	1.2		1.8
X	1.38		1.4	1.9		2.5	1.35		1.85

Location /Date	16/10/2006			15/6/2007		
	Without Weir	With Sindhrot Weir	With Sindhrot & Badalpur weir	Without Weir	With Sindhrot Weir	With Sindhrot & Badalpur weir
G	5.35	5.71	5.82	4.76	5.35	5.52
H	5.41	6.12	6.2	4.82	5.78	5.93
I	5.8	7.1	7.2	5.05	6.5	6.7
J	5.5	6.7	6.58	4.6	5.5	5.47
K	5.4	6	5.9	4.33	5.03	4.96
L	5.9	6.31	6.22	4.29	4.85	4.78
S	2.3		2.7	1.74		2.25
T	2.1		2.95	1.75		2.7
U	2.32		3	1.98		2.8
V	2		2.55	1.6		2.3
W	1.6		2.35	1.2		2.1
X	1.9		3	1.4		2.6

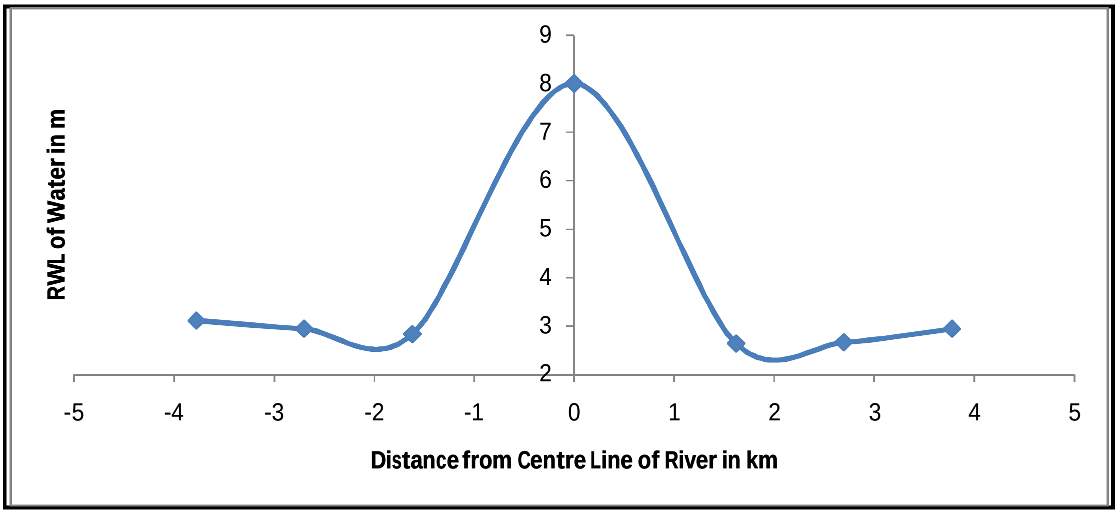


Figure 5.6 Water Mound Development for Sindhrot Weir at Section 1-1 on Date 14/6/2005

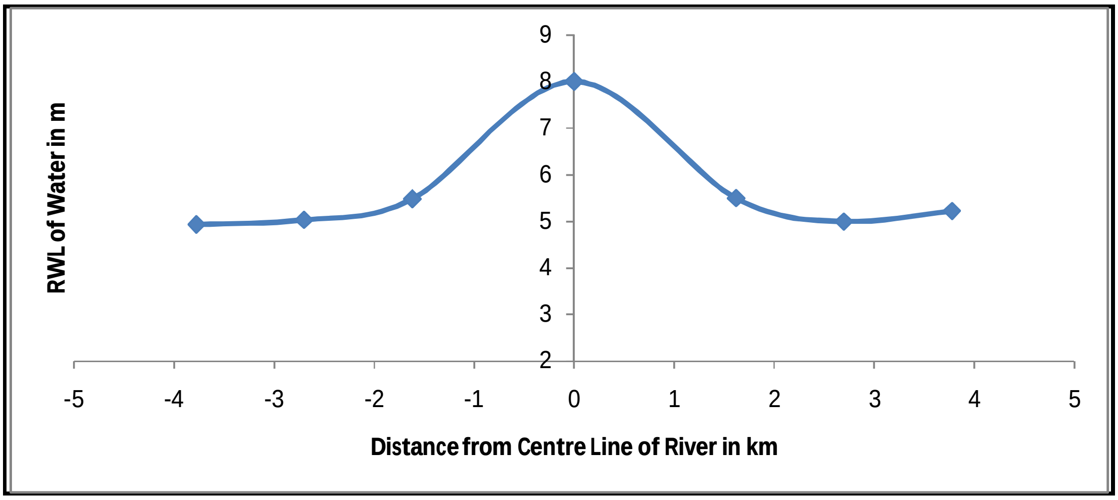


Figure 5.7 Water Mound Development for Sindhrot Weir at Section 1-1 on Date 15/10/2005

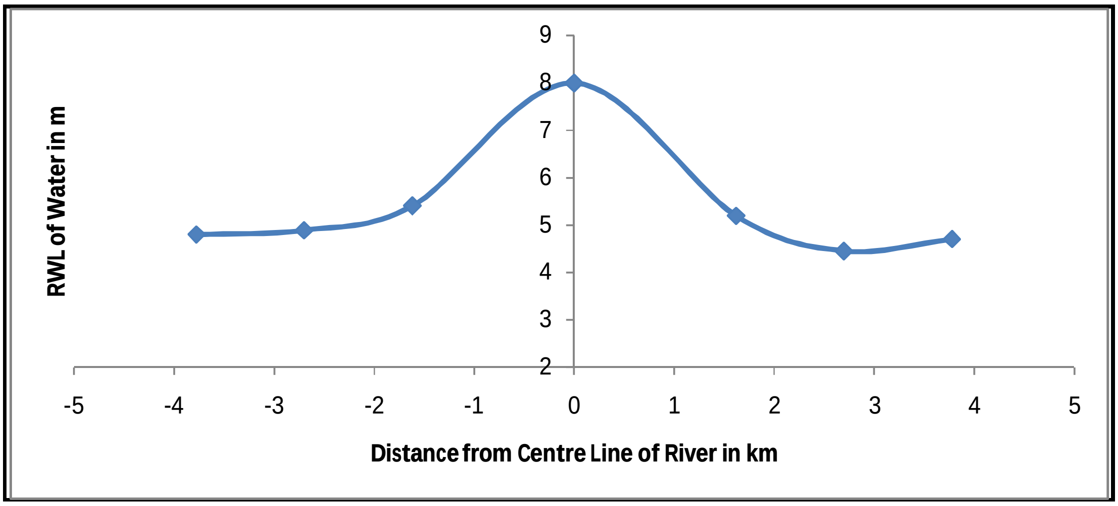


Figure 5.8 Water Mound Development for Sindhrot Weir at Section 1-1 on Date 16/6/2006

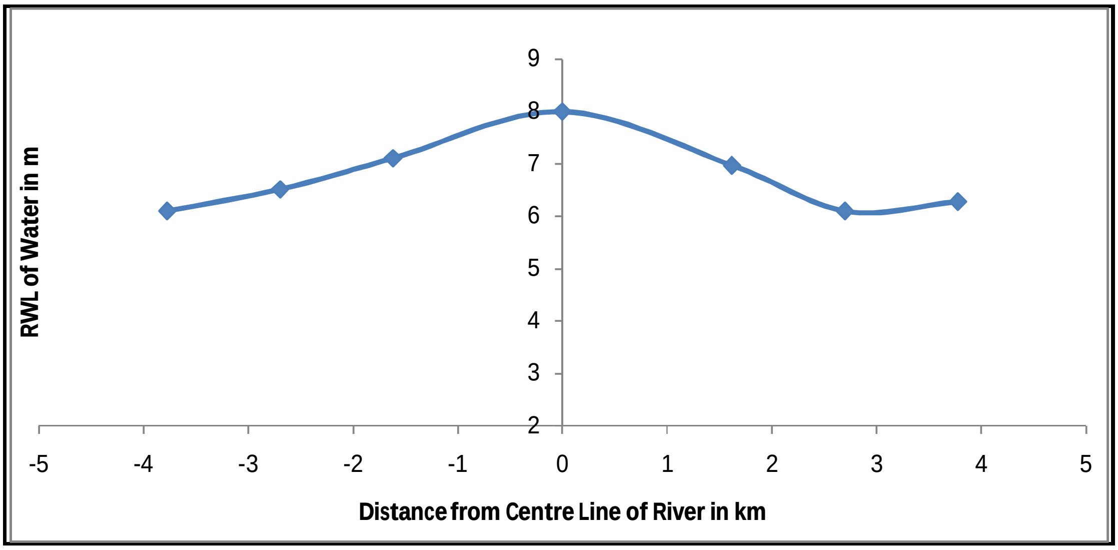


Figure 5.9 Water Mound Development for Sindhrot Weir at Section 1-1 on Date 16/10/2006

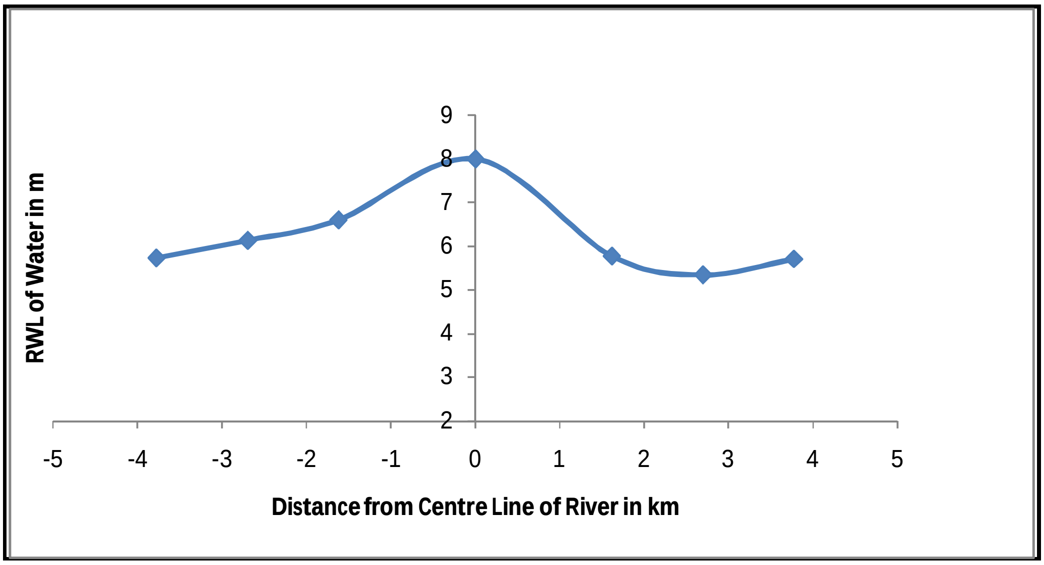


Figure 5.10 Water Mound Development for Sindhrot Weir at Section 1-1 on Date 15/6/2007

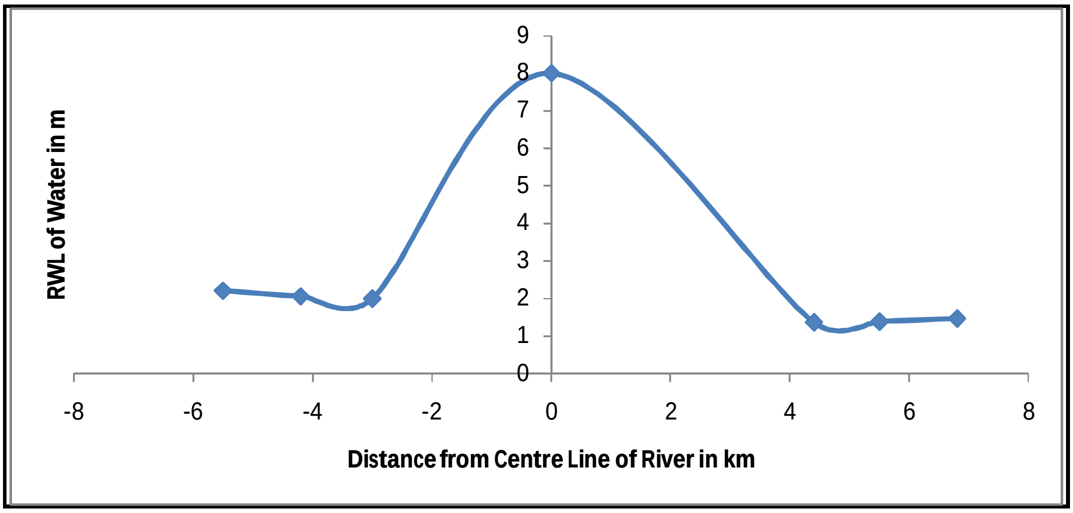


Figure 5.11 Water Mound Development for Badalpur Weir at Section 2-2 on Date 14/6/2005

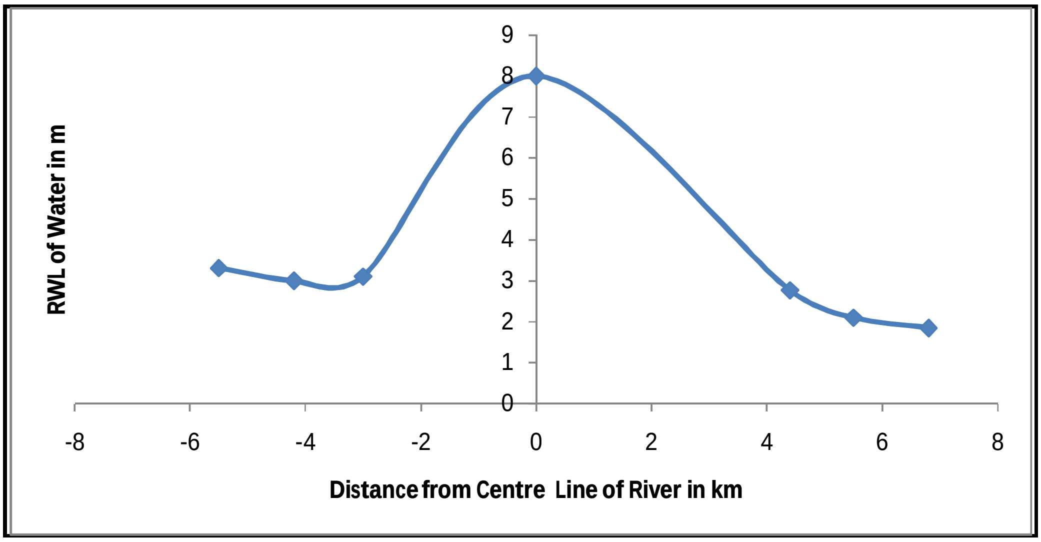


Figure 5.12 Water Mound Development for Badalpur Weir at Section 2-2 on Date 15/10/2005

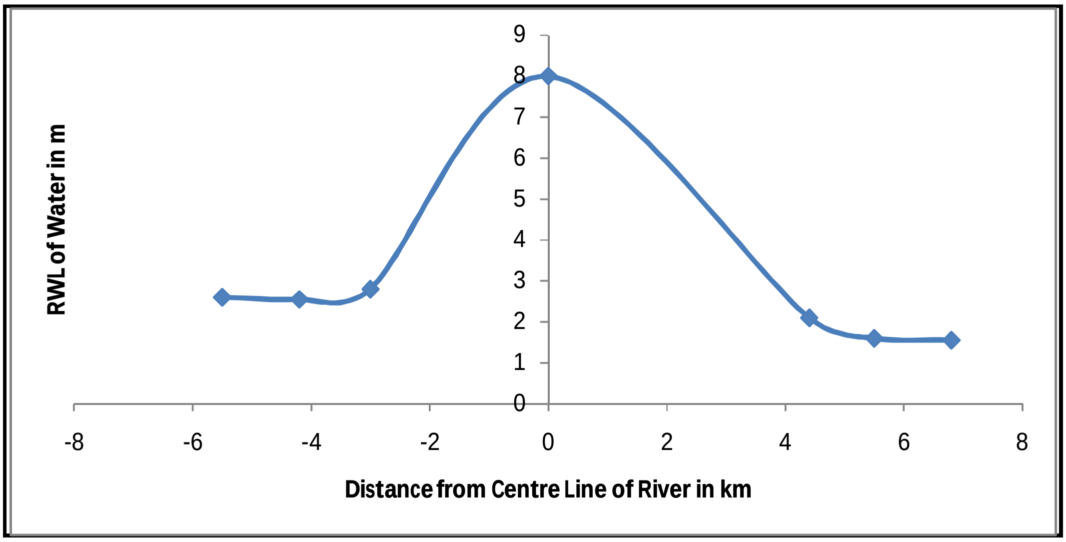


Figure 5.13 Water Mound Development for Badalpur Weir at Section 2-2 on Date 16/6/2006

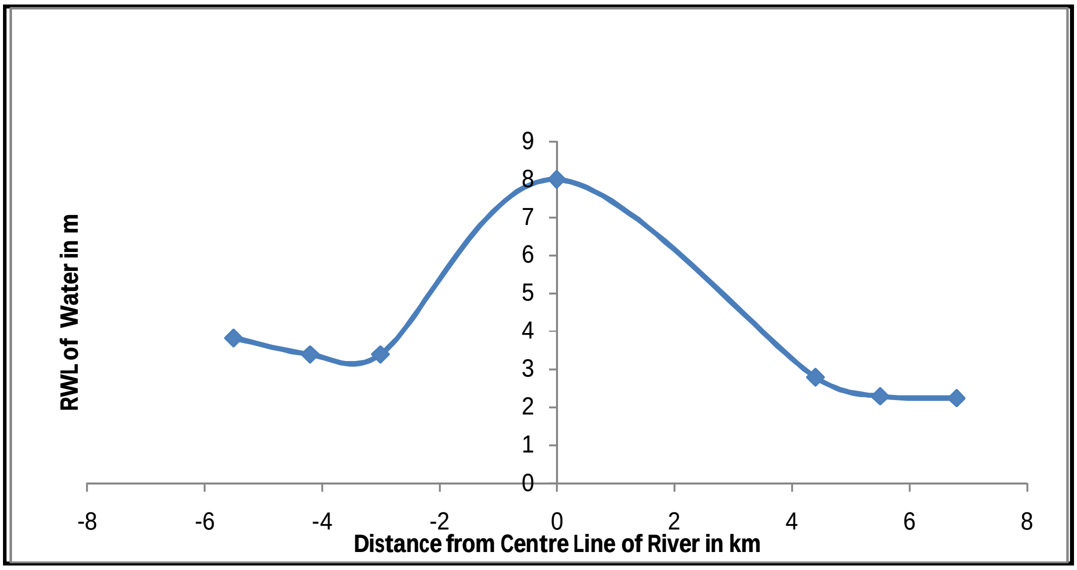


Figure 5.14 Water Mound Development for Badalpur Weir at Section 2-2 on Date 16/10/2006

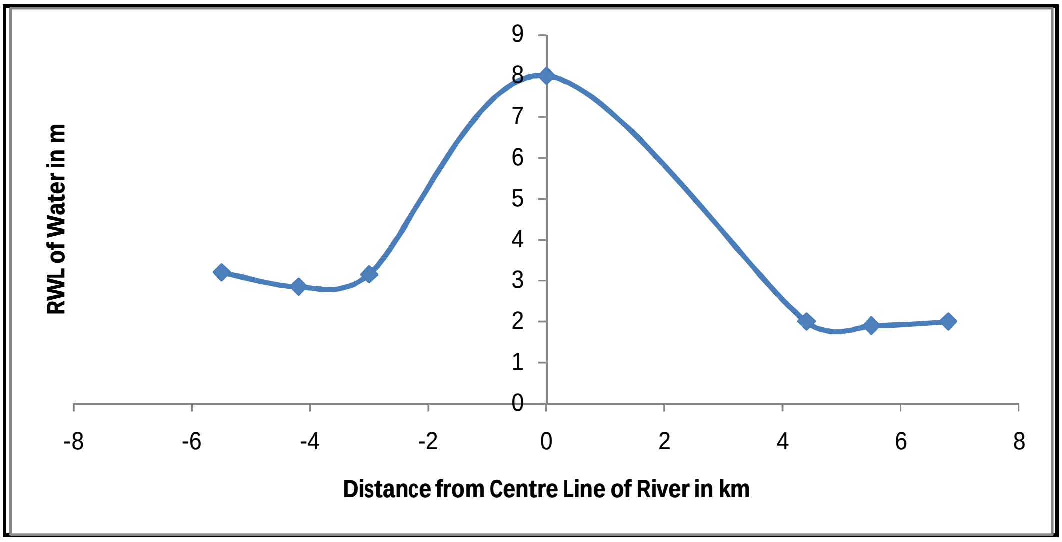


Figure 5.15 Water Mound Development for Badalpur Weir at Section 2-2 on Date 15/6/2007

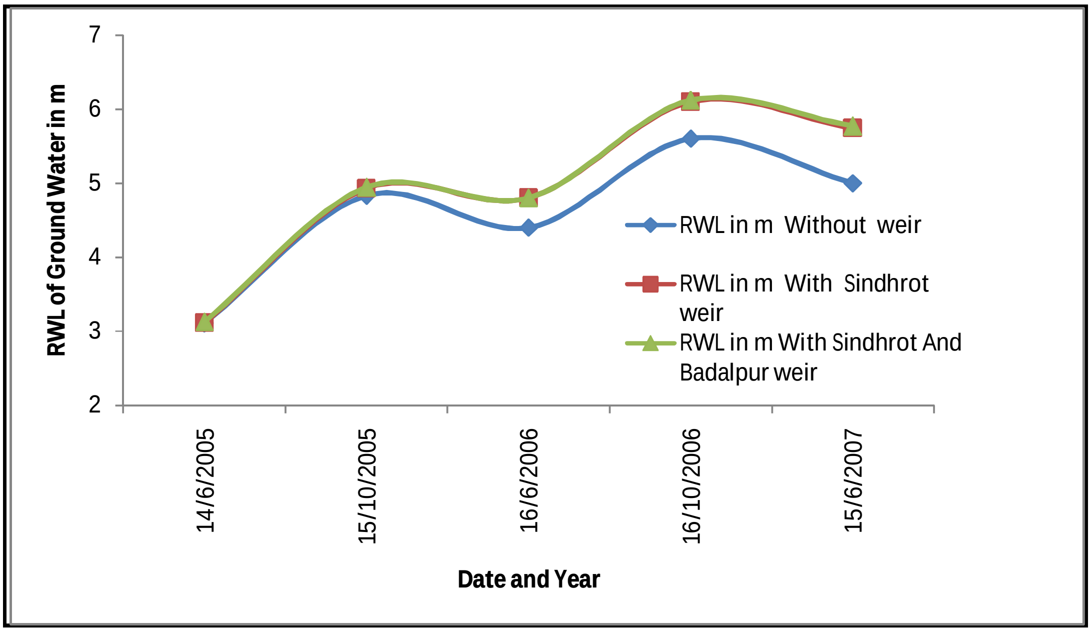


Figure 5.16 Temporal variation of groundwater table elevation at well A under predictive simulation

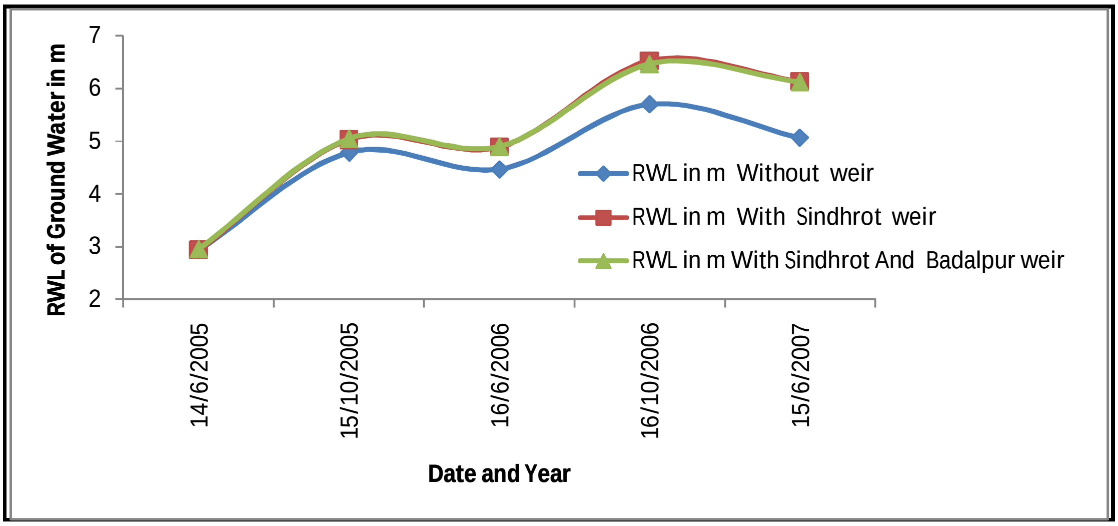


Figure 5.17 Temporal variation of groundwater table elevation at well B under predictive simulation

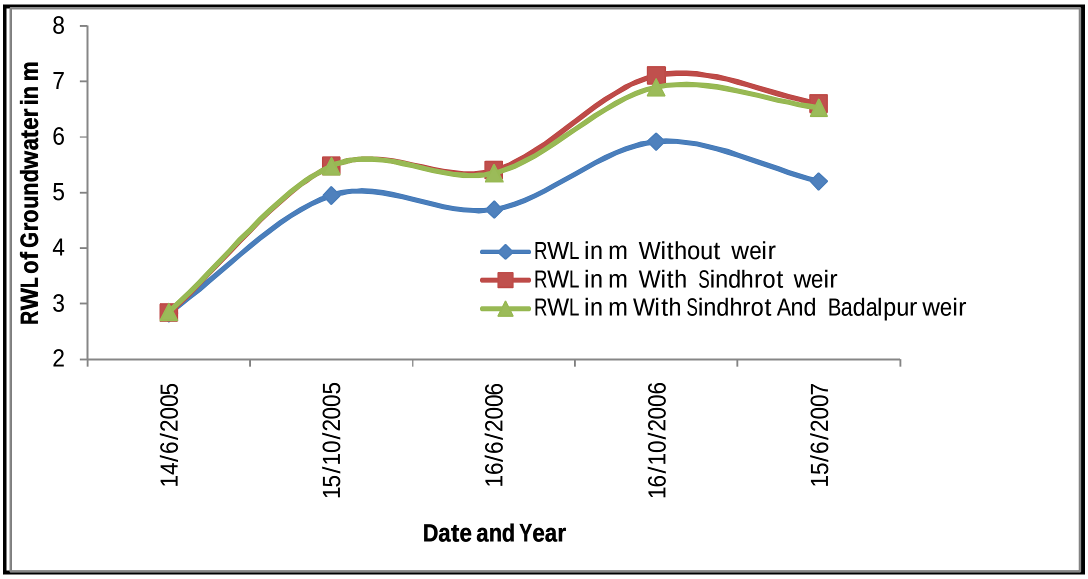


Figure 5.18 Temporal variation of groundwater table elevation at well C under predictive simulation

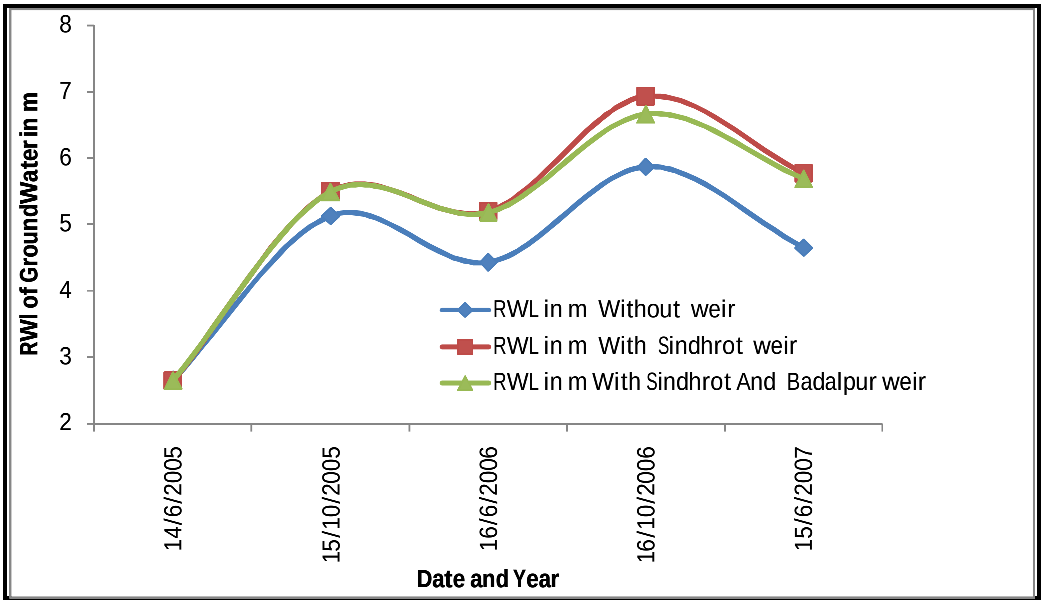


Figure 5.19 Temporal variation of groundwater table elevation at well D under predictive simulation

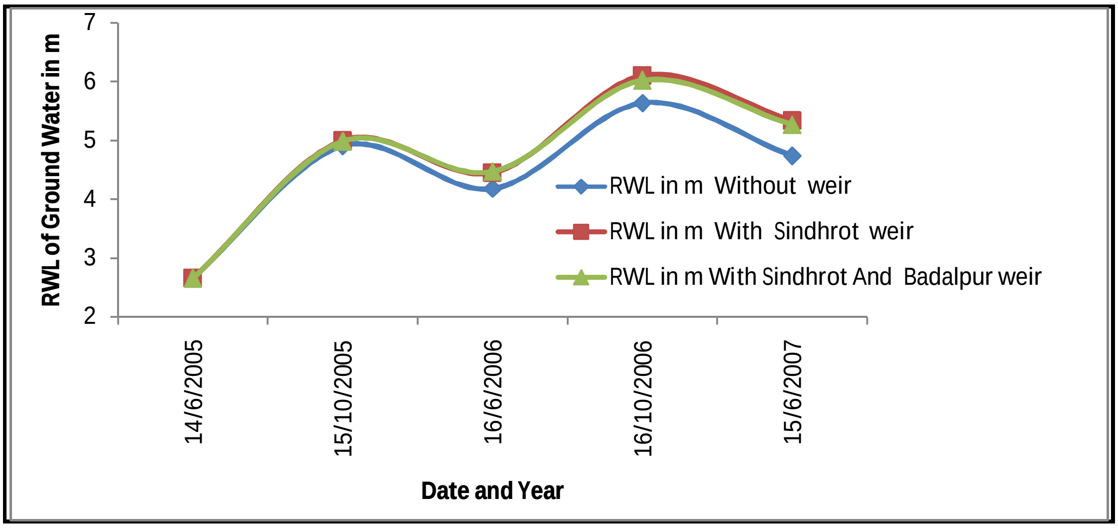


Figure 5.20 Temporal variation of groundwater table elevation at well E under predictive simulation

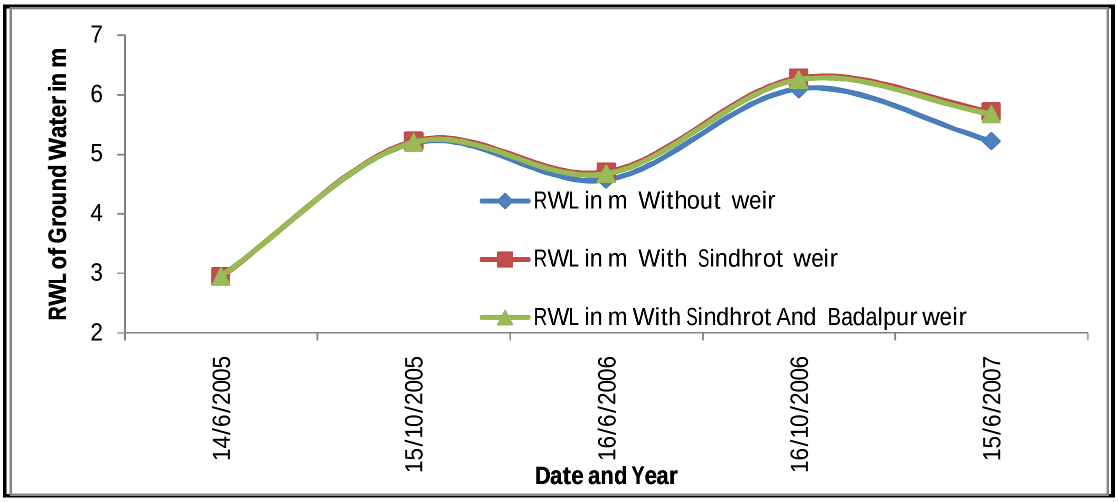


Figure 5.21 Temporal variation of groundwater table elevation at well F under predictive simulation

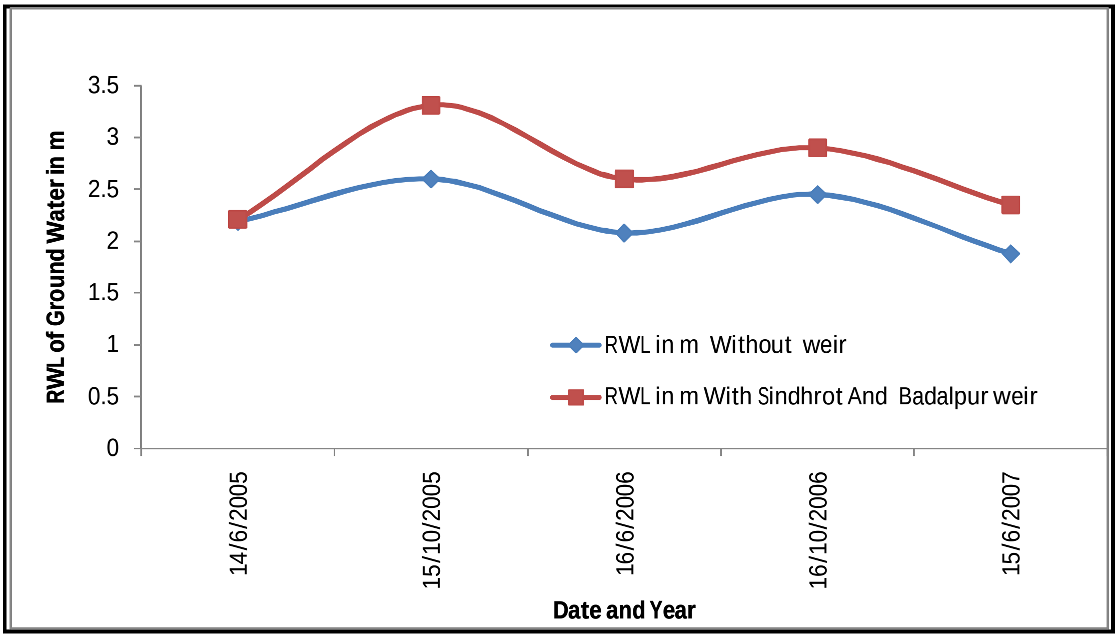


Figure 5.22 Temporal variation of groundwater table elevation at well M under predictive simulation

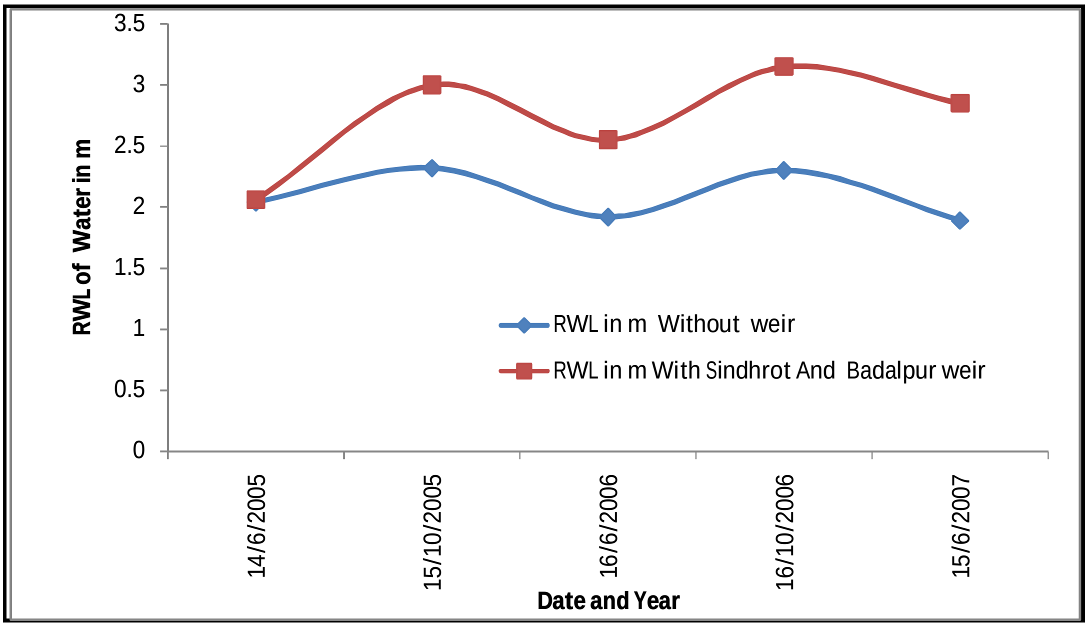


Figure 5.23 Temporal variation of groundwater table elevation at well N under predictive simulation

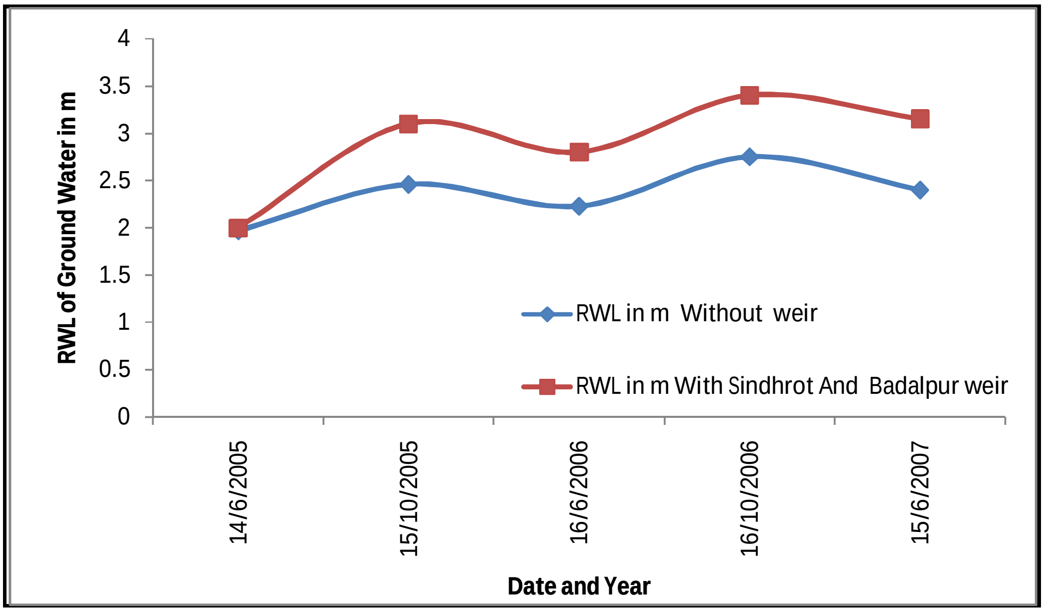


Figure 5.24 Temporal variation of groundwater table elevation at well O under predictive simulation

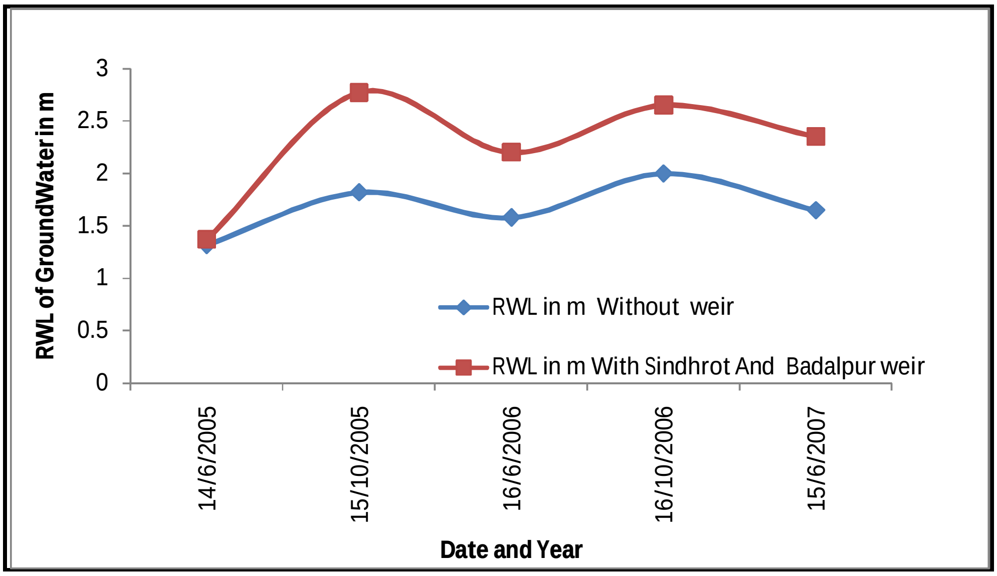


Figure 5.25 Temporal variation of groundwater table elevation at well P under predictive simulation

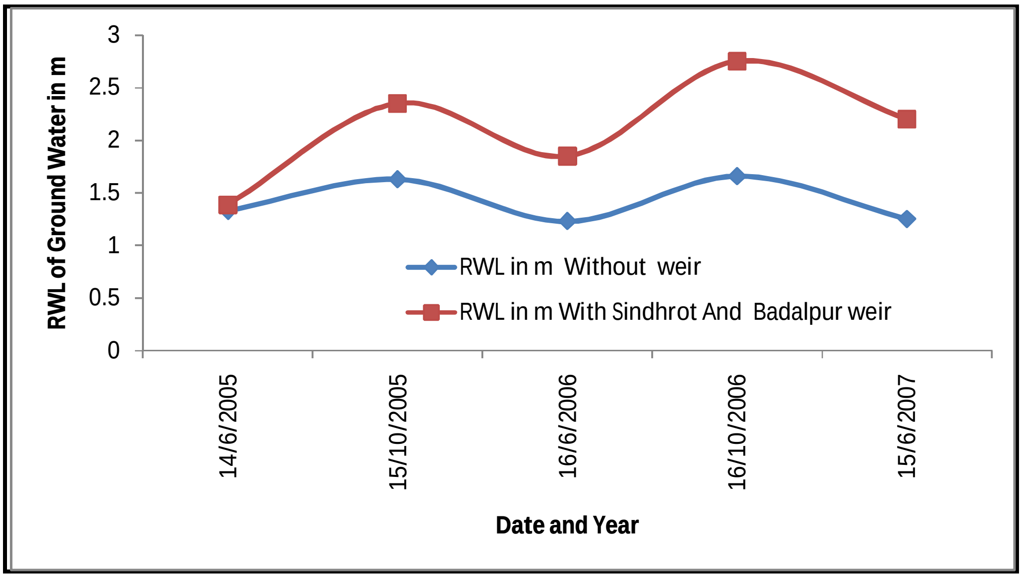


Figure 5.26 Temporal variation of groundwater table elevation at well Q under predictive simulation

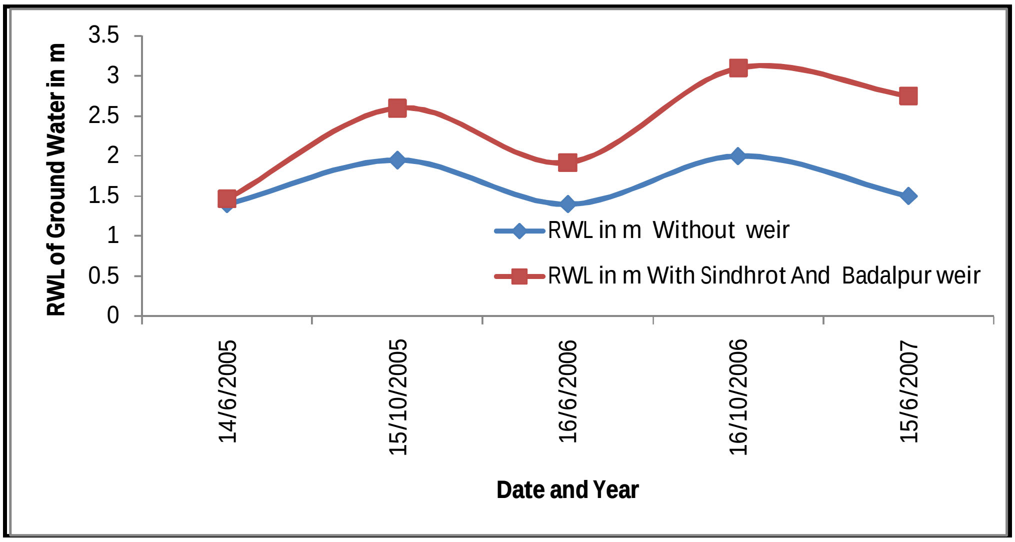


Figure 5.27 Temporal variation of groundwater table elevation at well R under predictive simulation

Pre-monsoon and post-monsoon water mound nature is studied. Comparing the groundwater mound for various dates for pre-monsoon and post-monsoon conditions with Sindhrot weir at section 1-1, following observations are made.

1. The rise of 1.81, 2.09, 2.65, 2.86, 2.34 and 2.28 m for locations A, B, C, D, E, and F respectively was observed in Reduced Level of groundwater table from 14/06/2005 to 15/10/2005 due to recharge from rainfall and ponded water on upstream of Sindhrot weir (Fig.5.6 and 5.7).
2. The rise of 1.68, 1.91, 2.57, 2.56, 1.79 and 1.76 m for locations A, B, C, D, E, and F respectively was observed in Reduced Level of groundwater table from 14/06/2005 to 16/06/2006 due to recharge from ponded water on upstream of Sindhrot weir (Fig. 5.6 and 5.8). The rise is less compared to rise on 15/10/2005 due to no rainfall recharge and more pumping in pre-monsoon season.
3. The rise of 2.98, 3.58,4.28,4.29, 3.44 and 3.34 m for locations A, B, C, D, E, and F respectively was observed in Reduced Level of groundwater table from 14/06/2005 to 16/10/2006 due to recharge from rainfall and ponded water on upstream of Sindhrot weir (Fig.5.6 and 5.9). The rise is more compared to rise on 15/10/2005 due to accumulated effect of recharge.
4. The rise of 2.62, 3.19, 3.77, 3.13, 2.68 and 2.77 m for locations A, B, C, D, E, and F respectively was observed in Reduced Level of groundwater table from 14/06/2005 to 15/06/2007 due to recharge from ponded water on upstream of Sindhrot weir (Fig. 5.6 and 5.10). The rise is less compared to rise on 16/10/2006 due to no rainfall recharge and more pumping in pre-monsoon season.

Comparing the groundwater mound for various dates for pre-monsoon and post-monsoon conditions with Badalpur weir at section 2-2, following observations are made.

1. The rise of 1.1, 0.94, 1.1, 1.4, 0.96 and 1.13 m for locations M, N, O, P, Q and R respectively was observed in Reduced Level of groundwater table from 14/06/2005 to 15/10/2005 due to recharge from rainfall and ponded water on upstream of Badalpur weir (Fig.5.11 and 5.12).
2. The rise of 0.39, 0.49, 0.80, 0.83, 0.46 and 0.45 m for locations M, N, O, P, Q and R respectively was observed in Reduced Level of groundwater table from 14/06/2005 to 16/06/2006 due to recharge from ponded water on upstream of

Badalpur weir (Fig. 5.11 and 5.13). The rise is less compared to rise on 15/10/2005 due to no rainfall recharge and more pumping in pre-monsoon season.

3. The rise of 0.69, 1.09, 1.4, 1.28,1.36 and 1.63 m for locations M, N, O, P, Q and R respectively was observed in Reduced Level of groundwater table from 14/06/2005 to 16/10/2006 due to recharge from rainfall and ponded water on upstream of Badalpur weir (Fig.5.11 and 5.14). The rise is more compared to rise on 15/10/2005 due to accumulated effect of recharge.
4. The rise of 0.14, 0.79, 1.15, 0.98, 0.81 and 1.28 m for locations M, N, O, P, Q and R respectively was observed in Reduced Level of groundwater table from 14/06/2005 to 15/06/2007 due to recharge from ponded water on upstream of Badalpur weir (Fig. 5.11 and 5.15). The rise is less compared to rise on 16/10/2006 due to no rainfall recharge and more pumping in pre-monsoon season.
5. The unsymmetrical behavior in the groundwater mounds along the centre line of river is reflected in Figures 5.11 to 5.15 because on right hand side irrigation return flow is adding into the groundwater in MRBC area where as in left hand side irrigation is done by groundwater pumping.

From figure 5.16 to 5.21 of temporal variation of groundwater table at locations A, B, C, D, E, and F on upstream side of Sindhrot weir it was found that the Reduced Water Levels are higher with Sindhrot weir compared to without weir. The effect of the Badalpur weir on the Reduced Water Levels at above locations, upstream of Sindhrot weir is not significant. The trends of variation in groundwater table from pre-monsoon to post-monsoon with weir and without weir are similar for all above locations.

From figure 5.22 to 5.27 of temporal variation of groundwater table at locations M, N, O, P, Q and R on upstream side of Badalpur weir it was found that the Reduced Water Levels are higher with Sindhrot and Badalpur weir compared to without weir. The trends of variation in groundwater table from pre-monsoon to post-monsoon with Sindhrot & Badalpur weir and without weir are similar for all above locations.

Area of influence is more at Badalpur weir as compared to Sindhrot weir. The Badalpur weir is about 41.66 km downstream of Sindhrot weir. Reduced water levels are found to be showing rising trend with weir compared to without weir. General groundwater flow is found from north-east to south-west direction is observed. Rise in water table below river is observed. Reduced water levels in unconfined aquifer are found to be showing rising trend with weir compared to without weir. Water levels in locations surrounding of sindhrot weir are not much affected by Badalpur weir. Increase in water table at nearby locations in two years after construction of Sindhrot weir is found to rise by 0.5 m to 1.43 m. Construction of the weir has resulted increase in the groundwater recharge due to fresh surface water seepage in the study area and also helps in reducing salinity.

The North and South boundary of the model area is considered as catchment boundary of Mahi lower basin. As the study area receives rainfall only during four months of monsoon, the observed water table contours are not found parallel to these boundaries during pre-monsoon hence the variable head boundary is considered based on observed values. The major objective of the study is to investigate the effect of recharge in the vicinity of the river. Thus the water level fluctuations at boundaries are assumed beyond area of influence for river recharge. However, the discrepancy in assumed water level and actual water level at boundary affects the inflow- outflow from boundaries in total water budget of modeled area.

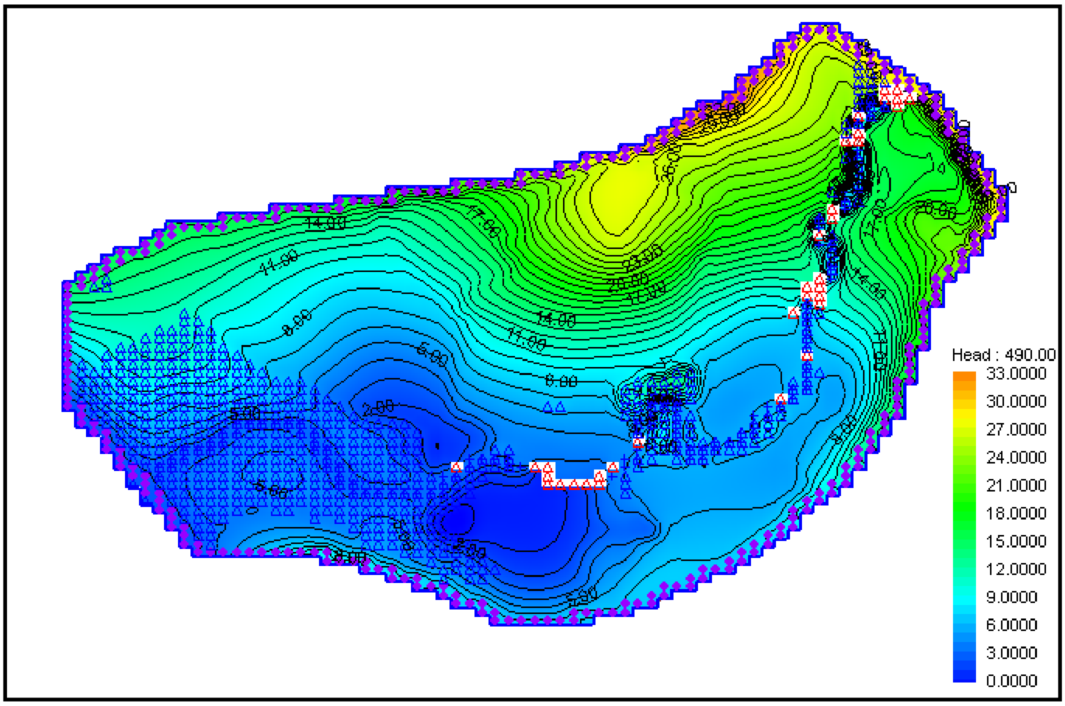


Figure 5.28 Predicted water table contours without weir 16/10/2006 (12:00 AM).

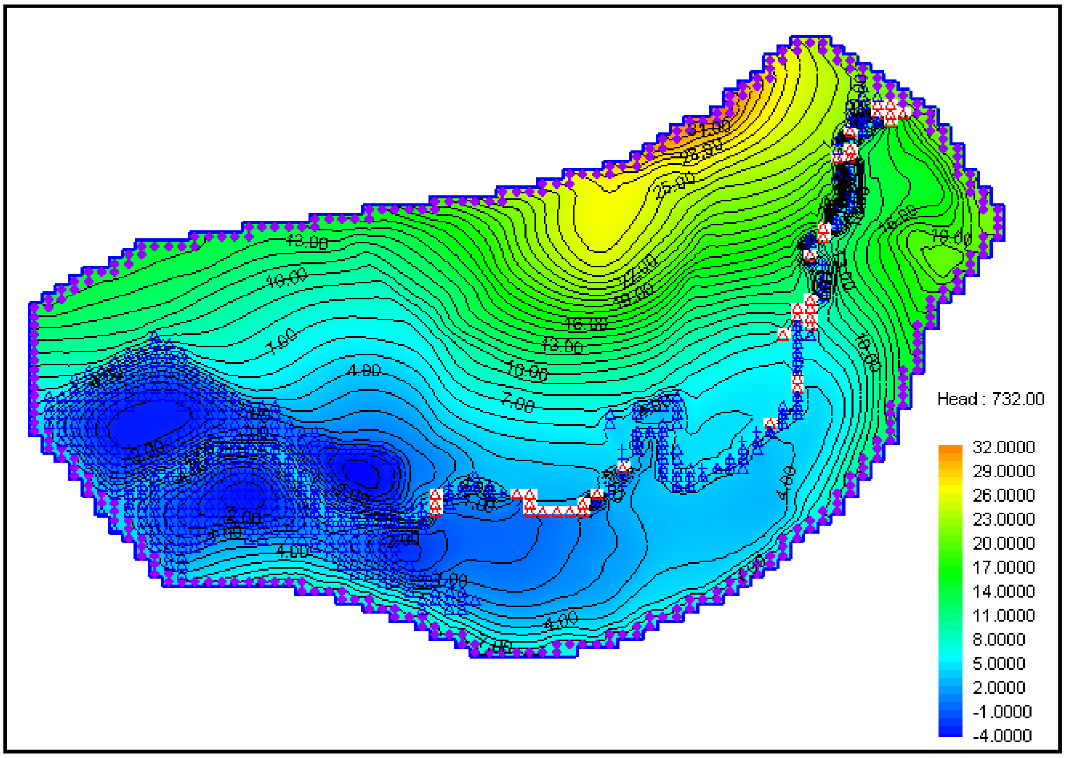


Figure 5.29 Predicted water table contours without weir 15/06/2007 (12:00 AM).

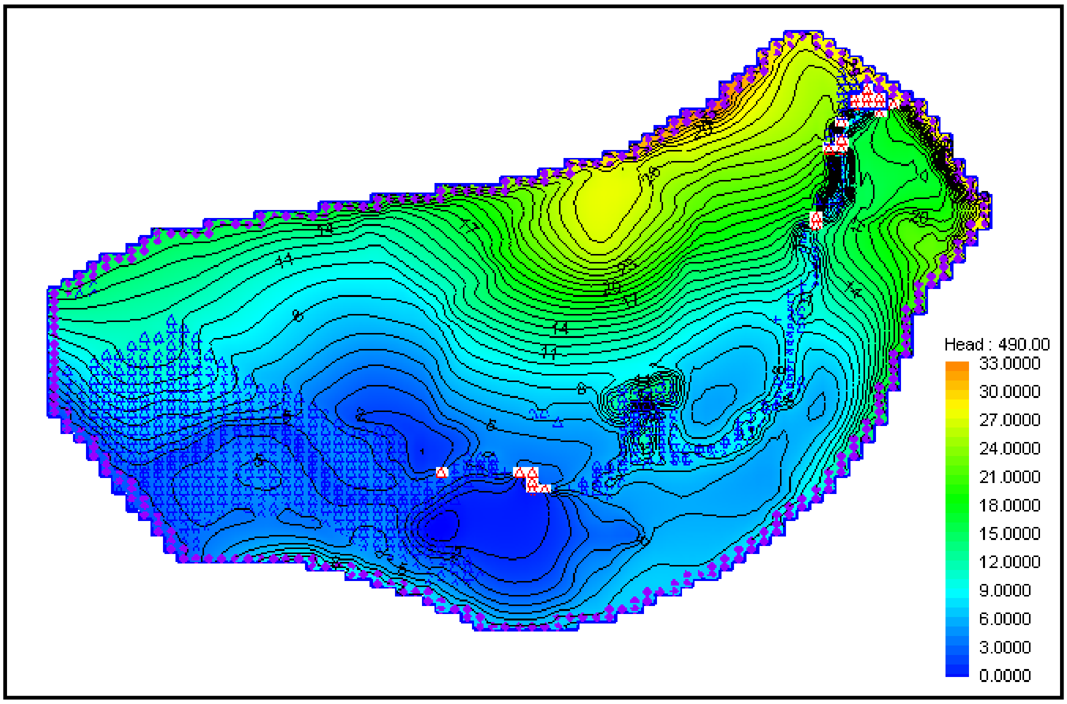


Figure 5.30 Predicted water table contours with Sindhrot weir 16/10/2006 (12:00 AM).

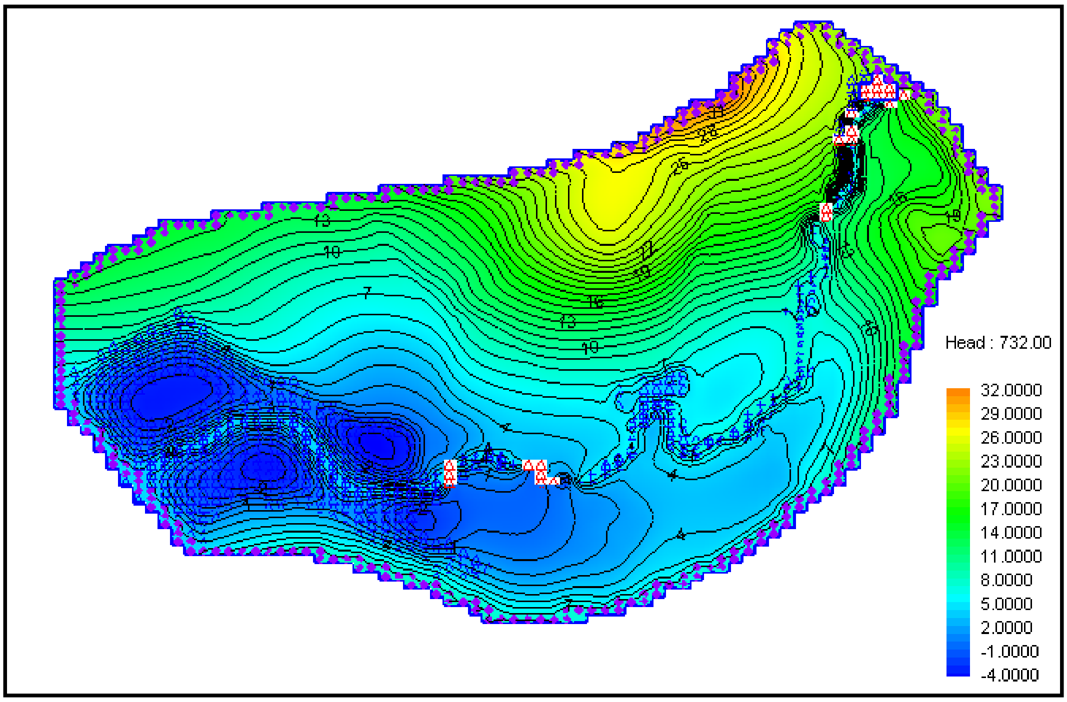


Figure 5.31 Predicted water table contours with Sindhrot weir 15/06/2007 (12:00 AM).

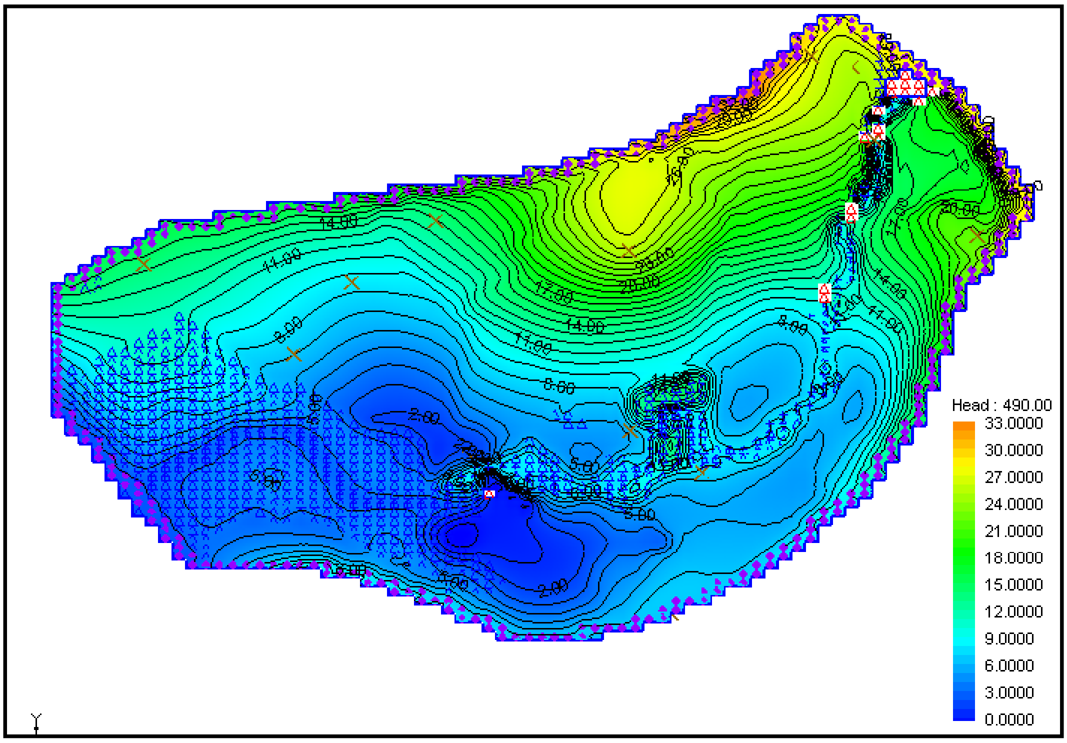


Figure 5.32 Predicted water table contours with Sindhrot & Badalpur weir 16/10/2006 (12:00 AM).

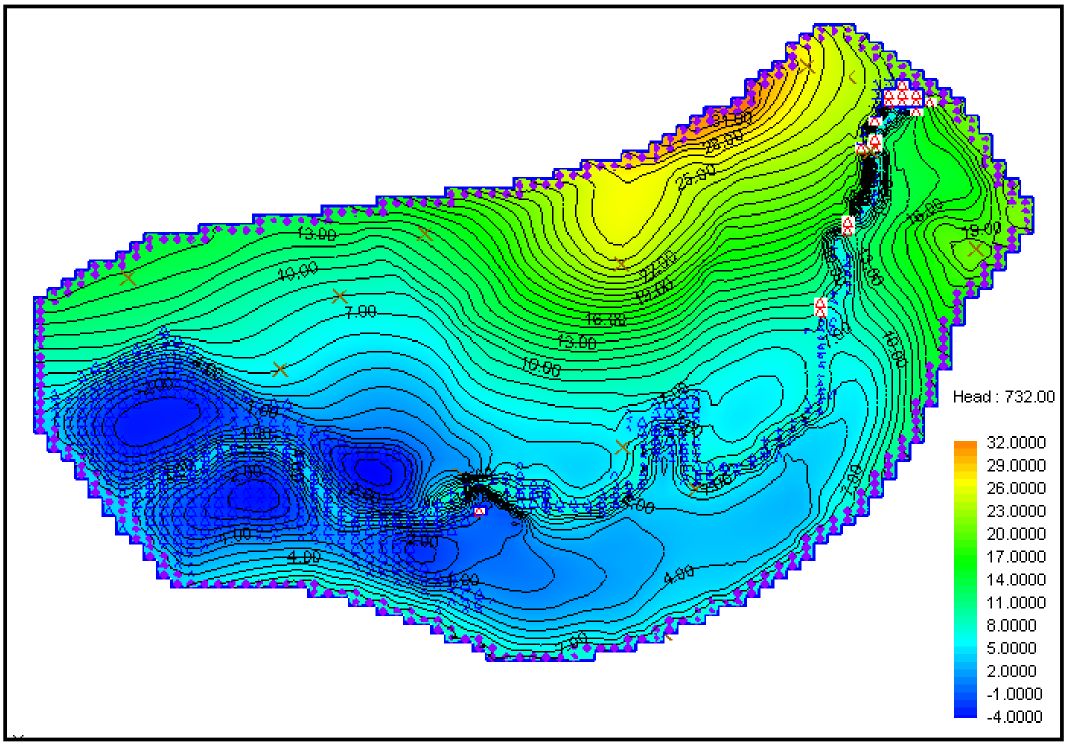


Figure 5.33 Predicted water table contours with Sindhrot & Badalpur weir 15/06/2007 (12:00 AM).

6 REGRESSION ANALYSIS OF WATER QUALITY DATA

In this chapter detailed analysis of water quality, RWL and rainfall data monitored by GWRDC and SWDC as well as field investigation for water quality is described.

6.1 Regression Analysis

Water quality data of wells in unconfined aquifer collected from offices have been used to establish the average equations for linear relations between TDS and distance from Kavi. Graphs for wells at equidistance from centre line of river considering equal effect are prepared. The different ranges of equi-distances from river centre line are considered. Similarly water quality data of wells used for establishing the average equations for linear relationship between TDS and distance from centre line of river. The graphs for wells at equidistance from Kavi considering equal effect are prepared. The different ranges of equidistance from Kavi are considered. The average equations for linear relations have been established for wells within each range of distances. Analysis has been carried out to determine correlation coefficient (r) and standard error of estimates (S_{yx}) of average linear equations.

The Multiple Linear Regression Analysis has been carried out for establishing the linear relationships between three parameters such as TDS, Distance from Kavi and RWL. TDS has been taken as dependent variable because the analysis has been carried out to study the variation of salinity in Mahi estuarine area and other two have been taken as independent variables. Using pre-monsoon water quality data of 12 years(1995 to 2006) of 26 unconfined wells the equations for multiple linear relations established and from these year wise equations an average equation has been established. Also the relationships of TDS with RWL and distances from Kavi have been established for the data averaged over number of years. (1995 to 2006). The equations and values of the correlation coefficient (r) and standard error of estimates (S1.23) have been calculated for left bank, right bank and both bank.

The Multiple Linear Regression Analysis has been carried out for establishing the linear relationships between four parameters such as TDS, Distances from Kavi and RWL and rainfall. TDS has been taken as dependent variable because the analysis has been carried out to study the variation of salinity in Mahi estuarine area and other three have been taken as independent variables. Using pre-monsoon water quality data of 12 years(1995 to 2006) of 26 unconfined wells the equations for multiple linear relations established and from these year wise equations an average equation has been established.

The water quality data collected from offices are graphically represented to show the year wise variation in TDS with reference to rainfall for different wells in different talukas in the study area.

6.1.1 Linear Regression Analysis

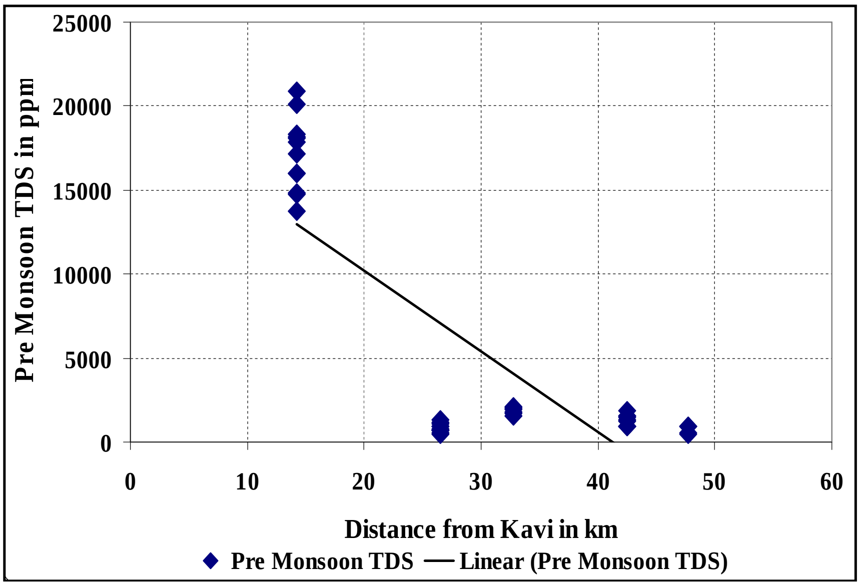
This analysis has been carried out for unconfined wells because the objective of the study is to observe the effect of recharge from surface water due to weir. The water quality data of 12 years (1995 to 2006) of 26 unconfined wells have been arranged in appropriate format to obtain these types of graphs. The maps of Survey of India (1: 50,000) have been used to determine the distances of observation wells from centre line of river. Also these maps have been used to obtain the distances of observation wells from the location of village Kavi, where river Mahi emerges in the Gulf of Cambay (table 4.7). In this analysis graphs have been drawn for pre-monsoon conditions because there is worst condition observed for salinity i.e. more value of Total Dissolved Solids (TDS) in pre-monsoon season. This condition occurs due to less ground water recharge in pre-monsoon season whereas in post-monsoon season, there is more groundwater recharge due to rainfall. This analysis has been carried out in two different ways as described below:

(1) These graphs have been prepared for establishing the relation between TDS (in ppm) and distance from Kavi (in kms). The graphs have been prepared for wells which are at equidistance from centre line of river. So that the effect of recharge of fresh water from the river at the wells under consideration is approximately equal. The range of distances of wells from the centre line of the river for establishing the relation between TDS & Distance from Kavi have been chosen as below:

- ⇨ Equidistance from river centre line: 1.80km to 3.20km (Graph 6.1)
- ⇨ Equidistance from river centre line: 4.20km to 6.90km (Graph 6.2)
- ⇨ Equidistance from river centre line: 8.65km to 12.40km (Graph 6.3)

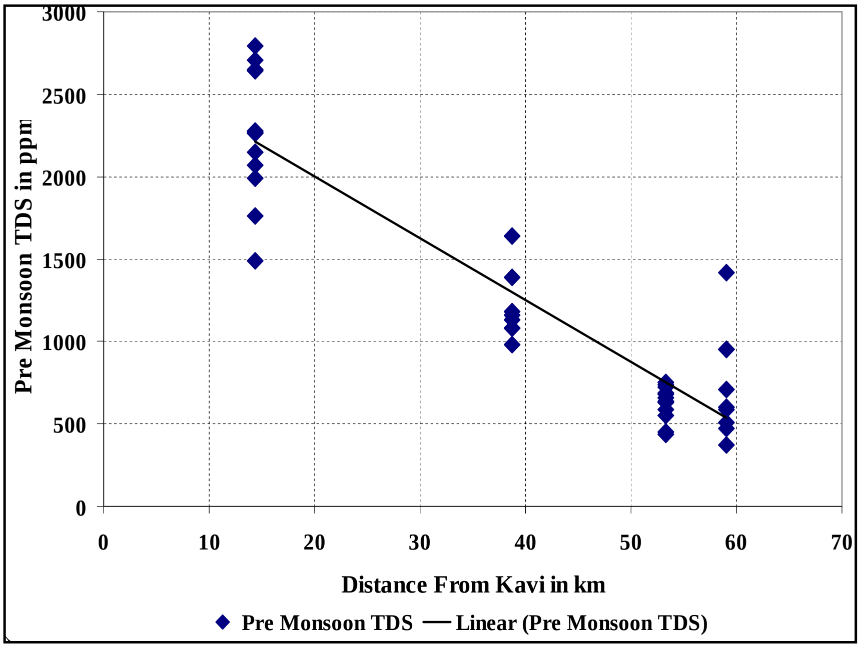
(2) These graphs have been prepared for establishing the relation between TDS (in ppm) and distance from centre line of river (in kms). The graphs have been prepared for wells which are at equidistance from the location of village Kavi. So that the effect of tides from Kavi at the wells under consideration is approximately equal. The ranges of distances of wells from the centre line of the river for establishing the relation between TDS & Distance from centre line of river have been chosen as below:

- ⇨ Equidistance from Kavi: 6.50km to 10.60km (Graph 6.4)
- ⇨ Equidistance from Kavi: 14.25km to 18.40km (Graph 6.5)
- ⇨ Equidistance from Kavi: 24.40km to 30.00km (Graph 6.6)
- ⇨ Equidistance from Kavi: 32.75km to 42.50km (Graph 6.7)
- ⇨ Equidistance from Kavi: 56.75km to 59.45km (Graph 6.8)



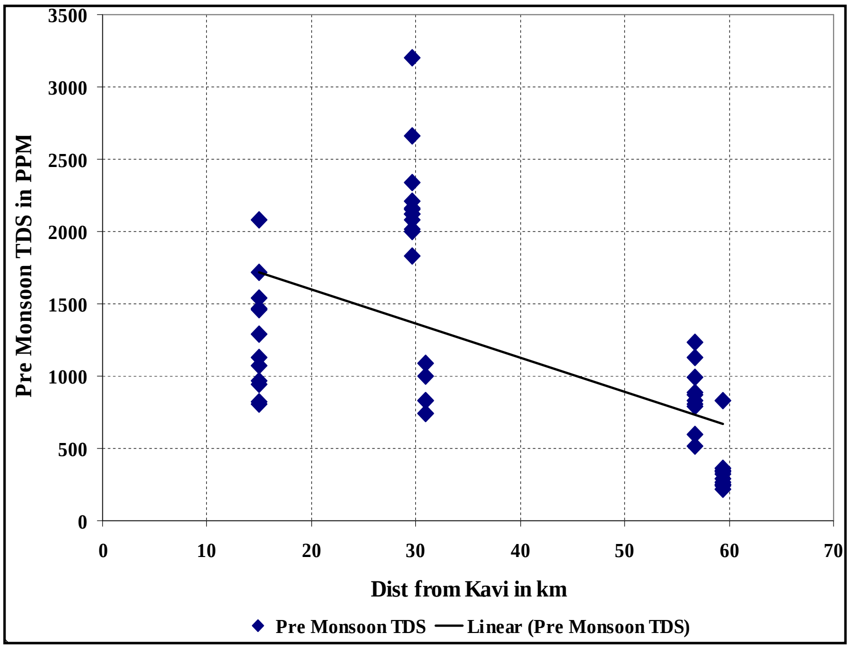
Graph 6.1 Pre-Monsoon TDS V/S Distance from Kavi

Equidistance from River Centre Line 1.80 km to 3.2 km



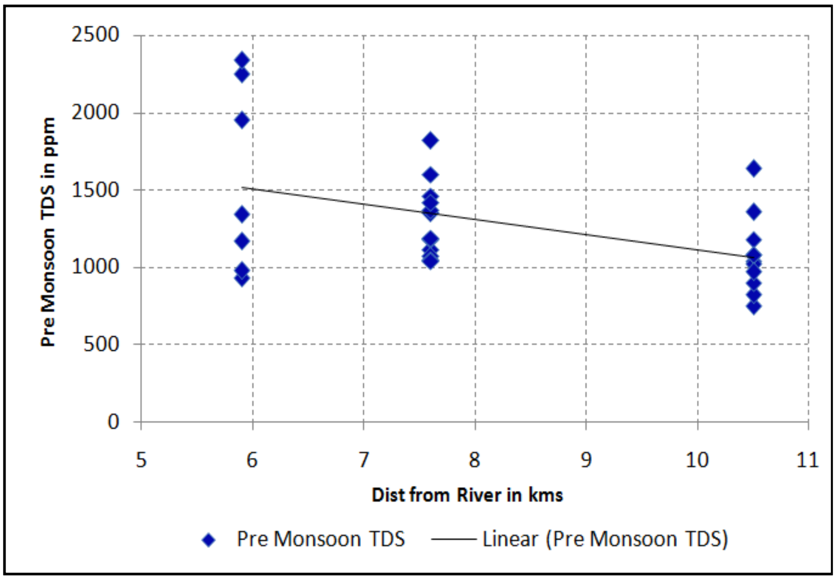
Graph 6.2 Pre-Monsoon TDS V/S Distance from Kavi

Equidistance from River Centre Line 4.20 km to 6.90 km



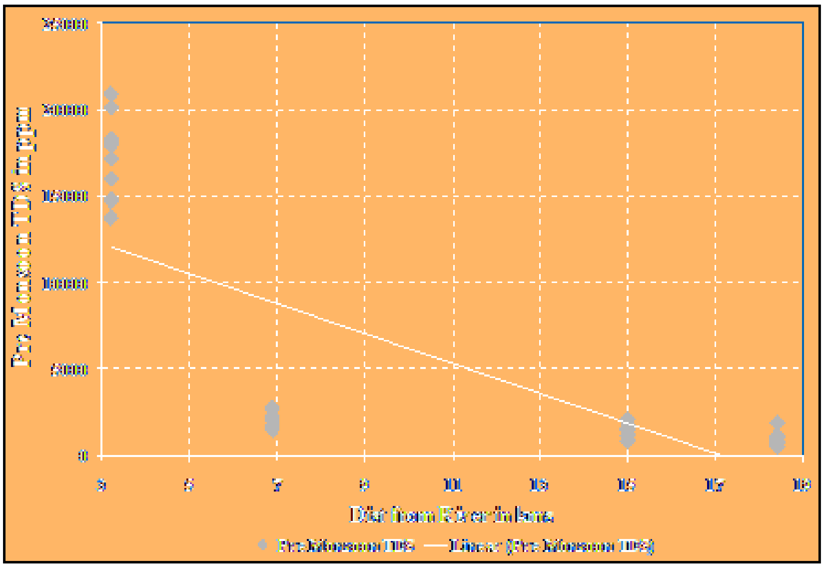
Graph 6.3 Pre-Monsoon TDS V/S Distance from Kavi

Equidistance from River Centre Line 8.65 km to 15.00 km



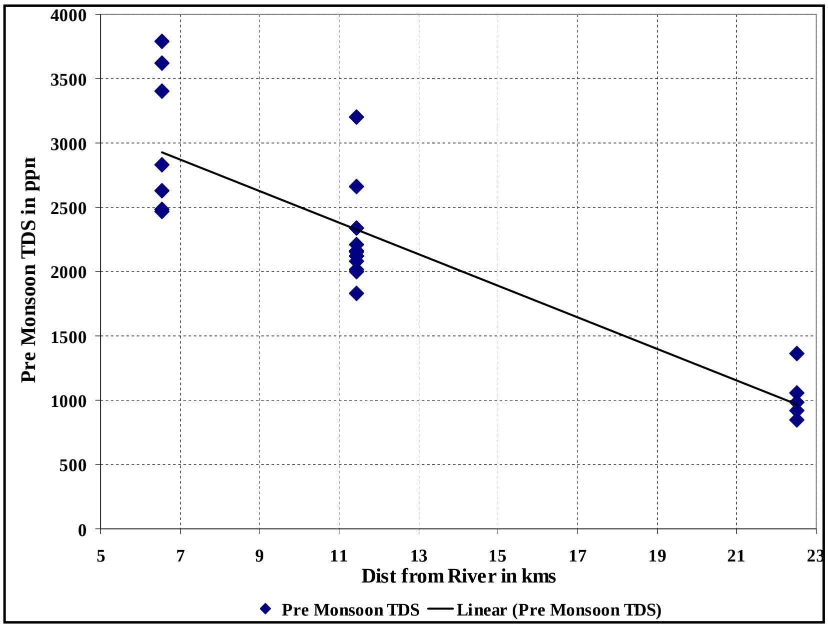
Graph 6.4 Pre-Monsoon TDS V/S Distance from River Centre Line

Equidistance from Kavi 6.50 km to 10.60 km

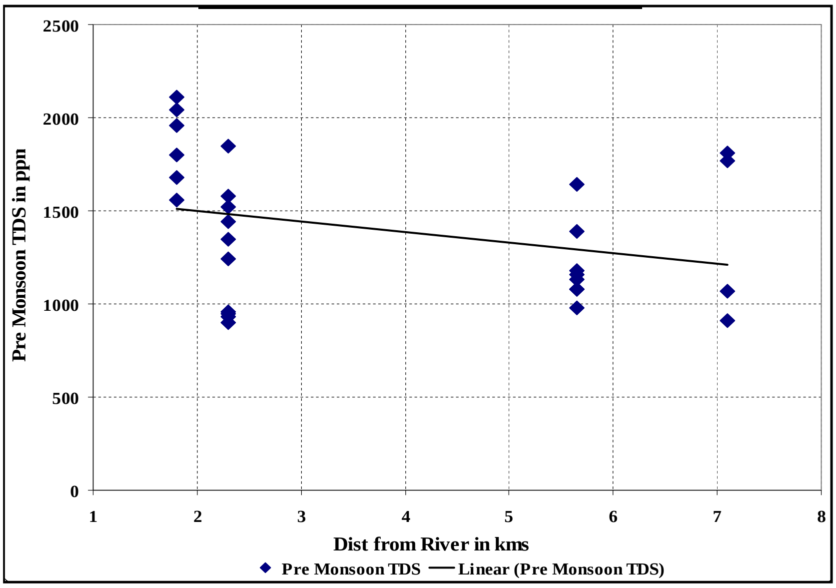


Graph 6.5 Pre-Monsoon TDS V/S Distance from River Centre Line

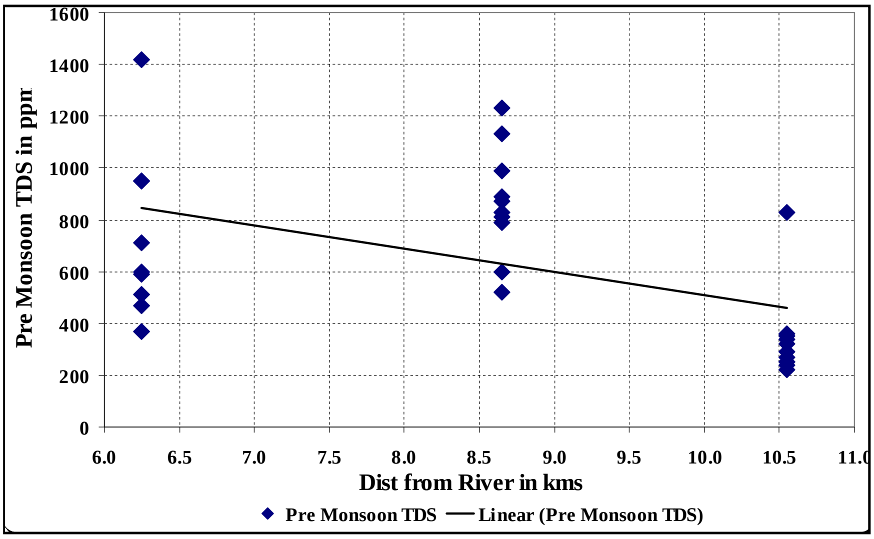
Equidistance from Kavi 14.25 km to 18.40 km



Graph 6.6 TDS V/S Distance from River Centre Line Equidistance from Kavi 24.40 km to 30.00 km



Graph 6.7 Pre-Monsoon TDS V/S Distance from River Centre Line Equidistance from Kavi 32.75 km to 42.50 km



Graph 6.8 Pre-Monsoon TDS V/S Distance from River Centre Line

Equidistance from Kavi 56.75 km to 59.45 km

The average equations for Linear relations have been established for wells within each range of distance from centre line of river (graph 6.1 to 6.3) and each range of distance from Kavi (graph 6.4 to 6.8). Analysis has been carried out to determine correlation coefficient (r), Standard Error of Estimate (S_{YX}) of average linear equations and this has been shown in Table 6.1.

Correlation Coefficient (r) is commonly used statistical parameter for measuring the degree of association of two linearly dependent variables x and y. It is defined by

$$r = \frac{\sum(\Delta X * \Delta Y)}{\sqrt{\sum(\Delta X)^2 * \sum(\Delta Y)^2}} \quad \text{...........} \quad (6.1)$$

$\Delta X = X - \bar{X}$ Where $\bar{X} = \frac{\sum X}{N}$

$\Delta Y = Y - \bar{Y}$ Where $\bar{Y} = \frac{\sum Y}{N}$

X = Distance from Kavi or River

Y = Observed TDS in ppm

N = No. of observations for X

The correlation coefficient lies between -1 and +1 i. e. $-1 \leq r \leq +1$

r = +1 shows perfect positive correlation between two variables. For such variables an increase in the value of one variable is associated with a proportional increase in the value of the other variables. The points on the scattered diagram for such variables are in a straight line in an increasing order.

r = -1 shows perfect negative correlation between two variables. For such variables an increase in the value of one variable is associated with a proportional decrease in the value of the other variables. The points on the scattered diagram for such variables are in a straight line in the decreasing order.

Standard error of estimate (S_{yx}) is a measure of scatter about the regression line of Y on X. It is given by,

$$S_{yx} = \sqrt{\frac{\sum (Y - Y_{est})^2}{N - 2}} \quad \text{.........(6.2)}$$

Where Y = Observed TDS in ppm

Y_{est} = Estimated TDS in ppm using obtained equation

N = no. of observations

Table 6.1 Linear Regression Equations and Values of "r" & "S_{YX}" for Graphs 6.1 To 6.8

Graph	Graph Title	Equation	Correlation Coefficient r	Standard Error of Estimate S_{YX} ppm
6.1	Equidistance from River Centre Line: 1.80km to 3.20km	Y = -478.43X +19752	-0.7890	4508.159
6.2	Equidistance from River Centre Line: 4.20km to 6.90km	Y = -37.445X + 2748.20	-0.9144	305.540
6.3	Equidistance from River Centre Line: 8.65km to 12.40km	Y = -23.472X + 2066.80	-0.57346	607.039
6.4	Equidistance from Kavi: 6.50km to 10.60km	Y = -99.51X + 2105	-0.47757	347.413
6.5	Equidistance from Kavi: 14.25km to 18.40km	Y = -865.76X + 14815.00	-0.76531	4529.622
6.6	Equidistance from Kavi: 24.40km to 30.00km	Y = -122.79X + 3733.20	-0.87032	408.473
6.7	Equidistance from Kavi: 32.75km to 42.50km	Y = -56.159X + 1610.80	-0.30779	368.898
6.8	Equidistance from Kavi: 56.75km to 59.45km	Y = -90.216X + 1409.90	-0.48656	292.883

In Graphs 6.1 to 6.3	X = Distances From Kavi in kms
	Y = TDS in ppm
In Graphs 6.4 to 6.8	X = Distances from River centre line in kms
	Y = TDS in ppm

It is observed from graph 6.1 to 6.3 that Total Dissolved Solids (TDS) decreases with increased distance from Kavi where Mahi River merges in the Gulf of Cambay. It is also observed from graph 6.4 to 6.8 that TDS decreases with increasing distance from centre line of river.

The correlation coefficient r is a useful measure of the goodness of regression, commonly used to study the degree of statistical relationship between a set of variables. From Table 6.1, for graphs 6.1, 6.2, 6.5 & 6.6 the linear regression equations show that the correlation coefficient r is ranging between -0.76531 to -0.9144 which indicates a close negative linear correlationship between dependent variable TDS of groundwater (Y) and independent variable, distance from centre line of river or distance from Kavi where Mahi River merges in the Gulf of Cambay (X). An increase in the distance from centre line of river or distance from Kavi is associated with a proportional decrease in the value of TDS of groundwater.

Similarly for graphs 6.3, 6.4 and 6.8 the linear regression equations show that the correlation coefficient r is ranging between -0.47757 to -0.57346 which indicates an average negative linear correlationship between the above two variables. It is also found from regression equation of graph 6.7 that the correlation coefficient r is -0.30779 which indicates poor negative linear correlationship between the above two variables. The dependent variable TDS of groundwater is not significantly influenced by the independent variable, distance from centre line of river or distance from Kavi only. So perfect match is not indicated and analysis by multiple linear regressions with additional independent variables is required.

Standard error of estimate SYX is a measure of scatter about the best fit regression line of TDS of groundwater (Y) on distance from centre line of river or distance from Kavi (X). Its value is found ranging from 292.883 ppm to 4529.622 ppm.

6.1.2 Multiple Linear Regression Analysis for Three Parameters

This analysis has been carried out for establishing the linear relationships between three different parameters in Mahi estuarine area. In this analysis, parameters such as Total Dissolved Solids (TDS in ppm), distances from Kavi (in kms) and Reduced Water Level (RWL in m) have been used for establishing the linear relationship. TDS in ppm has been taken as dependent variable because the analysis has been carried out to study the variation of salinity in Mahi estuarine area. The other two parameter such as Distances from Kavi (in kms) and (RWL in m) have been taken as independent variables. The general form of multiple linear relationships of these parameters follows relationships as given below:

$$X_1 = a + bX_2 + cX_3 \qquad \text{.........} \quad (6.3)$$

Where a, b & c = the constants determined by the method of least squares.

X_1 = TDS in ppm

X_2 = Distances from Kavi in kms

X_3 = Reduced Water Level in m

The least square regression plane of X_1 on X_2 and X_3 can be determined by solving simultaneously the three normal equations.

$$\begin{aligned} \sum X_1 &= an + b\sum X_2 + c\sum X_3 \\ \sum X_1 X_2 &= a\sum X_2 + b\sum {X_2}^2 + c\sum X_2 X_3 \\ \sum X_1 X_3 &= a\sum X_3 + b\sum X_2 X_3 + c\sum {X_3}^2 \end{aligned} \quad \text{......... (6.4)}$$

Where n is the set of data points (X_1, X_2, X_3)

The coefficient of multiple correlations is given by

$$r_{1.23} = \sqrt{\frac{{r_{12}}^2 + {r_{13}}^2 + 2r_{12}\, r_{13}\, r_{23}}{1 - {r_{23}}^2}} \quad \text{......... (6.5)}$$

Where

$$r_{12} = \frac{\sum X_1 X_2 - \text{n}\, \overline{X_1}\, \overline{X_2}}{(n-1)\, \sigma_1\, \sigma_2} \quad \text{......... (6.6)}$$

r_{12} = the linear correlation coefficient between the variables X_1 and X_2, ignoring the variable X_3; and similarly r_{13} and r_{23}. r_{12}, r_{13}, r_{23} are partial correlation coefficients.

$$\bar{X} = \frac{\sum X}{n}$$

Standard deviation = $\sigma = \sqrt{\frac{\sum (X-\bar{X})^2}{n-1}}$

n = number of set of data points

The Standard error of estimate of X_1 with respect to X_2 and X_3 is given by

$$S_{1.23} = \sqrt{\frac{\sum (X_1 - X_{1est})^2}{n-3}} \quad \text{......... (6.7)}$$

X_{1est} = value of X_1 for the given values of X_2 and X_3 in equation (6.3).

This analysis has been carried out by using pre-monsoon data of 26 unconfined well. The water quality data of 12 years (1995 to 2006) of 26 unconfined wells have been used to obtain this type of multiple linear relationships. Equations for multiple linear relations have been established by using each year (1995 to 2006) data for 26 wells. From these year wise equations an average equation has been established.

The effect of recharge due to Mahi Right Bank Canal (MRBC) irrigation have been observed in the area on right bank of the river, while in the area on the left bank of the river, the recharge due to irrigation is not observed as there is no left bank irrigation canal in past. So, the analysis for left bank, right bank and for both bank have been carried out separately.

The correlation coefficient (r) and standard error of estimates ($S_{1.23}$) have been calculated from these equations. The equations and values of "r" and "$S_{1.23}$" have been shown in Table given below:

- ⇨ For Left Bank i.e. for Vadodara district (Table 6.2)
- ⇨ For Right Bank i.e. for Anand district (Table 6.3)
- ⇨ For Both Banks (Table 6.4)

Table 6.2 Multiple Linear Regression Equations and Values of "r" and "$S_{1.23}$" for Left Bank

Year	Equation	Multiple Correlation Coefficient ($r_{1.23}$)	Standard Error of Estimate ($S_{1.23}$) in ppm
1995	$X_1 = 1909.88 - 11.02X_2 - 46.80X_3$	0.904	647.00
1996	$X_1 = 2051.64 - 18.04X_2 - 0.74X_3$	0.898	977.46
1997	$X_1 = 2191.30 - 7.97X_2 - 22.53X_3$	0.994	1039.12
1998	$X_1 = 1574.72 - 2.89X_2 - 26.12X_3$	0.956	930.00
1999	$X_1 = 2396.37 - 21.83X_2 + 10.65X_3$	0.951	625.54
2000	$X_1 = 1742.11 - 9.65X_2 - 1.78X_3$	0.905	666.71
2001	$X_1 = 2281.28 - 27.70X_2 + 22.25X_3$	0.998	712.39
2002	$X_1 = 1487.97 - 10.26X_2 - 8.08X_3$	0.910	313.76
2003	$X_1 = 3422.53 - 42.34X_2 + 51.77X_3$	0.951	347.99
2004	$X_1 = 3421.12 - 50.20X_2 + 14.17X_3$	0.999	268.70
2005	$X_1 = 2550.40 - 34.16X_2 + 22.57X_3$	0.913	682.24
2006	$X_1 = 5963.81 - 94.15X_2 + 20.50X_3$	0.985	825.28
Year wise Average Equation	$X_1 = 2582.76 - 27.52X_2 + 2.99X_3$	0.947	740.50
Equation for data averaged over Number of Years	$X_1 = 2087.80 - 17.14X_2 - 6.84X_3$	0.946	733.85

Where, X_1 = TDS in ppm

X_2 = Distances from Kavi in kms

X_3 = Reduced Water Level in m

The multiple linear regression equations for estimating a dependent variable TDS for groundwater (X_1) from two independent variables, distance from Kavi (X_2) and reduced water level (X_3) for left bank of River Mahi of study area are represented in table 6.2. The multiple correlation coefficient $r_{1.23}$ between the dependent variable TDS of groundwater (X_1) and two independent variable, distance from Kavi (X_2) & reduced water level (X_3) is found from partial correlation coefficients which uses the standard deviation of X_1 and X_2. The value of $r_{1.23}$ lies between 0 & 1.

It is found from table 6.2 that for the multiple linear regression equations the value of multiple correlation coefficient $r_{1.23}$ is ranging between 0.898 to 0.999 which indicates a close linear correlationship of (X_2) and (X_3) on (X_1).

The table 6.2 shows the value of standard error of estimate $S_{1.23}$ of X_1 with respect to X_2 and X_3 for the multiple linear regression equations is ranging between 268.70 ppm to 1039.72 ppm for left bank.

Table 6.3 Multiple Linear Regression Equations and Values of "$r_{1.23}$" and "$S_{1.23}$" for Right Bank

Year	Equation	Multiple Correlation Coefficient ($r_{1.23}$)	Standard Error of Estimate ($S_{1.23}$) in ppm
1995	$X_1 = 1445.51 - 18.44X_2 + 5X_3$	0.953	591.34
1996	$X_1 = 1549.60 - 16.80X_2 + 7.57X_3$	0.927	529.86
1997	$X_1 = 1409.05 - 10.33X_2 - 1.73X_3$	0.9996	492.82
1998	$X_1 = 1129.72 - 18.53X_2 + 16.10X_3$	0.939	273.90
1999	$X_1 = 1753.94 - 17.37X_2 + 5.05X_3$	0.96	594.91
2000	$X_1 = 1377 - 12.83X_2 + 3.83X_3$	0.932	455.59
2001	$X_1 = 1460.05 - 6.49X_2 - 6.23X_3$	0.946	477.16
2002	$X_1 = 1489.40 - 20.63X_2 + 23.47X_3$	0.921	200.79
2003	$X_1 = 1642.51 - 11.22X_2 + 1.00X_3$	0.96	303.09
2004	$X_1 = 1475.36 - 18.73X_2 + 14.13X_3$	0.935	486.35
2005	$X_1 = 1344.38 - 9.03X_2 + 5.70X_3$	0.971	264.65
2006	$X_1 = 1518.84 - 9.98X_2 - 4.90X_3$	0.916	1298.91
Year wise Average Equation	X1 = 1382.95 - 14.20X2 + 5.75X3	0.947	410.23
Equation for data averaged over No. of Years	X1 = 1567.06 - 14.27X2 - 1.82X3	0.992	446.71

Where, X_1 = TDS in ppm

X_2 = Distances from Kavi in kms

X_3 = Reduced Water Level in m

The multiple linear regression equations for estimating a dependent variable TDS for groundwater (X_1) from two independent variables, distance from Kavi (X_2) and reduced water level (X_3) for right bank of River Mahi of study area are represented in table 6.3. It is found from table 6.3 that for the multiple linear regression equations the value of multiple correlation coefficient r1.23 is ranging between 0.916 to 0.9996 which indicates a close linear correlationship of (X_2) and (X_3) on (X_1). The table 6.3 shows the value of standard error of estimate $S_{1.23}$ of X_1 with respect to X_2 and X_3 for the multiple linear regression equations is ranging between 200.79 ppm to 1298.91 ppm for right bank.

Table 6.4 Multiple Linear Regression Equations and Values of "r" and "$S_{1.23}$" for Both Banks

Year	Equation	Multiple Correlation Coefficient ($r_{1.23}$)	Standard Error of Estimate ($S_{1.23}$) in ppm
1995	$X_1 = 1579.37 + 10.52X_2 - 44.96X_3$	0.961	673.61
1996	$X_1 = 1953.82 - 8.72X_2 - 22.28X_3$	0.932	613.17
1997	$X_1 = 1646.58 + 4.63X_2 - 33.13X_3$	0.921	824.49
1998	$X_1 = 1633.34 + 0.831X_2 - 29.52X_3$	0.958	687.69
1999	$X_1 = 2045.07 - 16.29X_2 - 8.99X_3$	0.907	561.42
2000	$X_1 = 1743.88 + 2.62X_2 - 38.85X_3$	0.994	688.18
2001	$X_1 = 1629.44 - 6.27X_2 - 12.07X_3$	0.991	563.23
2002	$X_1 = 1515.68 - 6.79X_2 - 6.97X_3$	0.888	317.95
2003	$X_1 = 1479.48 - 1.80X_2 - 10.65X_3$	0.816	511.40
2004	$X_1 = 1872.58 - 21.52X_2 - 0.07X_3$	0.985	439.30
2005	$X_1 = 1496.89 + 3.77X_2 - 21.10X_3$	0.977	461.79
2006	$X_1 = 1956.52 - 10.93X_2 - 14.60X_3$	0.946	839.95
Year wise Average Equation	$X_1 = 1712.72 - 4.16X_2 - 20.27X_3$	0.940	520.64
Equation for data averaged over Number of Years	$X_1 = 1666.41 - 3.60X_2 - 21.17X_3$	0.978	478.92

Where, X_1 = TDS in ppm

X_2 = Distances from Kavi in kms

X_3 = Reduced Water Level in m

The multiple linear regression equations for estimating a dependent variable TDS for groundwater (X_1) from two independent variables, distance from Kavi (X_2) and reduced water level (X_3) for both banks of River Mahi of study area are represented in table 6.4. It is found from table 6.4 that for the multiple linear regression equations the value of multiple correlation coefficient $r_{1.23}$ is ranging between 0.816 to 0.994 which indicates a close linear correlationship of (X_2) and (X_3) on (X_1). The table 6.3 shows the value of standard error of estimate $S_{1.23}$ of X_1 with respect to X_2 and X_3 for the multiple linear regression equations is ranging between 317.95 ppm to 839.95 ppm for both banks.

6.1.3 Multiple Linear Regression Analysis for Four Parameters

This analysis has been carried out for establishing the linear relationships between four different parameters in Mahi estuarine area. In this analysis, parameters such as TDS in ppm, distances from Kavi (in kms), RWL (in m) and Rainfall (in mm) have been used for establishing the linear relationship. TDS in ppm has been taken as dependent variable because the analysis has been carried out to study the variation of salinity in Mahi estuarine area. The other three parameters such as distance from Kavi (in kms), RWL in m and Rainfall (in mm) have been taken as independent variables. The general form of multiple linear relationships of these parameters follows relationship as given below:

$$X_1 = a + bX_2 + cX_3 + dX_4 \quad \text{................} \quad (6.8)$$

Where a, b, c & d = the constants determined by the method of least squares.

X_1 = TDS in ppm

X_2 = Distances from Kavi in kms

X_3 = Reduced Water Level in m

X_4 = Rainfall in mm

This analysis has been carried out by using pre-monsoon data of 26 unconfined well. The water quality data of 12 years (1995 to 2006) of 26 unconfined wells have been used to obtain this type of multiple linear relationships. Equations for multiple linear relations have been established by using each year (1995 to 2006) data for 26 wells. From these year wise equations an average equation has been established.

Also the multiple regression analysis has been carried out for the relationships of TDS with RWL, distances from Kavi and rainfall have been established for the data averaged over no. of years (from 1995 to 2006).

The multiple correlation coefficient (r) and standard error of estimates ($S_{1.234}$) have been calculated from these equations. The equations and values of "r" and "$S_{1.234}$" have been shown in Table 6.5.

Table 6.5 Multiple Linear Regression Equations and Values of "r" and "$S_{1.234}$" for Both Banks

Year	Equation	Multiple Correlation Coefficient ($r_{1.234}$)	Standard Error of Estimate ($S_{1.234}$) in ppm
1995	$X_1 = 1543.70 - 3.80X_2 - 20.40X_3 - 0.10X_4$	0.982	646
1996	$X_1 = 1735.10 + 5.90X_2 - 8.20X_3 - 1.30X_4$	0.995	722
1997	$X_1 = 1833.40 + 11.90X_2 - 45.80X_3 - 0.50X_4$	0.942	692
1998	$X_1 = 1254.50 - 2.50X_2 - 14.90X_3 + 0.20X_4$	0.967	678
1999	$X_1 = 2495.40 - 18.50X_2 - 6.30X_3 - 0.50X_4$	0.915	558
2000	$X_1 = 2893.30 + 6.90X_2 + 3.20X_3 + 5.50X_4$	0.956	433
2001	$X_1 = 2608.40 - 0.60X_2 - 10.70X_3 - 3.10X_4$	0.993	777
2002	$X_1 = 2016.20 - 0.30X_2 - 2.90X_3 - 1.60X_4$	0.989	364
2003	$X_1 = 1418.40 - 25.90X_2 + 3.40X_3 + 1.60X_4$	0.967	577
2004	$X_1 = 2211.50 - 14.50X_2 + 4.00X_3 - 0.90X_4$	0.980	510
2005	$X_1 = 770.53 - 24.09X_2 - 4.36X_3 + 1.94X_4$	0.999	495
2006	$X_1 = 1295 - 18.00X_2 - 3.40X_3 + 0.40X_4$	0.997	566
Year wise Average Equation	$X_1 = 1839.62 - 6.96X_2 - 11.30X_3 + 0.14X_4$	0.974	626.28
Equation for data averaged over Number of Years	$X_1 = 2399.40 + 1.70X_2 - 11.40X_3 - 1.60X_4$	0.983	510.48

Where, X_1 = TDS in ppm

X_2 = Distances from Kavi in kms

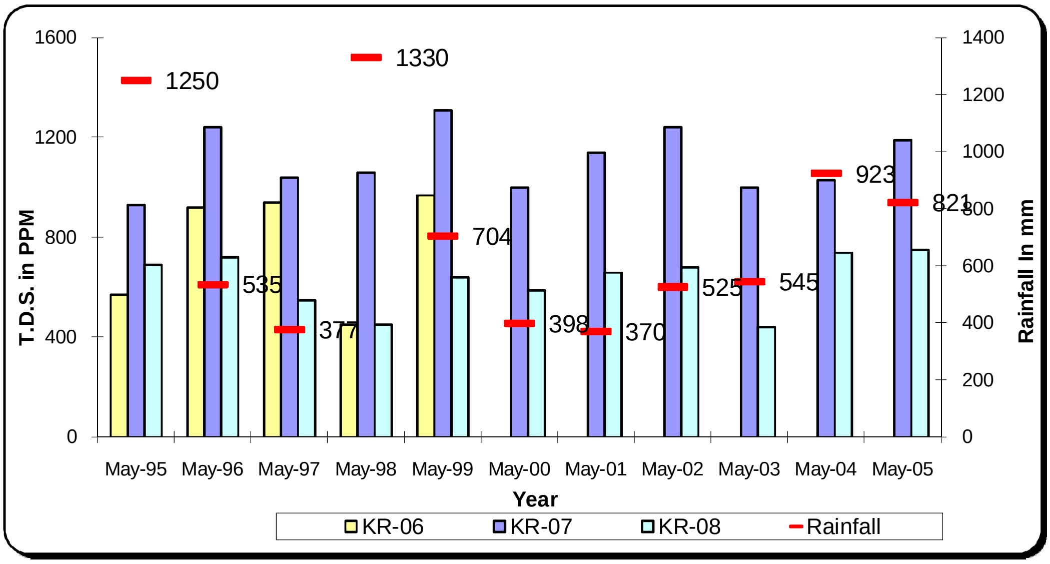
X_3 = Reduced Water Level in m

X_4 = Rainfall in mm

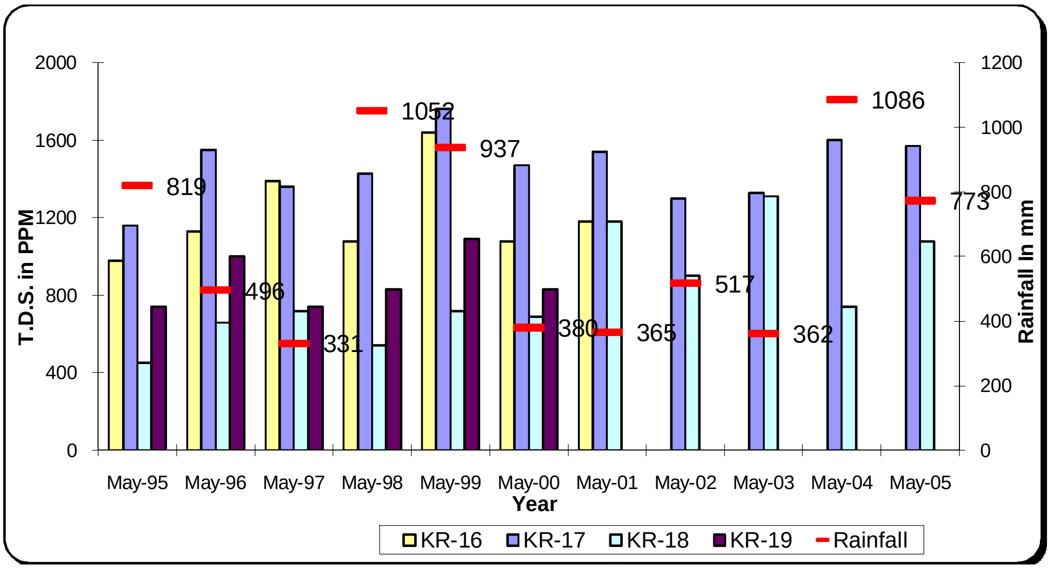
The multiple linear regression equations for estimating a dependent variable TDS for groundwater (X_1) from three independent variables, distance from Kavi (X_2), reduced water level (X_3) and rainfall (X_4) for both banks of River Mahi of study area are represented in table 6.5. It is found from table 6.5 that for the multiple linear regression equations the value of multiple correlation coefficient $r_{1.234}$ is ranging between 0.915 to 0.999 which indicates a close linear correlationship of (X_2), (X_3) and (X_4) on(X_1). The table 6.5 shows the value of standard error of estimate $S_{1.234}$ of X_1 with respect to X_2, X_3 and X_4 for the multiple linear regression equations is ranging between 364 ppm to 777 ppm for both banks.

6.1.4 Year Wise Variation in TDS With Reference to Rainfall

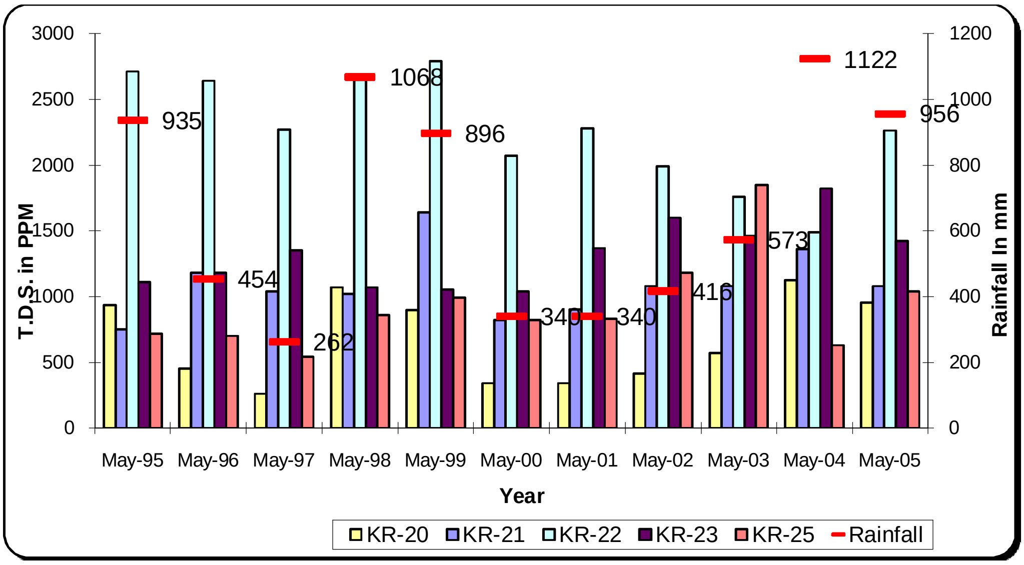
Another analysis which shows the year wise variation in TDS with reference to Rainfall for different wells in different taluka (Graph 6.9 to 6.14) i.e. for Anand taluka (Graph 6.9), for Borsad taluka (Graph 6.10), For Khambhat (Cambay) taluka (Graph 6.11), for Savli taluka (Graph 6.12), for Vadodara taluka (Graph 6.13) and for Padra taluka (Graph 6.14).



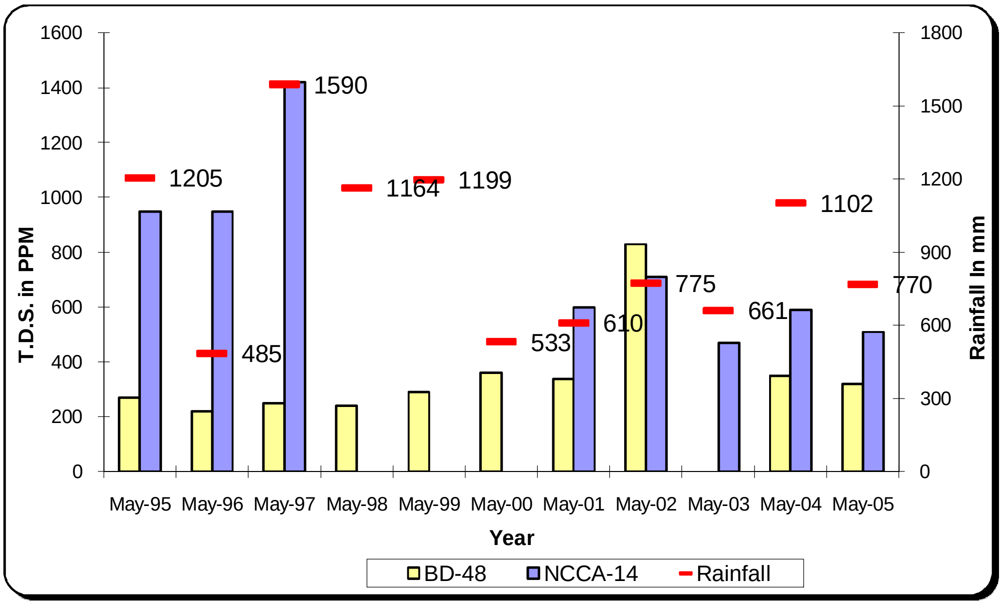
Graph 6.9 Year Wise Variation in TDS With Reference to Rainfall for Different Wells in Anand Taluka



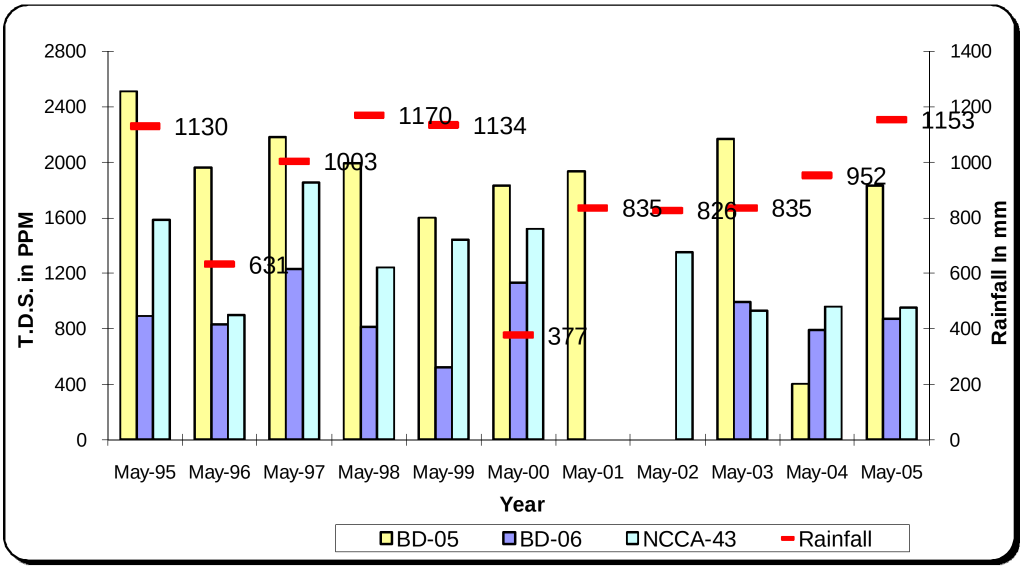
Graph 6.10 Year Wise Variation in TDS With Reference to Rainfall for Different Wells in Borsad Taluka



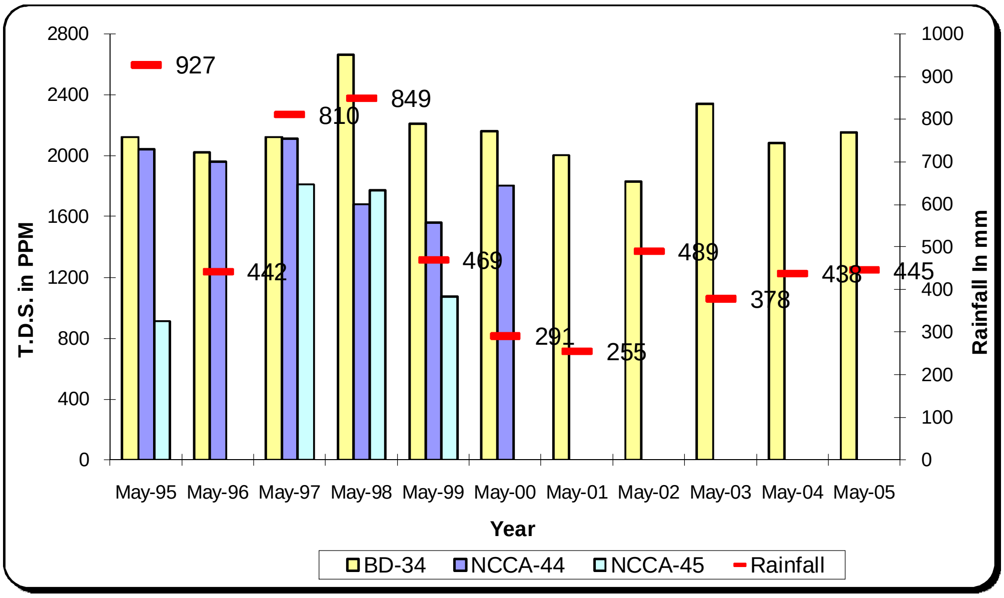
Graph 6.11 Year Wise Variation in TDS With Reference to Rainfall for Different Wells in Khambhat (Cambay) Taluka



Graph 6.12 Year Wise Variation in TDS With Reference to Rainfall for Different Wells in Savli Taluka



Graph 6.13 Year Wise Variation in TDS With Reference to Rainfall for Different Wells in Vadodara Taluka



Graph 6.14 Year Wise Variation in TDS With Reference to Rainfall for Different Wells in Padra Taluka

It is observed from Graphs 6.9 to 6.14, that impact of rainfall on TDS is inversely proportional i.e. high value of rainfall shows less value of TDS and less value of rainfall shows high values of TDS for different taluka in Mahi estuarine area.

6.2 Lab Analysis for Water Quality

To get the comprehensive picture of ground water quality changes in Mahi estuarine area in pre and post monsoon season, the sampling was done in a specific manner. The sampling was carried out for ground water quality in the affected area from wells parallel to the Mahi River on both sides within 10 km distance from river. The representative water samples of 36 wells were collected in Plastic containers in May-June for pre-monsoon and in November for post-monsoon period of year 2003. The locations of wells for water samples are shown in figure 6.1. Samples analyzed in the laboratory for different parameters and also analyzed them graphically.

The water samples then were analyzed using standard methods (Lenore et al., 1998), for different important chemical parameters like pH, EC, TDS, Cl, CO_3, HCO_3, TH, Na, Ca, Mg, K and So_4 to evaluate water quality both in pre and post monsoon period in the Environmental Engineering Laboratory, Civil Engineering Department, Faculty of Technology and Engineering, The M. S. University of Baroda, Vadodara.

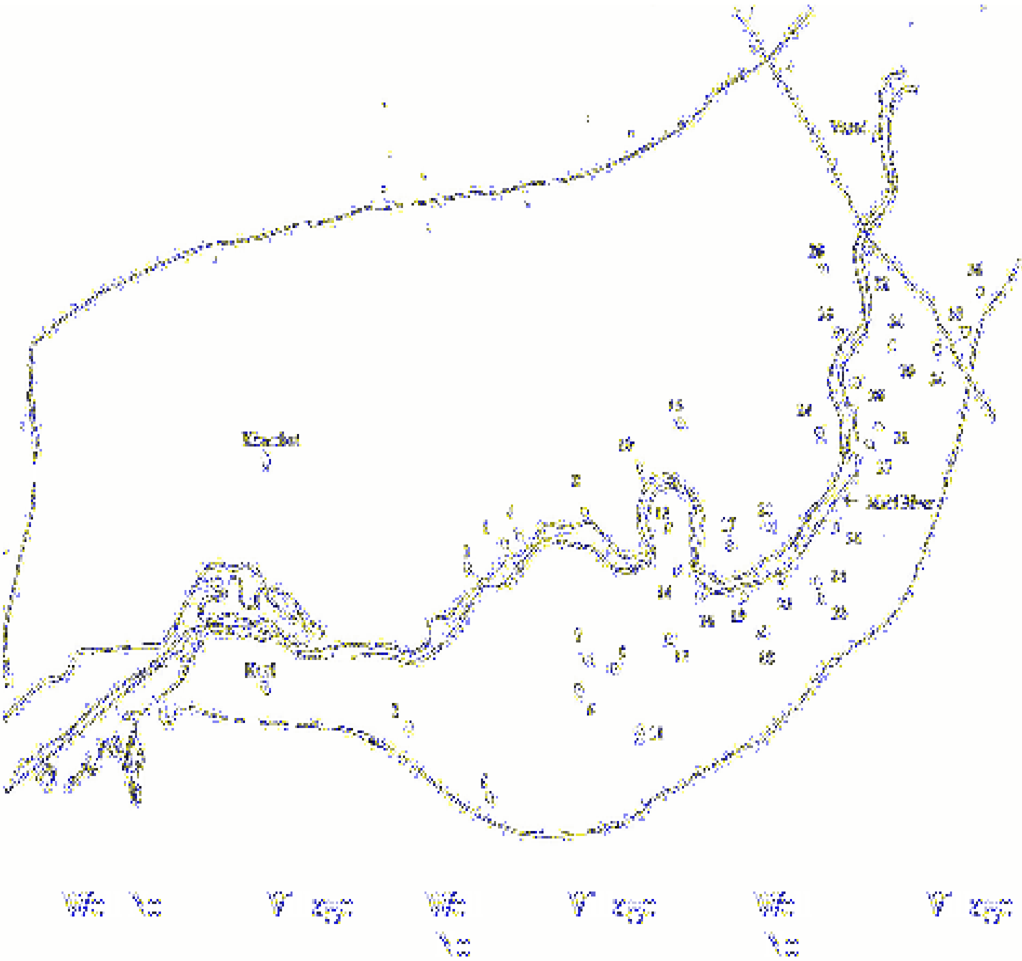


Figure 6.1 Locations of Wells for Water Samples

Results obtained in the laboratory are recorded as statement of different chemical analysis of Mahi estuarine area (distance from Kavi and distance from centre line of river) (Table 6.6).

6.2.1 Graphical Analysis

These laboratory results are also represented graphically as TDS, Cl and TH V/S distances from Kavi and distances from centre line of river to see at a glance the change of ground water quality in Mahi estuarine area in pre monsoon and post monsoon season.

(1) TDS (Total dissolved solids) v/s distance from Kavi. (Graphs 6.15, 6.16 &6.17)

(2) Cl (Chlorides) v/s distance from Kavi (Graphs 6.18, 6.19 &6.20)

(3) TH (Total hardness) v/s distance from Kavi (Graphs 6.21, 6.22 &6.23)

(4) TDS (Total dissolved solids) v/s distance from river. (Graphs 6.24, 6.25&6.26)

(5) Cl (Chlorides)v/s distance from river (Graphs 6.27, 6.28 & 6.29)

(6) TH(Total hardness)v/s distance from river (Graphs 6.30, 6.31&6.32)

Table 6.6 Statement of Chemical Analysis of Water Samples in Mahi Estuarine Area (Dist. from Kavi and Dist. from Centre Line of River)

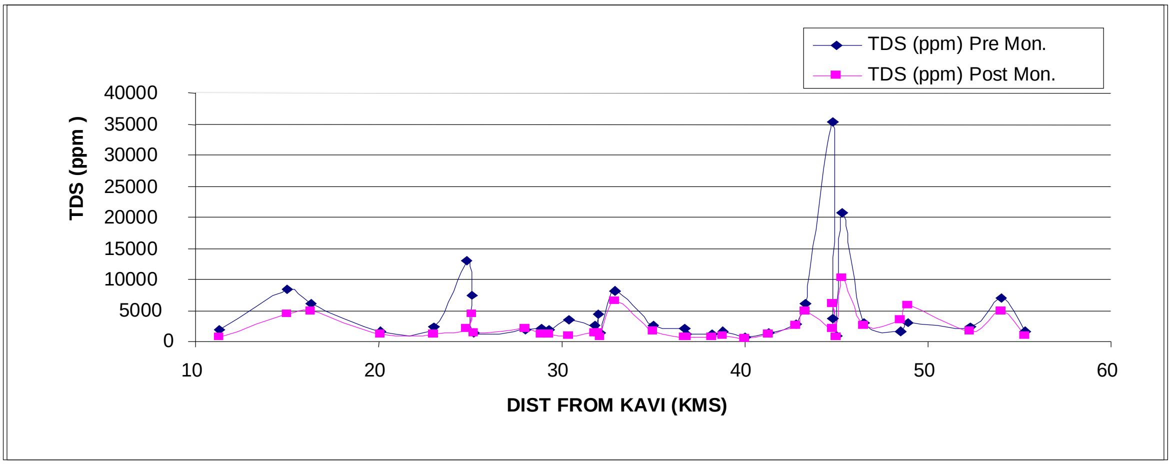
Sample No.	Dist. from kavi km	Dist. from river km	Village	EC (m mhos/cm		pH		TDS (ppm)	
				Pre Mon soon	Post Mon soon.	Pre Mon soon.	Post Mon soon.	Pre Mon soon.	Post Mon soon.
18	11.35	6	Kankapura	502	1041	7.9	8.93	1746	798
21	15	3.3	Sarod	3250	5950	7.6	8.27	8472	4436
23	16.25	5.75	Badalpur	2560	5390	7.6	8.22	5962	4916
13	20.15	6.25	Dahevan	681	1440	8.6	8.78	1712	1168
28	23	8	Uber	1358	1385	7.7	8.47	2272	1258
15	24.8	5.15	Kareli	4050	3410	7.5	8.26	13036	2074
19	25.05	4	Tithor	3400	5780	6.9	8.2	7352	4438
32	25.2	3.5	Sarol	872	1690	8.4	8.58	1504	1404
29	27.95	4.15	Karakhadi	1090	2980	8	8.55	1906	2152
31	28.85	7	Walvod	1290	1447	8.5	8.53	2208	1262
4	29.3	7.65	Kahanva	874	1513	7.6	8.45	1748	1096
6	30.4	4.5	Chokari	2840	1235	7.5	8.45	3390	900
20	31.75	0.45	Mahmad pura	1300	1836	7.8	8.44	2564	1480
26	32	1.7	Sultanpura	1990	1651	7.6	8.69	4398	1476
12	32.1	6.5	Khedasa	473	998	8.3	8.6	1428	752
35	32.9	2.5	Dabka	4190	6900	7.4	8.32	8076	6442
16	35	1.35	Gambhira	1250	2860	7.9	8.45	2556	1662
11	36.7	3.65	Dhobi kuva	632	993	7.8	8.97	2006	736
17	36.75	1.6	Mujpur	400	911	7.9	8.38	1128	602
5	38.15	1.05	Baman gam	456	947	8.4	8.4	1088	706
3	38.75	1.15	Ekalbara	443	1113	7.8	8.29	1554	966
7	40	3.5	Dabhasa (Pasand)	333	709	7.8	8.5	654	494
1	41.25	3.65	Dabhasa	833	1444	8	8.62	1448	1062
34	42.75	1.2	Umeta	1270	2950	7.8	8.11	2808	2570
8	43.25	2.4	Jaspur	2410	6120	7.3	7.76	6062	4966
14	44.75	0.65	Kotana	16400	3220	7.6	8.44	35414	1978
30	44.8	0.85	Sindhrot	1976	6030	7.8	8.15	3630	5968
9	45	2.75	Bhetasi Talpad	430	912	7.4	8.63	960	630
22	45	0.85	Kahanvadi	328	797	8	8.38	842	644
36	45.25	0.7	Angadh	12100	10630	7.2	7.85	20812	10312
33	46.5	2.55	Sherkhi (Sonafarm)	1420	2820	7.9	8.37	2968	2634
2	48.5	0.35	Fajal pur	1210	4970	7.6	8.51	1610	3502
27	48.9	1.6	Nandesari	1260	6790	7.6	8.19	3072	5796
10	52.25	6.35	Karachia	955	2910	7.5	8.21	2408	1704
25	54	7.75	Dashrath	2200	5120	6.6	8.2	7042	4962
24	55.25	8.5	Ajod	578	1153	7.8	8.39	1712	994

Sample No.	Dist. from kavi km	Dist. from river km	Village	Ca++ (ppm)		Mg++ (ppm)		Na+ (ppm)	
				Pre Mon soon.	Post Mon soon.	Pre Mon soon.	Post Mon soon.	Pre Mon soon.	Post Mon soon.
18	11.35	6	Kankapura	33.65	56	33.02	14.33	-	-
21	15	3.3	Sarod	180.3	356	177.3	81.11	-	-
23	16.25	5.75	Badalpur	220.3	184	179.7	183.6	1723	671.6
13	20.15	6.25	Dahevan	28.04	32	33.99	15.3	-	-
28	23	8	Uber	92.14	120	63.13	20.64	-	-
15	24.8	5.15	Kareli	248.4	228	206.4	66.05	-	-
19	25.05	4	Tithor	192.3	92	211.2	161	-	-
32	25.2	3.5	Sarol	36.85	144	52.65	13.6	-	-
29	27.95	4.15	Karakhadi	43.26	96	56.34	30.11	-	-
31	28.85	7	Walvod	40.06	72	212.4	73.58	-	-
4	29.3	7.65	Kahanva	60.09	182	58.28	47.97	-	-
6	30.4	4.5	Chokari	220	52	218.6	43.22	1774	237
20	31.75	0.45	Mahmad pura	35.25	44	39.34	16.03	-	-
26	32	1.7	Sultanpura	120.2	68	145.7	22.34	-	-
12	32.1	6.5	Khedasa	32.04	64	58.28	34.24	-	-
35	32.9	2.5	Dabka	204.3	410	272	245.3	3878	311.25
16	35	1.35	Gambhira	56.08	52	21.85	33.51	-	-
11	36.7	3.65	Dhobi kuva	36.05	44	46.14	12.38	1787	244.5
17	36.75	1.6	Mujpur	60.09	128	48.56	19.91	-	-
5	38.15	1.05	Baman gam	26.03	59.7	57.06	42.58	-	-
3	38.75	1.15	Ekalbara	80.12	214	97.13	56.09	-	-
7	40	3.5	Dabhasa (Pasand)	24.03	60	21.85	13.36	-	-
1	41.25	3.65	Dabhasa	86.53	56.1	42.25	47.08	-	-
34	42.75	1.2	Umeta	132.2	256	106.9	90.82	-	-
8	43.25	2.4	Jaspur	212.3	480	182.1	201.6	-	-
14	44.75	0.65	Kotana	681	72	655.5	83.29	-	-
30	44.8	0.85	Sindhrot	156.2	400	123.9	170	-	-
9	45	2.75	Bhetasi Talpad	52.07	68	48.56	49.05	-	-
22	45	0.85	Kahanvadi	76.11	48	43.71	38.13	-	-
36	45.25	0.7	Angadh	1302	1120	1105	480.8	-	-
33	46.5	2.55	Sherkhi (Sonafarm)	196.3	424	221	137.5	-	-
2	48.5	0.35	Fajal pur	240.4	267	194.2	27.52	-	-
27	48.9	1.6	Nandesari	216.3	408	109.3	124.3	-	-
10	52.25	6.35	Karachia	152.2	128	104.4	87.91	-	-
25	54	7.75	Dashrath	641	980	330.3	408	-	-
24	55.25	8.5	Ajod	64.09	44	46.13	40.31	-	-

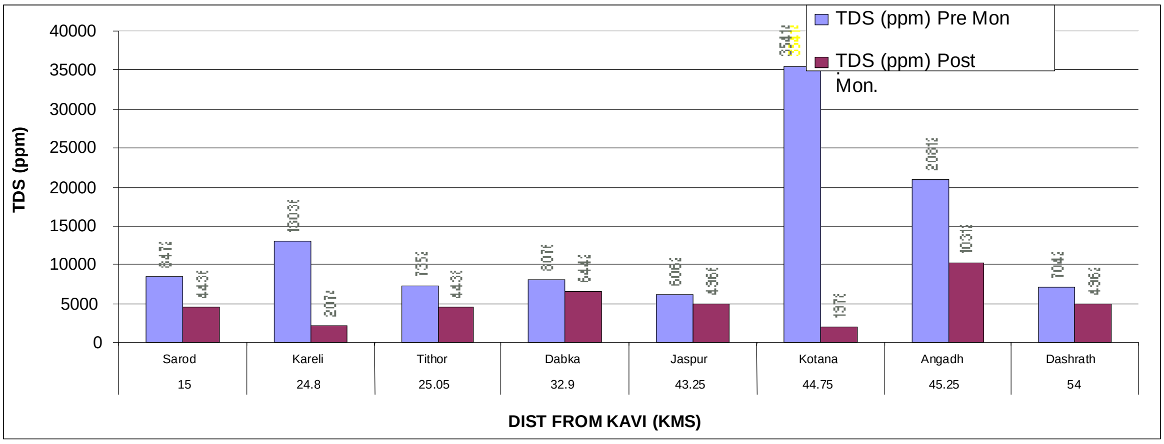
Sample No.	Dist. from kavi km	Dist. from river km	Village	Co3 (ppm)		HCO3 (ppm)		Cl- (ppm)	
				Pre Mon soon.	Post Mon soon.	Pre Mon soon.	Post Mon soon.	Pre Mon soon.	Post Mon soon.
18	11.35	6	Kankapura	Nil	Nil	707.6	420	999.69	259.92
21	15	3.3	Sarod	Nil	Nil	793	280	5248.37	2199.32
23	16.25	5.75	Badalpur	Nil	Nil	536.8	130	4398.63	2149.33
13	20.15	6.25	Dahevan	18	Nil	1024.8	690	299.9	319.9
28	23	8	Uber	Nil	Nil	671	280	1449.53	449.86
15	24.8	5.15	Kareli	Nil	Nil	732	380	5498.29	1099.66
19	25.05	4	Tithor	Nil	Nil	707.6	260	7747.59	2374.26
32	25.2	3.5	Sarol	Nil	Nil	817.4	480	999.69	459.86
29	27.95	4.15	Karakhadi	Nil	Nil	915	600	1399.56	974.7
31	28.85	7	Walvod	Nil	Nil	793	470	1199.62	309.9
4	29.3	7.65	Kahanva	Nil	Nil	805.2	300	659.8	579.82
6	30.4	4.5	Chokari	Nil	Nil	585.6	420	3099.03	349.89
20	31.75	0.45	Mahmad pura	Nil	Nil	896.6	540	1799.44	439.86
26	32	1.7	Sultanpura	Nil	Nil	695.4	490	2199.31	459.86
12	32.1	6.5	Khedasa	Nil	Nil	902.8	510	399.87	299.907
35	32.9	2.5	Dabka	Nil	Nil	610	210	7197.76	2924.09
16	35	1.35	Gambhira	Nil	Nil	878.4	510	1999.38	519.84
11	36.7	3.65	Dhobi kuva	Nil	Nil	805.2	510	549.82	179.94
17	36.75	1.6	Mujpur	Nil	Nil	805.2	330	1199.62	219.93
5	38.15	1.05	Baman gam	Nil	Nil	780.2	350	280	269.92
3	38.75	1.15	Ekalbara	Nil	Nil	549	170	359.88	419.87
7	40	3.5	Dabhasa (Pasand)	Nil	Nil	585.6	300	199.9	269.92
1	41.25	3.65	Dabhasa	Nil	Nil	488	340	434.86	419.87
34	42.75	1.2	Umeta	Nil	Nil	646.6	150	1499.53	824.74
8	43.25	2.4	Jaspur	Nil	Nil	549	110	1999.4	2649.18
14	44.75	0.65	Kotana	Nil	Nil	488	230	15995.1	909.72
30	44.8	0.85	Sindhrot	Nil	Nil	549	130	3398.94	2499.23
9	45	2.75	Bhetasi Talpad	Nil	Nil	658.8	380	474.85	249.92
22	45	0.85	Kahanvadi	Nil	Nil	695.4	330	599.81	199.94
36	45.25	0.7	Angadh	Nil	Nil	451.4	100	14995.3	6697.92
33	46.5	2.55	Sherkhi (Sonafarm)	Nil	Nil	707.6	170	1199.62	824.74
2	48.5	0.35	Fajal pur	Nil	Nil	524.6	170	2199.3	2024.37
27	48.9	1.6	Nandesari	Nil	Nil	622.2	140	1249.61	2924.09
10	52.25	6.35	Karachia	Nil	Nil	793	340	799.75	669.79
25	54	7.75	Dashrath	Nil	Nil	475.8	180	499.84	399.88
24	55.25	8.5	Ajod	Nil	Nil	732	280	999.69	369.89

Sample No.	Dist. from kavi km	Dist. from river km	Village	SO4 (ppm)		K (ppm)		TH (ppm)	
				Pre Mon soon.	Post Mon soon.	Pre Mon soon.	Post Mon soon.	Pre Mon soon.	Post Mon soon.
18	11.35	6	Kankapura	-	-	-	-	169.62	115
21	15	3.3	Sarod	-	-	-	-	910.26	690
23	16.25	5.75	Badalpur	8.8	381.395	13.68	4.7	960.29	940
13	20.15	6.25	Dahevan	-	-	-	-	168.01	95
28	23	8	Uber	-	-	-	-	352.1	205
15	24.8	5.15	Kareli	-	-	-	-	1098.37	500
19	25.05	4	Tithor	-	-	-	-	1062.08	755
32	25.2	3.5	Sarol	-	-	-	-	253.66	200
29	27.95	4.15	Karakhadi	-	-	-	-	275.26	220
31	28.85	7	Walvod	-	-	-	-	914.76	375
4	29.3	7.65	Kahanva	-	-	-	-	300.08	380
6	30.4	4.5	Chokari	82.25	12.34	17.25	6.65	1120.02	230
20	31.75	0.45	Mahmad pura	-	-	-	-	197.25	110
26	32	1.7	Sultanpura	-	-	-	-	720.17	160
12	32.1	6.5	Khedasa	-	-	-	-	272.03	205
35	32.9	2.5	Dabka	317.9	268.38	7.36	4.66	1324.31	1420
16	35	1.35	Gambhira	-	-	-	-	146.05	190
11	36.7	3.65	Dhobi kuva	256.5	23.4	4.709	1.522	226.05	95
17	36.75	1.6	Mujpur	-	-	-	-	260.06	210
5	38.15	1.05	Baman gam	-	-	-	-	261	235
3	38.75	1.15	Ekalbara	-	-	-	-	180.1	445
7	40	3.5	Dabhasa (Pasand)	-	-	-	-	114	115
1	41.25	3.65	Dabhasa	-	-	-	-	260.51	250
34	42.75	1.2	Umeta	-	-	-	-	572.19	630
8	43.25	2.4	Jaspur	-	-	-	-	962.27	1310
14	44.75	0.65	Kotana	-	-	-	-	3380.37	415
30	44.8	0.85	Sindhrot	-	-	-	-	666.24	1100
9	45	2.75	Bhetasi Talpad	-	-	-	-	252.04	270
22	45	0.85	Kahanvadi	-	-	-	-	256.1	205
36	45.25	0.7	Angadh	-	-	-	-	5851.93	3100
33	46.5	2.55	Sherkhi (Sonafarm)	-	-	-	-	1106.29	990
2	48.5	0.35	Fajal pur	-	-	-	-	1040.08	380
27	48.9	1.6	Nandesari	-	-	-	-	666.27	920
10	52.25	6.35	Karachia	-	-	-	-	582.11	490
25	54	7.75	Dashrath	-	-	-	-	2000.93	2660
24	55.25	8.5	Ajod	-	-	-	-	254.05	210

Note: - Indicate chemical analysis not done.

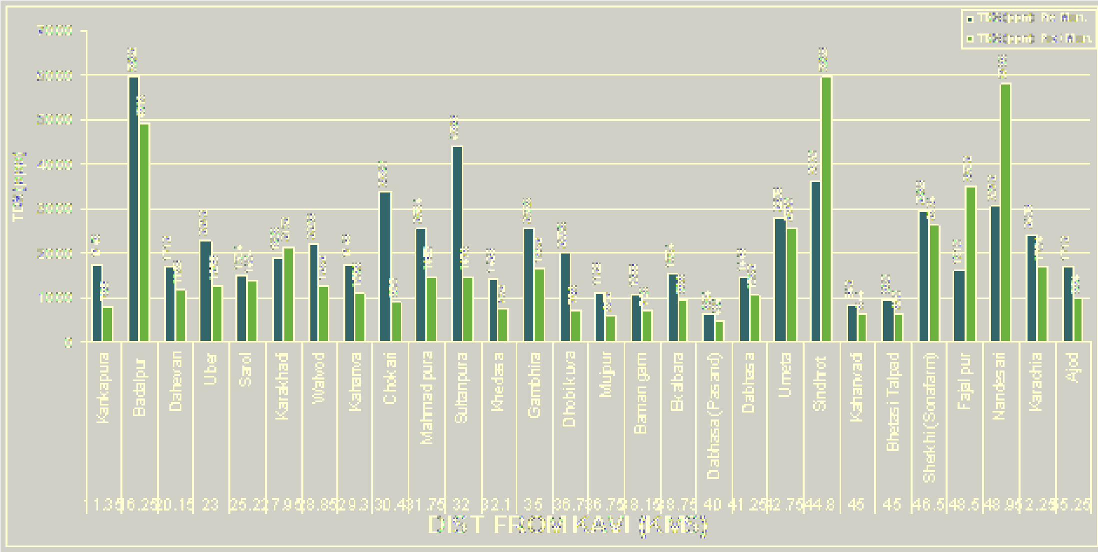


Graph 6.15 Total Dissolved Solids V/S Distance from Kavi



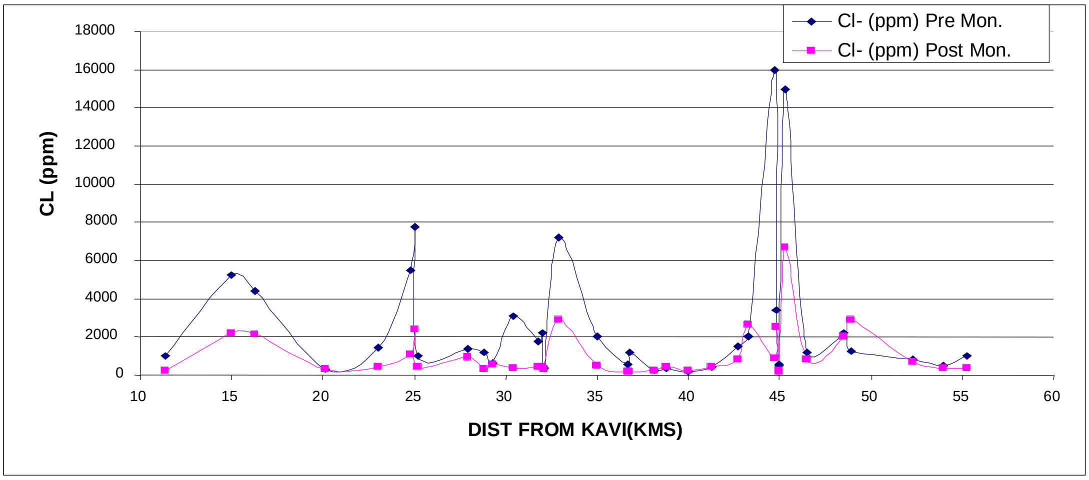
Graph 6.16 Total Dissolved Solids V/S Distance from Kavi

(Pre-Monsoon TDS > 6000 ppm)

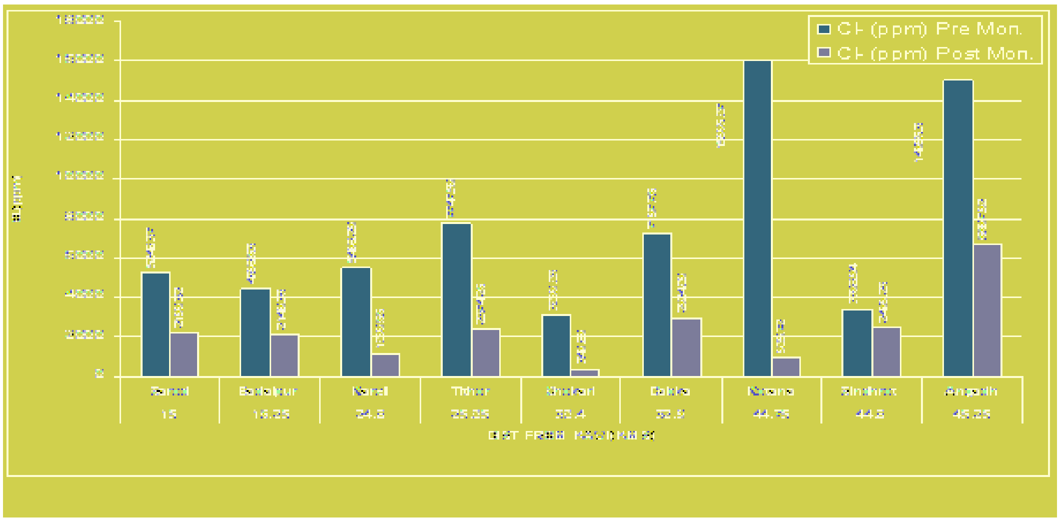


Graph 6.17 Total Dissolved Solids V/S Distance from Kavi

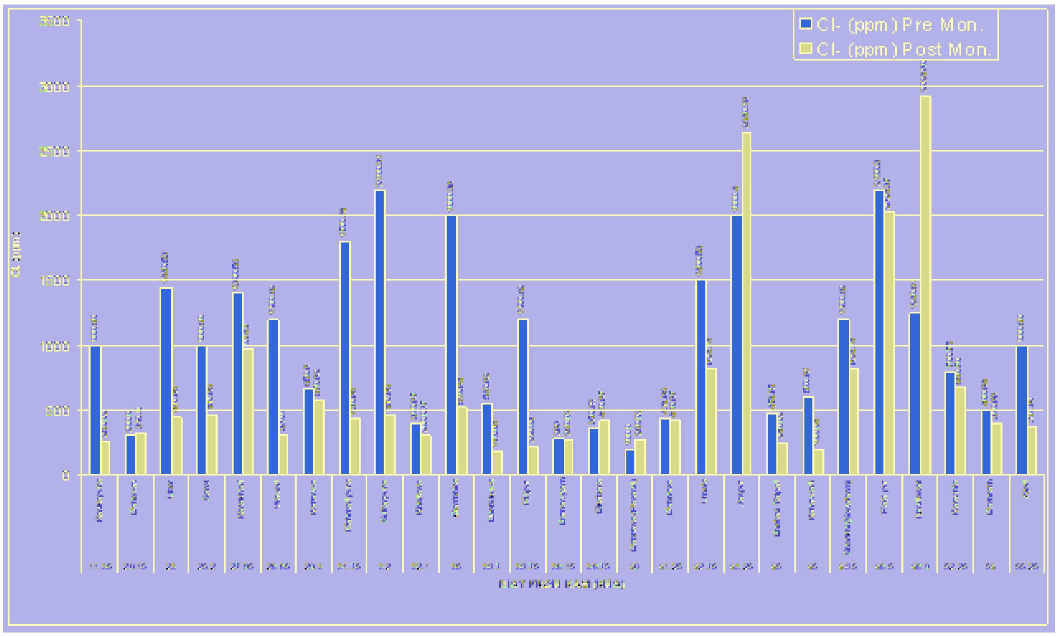
(Pre-monsoon TDS < 6000 ppm)



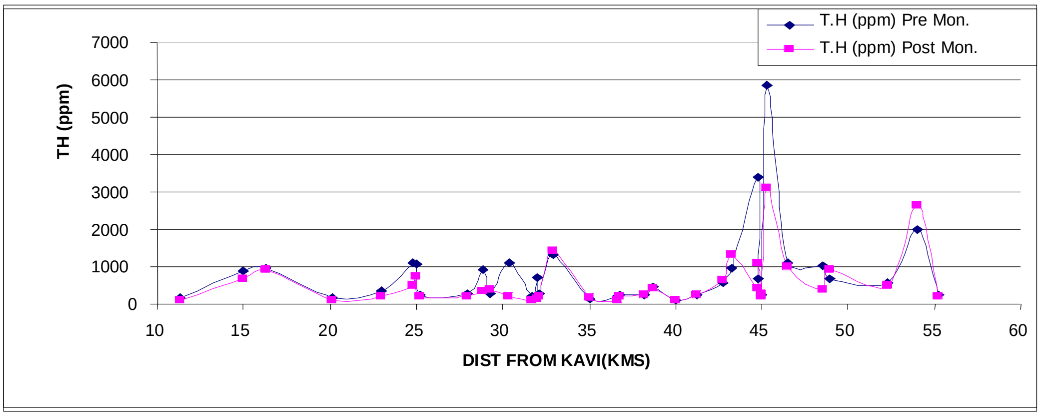
Graph 6.18 Chlorides V/S Distance from Kavi



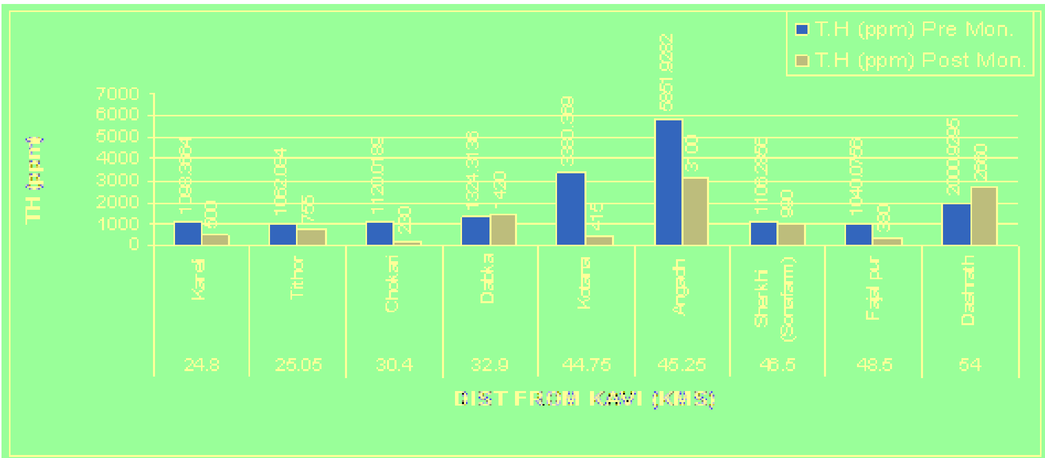
Graph 6.19 Chlorides V/S Distance from Kavi (Pre-Monsoon Cl > 3000 ppm)



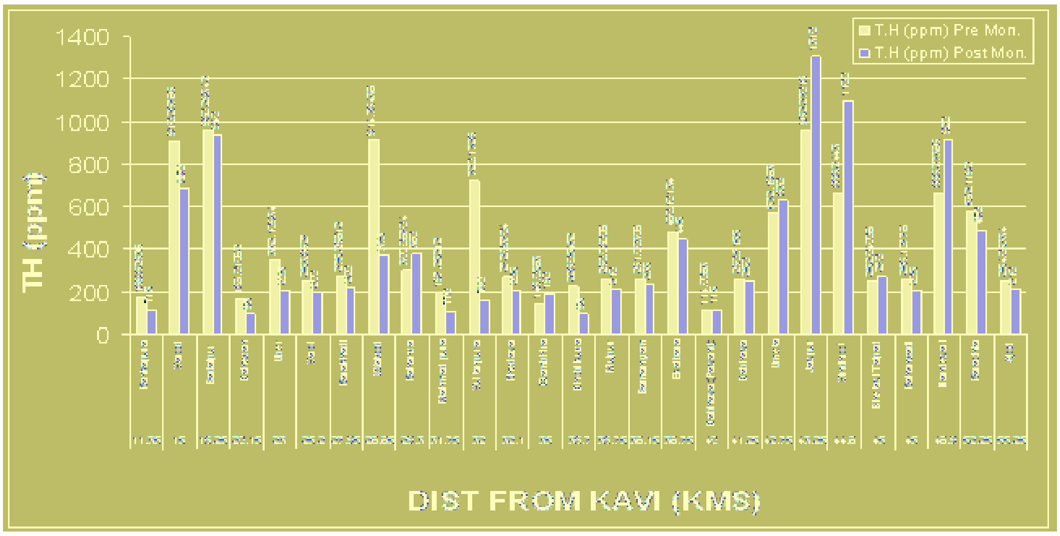
Graph 6.20 Chlorides V/S Distance from Kavi (Pre-Monsoon Cl < 3000 ppm



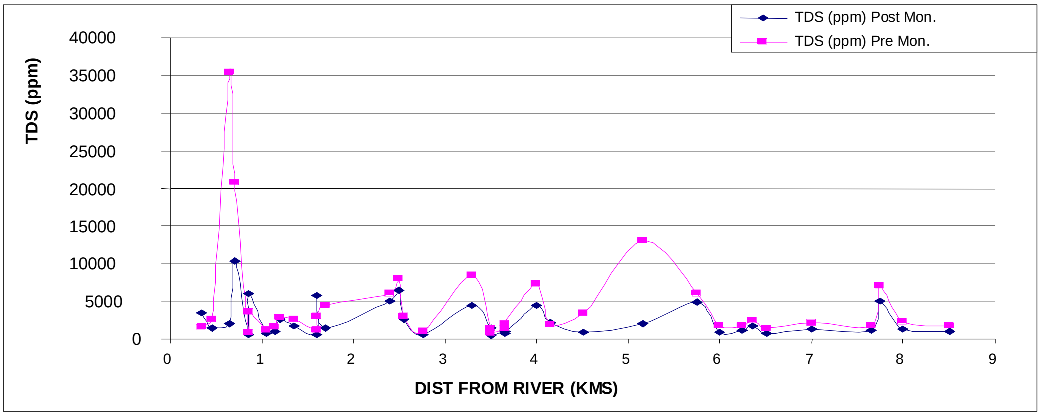
Graph 6.21 Total Hardness V/S Distance from Kavi



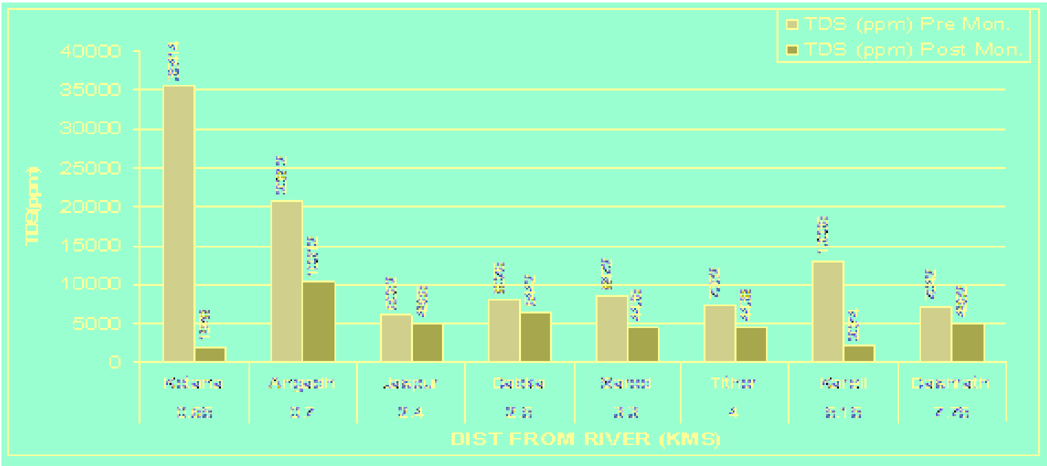
Graph 6.22 Total Hardness V/S Distance from Kavi (Pre-Monsoon TH > 1000 ppm)



Graph 6.23 Total Hardness V/S Distance from Kavi (Pre-Monsoon TH < 1000 ppm)

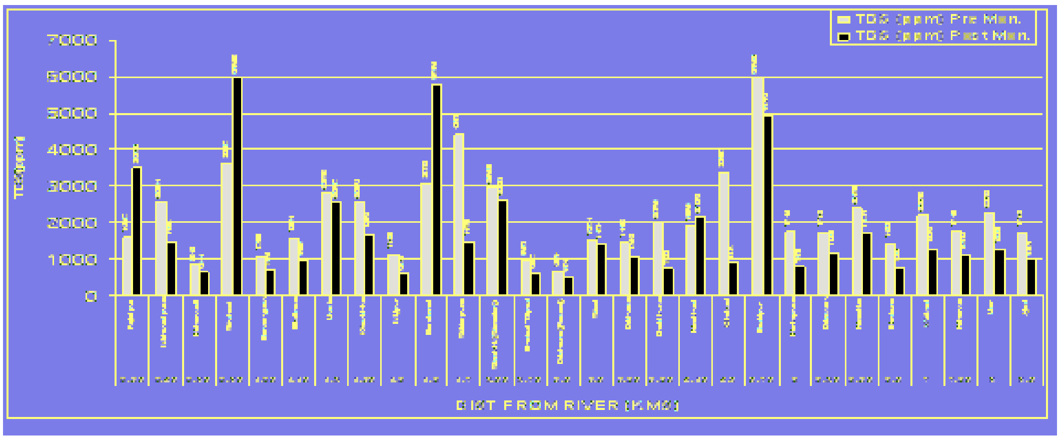


Graph 6.24 Total Dissolved Solids V/S Distance from River



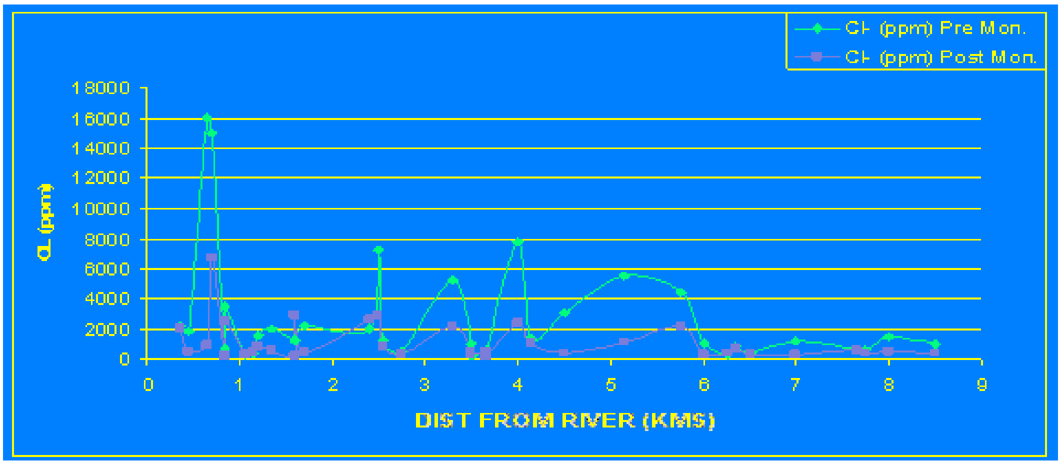
Graph 6.25 Total Dissolved Solids V/S Distance from River

(Pre-Monsoon TDS > 6000 ppm)

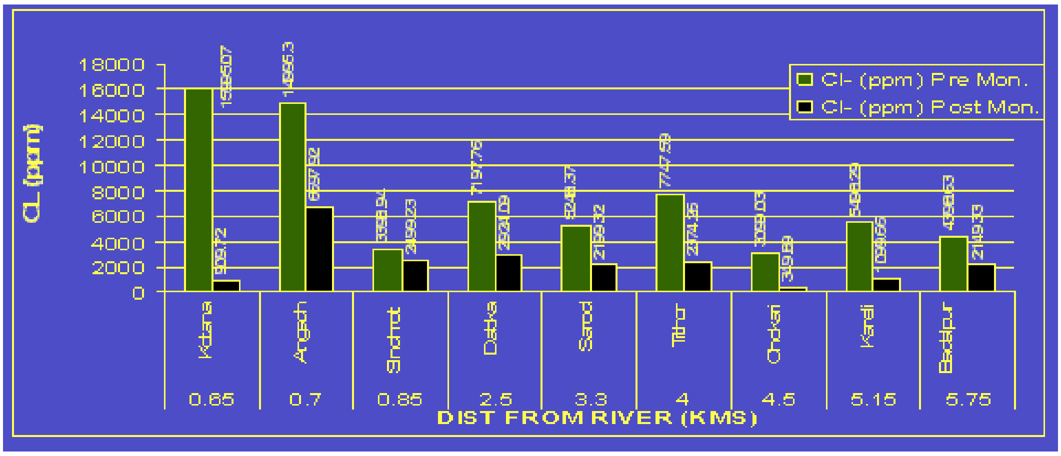


Graph 6.26 Total Dissolved Solids V/S Distance from River

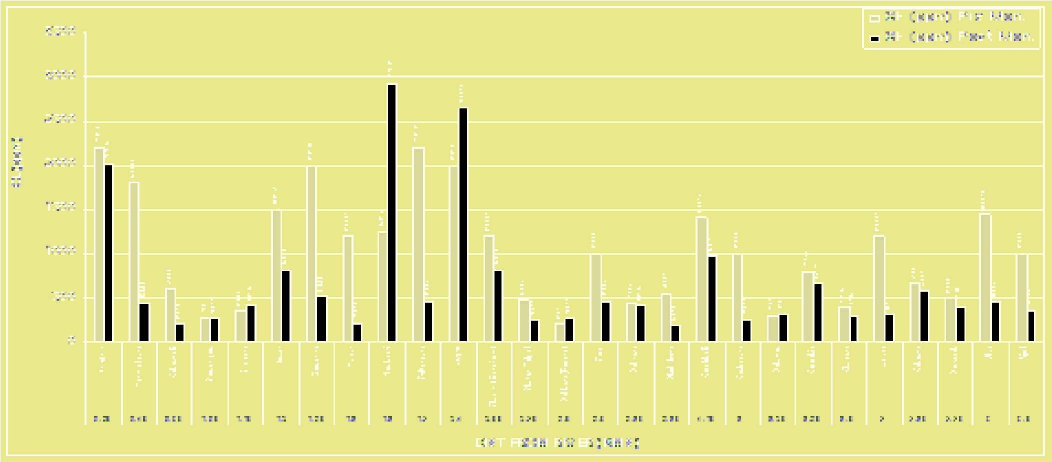
(Pre-monsoon TDS < 6000 ppm)



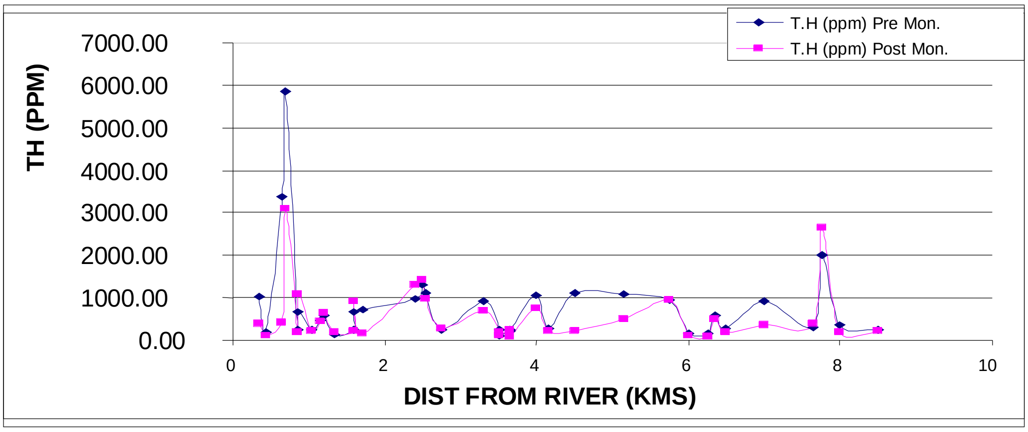
Graph 6.27 Chlorides V/S Distance from River



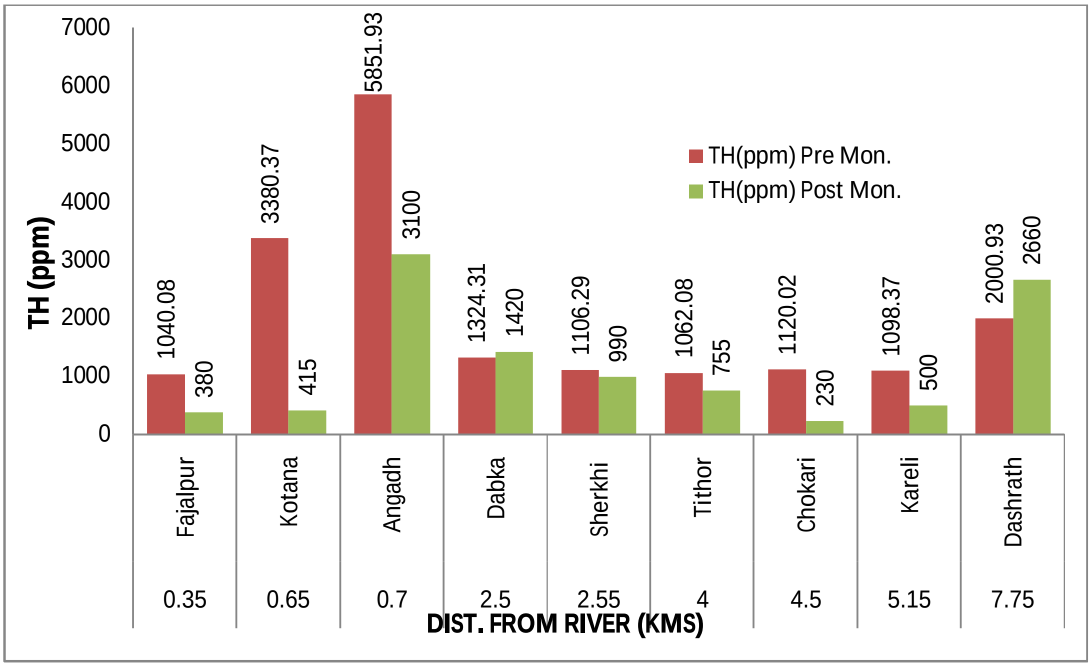
Graph 6.28 Chlorides V/S Distance from River (Pre-Monsoon Cl > 3000 ppm)



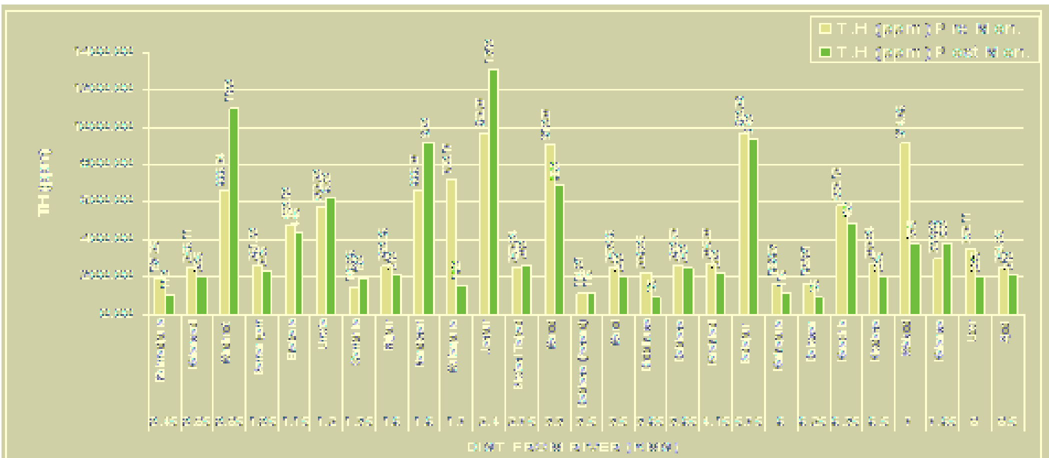
Graph 6.29 Chlorides V/S Distance from River (Pre-Monsoon Cl < 3000 ppm)



Graph 6.30 Total Hardness V/S Distance from River



Graph 6.31 Total Hardness V/S Distance from River (Pre-Monsoon TH > 1000 ppm)



Graph 6.32 Total Hardness V/S Distance from River (Pre-Monsoon TH < 1000 ppm)

Interpretations of the graphs from 6.15 to 6.32 are discussed in chapter-7, section 7.2.

7 RESULTS AND DISCUSSIONS

In this chapter results of regression analysis, lab analysis and graphical analysis are presented along with discussions on it. The results and discussions from model simulation are included in chapter-5.

7.1 Results, Discussions on Regression & Graphical Analysis

(i) It is observed from graph 6.1 to 6.3 that Total Dissolved Solids (TDS) decreases with increased distance from Kavi where Mahi River merges in the Gulf of Cambay. It is also observed from graph 6.4 to 6.8 that TDS decreases with increasing distance from centre line of river.

(ii) The correlation coefficient r is a useful measure of the goodness of regression, commonly used to study the degree of statistical relationship between a set of variables. From Table 6.1, for graphs 6.1, 6.2, 6.5 & 6.6 the linear regression equations show that the correlation coefficient r is ranging between -0.76531 to -0.9144 which indicates a close negative linear correlationship between dependent variable TDS of groundwater (Y) and independent variable, distance from centre line of river or distance from Kavi where Mahi River merges in the Gulf of Cambay (X). An increase in the distance from centre line of river or distance from Kavi is associated with a proportional decrease in the value of TDS of groundwater. Similarly for graphs 6.3, 6.4 and 6.8 the linear regression equations show that the correlation coefficient r is ranging between -0.47757 to -0.57346 which indicates an average negative linear correlationship between the above two variables. It is also found from regression equation of graph 6.7 that the correlation coefficient r is -0.30779 which indicates poor negative linear correlationship between the above two variables. The dependent variable TDS of groundwater is not significantly influenced by the independent variable, distance from centre line of river or distance from Kavi only. So perfect match is not indicated and analysis by multiple linear regressions with additional independent variables is required. Standard error of estimate S_{YX} is a measure of scatter about the best fit regression line of TDS of groundwater (Y) on distance from centre line of river or distance from Kavi (X). Its value is found ranging from 292.883 ppm to 4529.622 ppm

(iii) The multiple linear regression equations for estimating a dependent variable TDS for groundwater (X_1) from two independent variables, distance from Kavi (X_2) and reduced water level (X_3) for left bank of River Mahi of study area are represented in table 6.2. The multiple correlation coefficient $r_{1.23}$ between the dependent variable TDS of groundwater (X_1) and two independent variable, distance from Kavi (X_2) & reduced water level (X_3) is found from partial correlation coefficients which uses the standard deviation of X_1 and X_2. The value of $r_{1.23}$ lies between 0 & 1. It is found from table 6.2 that for the multiple linear regression equations the value of multiple correlation coefficient $r_{1.23}$ is ranging between 0.898 to 0.999 which indicates a close linear correlationship of (X_2) and (X_3) on (X_1). The table 6.2 shows the value of standard error of estimate $S_{1.23}$ of X_1 with respect to X_2 and X_3 for the multiple linear regression equations is ranging between 268.70 ppm to 1039.72 ppm for left bank.

(iv) The multiple linear regression equations for estimating a dependent variable TDS for groundwater (X_1) from two independent variables, distance from Kavi (X_2) and reduced water level (X_3) for right bank of River Mahi of study area are represented in table 6.3. It is found from table 6.3 that for the multiple linear regression equations the value of multiple correlation coefficient $r_{1.23}$ is ranging between 0.916 to 0.9996 which indicates a close linear correlationship of (X_2) and (X_3) on (X_1). The table 6.3 shows the value of standard error of estimate $S_{1.23}$ of X_1 with respect to X_2 and X_3 for the multiple linear regression equations is ranging between 200.79 ppm to 1298.91 ppm for right bank.

(v) The multiple linear regression equations for estimating a dependent variable TDS for groundwater (X_1) from two independent variables, distance from Kavi (X_2) and reduced water level (X_3) for both banks of River Mahi of study area are represented in table 6.4. It is found from table 6.4 that for the multiple linear regression equations the value of multiple correlation coefficient $r_{1.23}$ is ranging between 0.816 to 0.994 which indicates a close linear correlationship of (X_2) and (X_3) on (X_1). The table 6.4 shows the value of standard error of estimate $S_{1.23}$ of X_1 with respect to X_2 and X_3 for the multiple linear regression equations is ranging between 317.95 ppm to 839.95 ppm for both banks.

(vi) The multiple linear regression equations for estimating a dependent variable TDS for groundwater (X_1) from three independent variables, distance from Kavi (X_2), reduced water level (X_3) and rainfall (X_4) for both banks of River Mahi of study area are represented in table 6.5. It is found from table 6.5 that for the multiple linear regression equations the value of multiple correlation coefficient $r_{1.234}$ is ranging between 0.915 to 0.999 which indicates a close linear correlationship of (X_2), (X_3) and (X_4) on(X_1). The table 6.5 shows the value of standard error of estimate $S_{1.234}$ of X_1 with respect to X_2, X_3 and X_4 for the multiple linear regression equations is ranging between 364 ppm to 777 ppm for both banks.

(vii) It is observed from Graphs 6.9 to 6.14, that impact of rainfall on TDS is inversely proportional i.e. high value of rainfall shows less value of TDS and less value of rainfall shows high values of TDS for different taluka in Mahi estuarine area

7.2 Results, Discussions on Lab as well as Graphical Analysis

Results obtained in the laboratory are recorded in table 6.6. These laboratory results are also represented graphically as TDS, Cl and TH V/S distance from Kavi and distance from centre line of Mahi River to see at a glance the change of groundwater quality in Mahi estuarine area in pre –monsoon and post- monsoon. Based on results obtained from chemical analysis of water samples following discussions and conclusions are made.

7.2.1 Considering Distances from Kavi (Sea) in Mahi Estuarine Area

For TDS:

Table 7.1 Measured TDS of Mahi Estuarine Area (Distance from Kavi) For the Year 2003

Village	Distance from Kavi (km)	TDS in ppm	
		Pre-monsoon	Post-monsoon
Sarod	15	8472	4436
Kareli	24.8	13036	2074
Dabka	32.9	8076	6442
Kotana	44.75	35414	1978
Angadh	45.25	20612	10312

1. From Table 6.6 and graphs for pre-monsoon & Post-monsoon results of TDS, it is observed that as the distance from Kavi town increases, the TDS values decreases of ground water samples.
   The high pre-monsoon values of the TDS get normalized after the post-monsoon period because of rain water recharge and dilution with the high TDS water.
2. From Table 7.1 and graphs 6.15, 6.16 & 6.17 for pre-monsoon & Post-monsoon results of TDS, it is observed that very high values of TDS for pre-monsoon of groundwater samples at distances of 44.75 and 45.25 km of Kotana and Angadh observed are 35414 ppm and 20,612 ppm. This may be because of their locations very nearer to river and the effect of tidal water. Minimization of flow is observed in river due to construction of dams, weirs and construction of many French wells in Mahi River by Industries and Vadodara Mahanagar Seva Sadan for withdrawal of water. Also this is highly

intensified agricultural area. Many wells are located in this area and due to high withdrawal of ground water a vacuum in the aquifer may be created and resulted into sea water intrusion. Upcoming of groundwater during pumping may be the main cause of high TDS values.

The post-monsoon values of TDS decreased more at the Kotana as compared to Angadh. This may be due to less depth of tube well at Kotana compared to Angadh. Another possible reason may be local geological formations.

3. It was also seen that the pre-monsoon TDS values of groundwater samples of Sarod, Kareli and Dabka at 15, 24.8 and 32.9 km distances from Kavi are 8472 ppm, 13036 ppm and 8076 ppm. The high pre-monsoon TDS values of groundwater samples of Sarod and Kareli as compared to Dabka are observed. This may be due to their location near Kavi (Sea) and they are in Jambusar taluka, which is nearer to the bay of Khambhat. All the wells in Jambusar taluka are affected by sea water intrusion. Kareli is at more distance from Kavi as compared to Sarod but the high TDS is observed at Kareli. The probable reason may be due to over withdrawal of groundwater or may be due to local geological formation. At Dabka, value of TDS decreased compared to Sarod as Dabka is 17.90 km away on upstream from Sarod.

   The post-monsoon TDS values decreased more at Kareli compared to Sarod. This may be the effect of rainfall recharge dilution and their location from Kavi. The decrease in TDS value at Dabka is less compared to Sarod and Kareli. This may be due to local geological formation.

For Cl:

Table 7.2 Measured Cl of Mahi Estuarine Area (Distance from Kavi) for the Year 2003

Village	Distance from Kavi (km)	Cl in ppm	
		Pre-monsoon	Post-monsoon
Tithor	25.05	7747.59	2374.26
Dabka	32.9	7197.76	2924.09
Kotana	44.75	15995.07	909.72
Angadh	45.25	14995.3	6697.92

1. From Table 6.6 and graphs for pre-monsoon and post-monsoon results of Cl, it is observed that as the distance from Kavi town increases the Cl values decreases of ground water. The high pre-monsoon values of the Cl get decreased after the post-monsoon period because of the rain water recharge.
2. From Table 7.2 and graphs 6.18, 6.19 & 6.20 for pre-monsoon and post-monsoon results of Cl, it is observed that high values of Cl for pre-monsoon of ground water samples of Kotana and Angadh at 44.75 km and 45.25 km distances from Kavi are 15995.07 ppm & 14995.3 ppm. The higher Cl value observed at Kotana compared to Angadh similar to TDS values variation.

   The post-monsoon Cl values decreased less at Angadh as compared to Kotana similar to TDS decreased. This may be for the same reasons as mentioned for high TDS of groundwater samples at Kotana and Angadh considering distances from Kavi.
3. It was also seen that the pre-monsoon Cl values of ground water samples of Tithor and Dabka at 25.05 and 32.90 km distances from Kavi are 7747.59 ppm and 7197.76 ppm. The Cl value is less at Dabka as compared to Tithor as the Dabka is far away from Tithor by about 7.85 km upstream. Another possible reason may be Tithor is located on the bank of river where effect of river meandering to prove high amount of Cl in ground water.

   The post- monsoon values of Cl decreased. The decrease in Cl value at Dabka is less compared to Tithor. This may be due to local geological formations.

For TH:

Table 7.3 Measured TH of Mahi Estuarine Area (Distance from Kavi) for the Year 2003

Village	Distance from Kavi (km)	TH in ppm	
		Pre-monsoon	Post-monsoon
Kotana	44.75	3380.37	415
Angadh	45.25	5851.93	3100

1. From table 6.6 and graphs for pre-monsoon and post-monsoon results of TH, it is observed that as the distance from Kavi town increases the TH values varying of ground water samples and so no clear relation can be predicted.

The high pre-monsoon values of the TH decreased after the post-monsoon period because of the rain water recharge.

2. From table 7.3 and graphs 6.21, 6.22 & 6.23 for pre-monsoon and post-monsoon results of TH, it is observed that values of TH for pre-monsoon of groundwater samples of Kotana and Angadh are high. The high value of pre-monsoon TH at Kotana decreased much more compared to Angadh is observed after monsoon. This is similar to variation of TDS and Cl at above stations.

   This may be for the same reasons as mentioned for high TDS of groundwater samples at Kotana and Angadh considering distances from Kavi.

7.2.2 Considering Distances from Mahi River in Mahi Estuarine Area.

For TDS:

Table 7.4 Measured TDS of Mahi Estuarine Area (Distance from River) for the Year 2003

Village	Distance from River km	TDS in ppm	
		Pre-monsoon	Post-monsoon
Kotana	0.65	35414	1978
Angadh	0.70	20612	10312
Dabka	2.50	8076	6442
Sarod	3.30	8472	4436
Kareli	5.15	13036	2074

1. From Table 6.6 and graphs for pre-monsoon and post-monsoon results of TDS, it is observed that as the distance from river increases the TDS values decreases of ground water samples.

   The high pre-monsoon values of the TDS gets diluted after the post-monsoon period because of the rain water recharge and may be due to recharge of the flooded river water.

2. From table 7.4 and graphs 6.24, 6.25 and 6.26 for pre-monsoon and post-monsoon results of TDS, it is observed that very high values of TDS for pre-monsoon of groundwater samples at distances from river 0.65 km and 0.70 km of Kotana and Angadh are 35414 ppm and 20,612 ppm. The post-monsoon

values of TDS decreased less at Angadh. This may be for the same reasons as mentioned for high TDS of groundwater samples at Kotana and Angadh considering distances from Kavi (Sea).

3. It was also seen that the pre-monsoon TDS values of groundwater samples of Dabka, Sarod and Kareli at 2.50, 3.30 and 5.15 km distances from river are 8076 ppm, 8472 ppm and 13036 ppm. The high pre-monsoon TDS values are at Sarod and Kareli as compared to Dabka. The post-monsoon TDS values decreased more at Kareli compared to Sarod. This may be for the same reasons as mentioned for high TDS values of groundwater samples at Sarod, Kareli and Dabka considering distances from Kavi (Sea). The decrease in TDS value at Dabka is less compared to Sarod and Kareli as Dabka is 17.90 km away on upstream from Sarod and 8.1 km on upstream from Kareli. This may be due to local geological formation. The decrease in post-monsoon TDS value is less compared to Sarod and Kareli. This may be due to local geological formations.

For Cl:

Table 7.5 Measured Cl of Mahi Estuarine Area (Distance from River) for the Year 2003

Village	Distance from River in km	Cl in ppm	
		Pre-monsoon	Post-monsoon
Kotana	0.65	15995.07	909.72
Angadh	0.70	14995.3	6697.92
Dabka	2.5	7197.76	2924.09
Sarod	3.3	5248.37	2199.32
Tithor	4.0	7747.59	2374.26
Kareli	5.15	5498.29	1099.66
Badalpur	5.75	4398.63	2149.33

1. From Table 6.6 and graphs for pre-monsoon and post-monsoon results of Cl, it is observed that as the distance from river increases the Cl values decreases of ground water samples.

The high pre-monsoon values of Cl get diluted after the post-monsoon period because of the rain water recharge, and may be due to recharge of the flooded river water.

2. From Table 7.5 and graphs 6.27, 6.28 and 6.29 for pre-monsoon and post-monsoon results of Cl, it is observed that the pre-monsoon Cl values of groundwater samples of Kotana and Angadh at 0.65 km and 0.70 km distances from river are 15995.07 ppm and 14995.3 ppm. They are very high. The higher Cl value observed at Kotana compared to Angadh similar to variation of TDS for pre-monsoon for above stations. The post-monsoon Cl values decreased less at Angadh similar to TDS decrease. This may be for same reasons as mentioned for high TDS of groundwater samples at Kotana and Angadh considering distances from Kavi.
3. Similarly, it was also seen that the high pre-monsoon Cl values of groundwater samples at Dabka, Sarod, Tithor, Kareli and Badalpur. The pre-monsoon Cl value is higher at Tithor as compared to Sarod; the reason may be meandering of river at Tithor and may be due to local geological formation. The post-monsoon Cl values at Tithor are higher as compared to Sarod. This may be for the same reasons as mentioned for high pre-monsoon Cl values of groundwater samples at Tithor and Sarod considering distances from Kavi. Similarly, at Badalpur Cl value is higher as compared to Kareli may be due to Badalpur is at 16.25 km from Kavi and Kareli is at 24.8 km from Kavi.

For TH:

Table 7.6 Measured TH of Mahi Estuarine Area (Distance from River) for the Year 2003.

Village	Distance from River km	TH in ppm	
		Pre-monsoon	Post-monsoon
Kotana	0.65	3380.37	415
Angadh	0.70	5851.93	3100

1. From table 6.6 and graphs for pre-monsoon and post-monsoon results of TH, it is observed that as the distance from river increases the TH values varying of ground water samples and so clear relation cannot be predicted.

The high pre-monsoon values of TH decreased after the post-monsoon period for most of ground water samples because of the rain water recharge.

2. From Table 7.6 and graphs 6.30, 6.31 and 6.32 for pre-monsoon and post-monsoon results of TH, it is observed that values of TH for pre-monsoon of groundwater samples of Kotana and Angadh are high. The post-monsoon TH values decreased much more at Kotana as compared to Angadh are observed. This is similar to variation of TDS and Cl at above stations. This may be for the same reasons as mentioned for high TDS of groundwater samples at Kotana and Angadh considering distances from Kavi.

. **7.2.3 Considering Location of Villages on Right or Left Bank.**

The values of pre-monsoon and post-monsoon TDS of ground water samples of villages located on Right Bank of river are observed less compared to the villages on left bank of river. This may be due to irrigation by MRBC from Wanakbori weir on right bank of Mahi River.

8 CONCLUSIONS

In this chapter summary, conclusions and Research contribution of the present study are discussed.

8.1 Summary

The present study is related to groundwater fluctuations in Mahi estuarine area which is laying in part of three districts of Gujarat namely Anand, Vadodara, and Bharuch. The tidal effect of sea in the Mahi estuary has increased the sea water intrusion in the land ward side. The groundwater has been contaminated over the period and the quality of the ground water is continuously deteriorating. Major portion of this area is comprises agricultural land. The groundwater system of this area is dynamic in nature because of monsoon recharge due to rain, irrigation return flow and groundwater pumping. The water level and water quality are also affected by natural recharge of surface water of River Mahi.

The present study attempts modeling of groundwater regime in the study area. The groundwater system of the study area is characterized by using inverse modeling and aquifer hydraulic conductivity values are obtained. The groundwater fluctuations are obtained during study period using model simulation. Mass balance of surface water and groundwater of unconfined aquifer is computed. The effect of fresh water pool, created by construction of weir, on adjoining groundwater table is investigated. The relation between salinity and distance from sea are obtained. Water quality of unconfined aquifer is studied with reference to natural recharge from river. Finally predictions are made for effect of alternative locations of weir on recharge of estuary area.

8.2 Conclusions

Based on results and discussions following conclusions are derived.

(i) General geology confirm to alluvial area consisting alternate layers of clay, sand, gravel, occasionally mixed with kankar. Such strata are suitable for artificial recharge of groundwater.

(ii) In conceptual model number of zones considered for horizontal permeability and specific yield are considered 23 which may be adequate to represent the variation in aquifer characteristics in the study area.

(iii) The calibration of model is carried out using data from the period June 1997 to June 1999 and the horizontal permeability is found to be in the range of 5 to 50 m/day.

(iv) The calibrated values are finalized by comparing the observed and computed groundwater level at various well locations. There is a very good match between the computed and observed heads in most of wells of the study area under validation.

(v) Higher water table is observed at north-east where as water level reduces towards west boundary. The contours of groundwater level are obtained for pre and post monsoon, General groundwater flow is found from north-east to south-west direction. Groundwater profiles are obtained across river. In each profiles mound below river is observed. The unsymmetrical behavior in the groundwater mounds along the centre line of river is reflected in Figures 5.11 to 5.15 because on right hand side irrigation return flow is adding into the groundwater in MRBC area where as in left hand side irrigation is done by groundwater pumping.

(vi) The weirs are introduced as low permeability cells in unconfined aquifer. Length of Badalpur weir is more than Sindhrot weir. Hence area of influence is more at Badalpur weir as compared to Sindhrot weir.

(vii) Construction of the weir has resulted in increase in the groundwater recharge due to fresh surface water seepage in the study area and also helps in reducing salinity. Reduced water levels in unconfined aquifer are found to be showing rising trend with weir compared to without weir condition. Introduction of weir cause more recharge in nearby area. Increase in water table at nearby locations in two years after construction of Sindhrot weir is found and it is raised by 0.5 m to 1.43 m.

(viii) Water levels in locations surrounding of Sindhrot weir are not much affected by Badalpur weir. As Badalpur weir is located sufficiently downstream of Sindhrot weir.

(ix) Water quality analysis is carried out to find effect of distance from surface water. The Total Dissolved Solids (TDS) of ground water decreases with increasing distance from sea (Kavi) where Mahi River merges in the Gulf of Khambhat (Cambay). Similar trend is observed from centre line of river.

(x) The correlation coefficients obtained from linear regression equations indicates close, average and poor negative linear correlationship between dependent variable TDS of groundwater and independent variable, distance from centre line of river or distance from sea (Kavi).

(xi) The correlation coefficient 'r' for multiple linear relations between TDS of groundwater and two parameters i. e. distance from sea (Kavi) and Reduced Water Level (RWL) for left bank, right bank and both banks are found well within the range. The correlation coefficient 'r' for multiple linear relations between TDS of groundwater and three parameters i. e. distance from sea (Kavi), Reduced Water Level (RWL) and rainfall for both banks are found well within the range.

(xii) It is concluded from graphical analysis that impact of rainfall on TDS is inversely proportional i.e. high value of rainfall shows less value of TDS and less value of rainfall shows high values of TDS for different taluka in Mahi estuarine area

(xiii) Attempt is made to get relationship among parameters like TDS, RWL, distances from sea (Kavi) and rainfall but no clear relationship is obtained because of the complexity of the system in Mahi estuarine area.

(xiv) The pre-monsoon and post-monsoon TDS and Cl values of groundwater samples of Mahi estuarine area decreases as the distances from sea (Kavi) or river increases. The pre-monsoon and post-monsoon TH values of groundwater samples of Mahi estuarine area varying as the distances from sea (Kavi) or river increases. So, no clear relation can be predicted.

(xv) The high pre-monsoon values of the TDS, Cl and TH of groundwater samples of Mahi estuarine area get normalized after the post- monsoon period because of the rainfall recharge. This may be also due to recharge of the flooded river water.

(xvi) The very high values of TDS for pre-monsoon of groundwater samples of Kotana and Angadh are observed. This may be because of their locations very nearer to river and the effect of tidal water. Minimization of flow is observed in river due to construction of dams, weirs and construction of many French wells in Mahi River by Industries and Vadodara Mahanagar Seva Sadan for withdrawal of water. Also this is highly intensified agricultural area. Many wells are located in this area and due to high withdrawal of ground water a vacuum in the aquifer may be created and resulted into sea water intrusion. Upcoming of groundwater during pumping may be the main cause of high TDS values.

(xvii) The high pre-monsoon TDS values of groundwater samples at Sarod and Kareli as compared to Dabka are observed. This may be due to their location near Kavi (Sea) and they are in Jambusar taluka, which is nearer to the bay of Khambhat. All the wells in Jambusar taluka are affected by sea water intrusion. Kareli is at more distance from sea (Kavi) as compared to Sarod but the high TDS is observed at Kareli. The probable reason may be due to over withdrawal of groundwater or may be due to local geological formation. At Dabka, value of TDS decreased compared to Sarod as Dabka is 17.90 km away on upstream from Sarod.

(xviii) The values of pre-monsoon and post-monsoon TDS of ground water samples of villages located on Right Bank of river are observed less compared to the villages on left bank of river. This may be due to irrigation by MRBC from Wanakbori weir on right bank of Mahi River.

8.3 Research Contributions

1. The problem of salinity and water level fluctuations in study area is identified and the extent of area affected is found based on field data collection.
2. The conceptual groundwater model is developed with Mahi River as major recharge features. The depth and extent of unconfined aquifer is estimated based on bore log data.
3. Groundwater Model is constructed for study area and boundary conditions are worked out.
4. Zoning of study area is done for the aquifer parameter and inverse modelling is carried out. The aquifer hydraulic conductivity values are obtained.
5. Field samples are collected and water quality analysis is carried out and water quality parameters are found.
6. Regression analysis is carried out and the linear regression equations are developed to predict the groundwater quality.

7. Monsoon and non-monsoon recharge due to rainfall, surface water and irrigation is estimated based on the water table fluctuation method.
8. Groundwater Model simulation is carried out for without weir and one/ two weir scenarios.

Scope of Further Study

The study can be extended to extend the model area to include Sardar Sarovar Command to investigate consumptive use of surface water and groundwater for irrigation.

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ANNEXURE

ANNEXURE-I

RL's of Mahi River Water Level for Year June 1997 to June 1999, June 2003 to June 2005 and June 2005 to June 2007 at Khanpur, Poicha and Dhuvaran in m from m.s.l.

Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m
6/13/1997	9.07	7/22/1997	9.07	8/30/1997	12.94	10/8/1997	9.21
6/14/1997	9.07	7/23/1997	9.06	8/31/1997	13.69	10/9/1997	9.2
6/15/1997	9.07	7/24/1997	9.06	9/1/1997	12.195	10/10/1997	9.2
6/16/1997	9.075	7/25/1997	9.06	9/2/1997	12.235	10/11/1997	9.19
6/17/1997	9.145	7/26/1997	9.08	9/3/1997	10.88	10/12/1997	9.17
6/18/1997	9.25	7/27/1997	9.18	9/4/1997	10.42	10/13/1997	9.17
6/19/1997	9.16	7/28/1997	12.51	9/5/1997	10.36	10/14/1997	9.17
6/20/1997	9.07	7/29/1997	10.545	9/6/1997	10.32	10/15/1997	9.18
6/21/1997	9.065	7/30/1997	10.23	9/7/1997	10.26	10/16/1997	9.26
6/22/1997	9.065	7/31/1997	10.215	9/8/1997	10.29	10/17/1997	9.24
6/23/1997	9.07	8/1/1997	14.62	9/9/1997	10.13	10/18/1997	9.22
6/24/1997	9.185	8/2/1997	21.37	9/10/1997	10.25	10/19/1997	9.2
6/25/1997	9.57	8/3/1997	16.26	9/11/1997	10.12	10/20/1997	9.75
6/26/1997	10.76	8/4/1997	12.98	9/12/1997	10.2	10/21/1997	9.75
6/27/1997	10.31	8/5/1997	11.305	9/13/1997	10.09	10/22/1997	9.76
6/28/1997	10.53	8/6/1997	11.17	9/14/1997	10.33	10/23/1997	9.73
6/29/1997	9.94	8/7/1997	11.125	9/15/1997	10.26	10/24/1997	9.72
6/30/1997	9.62	8/8/1997	10.445	9/16/1997	10.155	10/25/1997	9.45
7/1/1997	9.505	8/9/1997	11.46	9/17/1997	9.975	10/26/1997	9.53
7/2/1997	9.48	8/10/1997	12.56	9/18/1997	9.927	10/27/1997	9.58
7/3/1997	9.545	8/11/1997	11.09	9/19/1997	10.34	10/28/1997	9.67
7/4/1997	9.735	8/12/1997	10.155	9/20/1997	10.315	10/29/1997	9.75
7/5/1997	9.63	8/13/1997	10.22	9/21/1997	10.09	10/30/1997	9.84
7/6/1997	9.42	8/14/1997	10.26	9/22/1997	9.86	10/31/1997	9.81
7/7/1997	9.165	8/15/1997	10.28	9/23/1997	9.805	11/1/1997	9.75
7/8/1997	9.2	8/16/1997	10.125	9/24/1997	9.81	11/2/1997	9.74
7/9/1997	9.14	8/17/1997	9.96	9/25/1997	10.18	11/3/1997	9.67
7/10/1997	9.11	8/18/1997	9.9	9/26/1997	9.87	11/4/1997	9.65
7/11/1997	9.09	8/19/1997	9.79	9/27/1997	9.72	11/5/1997	9.66
7/12/1997	9.105	8/20/1997	9.81	9/28/1997	9.65	11/6/1997	9.63
7/13/1997	9.08	8/21/1997	9.91	9/29/1997	9.72	11/7/1997	9.42
7/14/1997	9.09	8/22/1997	9.83	9/30/1997	9.72	11/8/1997	9.34
7/15/1997	9.065	8/23/1997	9.92	10/1/1997	9.57	11/9/1997	9.22
7/16/1997	9.065	8/24/1997	10.06	10/2/1997	9.56	11/10/1997	9.29
7/17/1997	9.05	8/25/1997	18.19	10/3/1997	9.32	11/11/1997	9.29
7/18/1997	9.06	8/26/1997	16.035	10/4/1997	9.26	11/12/1997	9.29
7/19/1997	9.225	8/27/1997	15.04	10/5/1997	9.22	11/13/1997	9.45
7/20/1997	9.02	8/28/1997	13.948	10/6/1997	9.265	11/14/1997	9.45
7/21/1997	9.1	8/29/1997	12	10/7/1997	9.255	11/15/1997	9.44

Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m
11/16/1997	9.53	12/27/1997	9.32	2/6/1998	9.26	3/19/1998	8.98
11/17/1997	9.47	12/28/1997	9.3	2/7/1998	9.27	3/20/1998	9
11/18/1997	9.48	12/29/1997	9.3	2/8/1998	9.26	3/21/1998	8.98
11/19/1997	9.47	12/30/1997	9.3	2/9/1998	9.26	3/22/1998	8.98
11/20/1997	9.47	12/31/1997	9.3	2/10/1998	9.26	3/23/1998	8.98
11/21/1997	9.42	1/1/1998	9.3	2/11/1998	9.26	3/24/1998	8.98
11/22/1997	9.43	1/2/1998	9.3	2/12/1998	9.26	3/25/1998	8.97
11/23/1997	9.36	1/3/1998	9.3	2/13/1998	9.26	3/26/1998	8.96
11/24/1997	9.31	1/4/1998	9.3	2/14/1998	9.26	3/27/1998	8.98
11/25/1997	9.3	1/5/1998	9.3	2/15/1998	9.09	3/28/1998	8.95
11/26/1997	9.27	1/6/1998	9.3	2/16/1998	9.02	3/29/1998	8.95
11/27/1997	9.37	1/7/1998	9.3	2/17/1998	9.02	3/30/1998	8.96
11/28/1997	9.38	1/8/1998	9.3	2/18/1998	9.02	3/31/1998	8.96
11/29/1997	9.36	1/9/1998	9.3	2/19/1998	9.02	4/1/1998	8.99
11/30/1997	9.36	1/10/1998	9.3	2/20/1998	9.02	4/2/1998	9.02
12/1/1997	9.36	1/11/1998	9.3	2/21/1998	9.01	4/3/1998	8.995
12/2/1997	9.36	1/12/1998	9.3	2/22/1998	9.01	4/4/1998	9
12/3/1997	9.33	1/13/1998	9.3	2/23/1998	9.01	4/5/1998	8.99
12/4/1997	9.33	1/14/1998	9.3	2/24/1998	9.01	4/6/1998	9.01
12/5/1997	9.32	1/15/1998	9.3	2/25/1998	9.01	4/7/1998	9
12/6/1997	9.31	1/16/1998	9.3	2/26/1998	9.01	4/8/1998	9
12/7/1997	9.31	1/17/1998	9.3	2/27/1998	9.02	4/9/1998	9
12/8/1997	9.31	1/18/1998	9.3	2/28/1998	9.01	4/10/1998	9
12/9/1997	9.32	1/19/1998	9.3	3/1/1998	9.01	4/11/1998	8.99
12/10/1997	9.31	1/20/1998	9.29	3/2/1998	9	4/12/1998	8.98
12/11/1997	9.31	1/21/1998	9.28	3/3/1998	9	4/13/1998	9.04
12/12/1997	9.32	1/22/1998	9.28	3/4/1998	8.99	4/14/1998	9.04
12/13/1997	9.315	1/23/1998	9.28	3/5/1998	8.99	4/15/1998	8.98
12/14/1997	9.32	1/24/1998	9.28	3/6/1998	8.99	4/16/1998	9
12/15/1997	9.32	1/25/1998	9.28	3/7/1998	9.02	4/17/1998	8.99
12/16/1997	9.31	1/26/1998	9.28	3/8/1998	9.02	4/18/1998	8.99
12/17/1997	9.31	1/27/1998	9.28	3/9/1998	9.12	4/19/1998	8.99
12/18/1997	9.3	1/28/1998	9.27	3/10/1998	9.11	4/20/1998	8.99
12/19/1997	9.3	1/29/1998	9.28	3/11/1998	9.12	4/21/1998	8.98
12/20/1997	9.3	1/30/1998	9.28	3/12/1998	9.11	4/22/1998	8.98
12/21/1997	9.3	1/31/1998	9.28	3/13/1998	9.11	4/23/1998	8.97
12/22/1997	9.3	2/1/1998	9.28	3/14/1998	8.98	4/24/1998	8.98
12/23/1997	9.29	2/2/1998	9.26	3/15/1998	8.98	4/25/1998	8.97
12/24/1997	9.31	2/3/1998	9.26	3/16/1998	9.02	4/26/1998	8.97
12/25/1997	9.34	2/4/1998	9.26	3/17/1998	9.07	4/27/1998	8.97
12/26/1997	9.33	2/5/1998	9.23	3/18/1998	8.98	4/28/1998	8.96

Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m
4/29/1998	8.97	6/8/1998	9.1	7/18/1998	9.12	8/27/1998	9.02
4/30/1998	9	6/9/1998	9.1	7/19/1998	9.04	8/28/1998	9.21
5/1/1998	8.99	6/10/1998	9.1	7/20/1998	9.02	8/29/1998	9.08
5/2/1998	8.98	6/11/1998	9.13	7/21/1998	9.01	8/30/1998	9.01
5/3/1998	8.98	6/12/1998	9.12	7/22/1998	8.96	8/31/1998	9.05
5/4/1998	8.97	6/13/1998	9.1	7/23/1998	8.945	9/1/1998	9.07
5/5/1998	8.97	6/14/1998	9.1	7/24/1998	8.95	9/2/1998	9.06
5/6/1998	8.97	6/15/1998	9.1	7/25/1998	8.94	9/3/1998	9.05
5/7/1998	8.95	6/16/1998	9.1	7/26/1998	8.93	9/4/1998	9.04
5/8/1998	8.97	6/17/1998	9.1	7/27/1998	8.96	9/5/1998	9.025
5/9/1998	9.02	6/18/1998	9.11	7/28/1998	8.95	9/6/1998	9.01
5/10/1998	9	6/19/1998	9.13	7/29/1998	8.95	9/7/1998	9.025
5/11/1998	8.98	6/20/1998	9.12	7/30/1998	9.285	9/8/1998	9.04
5/12/1998	8.97	6/21/1998	9.06	7/31/1998	9.18	9/9/1998	9.22
5/13/1998	8.97	6/22/1998	9.15	8/1/1998	9.16	9/10/1998	9.59
5/14/1998	8.97	6/23/1998	9.12	8/2/1998	9.41	9/11/1998	9.79
5/15/1998	8.97	6/24/1998	9.1	8/3/1998	9.63	9/12/1998	9.505
5/16/1998	8.98	6/25/1998	9.08	8/4/1998	9.555	9/13/1998	9.44
5/17/1998	8.97	6/26/1998	9.05	8/5/1998	9.38	9/14/1998	9.28
5/18/1998	8.97	6/27/1998	9.08	8/6/1998	9.245	9/15/1998	14.08
5/19/1998	8.97	6/28/1998	9.08	8/7/1998	9.145	9/16/1998	11.41
5/20/1998	8.97	6/29/1998	9.09	8/8/1998	9.205	9/17/1998	12.67
5/21/1998	9.01	6/30/1998	9.18	8/9/1998	9.17	9/18/1998	16.865
5/22/1998	9.01	7/1/1998	9.1	8/10/1998	9.165	9/19/1998	13.4
5/23/1998	9	7/2/1998	9.07	8/11/1998	9.14	9/20/1998	12.52
5/24/1998	8.99	7/3/1998	8.97	8/12/1998	9.31	9/21/1998	11.27
5/25/1998	8.935	7/4/1998	8.98	8/13/1998	9.21	9/22/1998	11.02
5/26/1998	8.935	7/5/1998	9	8/14/1998	9.14	9/23/1998	10.8
5/27/1998	8.935	7/6/1998	9.02	8/15/1998	9.135	9/24/1998	10.665
5/28/1998	9.13	7/7/1998	9.3	8/16/1998	9.07	9/25/1998	10.335
5/29/1998	9.13	7/8/1998	9.435	8/17/1998	9.045	9/26/1998	10.365
5/30/1998	9.08	7/9/1998	9.135	8/18/1998	9.03	9/27/1998	10.1
5/31/1998	9.08	7/10/1998	9.05	8/19/1998	9.025	9/28/1998	10.935
6/1/1998	9.09	7/11/1998	9.03	8/20/1998	9.01	9/29/1998	11.675
6/2/1998	9.09	7/12/1998	9.09	8/21/1998	9.01	9/30/1998	10.84
6/3/1998	9.1	7/13/1998	9.05	8/22/1998	9.01	10/1/1998	10.575
6/4/1998	9.1	7/14/1998	9	8/23/1998	9.01	10/2/1998	10.32
6/5/1998	9.095	7/15/1998	9.27	8/24/1998	9.035	10/3/1998	10.11
6/6/1998	9.09	7/16/1998	9.23	8/25/1998	9.02	10/4/1998	10.3
6/7/1998	9.1	7/17/1998	9.22	8/26/1998	9.02	10/5/1998	10.015

Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m
10/6/1998	9.565	11/15/1998	9.46	12/25/1998	9.21
10/7/1998	9.545	11/16/1998	9.46	12/26/1998	9.21
10/8/1998	9.47	11/17/1998	9.43	12/27/1998	9.21
10/9/1998	9.32	11/18/1998	9.37	12/28/1998	9.15
10/10/1998	9.23	11/19/1998	9.465	12/29/1998	9.14
10/11/1998	9.09	11/20/1998	9.17	12/30/1998	9.12
10/12/1998	9.36	11/21/1998	9.07	12/31/1998	9.14
10/13/1998	9.22	11/22/1998	9.06	1/1/1999	9.12
10/14/1998	9.14	11/23/1998	9.02	1/2/1999	9.08
10/15/1998	9.11	11/24/1998	9.02	1/3/1999	9.07
10/16/1998	9.315	11/25/1998	9.03	1/4/1999	9.05
10/17/1998	10.58	11/26/1998	9.03	1/5/1999	9.04
10/18/1998	10.62	11/27/1998	9.13	1/6/1999	9.04
10/19/1998	10.52	11/28/1998	9.07	1/7/1999	9.045
10/20/1998	10.325	11/29/1998	9.04	1/8/1999	9.05
10/21/1998	10.3	11/30/1998	9.11	1/9/1999	9.04
10/22/1998	10.26	12/1/1998	9.13	1/10/1999	9.07
10/23/1998	9.62	12/2/1998	9.13	1/11/1999	9.11
10/24/1998	9.62	12/3/1998	9.13	1/12/1999	9.03
10/25/1998	9.37	12/4/1998	9.08	1/13/1999	9.02
10/26/1998	9.61	12/5/1998	9.11	1/14/1999	8.99
10/27/1998	9.57	12/6/1998	9.12	1/15/1999	8.96
10/28/1998	9.63	12/7/1998	9.07	1/16/1999	9
10/29/1998	9.53	12/8/1998	9.07	1/17/1999	8.99
10/30/1998	9.53	12/9/1998	9.14	1/18/1999	8.97
10/31/1998	9.53	12/10/1998	9.07	1/19/1999	8.96
11/1/1998	9.51	12/11/1998	9.07	1/20/1999	8.96
11/2/1998	9.46	12/12/1998	9.06	1/21/1999	8.97
11/3/1998	9.46	12/13/1998	9.08	1/22/1999	8.97
11/4/1998	9.44	12/14/1998	9.08	1/23/1999	8.97
11/5/1998	9.42	12/15/1998	9.08	1/24/1999	8.97
11/6/1998	9.38	12/16/1998	9.06	1/25/1999	8.97
11/7/1998	9.35	12/17/1998	9.07	1/26/1999	8.97
11/8/1998	9.34	12/18/1998	9.08	1/27/1999	8.97
11/9/1998	9.35	12/19/1998	9.08	1/28/1999	8.98
11/10/1998	9.43	12/20/1998	9.08	1/29/1999	8.97
11/11/1998	9.47	12/21/1998	9.07	1/30/1999	8.97
11/12/1998	9.45	12/22/1998	9.18	1/31/1999	8.97
11/13/1998	9.47	12/23/1998	9.18	2/1/1999	9
11/14/1998	9.48	12/24/1998	9.205	2/2/1999	8.97

Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m
2/3/1999	8.97	3/15/1999	8.94	4/24/1999	8.95	6/3/1999	8.95
2/4/1999	8.98	3/16/1999	8.94	4/25/1999	8.95	6/4/1999	8.97
2/5/1999	8.98	3/17/1999	8.95	4/26/1999	8.94	6/5/1999	8.97
2/6/1999	8.98	3/18/1999	8.95	4/27/1999	8.94	6/6/1999	8.965
2/7/1999	8.98	3/19/1999	8.94	4/28/1999	8.94	6/7/1999	8.97
2/8/1999	8.98	3/20/1999	8.94	4/29/1999	8.94	6/8/1999	8.97
2/9/1999	8.98	3/21/1999	8.95	4/30/1999	8.94	6/9/1999	8.97
2/10/1999	9	3/22/1999	8.96	5/1/1999	8.94	6/10/1999	8.98
2/11/1999	8.97	3/23/1999	8.96	5/2/1999	8.94	6/11/1999	8.97
2/12/1999	8.98	3/24/1999	8.93	5/3/1999	8.94	6/12/1999	8.98
2/13/1999	8.98	3/25/1999	8.93	5/4/1999	8.93	6/13/1999	8.97
2/14/1999	8.97	3/26/1999	8.93	5/5/1999	8.93	6/14/1999	8.97
2/15/1999	8.96	3/27/1999	8.93	5/6/1999	8.94		
2/16/1999	8.96	3/28/1999	8.93	5/7/1999	8.94		
2/17/1999	8.96	3/29/1999	8.93	5/8/1999	8.94		
2/18/1999	8.96	3/30/1999	8.93	5/9/1999	8.9		
2/19/1999	8.96	3/31/1999	8.93	5/10/1999	8.87		
2/20/1999	8.96	4/1/1999	8.93	5/11/1999	8.87		
2/21/1999	8.95	4/2/1999	8.93	5/12/1999	8.87		
2/22/1999	8.94	4/3/1999	8.92	5/13/1999	8.98		
2/23/1999	8.95	4/4/1999	8.92	5/14/1999	8.88		
2/24/1999	8.95	4/5/1999	8.92	5/15/1999	8.88		
2/25/1999	8.94	4/6/1999	8.92	5/16/1999	8.88		
2/26/1999	8.95	4/7/1999	8.915	5/17/1999	8.88		
2/27/1999	8.95	4/8/1999	8.915	5/18/1999	8.88		
2/28/1999	8.95	4/9/1999	8.92	5/19/1999	8.97		
3/1/1999	8.95	4/10/1999	8.925	5/20/1999	8.97		
3/2/1999	8.95	4/11/1999	8.95	5/21/1999	8.97		
3/3/1999	8.95	4/12/1999	9	5/22/1999	8.97		
3/4/1999	8.93	4/13/1999	8.96	5/23/1999	8.95		
3/5/1999	8.93	4/14/1999	8.96	5/24/1999	8.94		
3/6/1999	8.93	4/15/1999	8.96	5/25/1999	8.96		
3/7/1999	8.95	4/16/1999	8.94	5/26/1999	8.95		
3/8/1999	8.98	4/17/1999	8.94	5/27/1999	8.97		
3/9/1999	8.98	4/18/1999	8.94	5/28/1999	8.96		
3/10/1999	8.98	4/19/1999	8.93	5/29/1999	8.95		
3/11/1999	8.95	4/20/1999	8.93	5/30/1999	8.95		
3/12/1999	8.95	4/21/1999	8.93	5/31/1999	8.96		
3/13/1999	8.95	4/22/1999	8.92	6/1/1999	8.95		
3/14/1999	8.95	4/23/1999	8.96	6/2/1999	8.95		

Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m
6/13/2003	8.85	7/23/2003	10.255	9/1/2003	9.73	10/11/2003	9.49
6/14/2003	8.85	7/24/2003	10.34	9/2/2003	9.67	10/12/2003	9.38
6/15/2003	8.85	7/25/2003	10.17	9/3/2003	9.61	10/13/2003	9.34
6/16/2003	8.85	7/26/2003	10.25	9/4/2003	9.59	10/14/2003	9.33
6/17/2003	8.85	7/27/2003	10.09	9/5/2003	9.53	10/15/2003	9.31
6/18/2003	8.85	7/28/2003	10.57	9/6/2003	9.54	10/16/2003	9.31
6/19/2003	8.95	7/29/2003	11.345	9/7/2003	9.46	10/17/2003	9.29
6/20/2003	8.87	7/30/2003	10.2	9/8/2003	9.47	10/18/2003	9.27
6/21/2003	9	7/31/2003	10.025	9/9/2003	9.46	10/19/2003	9.265
6/22/2003	9.38	8/1/2003	9.985	9/10/2003	9.51	10/20/2003	9.25
6/23/2003	9.615	8/2/2003	10.015	9/11/2003	9.46	10/21/2003	9.23
6/24/2003	9.71	8/3/2003	9.94	9/12/2003	9.38	10/22/2003	9.24
6/25/2003	9.66	8/4/2003	9.9	9/13/2003	9.28	10/23/2003	9.24
6/26/2003	9.59	8/5/2003	9.88	9/14/2003	9.13	10/24/2003	9.4
6/27/2003	9.33	8/6/2003	9.9	9/15/2003	9.02	10/25/2003	9.5
6/28/2003	9.23	8/7/2003	9.89	9/16/2003	8.99	10/26/2003	9.49
6/29/2003	9.02	8/8/2003	9.84	9/17/2003	8.97	10/27/2003	9.48
6/30/2003	9	8/9/2003	9.81	9/18/2003	8.97	10/28/2003	9.48
7/1/2003	8.97	8/10/2003	9.8	9/19/2003	9.425	10/29/2003	9.52
7/2/2003	8.96	8/11/2003	9.79	9/20/2003	9.645	10/30/2003	9.52
7/3/2003	8.97	8/12/2003	9.79	9/21/2003	9.72	10/31/2003	9.52
7/4/2003	9.41	8/13/2003	9.76	9/22/2003	9.27	11/1/2003	9.62
7/5/2003	9.41	8/14/2003	9.76	9/23/2003	10.47	11/2/2003	9.61
7/6/2003	9.49	8/15/2003	9.755	9/24/2003	10.22	11/3/2003	9.46
7/7/2003	9.4	8/16/2003	9.77	9/25/2003	12.16	11/4/2003	9.46
7/8/2003	9.34	8/17/2003	9.79	9/26/2003	11.115	11/5/2003	9.46
7/9/2003	9.33	8/18/2003	9.81	9/27/2003	12.21	11/6/2003	9.79
7/10/2003	9.36	8/19/2003	9.82	9/28/2003	11.52	11/7/2003	9.78
7/11/2003	9.36	8/20/2003	9.76	9/29/2003	10.785	11/8/2003	9.61
7/12/2003	9.51	8/21/2003	9.7	9/30/2003	10.415	11/9/2003	9.6
7/13/2003	9.45	8/22/2003	9.66	10/1/2003	10.835	11/10/2003	9.6
7/14/2003	9.395	8/23/2003	9.65	10/2/2003	10.52	11/11/2003	9.62
7/15/2003	9.36	8/24/2003	10.2	10/3/2003	10.355	11/12/2003	9.62
7/16/2003	9.45	8/25/2003	11.04	10/4/2003	9.97	11/13/2003	9.62
7/17/2003	9.78	8/26/2003	10.22	10/5/2003	9.87	11/14/2003	9.62
7/18/2003	10.04	8/27/2003	10.238	10/6/2003	9.81	11/15/2003	9.62
7/19/2003	9.86	8/28/2003	10.23	10/7/2003	9.695	11/16/2003	9.62
7/20/2003	9.86	8/29/2003	10.21	10/8/2003	9.65	11/17/2003	9.62
7/21/2003	9.915	8/30/2003	9.985	10/9/2003	9.62	11/18/2003	9.62
7/22/2003	9.99	8/31/2003	9.81	10/10/2003	9.58	11/19/2003	9.62

Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m
11/20/2003	9.62	12/30/2003	9.2	2/8/2004	9.07	3/19/2004	9.17
11/21/2003	9.62	12/31/2003	9.2	2/9/2004	8.97	3/20/2004	9.17
11/22/2003	9.6	1/1/2004	9.2	2/10/2004	8.95	3/21/2004	9.51
11/23/2003	9.6	1/2/2004	9.2	2/11/2004	8.95	3/22/2004	9.7
11/24/2003	9.6	1/3/2004	9.21	2/12/2004	8.95	3/23/2004	9.57
11/25/2003	9.6	1/4/2004	9.21	2/13/2004	8.95	3/24/2004	9.375
11/26/2003	9.57	1/5/2004	9.21	2/14/2004	8.95	3/25/2004	9.7
11/27/2003	9.47	1/6/2004	9.21	2/15/2004	8.95	3/26/2004	9.66
11/28/2003	9.46	1/7/2004	9.21	2/16/2004	8.95	3/27/2004	9.66
11/29/2003	9.45	1/8/2004	9.21	2/17/2004	8.95	3/28/2004	9.76
11/30/2003	9.45	1/9/2004	9.19	2/18/2004	9.02	3/29/2004	9.7
12/1/2003	9.2	1/10/2004	9.17	2/19/2004	9.07	3/30/2004	9.53
12/2/2003	9.2	1/11/2004	9.1	2/20/2004	9.07	3/31/2004	9.5
12/3/2003	9.2	1/12/2004	9.07	2/21/2004	9.07	4/1/2004	9.5
12/4/2003	9.2	1/13/2004	9.07	2/22/2004	9.07	4/2/2004	9.5
12/5/2003	9.2	1/14/2004	9.07	2/23/2004	9.2	4/3/2004	9.5
12/6/2003	9.21	1/15/2004	9.07	2/24/2004	9.2	4/4/2004	9.5
12/7/2003	9.45	1/16/2004	9.07	2/25/2004	9.2	4/5/2004	9.5
12/8/2003	9.47	1/17/2004	9.07	2/26/2004	9.42	4/6/2004	9.5
12/9/2003	9.46	1/18/2004	9.07	2/27/2004	9.42	4/7/2004	9.5
12/10/2003	9.46	1/19/2004	9.07	2/28/2004	9.42	4/8/2004	9.51
12/11/2003	9.46	1/20/2004	8.97	2/29/2004	9.42	4/9/2004	9.51
12/12/2003	9.46	1/21/2004	8.97	3/1/2004	9.42	4/10/2004	9.51
12/13/2003	9.46	1/22/2004	8.92	3/2/2004	9.42	4/11/2004	9.5
12/14/2003	9.46	1/23/2004	8.92	3/3/2004	9.42	4/12/2004	9.38
12/15/2003	9.46	1/24/2004	8.92	3/4/2004	9.42	4/13/2004	9.38
12/16/2003	9.46	1/25/2004	8.92	3/5/2004	9.42	4/14/2004	9.38
12/17/2003	9.46	1/26/2004	8.92	3/6/2004	9.42	4/15/2004	9.2
12/18/2003	9.46	1/27/2004	8.92	3/7/2004	9.42	4/16/2004	9.2
12/19/2003	9.46	1/28/2004	8.92	3/8/2004	9.51	4/17/2004	8.85
12/20/2003	9.46	1/29/2004	8.92	3/9/2004	9.51	4/18/2004	8.85
12/21/2003	9.42	1/30/2004	8.91	3/10/2004	9.17	4/19/2004	8.85
12/22/2003	9.2	1/31/2004	8.91	3/11/2004	9.17	4/20/2004	8.85
12/23/2003	9.2	2/1/2004	8.97	3/12/2004	9.17	4/21/2004	8.97
12/24/2003	9.2	2/2/2004	8.97	3/13/2004	9.17	4/22/2004	8.97
12/25/2003	9.2	2/3/2004	8.97	3/14/2004	9.17	4/23/2004	8.97
12/26/2003	9.2	2/4/2004	9.21	3/15/2004	9.51	4/24/2004	8.99
12/27/2003	9.2	2/5/2004	9.17	3/16/2004	9.51	4/25/2004	8.97
12/28/2003	9.21	2/6/2004	9.17	3/17/2004	9.42	4/26/2004	8.97
12/29/2003	9.2	2/7/2004	9.17	3/18/2004	9.17	4/27/2004	8.99

Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m
4/28/2004	8.99	6/7/2004	9.73	7/17/2004	9.09	8/26/2004	13.635
4/29/2004	8.99	6/8/2004	9.73	7/18/2004	9.1	8/27/2004	12.125
4/30/2004	8.87	6/9/2004	9.73	7/19/2004	9.1	8/28/2004	11.245
5/1/2004	8.87	6/10/2004	9.73	7/20/2004	9.09	8/29/2004	11.43
5/2/2004	9.04	6/11/2004	9.75	7/21/2004	9.08	8/30/2004	11.015
5/3/2004	9.17	6/12/2004	9.77	7/22/2004	9.08	8/31/2004	10.515
5/4/2004	9.12	6/13/2004	9.74	7/23/2004	9.07	9/1/2004	10.435
5/5/2004	9.07	6/14/2004	9.74	7/24/2004	9.07	9/2/2004	10.1
5/6/2004	9.07	6/15/2004	9.78	7/25/2004	9.07	9/3/2004	9.725
5/7/2004	9.07	6/16/2004	9.79	7/26/2004	9.07	9/4/2004	9.475
5/8/2004	9.07	6/17/2004	9.79	7/27/2004	9.07	9/5/2004	9.31
5/9/2004	9.07	6/18/2004	9.78	7/28/2004	9.09	9/6/2004	9.26
5/10/2004	9.12	6/19/2004	9.77	7/29/2004	9.1	9/7/2004	9.26
5/11/2004	9.42	6/20/2004	9.77	7/30/2004	9.11	9/8/2004	9.26
5/12/2004	9.46	6/21/2004	9.79	7/31/2004	9.16	9/9/2004	9.26
5/13/2004	9.46	6/22/2004	9.79	8/1/2004	10.16	9/10/2004	9.495
5/14/2004	9.63	6/23/2004	9.81	8/2/2004	9.97	9/11/2004	9.52
5/15/2004	9.7	6/24/2004	9.81	8/3/2004	10.185	9/12/2004	9.46
5/16/2004	9.71	6/25/2004	9.82	8/4/2004	9.815	9/13/2004	9.37
5/17/2004	9.71	6/26/2004	9.84	8/5/2004	9.625	9/14/2004	9.34
5/18/2004	9.71	6/27/2004	9.79	8/6/2004	10.015	9/15/2004	9.595
5/19/2004	9.67	6/28/2004	9.74	8/7/2004	10.295	9/16/2004	9.395
5/20/2004	9.67	6/29/2004	9.74	8/8/2004	11.42	9/17/2004	9.595
5/21/2004	9.57	6/30/2004	9.75	8/9/2004	10.755	9/18/2004	9.42
5/22/2004	9.57	7/1/2004	9.69	8/10/2004	11.95	9/19/2004	9.48
5/23/2004	9.57	7/2/2004	9.485	8/11/2004	12.15	9/20/2004	9.77
5/24/2004	9.7	7/3/2004	9.27	8/12/2004	12.76	9/21/2004	9.48
5/25/2004	9.7	7/4/2004	9.22	8/13/2004	17.49	9/22/2004	9.57
5/26/2004	9.7	7/5/2004	9.28	8/14/2004	18.66	9/23/2004	9.52
5/27/2004	9.7	7/6/2004	9.32	8/15/2004	19.02	9/24/2004	9.355
5/28/2004	9.7	7/7/2004	9.26	8/16/2004	14.995	9/25/2004	9.27
5/29/2004	9.7	7/8/2004	9.3	8/17/2004	13.91	9/26/2004	9.24
5/30/2004	9.7	7/9/2004	9.3	8/18/2004	13.27	9/27/2004	9.19
5/31/2004	9.7	7/10/2004	9.35	8/19/2004	11.66	9/28/2004	9.19
6/1/2004	9.7	7/11/2004	9.35	8/20/2004	11.04	9/29/2004	9.22
6/2/2004	9.7	7/12/2004	9.235	8/21/2004	11.185	9/30/2004	9.28
6/3/2004	9.7	7/13/2004	9.1	8/22/2004	10.94	10/1/2004	9.25
6/4/2004	9.72	7/14/2004	9.09	8/23/2004	10.83	10/2/2004	9.23
6/5/2004	9.73	7/15/2004	9.09	8/24/2004	14.64	10/3/2004	9.21
6/6/2004	9.73	7/16/2004	9.09	8/25/2004	16.55	10/4/2004	9.2

Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m
10/5/2004	9.2	11/14/2004	9.17	12/24/2004	9.23
10/6/2004	9.24	11/15/2004	9.17	12/25/2004	9.23
10/7/2004	9.21	11/16/2004	9.21	12/26/2004	9.22
10/8/2004	9.18	11/17/2004	9.24	12/27/2004	9.22
10/9/2004	9.17	11/18/2004	9.23	12/28/2004	9.22
10/10/2004	9.16	11/19/2004	9.23	12/29/2004	9.22
10/11/2004	9.16	11/20/2004	9.21	12/30/2004	9.22
10/12/2004	9.14	11/21/2004	9.21	12/31/2004	9.22
10/13/2004	9.13	11/22/2004	9.21	1/1/2005	9.22
10/14/2004	9.12	11/23/2004	9.2	1/2/2005	9.25
10/15/2004	9.12	11/24/2004	9.17	1/3/2005	9.25
10/16/2004	9.12	11/25/2004	9.12	1/4/2005	9.25
10/17/2004	9.11	11/26/2004	9.12	1/5/2005	9.26
10/18/2004	9.11	11/27/2004	9.1	1/6/2005	9.26
10/19/2004	9.11	11/28/2004	9.1	1/7/2005	9.26
10/20/2004	9.11	11/29/2004	9.1	1/8/2005	9.24
10/21/2004	9.11	11/30/2004	9.1	1/9/2005	9.25
10/22/2004	9.11	12/1/2004	9.1	1/10/2005	9.25
10/23/2004	9.12	12/2/2004	9.1	1/11/2005	9.25
10/24/2004	9.13	12/3/2004	9.1	1/12/2005	9.22
10/25/2004	9.11	12/4/2004	9.1	1/13/2005	9.22
10/26/2004	9.1	12/5/2004	9.1	1/14/2005	9.22
10/27/2004	9.1	12/6/2004	9.19	1/15/2005	9.22
10/28/2004	9.1	12/7/2004	9.19	1/16/2005	9.27
10/29/2004	9.1	12/8/2004	9.21	1/17/2005	9.32
10/30/2004	9.1	12/9/2004	9.23	1/18/2005	9.33
10/31/2004	9.1	12/10/2004	9.23	1/19/2005	9.21
11/1/2004	9.1	12/11/2004	9.2	1/20/2005	9.21
11/2/2004	9.1	12/12/2004	9.2	1/21/2005	9.2
11/3/2004	9.1	12/13/2004	9.11	1/22/2005	9.2
11/4/2004	9.1	12/14/2004	9.11	1/23/2005	9.42
11/5/2004	9.1	12/15/2004	9.11	1/24/2005	9.2
11/6/2004	9.1	12/16/2004	9.1	1/25/2005	9.2
11/7/2004	9.1	12/17/2004	9.24	1/26/2005	9.42
11/8/2004	9.12	12/18/2004	9.25	1/27/2005	9.2
11/9/2004	9.12	12/19/2004	9.24	1/28/2005	9.2
11/10/2004	9.12	12/20/2004	9.24	1/29/2005	9.2
11/11/2004	9.12	12/21/2004	9.24	1/30/2005	9.42
11/12/2004	9.12	12/22/2004	9.24	1/31/2005	9.21
11/13/2004	9.15	12/23/2004	9.23	2/1/2005	9.21

Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m
2/2/2005	9.21	3/14/2005	9.17	4/23/2005	9.21	6/2/2005	9.2
2/3/2005	9.21	3/15/2005	9.17	4/24/2005	9.43	6/3/2005	9.2
2/4/2005	9.21	3/16/2005	9.17	4/25/2005	9.21	6/4/2005	9.2
2/5/2005	9.21	3/17/2005	9.17	4/26/2005	9.21	6/5/2005	9.2
2/6/2005	9.43	3/18/2005	9.17	4/27/2005	9.2	6/6/2005	9.2
2/7/2005	9.21	3/19/2005	9.17	4/28/2005	9.2	6/7/2005	9.2
2/8/2005	9.44	3/20/2005	9.39	4/29/2005	9.2	6/8/2005	9.2
2/9/2005	9.21	3/21/2005	9.17	4/30/2005	9.2	6/9/2005	9.2
2/10/2005	9.21	3/22/2005	9.17	5/1/2005	9.42	6/10/2005	9.2
2/11/2005	9.21	3/23/2005	9.17	5/2/2005	9.2	6/11/2005	9.2
2/12/2005	9.21	3/24/2005	9.17	5/3/2005	9.2	6/12/2005	9.2
2/13/2005	9.43	3/25/2005	9.39	5/4/2005	9.2	6/13/2005	9.2
2/14/2005	9.21	3/26/2005	9.18	5/5/2005	9.2	6/14/2005	9.2
2/15/2005	9.21	3/27/2005	9.41	5/6/2005	9.2		
2/16/2005	9.2	3/28/2005	9.19	5/7/2005	9.2		
2/17/2005	9.2	3/29/2005	9.19	5/8/2005	9.42		
2/18/2005	9.2	3/30/2005	9.19	5/9/2005	9.42		
2/19/2005	9.2	3/31/2005	9.19	5/10/2005	9.2		
2/20/2005	9.42	4/1/2005	9.19	5/11/2005	9.2		
2/21/2005	9.2	4/2/2005	9.19	5/12/2005	9.16		
2/22/2005	9.2	4/3/2005	9.41	5/13/2005	9.2		
2/23/2005	9.2	4/4/2005	9.19	5/14/2005	9.42		
2/24/2005	9.2	4/5/2005	9.19	5/15/2005	9.42		
2/25/2005	9.2	4/6/2005	9.19	5/16/2005	9.2		
2/26/2005	9.2	4/7/2005	9.19	5/17/2005	9.2		
2/27/2005	9.42	4/8/2005	9.19	5/18/2005	9.2		
2/28/2005	9.19	4/9/2005	9.19	5/19/2005	9.2		
3/1/2005	9.19	4/10/2005	9.43	5/20/2005	9.2		
3/2/2005	9.19	4/11/2005	9.21	5/21/2005	9.19		
3/3/2005	9.19	4/12/2005	9.21	5/22/2005	9.41		
3/4/2005	9.19	4/13/2005	9.21	5/23/2005	9.41		
3/5/2005	9.19	4/14/2005	9.42	5/24/2005	9.41		
3/6/2005	9.41	4/15/2005	9.42	5/25/2005	9.41		
3/7/2005	9.19	4/16/2005	9.2	5/26/2005	9.41		
3/8/2005	9.44	4/17/2005	9.42	5/27/2005	9.41		
3/9/2005	9.21	4/18/2005	9.2	5/28/2005	9.41		
3/10/2005	9.21	4/19/2005	9.2	5/29/2005	9.41		
3/11/2005	9.2	4/20/2005	9.21	5/30/2005	9.19		
3/12/2005	9.2	4/21/2005	9.21	5/31/2005	9.19		
3/13/2005	9.41	4/22/2005	9.43	6/1/2005	9.19		

Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m
6/13/2005	9.2	7/23/2005	9.42	9/1/2005	9.23	10/11/2005	8.93
6/14/2005	9.2	7/24/2005	9.42	9/2/2005	9.12	10/12/2005	8.93
6/15/2005	9.2	7/25/2005	9.42	9/3/2005	8.98	10/13/2005	9.25
6/16/2005	9.2	7/26/2005	9.41	9/4/2005	8.87	10/14/2005	9.32
6/17/2005	9.2	7/27/2005	9.41	9/5/2005	8.83	10/15/2005	9.22
6/18/2005	9.36	7/28/2005	9.52	9/6/2005	8.82	10/16/2005	9.15
6/19/2005	9.6	7/29/2005	10.505	9/7/2005	8.82	10/17/2005	9.15
6/20/2005	9.65	7/30/2005	11.985	9/8/2005	9.025	10/18/2005	9.13
6/21/2005	9.65	7/31/2005	10.84	9/9/2005	9.14	10/19/2005	9.1
6/22/2005	9.6	8/1/2005	10.36	9/10/2005	9.26	10/20/2005	9.07
6/23/2005	9.55	8/2/2005	11.695	9/11/2005	9.24	10/21/2005	9.47
6/24/2005	9.78	8/3/2005	12.75	9/12/2005	9.69	10/22/2005	9.42
6/25/2005	9.76	8/4/2005	11.555	9/13/2005	9.525	10/23/2005	9.37
6/26/2005	9.63	8/5/2005	10.495	9/14/2005	9.365	10/24/2005	9.1
6/27/2005	9.635	8/6/2005	9.94	9/15/2005	9.3	10/25/2005	9.08
6/28/2005	9.86	8/7/2005	9.87	9/16/2005	9.26	10/26/2005	8.95
6/29/2005	9.86	8/8/2005	10.06	9/17/2005	9.39	10/27/2005	8.95
6/30/2005	11.27	8/9/2005	9.82	9/18/2005	9.45	10/28/2005	8.95
7/1/2005	11.755	8/10/2005	9.775	9/19/2005	9.45	10/29/2005	8.88
7/2/2005	11.83	8/11/2005	9.76	9/20/2005	10.19	10/30/2005	8.88
7/3/2005	10.6	8/12/2005	9.705	9/21/2005	9.74	10/31/2005	8.88
7/4/2005	10.4	8/13/2005	9.59	9/22/2005	9.71	11/1/2005	8.88
7/5/2005	9.83	8/14/2005	9.54	9/23/2005	10.84	11/2/2005	8.88
7/6/2005	9.59	8/15/2005	9.53	9/24/2005	10.575	11/3/2005	8.88
7/7/2005	9.51	8/16/2005	9.53	9/25/2005	9.96	11/4/2005	8.88
7/8/2005	9.48	8/17/2005	9.51	9/26/2005	9.89	11/5/2005	8.88
7/9/2005	9.51	8/18/2005	9.47	9/27/2005	9.82	11/6/2005	8.88
7/10/2005	9.48	8/19/2005	9.43	9/28/2005	9.77	11/7/2005	8.88
7/11/2005	9.43	8/20/2005	9.37	9/29/2005	9.81	11/8/2005	8.88
7/12/2005	9.4	8/21/2005	9.34	9/30/2005	9.95	11/9/2005	8.88
7/13/2005	9.49	8/22/2005	9.26	10/1/2005	9.85	11/10/2005	8.88
7/14/2005	9.35	8/23/2005	9.25	10/2/2005	9.65	11/11/2005	8.84
7/15/2005	9.28	8/24/2005	9.25	10/3/2005	9.52	11/12/2005	8.84
7/16/2005	9.18	8/25/2005	9.25	10/4/2005	9.34	11/13/2005	8.86
7/17/2005	9.16	8/26/2005	9.33	10/5/2005	9.17	11/14/2005	8.86
7/18/2005	9.21	8/27/2005	9.29	10/6/2005	9.05	11/15/2005	8.86
7/19/2005	9.24	8/28/2005	9.18	10/7/2005	8.97	11/16/2005	8.86
7/20/2005	9.425	8/29/2005	9.18	10/8/2005	8.96	11/17/2005	8.86
7/21/2005	9.38	8/30/2005	9.17	10/9/2005	8.94	11/18/2005	8.86
7/22/2005	9.37	8/31/2005	9.17	10/10/2005	8.93	11/19/2005	8.86

Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m
11/20/2005	8.86	12/30/2005	8.89	2/8/2006	8.92	3/20/2006	8.88
11/21/2005	8.86	12/31/2005	8.89	2/9/2006	8.9	3/21/2006	8.88
11/22/2005	8.94	1/1/2006	8.89	2/10/2006	8.88	3/22/2006	8.88
11/23/2005	8.91	1/2/2006	8.88	2/11/2006	8.88	3/23/2006	8.88
11/24/2005	8.86	1/3/2006	8.88	2/12/2006	8.88	3/24/2006	8.91
11/25/2005	8.86	1/4/2006	8.88	2/13/2006	8.883	3/25/2006	8.88
11/26/2005	8.86	1/5/2006	8.88	2/14/2006	8.88	3/26/2006	8.82
11/27/2005	8.94	1/6/2006	8.88	2/15/2006	8.88	3/27/2006	8.81
11/28/2005	9.04	1/7/2006	8.88	2/16/2006	8.88	3/28/2006	8.78
11/29/2005	9.04	1/8/2006	8.88	2/17/2006	8.88	3/29/2006	8.78
11/30/2005	9.12	1/9/2006	8.88	2/18/2006	8.88	3/30/2006	8.78
12/1/2005	9.11	1/10/2006	8.88	2/19/2006	8.88	3/31/2006	8.78
12/2/2005	9.09	1/11/2006	8.88	2/20/2006	8.88	4/1/2006	8.78
12/3/2005	9.07	1/12/2006	8.88	2/21/2006	8.88	4/2/2006	8.86
12/4/2005	8.87	1/13/2006	8.94	2/22/2006	8.9	4/3/2006	8.915
12/5/2005	8.85	1/14/2006	8.92	2/23/2006	8.9	4/4/2006	8.92
12/6/2005	8.88	1/15/2006	8.94	2/24/2006	8.9	4/5/2006	8.9
12/7/2005	8.9	1/16/2006	8.89	2/25/2006	8.89	4/6/2006	8.88
12/8/2005	8.9	1/17/2006	8.89	2/26/2006	8.88	4/7/2006	8.88
12/9/2005	8.88	1/18/2006	8.89	2/27/2006	8.88	4/8/2006	8.86
12/10/2005	8.88	1/19/2006	8.88	2/28/2006	8.88	4/9/2006	8.86
12/11/2005	8.88	1/20/2006	8.88	3/1/2006	8.88	4/10/2006	8.86
12/12/2005	8.88	1/21/2006	8.88	3/2/2006	8.88	4/11/2006	8.84
12/13/2005	8.88	1/22/2006	8.88	3/3/2006	8.88	4/12/2006	8.77
12/14/2005	8.88	1/23/2006	8.88	3/4/2006	8.89	4/13/2006	8.77
12/15/2005	8.88	1/24/2006	8.88	3/5/2006	8.89	4/14/2006	8.87
12/16/2005	8.88	1/25/2006	8.96	3/6/2006	8.89	4/15/2006	8.77
12/17/2005	8.9	1/26/2006	8.92	3/7/2006	8.89	4/16/2006	8.87
12/18/2005	8.9	1/27/2006	8.9	3/8/2006	8.89	4/17/2006	8.77
12/19/2005	9.04	1/28/2006	8.9	3/9/2006	8.89	4/18/2006	8.77
12/20/2005	9.04	1/29/2006	8.89	3/10/2006	8.89	4/19/2006	8.77
12/21/2005	8.94	1/30/2006	8.88	3/11/2006	8.89	4/20/2006	8.77
12/22/2005	9.07	1/31/2006	8.88	3/12/2006	8.89	4/21/2006	8.77
12/23/2005	9.19	2/1/2006	8.88	3/13/2006	8.88	4/22/2006	8.87
12/24/2005	9.12	2/2/2006	8.88	3/14/2006	8.88	4/23/2006	8.77
12/25/2005	8.96	2/3/2006	8.88	3/15/2006	8.88	4/24/2006	8.77
12/26/2005	8.9	2/4/2006	8.88	3/16/2006	8.88	4/25/2006	8.77
12/27/2005	8.89	2/5/2006	8.88	3/17/2006	8.88	4/26/2006	8.89
12/28/2005	8.88	2/6/2006	8.88	3/18/2006	8.88	4/27/2006	8.89
12/29/2005	8.89	2/7/2006	8.88	3/19/2006	8.88	4/28/2006	8.86

Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m
4/29/2006	8.86	6/8/2006	8.95	7/18/2006	8.82	8/27/2006	13.25
4/30/2006	8.86	6/9/2006	9.02	7/19/2006	8.78	8/28/2006	11.73
5/1/2006	8.86	6/10/2006	9.02	7/20/2006	8.84	8/29/2006	12.13
5/2/2006	8.86	6/11/2006	8.99	7/21/2006	8.98	8/30/2006	11.825
5/3/2006	8.86	6/12/2006	8.99	7/22/2006	9.08	8/31/2006	10.775
5/4/2006	8.86	6/13/2006	8.99	7/23/2006	9	9/1/2006	10.88
5/5/2006	8.86	6/14/2006	8.96	7/24/2006	8.96	9/2/2006	13.335
5/6/2006	8.86	6/15/2006	8.8	7/25/2006	8.98	9/3/2006	13.02
5/7/2006	8.86	6/16/2006	8.91	7/26/2006	8.92	9/4/2006	11.23
5/8/2006	8.86	6/17/2006	8.79	7/27/2006	8.92	9/5/2006	10.87
5/9/2006	8.86	6/18/2006	8.79	7/28/2006	8.97	9/6/2006	10.81
5/10/2006	8.86	6/19/2006	8.79	7/29/2006	12.31	9/7/2006	22.43
5/11/2006	8.86	6/20/2006	8.78	7/30/2006	13.01	9/8/2006	18.28
5/12/2006	8.86	6/21/2006	8.78	7/31/2006	12.88	9/9/2006	14.335
5/13/2006	8.86	6/22/2006	8.81	8/1/2006	12.25	9/10/2006	12.65
5/14/2006	8.86	6/23/2006	8.82	8/2/2006	15.32	9/11/2006	11.74
5/15/2006	8.86	6/24/2006	8.81	8/3/2006	12.195	9/12/2006	11.21
5/16/2006	8.86	6/25/2006	8.81	8/4/2006	12.055	9/13/2006	11.585
5/17/2006	8.86	6/26/2006	8.83	8/5/2006	11.165	9/14/2006	11.095
5/18/2006	8.86	6/27/2006	8.91	8/6/2006	11.24	9/15/2006	10.71
5/19/2006	8.86	6/28/2006	8.93	8/7/2006	16.85	9/16/2006	10.635
5/20/2006	8.86	6/29/2006	8.96	8/8/2006	17.89	9/17/2006	10.6
5/21/2006	8.86	6/30/2006	8.94	8/9/2006	20.84	9/18/2006	10.56
5/22/2006	8.86	7/1/2006	8.92	8/10/2006	16.6	9/19/2006	10.96
5/23/2006	8.86	7/2/2006	8.83	8/11/2006	20.685	9/20/2006	11.08
5/24/2006	8.86	7/3/2006	8.77	8/12/2006	26.82	9/21/2006	11.21
5/25/2006	8.96	7/4/2006	8.82	8/13/2006	20.34	9/22/2006	10.89
5/26/2006	8.97	7/5/2006	9.055	8/14/2006	16.61	9/23/2006	10.9
5/27/2006	8.95	7/6/2006	9.265	8/15/2006	13.27	9/24/2006	11.54
5/28/2006	8.94	7/7/2006	9.265	8/16/2006	12.8	9/25/2006	11.2
5/29/2006	8.92	7/8/2006	8.92	8/17/2006	16.87	9/26/2006	10.575
5/30/2006	8.92	7/9/2006	8.84	8/18/2006	14.58	9/27/2006	10.44
5/31/2006	8.9	7/10/2006	8.81	8/19/2006	16.95	9/28/2006	10.42
6/1/2006	8.9	7/11/2006	8.77	8/20/2006	25.09	9/29/2006	10.45
6/2/2006	8.9	7/12/2006	8.77	8/21/2006	16.94	9/30/2006	10.42
6/3/2006	8.94	7/13/2006	8.77	8/22/2006	16.32	10/1/2006	10.28
6/4/2006	8.95	7/14/2006	8.77	8/23/2006	15.5	10/2/2006	9.72
6/5/2006	8.96	7/15/2006	8.7	8/24/2006	14.96	10/3/2006	9.785
6/6/2006	8.95	7/16/2006	8.72	8/25/2006	12.905	10/4/2006	9.82
6/7/2006	8.95	7/17/2006	8.86	8/26/2006	13.02	10/5/2006	9.79

Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m
10/6/2006	10.42	11/15/2006	9.31	12/25/2006	9.27
10/7/2006	10.305	11/16/2006	9.31	12/26/2006	9.27
10/8/2006	10.14	11/17/2006	9.31	12/27/2006	9.27
10/9/2006	9.92	11/18/2006	9.3	12/28/2006	9.27
10/10/2006	9.975	11/19/2006	9.36	12/29/2006	9.27
10/11/2006	9.99	11/20/2006	9.31	12/30/2006	9.27
10/12/2006	9.98	11/21/2006	9.31	12/31/2006	9.27
10/13/2006	9.97	11/22/2006	9.31	1/1/2007	9.33
10/14/2006	9.97	11/23/2006	9.31	1/2/2007	9.34
10/15/2006	10.02	11/24/2006	9.31	1/3/2007	9.34
10/16/2006	10.04	11/25/2006	9.31	1/4/2007	9.37
10/17/2006	10.04	11/26/2006	9.31	1/5/2007	9.37
10/18/2006	10.04	11/27/2006	9.31	1/6/2007	9.37
10/19/2006	10.08	11/28/2006	9.31	1/7/2007	9.37
10/20/2006	10.26	11/29/2006	9.31	1/8/2007	9.37
10/21/2006	10.28	11/30/2006	9.31	1/9/2007	9.37
10/22/2006	10.32	12/1/2006	9.31	1/10/2007	9.37
10/23/2006	10.217	12/2/2006	9.31	1/11/2007	9.37
10/24/2006	9.97	12/3/2006	9.31	1/12/2007	9.37
10/25/2006	9.87	12/4/2006	9.31	1/13/2007	9.4
10/26/2006	9.87	12/5/2006	9.31	1/14/2007	9.4
10/27/2006	9.63	12/6/2006	9.31	1/15/2007	9.4
10/28/2006	9.51	12/7/2006	9.31	1/16/2007	9.39
10/29/2006	9.41	12/8/2006	9.31	1/17/2007	9.39
10/30/2006	9.39	12/9/2006	9.31	1/18/2007	9.42
10/31/2006	9.34	12/10/2006	9.31	1/19/2007	9.47
11/1/2006	9.33	12/11/2006	9.27	1/20/2007	9.47
11/2/2006	9.32	12/12/2006	9.27	1/21/2007	9.47
11/3/2006	9.22	12/13/2006	9.72	1/22/2007	9.37
11/4/2006	9.32	12/14/2006	9.27	1/23/2007	9.31
11/5/2006	9.34	12/15/2006	9.27	1/24/2007	9.31
11/6/2006	9.42	12/16/2006	9.27	1/25/2007	9.31
11/7/2006	9.37	12/17/2006	9.27	1/26/2007	9.31
11/8/2006	9.37	12/18/2006	9.27	1/27/2007	9.31
11/9/2006	9.37	12/19/2006	9.27	1/28/2007	9.31
11/10/2006	9.37	12/20/2006	9.27	1/29/2007	9.37
11/11/2006	9.33	12/21/2006	9.27	1/30/2007	9.37
11/12/2006	9.3	12/22/2006	9.27	1/31/2007	9.37
11/13/2006	9.3	12/23/2006	9.27	2/1/2007	9.34
11/14/2006	9.3	12/24/2006	9.27	2/2/2007	9.34

Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m	Date	River Water Level at Khanpur in m
2/3/2007	9.34	3/15/2007	9.25	4/24/2007	9.24	6/3/2007	9.37
2/4/2007	9.32	3/16/2007	9.25	4/25/2007	9.24	6/4/2007	9.37
2/5/2007	9.31	3/17/2007	9.25	4/26/2007	9.24	6/5/2007	9.37
2/6/2007	9.28	3/18/2007	9.22	4/27/2007	9.24	6/6/2007	9.32
2/7/2007	9.34	3/19/2007	9.22	4/28/2007	9.24	6/7/2007	9.31
2/8/2007	9.35	3/20/2007	9.27	4/29/2007	9.24	6/8/2007	9.27
2/9/2007	9.36	3/21/2007	9.28	4/30/2007	9.24	6/9/2007	9.27
2/10/2007	9.34	3/22/2007	9.37	5/1/2007	9.24	6/10/2007	9.27
2/11/2007	9.34	3/23/2007	9.28	5/2/2007	9.24	6/11/2007	9.27
2/12/2007	9.34	3/24/2007	9.22	5/3/2007	9.24	6/12/2007	9.27
2/13/2007	9.34	3/25/2007	9.22	5/4/2007	9.24	6/13/2007	9.22
2/14/2007	9.36	3/26/2007	9.22	5/5/2007	9.24	6/14/2007	9.22
2/15/2007	9.35	3/27/2007	9.22	5/6/2007	9.24		
2/16/2007	9.35	3/28/2007	9.22	5/7/2007	9.24		
2/17/2007	9.35	3/29/2007	9.22	5/8/2007	9.22		
2/18/2007	9.34	3/30/2007	9.22	5/9/2007	9.21		
2/19/2007	9.33	3/31/2007	9.27	5/10/2007	9.21		
2/20/2007	9.33	4/1/2007	9.27	5/11/2007	9.21		
2/21/2007	9.33	4/2/2007	9.23	5/12/2007	9.21		
2/22/2007	9.32	4/3/2007	9.25	5/13/2007	9.21		
2/23/2007	9.27	4/4/2007	9.25	5/14/2007	9.21		
2/24/2007	9.27	4/5/2007	9.25	5/15/2007	9.21		
2/25/2007	9.27	4/6/2007	9.25	5/16/2007	9.21		
2/26/2007	9.27	4/7/2007	9.25	5/17/2007	9.21		
2/27/2007	9.27	4/8/2007	9.25	5/18/2007	9.21		
2/28/2007	9.27	4/9/2007	9.25	5/19/2007	9.21		
3/1/2007	9.27	4/10/2007	9.25	5/20/2007	9.21		
3/2/2007	9.27	4/11/2007	9.25	5/21/2007	9.21		
3/3/2007	9.27	4/12/2007	9.25	5/22/2007	9.21		
3/4/2007	9.25	4/13/2007	9.25	5/23/2007	9.21		
3/5/2007	9.23	4/14/2007	9.25	5/24/2007	9.24		
3/6/2007	9.23	4/15/2007	9.25	5/25/2007	9.24		
3/7/2007	9.23	4/16/2007	9.25	5/26/2007	9.24		
3/8/2007	9.23	4/17/2007	9.27	5/27/2007	9.21		
3/9/2007	9.23	4/18/2007	9.26	5/28/2007	9.24		
3/10/2007	9.23	4/19/2007	9.26	5/29/2007	9.24		
3/11/2007	9.23	4/20/2007	9.24	5/30/2007	9.24		
3/12/2007	9.23	4/21/2007	9.24	5/31/2007	9.34		
3/13/2007	9.23	4/22/2007	9.24	6/1/2007	9.35		
3/14/2007	9.23	4/23/2007	9.24	6/2/2007	9.37		

Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m
6/13/1997	6.60	7/23/1997	6.45	9/1/1997	10.90	10/11/1997	6.60
6/14/1997	6.55	7/24/1997	6.45	9/2/1997	10.10	10/12/1997	6.55
6/15/1997	6.45	7/25/1997	6.50	9/3/1997	9.70	10/13/1997	6.65
6/16/1997	6.40	7/26/1997	6.50	9/4/1997	8.70	10/14/1997	6.65
6/17/1997	6.35	7/27/1997	6.60	9/5/1997	8.60	10/15/1997	6.60
6/18/1997	6.60	7/28/1997	11.00	9/6/1997	8.50	10/16/1997	6.60
6/19/1997	6.50	7/29/1997	9.00	9/7/1997	8.45	10/17/1997	6.80
6/20/1997	6.45	7/30/1997	8.40	9/8/1997	8.40	10/18/1997	6.70
6/21/1997	6.40	7/31/1997	8.30	9/9/1997	8.30	10/19/1997	6.65
6/22/1997	6.45	8/1/1997	9.50	9/10/1997	8.40	10/20/1997	7.60
6/23/1997	6.45	8/2/1997	20.00	9/11/1997	8.40	10/21/1997	7.60
6/24/1997	7.30	8/3/1997	15.70	9/12/1997	8.25	10/22/1997	7.70
6/25/1997	7.30	8/4/1997	11.50	9/13/1997	8.25	10/23/1997	7.60
6/26/1997	8.90	8/5/1997	10.20	9/14/1997	8.50	10/24/1997	7.55
6/27/1997	8.20	8/6/1997	9.50	9/15/1997	8.50	10/25/1997	7.35
6/28/1997	8.90	8/7/1997	9.70	9/16/1997	8.50	10/26/1997	7.35
6/29/1997	8.10	8/8/1997	8.60	9/17/1997	8.00	10/27/1997	7.35
6/30/1997	7.60	8/9/1997	9.30	9/18/1997	7.95	10/28/1997	7.40
7/1/1997	7.40	8/10/1997	11.10	9/19/1997	8.60	10/29/1997	7.70
7/2/1997	7.30	8/11/1997	9.70	9/20/1997	8.40	10/30/1997	7.75
7/3/1997	7.40	8/12/1997	8.50	9/21/1997	8.30	10/31/1997	7.75
7/4/1997	7.60	8/13/1997	8.10	9/22/1997	7.90	11/1/1997	7.70
7/5/1997	7.40	8/14/1997	8.10	9/23/1997	7.70	11/2/1997	7.70
7/6/1997	7.15	8/15/1997	8.40	9/24/1997	7.80	11/3/1997	7.60
7/7/1997	6.90	8/16/1997	8.30	9/25/1997	8.10	11/4/1997	7.50
7/8/1997	6.75	8/17/1997	7.90	9/26/1997	7.80	11/5/1997	7.40
7/9/1997	6.55	8/18/1997	7.80	9/27/1997	7.70	11/6/1997	7.40
7/10/1997	6.50	8/19/1997	7.60	9/28/1997	7.40	11/7/1997	7.35
7/11/1997	6.50	8/20/1997	7.60	9/29/1997	7.50	11/8/1997	7.25
7/12/1997	6.50	8/21/1997	7.85	9/30/1997	7.50	11/9/1997	6.90
7/13/1997	6.50	8/22/1997	7.80	10/1/1997	7.35	11/10/1997	6.90
7/14/1997	6.50	8/23/1997	8.00	10/2/1997	7.00	11/11/1997	6.80
7/15/1997	6.45	8/24/1997	8.20	10/3/1997	6.80	11/12/1997	6.90
7/16/1997	6.45	8/25/1997	16.80	10/4/1997	6.60	11/13/1997	7.10
7/17/1997	6.40	8/26/1997	14.50	10/5/1997	6.55	11/14/1997	7.10
7/18/1997	6.40	8/27/1997	13.00	10/6/1997	6.60	11/15/1997	7.15
7/19/1997	6.70	8/28/1997	12.90	10/7/1997	6.70	11/16/1997	7.25
7/20/1997	6.65	8/29/1997	10.60	10/8/1997	6.60	11/17/1997	7.20
7/21/1997	6.50	8/30/1997	11.00	10/9/1997	6.60	11/18/1997	7.20
7/22/1997	6.50	8/31/1997	12.10	10/10/1997	6.60	11/19/1997	7.10

Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m
11/20/1997	7.00	12/30/1997	6.90	2/8/1998	6.80	3/20/1998	6.45
11/21/1997	7.00	12/31/1997	6.90	2/9/1998	6.80	3/21/1998	6.45
11/22/1997	7.00	1/1/1998	6.90	2/10/1998	6.80	3/22/1998	6.40
11/23/1997	7.00	1/2/1998	6.90	2/11/1998	6.80	3/23/1998	6.35
11/24/1997	7.10	1/3/1998	6.90	2/12/1998	6.80	3/24/1998	6.35
11/25/1997	6.95	1/4/1998	6.90	2/13/1998	6.80	3/25/1998	6.35
11/26/1997	7.00	1/5/1998	6.90	2/14/1998	6.80	3/26/1998	6.35
11/27/1997	7.00	1/6/1998	6.90	2/15/1998	6.80	3/27/1998	6.30
11/28/1997	7.10	1/7/1998	6.90	2/16/1998	6.40	3/28/1998	6.35
11/29/1997	7.05	1/8/1998	6.90	2/17/1998	6.35	3/29/1998	6.30
11/30/1997	7.00	1/9/1998	6.90	2/18/1998	6.25	3/30/1998	6.30
12/1/1997	7.00	1/10/1998	6.90	2/19/1998	6.35	3/31/1998	6.30
12/2/1997	7.00	1/11/1998	6.90	2/20/1998	6.40	4/1/1998	6.35
12/3/1997	6.95	1/12/1998	6.90	2/21/1998	6.40	4/2/1998	6.40
12/4/1997	6.95	1/13/1998	6.90	2/22/1998	6.40	4/3/1998	6.40
12/5/1997	6.95	1/14/1998	6.90	2/23/1998	6.35	4/4/1998	6.45
12/6/1997	6.90	1/15/1998	6.90	2/24/1998	6.40	4/5/1998	6.40
12/7/1997	6.90	1/16/1998	6.90	2/25/1998	6.50	4/6/1998	6.40
12/8/1997	6.90	1/17/1998	6.90	2/26/1998	6.50	4/7/1998	6.40
12/9/1997	6.90	1/18/1998	6.90	2/27/1998	6.50	4/8/1998	6.40
12/10/1997	6.90	1/19/1998	6.90	2/28/1998	.6.35	4/9/1998	6.40
12/11/1997	6.90	1/20/1998	6.90	3/1/1998	6.20	4/10/1998	6.35
12/12/1997	6.90	1/21/1998	6.90	3/2/1998	6.30	4/11/1998	6.35
12/13/1997	6.90	1/22/1998	6.90	3/3/1998	6.30	4/12/1998	6.35
12/14/1997	6.90	1/23/1998	6.90	3/4/1998	6.35	4/13/1998	6.50
12/15/1997	6.90	1/24/1998	6.90	3/5/1998	6.30	4/14/1998	6.40
12/16/1997	6.90	1/25/1998	6.90	3/6/1998	6.35	4/15/1998	6.35
12/17/1997	6.90	1/26/1998	6.90	3/7/1998	6.40	4/16/1998	6.40
12/18/1997	6.90	1/27/1998	6.90	3/8/1998	6.5	4/17/1998	6.35
12/19/1997	6.90	1/28/1998	6.90	3/9/1998	6.50	4/18/1998	6.30
12/20/1997	6.90	1/29/1998	6.90	3/10/1998	6.50	4/19/1998	6.30
12/21/1997	6.90	1/30/1998	6.90	3/11/1998	6.50	4/20/1998	6.30
12/22/1997	6.90	1/31/1998	6.90	3/12/1998	6.40	4/21/1998	6.30
12/23/1997	6.90	2/1/1998	6.90	3/13/1998	6.40	4/22/1998	6.40
12/24/1997	6.90	2/2/1998	6.90	3/14/1998	6.40	4/23/1998	6.35
12/25/1997	6.90	2/3/1998	6.80	3/15/1998	6.35	4/24/1998	6.35
12/26/1997	6.90	2/4/1998	6.80	3/16/1998	6.35	4/25/1998	6.35
12/27/1997	6.90	2/5/1998	6.80	3/17/1998	6.35	4/26/1998	6.35
12/28/1997	6.90	2/6/1998	6.80	3/18/1998	6.40	4/27/1998	6.35
12/29/1997	6.90	2/7/1998	6.80	3/19/1998	6.45	4/28/1998	6.35

Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m
4/29/1998	6.40	6/8/1998	6.60	7/18/1998	6.70	8/27/1998	6.70
4/30/1998	6.40	6/9/1998	6.60	7/19/1998	6.55	8/28/1998	6.70
5/1/1998	6.45	6/10/1998	6.70	7/20/1998	6.50	8/29/1998	6.70
5/2/1998	6.50	6/11/1998	6.65	7/21/1998	6.45	8/30/1998	6.70
5/3/1998	6.40	6/12/1998	6.65	7/22/1998	6.40	8/31/1998	6.55
5/4/1998	6.40	6/13/1998	6.60	7/23/1998	6.40	9/1/1998	6.55
5/5/1998	6.35	6/14/1998	6.60	7/24/1998	6.40	9/2/1998	6.55
5/6/1998	6.35	6/15/1998	6.60	7/25/1998	6.40	9/3/1998	6.45
5/7/1998	6.30	6/16/1998	6.60	7/26/1998	6.40	9/4/1998	6.45
5/8/1998	6.45	6/17/1998	6.60	7/27/1998	6.40	9/5/1998	6.45
5/9/1998	6.40	6/18/1998	6.60	7/28/1998	6.40	9/6/1998	6.45
5/10/1998	6.40	6/19/1998	6.60	7/29/1998	6.40	9/7/1998	6.50
5/11/1998	6.40	6/20/1998	6.60	7/30/1998	6.70	9/8/1998	6.50
5/12/1998	6.35	6/21/1998	6.50	7/31/1998	6.70	9/9/1998	6.80
5/13/1998	6.35	6/22/1998	6.50	8/1/1998	6.70	9/10/1998	7.40
5/14/1998	6.45	6/23/1998	6.60	8/2/1998	7.00	9/11/1998	7.70
5/15/1998	6.45	6/24/1998	6.40	8/3/1998	7.00	9/12/1998	7.30
5/16/1998	6.45	6/25/1998	6.40	8/4/1998	7.00	9/13/1998	7.10
5/17/1998	6.40	6/26/1998	6.40	8/5/1998	7.20	9/14/1998	7.00
5/18/1998	6.40	6/27/1998	6.45	8/6/1998	6.85	9/15/1998	12.40
5/19/1998	6.50	6/28/1998	6.50	8/7/1998	6.70	9/16/1998	10.00
5/20/1998	6.45	6/29/1998	6.60	8/8/1998	6.65	9/17/1998	16.00
5/21/1998	6.55	6/30/1998	6.70	8/9/1998	6.60	9/18/1998	9.60
5/22/1998	6.50	7/1/1998	6.50	8/10/1998	6.60	9/19/1998	12.00
5/23/1998	6.40	7/2/1998	6.50	8/11/1998	6.60	9/20/1998	11.30
5/24/1998	6.35	7/3/1998	6.40	8/12/1998	6.80	9/21/1998	10.10
5/25/1998	6.35	7/4/1998	6.40	8/13/1998	6.70	9/22/1998	9.60
5/26/1998	6.35	7/5/1998	6.40	8/14/1998	6.60	9/23/1998	9.50
5/27/1998	6.50	7/6/1998	6.40	8/15/1998	6.60	9/24/1998	9.10
5/28/1998	6.60	7/7/1998	6.70	8/16/1998	6.50	9/25/1998	8.70
5/29/1998	6.65	7/8/1998	7.10	8/17/1998	6.50	9/26/1998	9.10
5/30/1998	6.60	7/9/1998	6.80	8/18/1998	6.50	9/27/1998	8.70
5/31/1998	6.60	7/10/1998	6.50	8/19/1998	6.50	9/28/1998	9.30
6/1/1998	6.55	7/11/1998	6.50	8/20/1998	6.50	9/29/1998	10.00
6/2/1998	6.55	7/12/1998	6.60	8/21/1998	6.45	9/30/1998	9.80
6/3/1998	6.50	7/13/1998	6.60	8/22/1998	6.45	10/1/1998	8.40
6/4/1998	6.60	7/14/1998	6.60	8/23/1998	6.45	10/2/1998	8.65
6/5/1998	6.60	7/15/1998	6.60	8/24/1998	6.45	10/3/1998	8.30
6/6/1998	6.60	7/16/1998	7.00	8/25/1998	6.55	10/4/1998	8.50
6/7/1998	6.60	7/17/1998	6.80	8/26/1998	6.60	10/5/1998	8.50

Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m
10/6/1998	7.70	11/15/1998	6.90	12/25/1998	6.60	2/3/1999	6.45
10/7/1998	7.50	11/16/1998	6.90	12/26/1998	6.60	2/4/1999	6.45
10/8/1998	7.70	11/17/1998	6.90	12/27/1998	6.60	2/5/1999	6.40
10/9/1998	7.50	11/18/1998	6.80	12/28/1998	6.55	2/6/1999	6.40
10/10/1998	7.30	11/19/1998	6.60	12/29/1998	6.50	2/7/1999	6.40
10/11/1998	7.00	11/20/1998	6.60	12/30/1998	6.50	2/8/1999	6.40
10/12/1998	6.95	11/21/1998	6.44	12/31/1998	6.50	2/9/1999	6.40
10/13/1998	6.90	11/22/1998	6.30	1/1/1999	6.50	2/10/1999	6.40
10/14/1998	6.85	11/23/1998	6.30	1/2/1999	6.50	2/11/1999	6.40
10/15/1998	6.80	11/24/1998	6.25	1/3/1999	6.40	2/12/1999	6.40
10/16/1998	7.00	11/25/1998	6.25	1/4/1999	6.40	2/13/1999	6.40
10/17/1998	9.10	11/26/1998	6.30	1/5/1999	6.40	2/14/1999	6.40
10/18/1998	8.75	11/27/1998	6.30	1/6/1999	6.40	2/15/1999	6.40
10/19/1998	8.80	11/28/1998	6.40	1/7/1999	6.40	2/16/1999	6.40
10/20/1998	8.80	11/29/1998	6.40	1/8/1999	6.40	2/17/1999	6.40
10/21/1998	8.50	11/30/1998	6.40	1/9/1999	6.45	2/18/1999	6.40
10/22/1998	8.20	12/1/1998	6.40	1/10/1999	6.45	2/19/1999	6.45
10/23/1998	7.50	12/2/1998	6.40	1/11/1999	6.45	2/20/1999	6.45
10/24/1998	7.40	12/3/1998	6.40	1/12/1999	6.45	2/21/1999	6.40
10/25/1998	7.40	12/4/1998	6.40	1/13/1999	6.40	2/22/1999	6.40
10/26/1998	7.40	12/5/1998	6.40	1/14/1999	6.40	2/23/1999	6.40
10/27/1998	7.40	12/6/1998	6.40	1/15/1999	6.40	2/24/1999	6.40
10/28/1998	7.35	12/7/1998	6.40	1/16/1999	6.40	2/25/1999	6.40
10/29/1998	7.25	12/8/1998	6.40	1/17/1999	6.40	2/26/1999	6.40
10/30/1998	7.20	12/9/1998	6.40	1/18/1999	6.40	2/27/1999	6.40
10/31/1998	7.25	12/10/1998	6.45	1/19/1999	6.45	2/28/1999	6.40
11/1/1998	7.20	12/11/1998	6.40	1/20/1999	6.45	3/1/1999	6.40
11/2/1998	7.15	12/12/1998	6.40	1/21/1999	6.45	3/2/1999	6.50
11/3/1998	7.10	12/13/1998	6.50	1/22/1999	6.40	3/3/1999	6.50
11/4/1998	7.10	12/14/1998	6.40	1/23/1999	6.40	3/4/1999	6.50
11/5/1998	7.10	12/15/1998	6.40	1/24/1999	6.40	3/5/1999	6.40
11/6/1998	6.90	12/16/1998	6.40	1/25/1999	6.40	3/6/1999	6.40
11/7/1998	6.90	12/17/1998	6.40	1/26/1999	6.40	3/7/1999	6.40
11/8/1998	6.75	12/18/1998	6.40	1/27/1999	6.40	3/8/1999	6.40
11/9/1998	6.75	12/19/1998	6.40	1/28/1999	6.40	3/9/1999	6.40
11/10/1998	6.85	12/20/1998	6.40	1/29/1999	6.40	3/10/1999	6.40
11/11/1998	6.85	12/21/1998	6.40	1/30/1999	6.40	3/11/1999	6.40
11/12/1998	6.90	12/22/1998	6.40	1/31/1999	6.40	3/12/1999	6.40
11/13/1998	6.20	12/23/1998	6.50	2/1/1999	6.45	3/13/1999	6.40
11/14/1998	6.90	12/24/1998	6.60	2/2/1999	6.45	3/14/1999	6.45

Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m
3/15/1999	6.50	4/24/1999	6.50	6/3/1999	6.50
3/16/1999	6.40	4/25/1999	6.40	6/4/1999	6.55
3/17/1999	6.40	4/26/1999	6.40	6/5/1999	6.55
3/18/1999	6.40	4/27/1999	6.40	6/6/1999	6.55
3/19/1999	6.40	4/28/1999	6.40	6/7/1999	6.55
3/20/1999	6.40	4/29/1999	6.35	6/8/1999	6.55
3/21/1999	6.35	4/30/1999	6.30	6/9/1999	6.55
3/22/1999	6.35	5/1/1999	6.30	6/10/1999	6.55
3/23/1999	6.40	5/2/1999	6.40	6/11/1999	6.55
3/24/1999	6.35	5/3/1999	6.40	6/12/1999	6.55
3/25/1999	6.35	5/4/1999	6.35	6/13/1999	6.60
3/26/1999	6.35	5/5/1999	6.35	6/14/1999	6.55
3/27/1999	6.35	5/6/1999	6.35		
3/28/1999	6.35	5/7/1999	6.35		
3/29/1999	6.35	5/8/1999	6.35		
3/30/1999	6.35	5/9/1999	6.35		
3/31/1999	6.40	5/10/1999	6.35		
4/1/1999	6.35	5/11/1999	6.35		
4/2/1999	6.35	5/12/1999	6.40		
4/3/1999	6.35	5/13/1999	6.40		
4/4/1999	6.30	5/14/1999	6.40		
4/5/1999	6.30	5/15/1999	6.35		
4/6/1999	6.30	5/16/1999	6.35		
4/7/1999	6.30	5/17/1999	6.35		
4/8/1999	6.35	5/18/1999	6.50		
4/9/1999	6.50	5/19/1999	6.70		
4/10/1999	6.45	5/20/1999	6.50		
4/11/1999	6.50	5/21/1999	6.50		
4/12/1999	6.50	5/22/1999	6.50		
4/13/1999	6.50	5/23/1999	6.50		
4/14/1999	6.50	5/24/1999	6.50		
4/15/1999	6.45	5/25/1999	6.50		
4/16/1999	6.45	5/26/1999	6.55		
4/17/1999	6.35	5/27/1999	6.55		
4/18/1999	6.35	5/28/1999	6.55		
4/19/1999	6.35	5/29/1999	6.55		
4/20/1999	6.35	5/30/1999	6.50		
4/21/1999	6.35	5/31/1999	6.50		
4/22/1999	6.35	6/1/1999	6.55		
4/23/1999	6.50	6/2/1999	6.50		

Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m
6/13/2003	6.75	7/23/2003	8.00	9/1/2003	7.60	10/11/2003	7.25
6/14/2003	6.75	7/24/2003	8.70	9/2/2003	7.50	10/12/2003	6.95
6/15/2003	6.75	7/25/2003	8.40	9/3/2003	7.50	10/13/2003	6.90
6/16/2003	6.80	7/26/2003	8.35	9/4/2003	7.40	10/14/2003	6.90
6/17/2003	6.90	7/27/2003	8.20	9/5/2003	7.25	10/15/2003	6.90
6/18/2003	6.95	7/28/2003	8.35	9/6/2003	7.20	10/16/2003	6.90
6/19/2003	7.00	7/29/2003	10.20	9/7/2003	7.20	10/17/2003	6.80
6/20/2003	7.05	7/30/2003	8.60	9/8/2003	7.15	10/18/2003	6.80
6/21/2003	7.10	7/31/2003	8.10	9/9/2003	7.15	10/19/2003	6.75
6/22/2003	7.20	8/1/2003	8.00	9/10/2003	7.15	10/20/2003	6.75
6/23/2003	7.50	8/2/2003	7.95	9/11/2003	7.20	10/21/2003	6.75
6/24/2003	7.85	8/3/2003	7.95	9/12/2003	7.10	10/22/2003	6.85
6/25/2003	7.40	8/4/2003	7.85	9/13/2003	6.90	10/23/2003	6.90
6/26/2003	7.40	8/5/2003	7.80	9/14/2003	6.80	10/24/2003	7.05
6/27/2003	7.25	8/6/2003	7.75	9/15/2003	6.70	10/25/2003	7.10
6/28/2003	7.15	8/7/2003	7.80	9/16/2003	6.60	10/26/2003	7.15
6/29/2003	7.10	8/8/2003	7.70	9/17/2003	6.60	10/27/2003	7.15
6/30/2003	7.10	8/9/2003	7.70	9/18/2003	6.60	10/28/2003	7.20
7/1/2003	7.00	8/10/2003	7.60	9/19/2003	6.60	10/29/2003	7.40
7/2/2003	6.95	8/11/2003	7.60	9/20/2003	7.30	10/30/2003	7.40
7/3/2003	6.90	8/12/2003	7.65	9/21/2003	7.45	10/31/2003	7.40
7/4/2003	7.10	8/13/2003	7.55	9/22/2003	7.20	11/1/2003	7.35
7/5/2003	7.20	8/14/2003	7.50	9/23/2003	7.60	11/2/2003	7.35
7/6/2003	7.20	8/15/2003	7.50	9/24/2003	8.40	11/3/2003	7.15
7/7/2003	7.20	8/16/2003	7.50	9/25/2003	9.50	11/4/2003	7.15
7/8/2003	7.10	8/17/2003	7.50	9/26/2003	10.00	11/5/2003	7.10
7/9/2003	7.05	8/18/2003	7.50	9/27/2003	10.75	11/6/2003	7.40
7/10/2003	7.05	8/19/2003	7.55	9/28/2003	10.45	11/7/2003	7.65
7/11/2003	7.05	8/20/2003	7.50	9/29/2003	9.65	11/8/2003	7.70
7/12/2003	7.20	8/21/2003	7.50	9/30/2003	8.70	11/9/2003	7.55
7/13/2003	7.20	8/22/2003	7.45	10/1/2003	9.70	11/10/2003	7.40
7/14/2003	7.10	8/23/2003	7.40	10/2/2003	8.90	11/11/2003	7.45
7/15/2003	7.05	8/24/2003	7.80	10/3/2003	8.60	11/12/2003	7.55
7/16/2003	7.05	8/25/2003	10.20	10/4/2003	8.10	11/13/2003	7.55
7/17/2003	7.30	8/26/2003	8.70	10/5/2003	7.80	11/14/2003	7.55
7/18/2003	8.00	8/27/2003	8.40	10/6/2003	7.70	11/15/2003	7.55
7/19/2003	7.80	8/28/2003	8.40	10/7/2003	7.55	11/16/2003	7.55
7/20/2003	7.80	8/29/2003	8.40	10/8/2003	7.40	11/17/2003	7.25
7/21/2003	7.70	8/30/2003	8.05	10/9/2003	7.40	11/18/2003	7.40
7/22/2003	7.70	8/31/2003	7.80	10/10/2003	7.35	11/19/2003	7.20

Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m
11/20/2003	7.20	12/30/2003	6.70	2/8/2004	6.60	3/19/2004	6.75
11/21/2003	7.15	12/31/2003	6.70	2/9/2004	6.60	3/20/2004	6.70
11/22/2003	6.95	1/1/2004	6.70	2/10/2004	6.50	3/21/2004	7.30
11/23/2003	6.70	1/2/2004	6.75	2/11/2004	6.40	3/22/2004	7.60
11/24/2003	7.25	1/3/2004	6.75	2/12/2004	6.55	3/23/2004	7.65
11/25/2003	7.25	1/4/2004	6.75	2/13/2004	6.50	3/24/2004	7.60
11/26/2003	7.20	1/5/2004	6.70	2/14/2004	6.45	3/25/2004	7.70
11/27/2003	7.10	1/6/2004	6.70	2/15/2004	6.40	3/26/2004	7.60
11/28/2003	6.65	1/7/2004	6.75	2/16/2004	6.40	3/27/2004	7.50
11/29/2003	6.65	1/8/2004	6.70	2/17/2004	6.40	3/28/2004	7.65
11/30/2003	6.60	1/9/2004	6.60	2/18/2004	6.60	3/29/2004	7.70
12/1/2003	6.55	1/10/2004	6.60	2/19/2004	6.65	3/30/2004	7.70
12/2/2003	6.90	1/11/2004	6.60	2/20/2004	6.60	3/31/2004	7.00
12/3/2003	6.70	1/12/2004	6.60	2/21/2004	6.50	4/1/2004	7.00
12/4/2003	6.70	1/13/2004	6.60	2/22/2004	6.50	4/2/2004	6.80
12/5/2003	6.70	1/14/2004	6.70	2/23/2004	6.95	4/3/2004	6.85
12/6/2003	6.70	1/15/2004	6.70	2/24/2004	7.00	4/4/2004	6.85
12/7/2003	6.75	1/16/2004	6.75	2/25/2004	7.20	4/5/2004	6.85
12/8/2003	7.20	1/17/2004	6.70	2/26/2004	7.35	4/6/2004	6.95
12/9/2003	7.00	1/18/2004	6.60	2/27/2004	7.35	4/7/2004	6.70
12/10/2003	7.00	1/19/2004	6.50	2/28/2004	7.25	4/8/2004	6.70
12/11/2003	7.00	1/20/2004	6.55	2/29/2004	7.20	4/9/2004	6.90
12/12/2003	7.00	1/21/2004	6.80	3/1/2004	7.25	4/10/2004	6.85
12/13/2003	7.15	1/22/2004	6.85	3/2/2004	7.15	4/11/2004	6.85
12/14/2003	6.90	1/23/2004	6.90	3/3/2004	7.15	4/12/2004	6.85
12/15/2003	6.90	1/24/2004	6.90	3/4/2004	7.15	4/13/2004	6.80
12/16/2003	7.00	1/25/2004	6.90	3/5/2004	7.20	4/14/2004	6.65
12/17/2003	6.95	1/26/2004	6.90	3/6/2004	7.10	4/15/2004	6.50
12/18/2003	6.80	1/27/2004	6.90	3/7/2004	6.90	4/16/2004	6.40
12/19/2003	6.75	1/28/2004	6.90	3/8/2004	7.30	4/17/2004	6.35
12/20/2003	6.70	1/29/2004	6.85	3/9/2004	7.20	4/18/2004	6.35
12/21/2003	6.70	1/30/2004	6.85	3/10/2004	6.90	4/19/2004	6.35
12/22/2003	6.70	1/31/2004	6.90	3/11/2004	7.10	4/20/2004	6.40
12/23/2003	6.70	2/1/2004	7.05	3/12/2004	7.20	4/21/2004	6.50
12/24/2003	6.70	2/2/2004	7.10	3/13/2004	7.20	4/22/2004	6.60
12/25/2003	6.70	2/3/2004	7.10	3/14/2004	7.15	4/23/2004	6.60
12/26/2003	6.70	2/4/2004	7.20	3/15/2004	7.15	4/24/2004	6.60
12/27/2003	6.70	2/5/2004	6.80	3/16/2004	7.10	4/25/2004	6.55
12/28/2003	6.75	2/6/2004	6.75	3/17/2004	7.10	4/26/2004	6.45
12/29/2003	6.75	2/7/2004	6.80	3/18/2004	6.85	4/27/2004	6.65

Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m
4/28/2004	6.65	6/7/2004	7.70	7/17/2004	6.60	8/26/2004	12.30
4/29/2004	6.55	6/8/2004	7.70	7/18/2004	6.60	8/27/2004	10.90
4/30/2004	6.45	6/9/2004	7.70	7/19/2004	6.60	8/28/2004	10.00
5/1/2004	6.40	6/10/2004	7.80	7/20/2004	6.60	8/29/2004	9.90
5/2/2004	7.00	6/11/2004	7.75	7/21/2004	6.60	8/30/2004	9.55
5/3/2004	7.05	6/12/2004	7.75	7/22/2004	6.60	8/31/2004	8.85
5/4/2004	7.05	6/13/2004	7.75	7/23/2004	6.60	9/1/2004	8.70
5/5/2004	7.00	6/14/2004	7.75	7/24/2004	6.60	9/2/2004	8.30
5/6/2004	6.65	6/15/2004	7.80	7/25/2004	6.60	9/3/2004	7.85
5/7/2004	6.50	6/16/2004	7.80	7/26/2004	6.60	9/4/2004	7.45
5/8/2004	6.45	6/17/2004	7.80	7/27/2004	6.60	9/5/2004	7.20
5/9/2004	6.45	6/18/2004	7.80	7/28/2004	6.60	9/6/2004	7.10
5/10/2004	6.70	6/19/2004	7.80	7/29/2004	6.60	9/7/2004	7.10
5/11/2004	7.10	6/20/2004	7.80	7/30/2004	6.65	9/8/2004	7.10
5/12/2004	7.20	6/21/2004	7.80	7/31/2004	6.85	9/9/2004	7.10
5/13/2004	7.45	6/22/2004	7.80	8/1/2004	8.30	9/10/2004	7.10
5/14/2004	7.70	6/23/2004	7.80	8/2/2004	8.20	9/11/2004	7.35
5/15/2004	7.90	6/24/2004	7.85	8/3/2004	8.55	9/12/2004	7.35
5/16/2004	8.00	6/25/2004	7.85	8/4/2004	8.15	9/13/2004	7.15
5/17/2004	8.00	6/26/2004	7.85	8/5/2004	7.80	9/14/2004	7.15
5/18/2004	7.90	6/27/2004	7.80	8/6/2004	7.60	9/15/2004	7.10
5/19/2004	7.65	6/28/2004	7.70	8/7/2004	9.00	9/16/2004	7.30
5/20/2004	7.55	6/29/2004	7.70	8/8/2004	9.30	9/17/2004	7.25
5/21/2004	7.50	6/30/2004	7.70	8/9/2004	9.25	9/18/2004	7.20
5/22/2004	7.40	7/1/2004	7.60	8/10/2004	10.10	9/19/2004	7.10
5/23/2004	7.40	7/2/2004	7.30	8/11/2004	10.75	9/20/2004	7.60
5/24/2004	7.50	7/3/2004	7.20	8/12/2004	11.50	9/21/2004	7.50
5/25/2004	7.50	7/4/2004	6.90	8/13/2004	16.20	9/22/2004	7.40
5/26/2004	7.50	7/5/2004	6.85	8/14/2004	16.90	9/23/2004	7.35
5/27/2004	7.55	7/6/2004	6.90	8/15/2004	17.70	9/24/2004	7.20
5/28/2004	7.70	7/7/2004	6.95	8/16/2004	13.40	9/25/2004	7.00
5/29/2004	7.70	7/8/2004	6.90	8/17/2004	12.40	9/26/2004	7.00
5/30/2004	7.70	7/9/2004	6.90	8/18/2004	11.90	9/27/2004	6.95
5/31/2004	7.70	7/10/2004	7.00	8/19/2004	10.60	9/28/2004	6.90
6/1/2004	7.70	7/11/2004	6.90	8/20/2004	9.40	9/29/2004	6.90
6/2/2004	7.70	7/12/2004	6.75	8/21/2004	9.25	9/30/2004	6.90
6/3/2004	7.70	7/13/2004	6.70	8/22/2004	9.65	10/1/2004	6.95
6/4/2004	7.70	7/14/2004	6.65	8/23/2004	9.90	10/2/2004	6.90
6/5/2004	7.70	7/15/2004	6.65	8/24/2004	11.10	10/3/2004	6.90
6/6/2004	7.70	7/16/2004	6.60	8/25/2004	14.90	10/4/2004	6.90

Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m
10/5/2004	6.90	11/14/2004	6.90	12/24/2004	6.70	2/2/2005	6.80
10/6/2004	6.90	11/15/2004	6.90	12/25/2004	6.70	2/3/2005	6.80
10/7/2004	6.90	11/16/2004	6.90	12/26/2004	6.70	2/4/2005	6.80
10/8/2004	6.90	11/17/2004	6.90	12/27/2004	6.70	2/5/2005	6.75
10/9/2004	6.90	11/18/2004	6.90	12/28/2004	6.70	2/6/2005	6.70
10/10/2004	6.90	11/19/2004	6.80	12/29/2004	6.75	2/7/2005	6.70
10/11/2004	6.90	11/20/2004	6.80	12/30/2004	6.75	2/8/2005	6.75
10/12/2004	6.85	11/21/2004	6.80	12/31/2004	6.75	2/9/2005	6.75
10/13/2004	6.75	11/22/2004	6.80	1/1/2005	6.75	2/10/2005	6.75
10/14/2004	6.80	11/23/2004	6.70	1/2/2005	6.75	2/11/2005	6.70
10/15/2004	6.75	11/24/2004	6.65	1/3/2005	6.75	2/12/2005	6.70
10/16/2004	6.80	11/25/2004	6.65	1/4/2005	6.80	2/13/2005	6.70
10/17/2004	6.75	11/26/2004	6.65	1/5/2005	6.85	2/14/2005	6.70
10/18/2004	6.75	11/27/2004	6.70	1/6/2005	6.85	2/15/2005	6.70
10/19/2004	6.75	11/28/2004	6.70	1/7/2005	6.85	2/16/2005	6.70
10/20/2004	6.75	11/29/2004	6.70	1/8/2005	6.85	2/17/2005	6.70
10/21/2004	6.70	11/30/2004	6.65	1/9/2005	6.85	2/18/2005	6.70
10/22/2004	6.70	12/1/2004	6.30	1/10/2005	6.80	2/19/2005	6.65
10/23/2004	6.70	12/2/2004	6.70	1/11/2005	6.80	2/20/2005	6.65
10/24/2004	6.75	12/3/2004	6.85	1/12/2005	6.70	2/21/2005	6.65
10/25/2004	6.75	12/4/2004	6.75	1/13/2005	6.65	2/22/2005	6.65
10/26/2004	6.70	12/5/2004	6.65	1/14/2005	6.75	2/23/2005	6.65
10/27/2004	6.65	12/6/2004	6.70	1/15/2005	6.80	2/24/2005	6.65
10/28/2004	6.65	12/7/2004	6.70	1/16/2005	6.90	2/25/2005	6.70
10/29/2004	6.65	12/8/2004	6.80	1/17/2005	7.00	2/26/2005	6.70
10/30/2004	6.65	12/9/2004	6.80	1/18/2005	7.00	2/27/2005	6.65
10/31/2004	6.75	12/10/2004	6.80	1/19/2005	6.95	2/28/2005	6.65
11/1/2004	6.75	12/11/2004	6.75	1/20/2005	6.80	3/1/2005	6.65
11/2/2004	6.70	12/12/2004	6.60	1/21/2005	6.70	3/2/2005	6.65
11/3/2004	6.75	12/13/2004	6.60	1/22/2005	6.70	3/3/2005	6.65
11/4/2004	6.75	12/14/2004	6.60	1/23/2005	6.70	3/4/2005	6.70
11/5/2004	6.70	12/15/2004	6.65	1/24/2005	6.70	3/5/2005	6.75
11/6/2004	6.65	12/16/2004	6.65	1/25/2005	6.70	3/6/2005	6.70
11/7/2004	6.75	12/17/2004	6.75	1/26/2005	6.70	3/7/2005	6.70
11/8/2004	6.85	12/18/2004	6.85	1/27/2005	6.70	3/8/2005	6.70
11/9/2004	6.70	12/19/2004	6.85	1/28/2005	6.70	3/9/2005	6.75
11/10/2004	6.80	12/20/2004	6.85	1/29/2005	6.70	3/10/2005	6.75
11/11/2004	6.70	12/21/2004	6.85	1/30/2005	6.70	3/11/2005	6.70
11/12/2004	6.70	12/22/2004	6.80	1/31/2005	6.70	3/12/2005	6.65
11/13/2004	6.85	12/23/2004	6.80	2/1/2005	6.80	3/13/2005	6.70

Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m
3/14/2005	6.70	4/23/2005	6.80	6/2/2005	6.80
3/15/2005	6.65	4/24/2005	6.40	6/3/2005	6.80
3/16/2005	6.60	4/25/2005	6.75	6/4/2005	6.80
3/17/2005	6.65	4/26/2005	6.70	6/5/2005	6.80
3/18/2005	6.65	4/27/2005	6.70	6/6/2005	6.80
3/19/2005	6.60	4/28/2005	6.70	6/7/2005	6.80
3/20/2005	6.55	4/29/2005	6.70	6/8/2005	6.80
3/21/2005	6.60	4/30/2005	6.70	6/9/2005	6.80
3/22/2005	6.70	5/1/2005	6.70	6/10/2005	6.80
3/23/2005	6.70	5/2/2005	6.70	6/11/2005	6.80
3/24/2005	6.65	5/3/2005	6.70	6/12/2005	6.80
3/25/2005	6.65	5/4/2005	6.70	6/13/2005	6.80
3/26/2005	6.65	5/5/2005	6.70	6/14/2005	6.80
3/27/2005	6.65	5/6/2005	6.75		
3/28/2005	6.70	5/7/2005	6.75		
3/29/2005	6.70	5/8/2005	6.75		
3/30/2005	6.70	5/9/2005	6.75		
3/31/2005	6.70	5/10/2005	6.75		
4/1/2005	6.70	5/11/2005	6.75		
4/2/2005	6.60	5/12/2005	6.75		
4/3/2005	6.60	5/13/2005	6.75		
4/4/2005	6.55	5/14/2005	6.75		
4/5/2005	6.50	5/15/2005	6.75		
4/6/2005	6.50	5/16/2005	6.75		
4/7/2005	6.55	5/17/2005	6.75		
4/8/2005	6.60	5/18/2005	6.75		
4/9/2005	6.60	5/19/2005	6.75		
4/10/2005	6.90	5/20/2005	6.75		
4/11/2005	6.90	5/21/2005	6.75		
4/12/2005	6.90	5/22/2005	6.75		
4/13/2005	6.85	5/23/2005	6.75		
4/14/2005	6.80	5/24/2005	6.75		
4/15/2005	6.75	5/25/2005	6.75		
4/16/2005	6.70	5/26/2005	6.75		
4/17/2005	6.70	5/27/2005	6.75		
4/18/2005	6.70	5/28/2005	6.75		
4/19/2005	6.75	5/29/2005	6.80		
4/20/2005	6.75	5/30/2005	6.80		
4/21/2005	6.80	5/31/2005	6.80		
4/22/2005	6.80	6/1/2005	6.80		

Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m
6/13/2005	6.80	7/23/2005	7.30	9/1/2005	6.95	10/11/2005	6.65
6/14/2005	6.80	7/24/2005	7.30	9/2/2005	6.85	10/12/2005	6.65
6/15/2005	6.80	7/25/2005	7.30	9/3/2005	6.65	10/13/2005	6.80
6/16/2005	6.80	7/26/2005	7.30	9/4/2005	6.60	10/14/2005	7.20
6/17/2005	6.80	7/27/2005	7.30	9/5/2005	6.55	10/15/2005	7.10
6/18/2005	7.10	7/28/2005	7.35	9/6/2005	6.55	10/16/2005	7.00
6/19/2005	7.45	7/29/2005	8.50	9/7/2005	6.55	10/17/2005	6.95
6/20/2005	7.60	7/30/2005	10.80	9/8/2005	6.75	10/18/2005	6.95
6/21/2005	7.60	7/31/2005	9.30	9/9/2005	6.85	10/19/2005	6.70
6/22/2005	7.65	8/1/2005	8.60	9/10/2005	7.10	10/20/2005	6.75
6/23/2005	7.50	8/2/2005	9.75	9/11/2005	7.10	10/21/2005	7.15
6/24/2005	7.75	8/3/2005	11.20	9/12/2005	7.60	10/22/2005	7.65
6/25/2005	7.80	8/4/2005	10.85	9/13/2005	7.40	10/23/2005	7.50
6/26/2005	7.50	8/5/2005	9.00	9/14/2005	7.30	10/24/2005	7.10
6/27/2005	7.50	8/6/2005	8.10	9/15/2005	7.20	10/25/2005	6.90
6/28/2005	8.20	8/7/2005	7.90	9/16/2005	7.20	10/26/2005	6.80
6/29/2005	8.00	8/8/2005	8.20	9/17/2005	7.25	10/27/2005	6.75
6/30/2005	9.00	8/9/2005	7.90	9/18/2005	7.35	10/28/2005	6.65
7/1/2005	10.90	8/10/2005	7.80	9/19/2005	7.40	10/29/2005	6.65
7/2/2005	9.00	8/11/2005	7.80	9/20/2005	8.70	10/30/2005	6.70
7/3/2005	8.80	8/12/2005	7.70	9/21/2005	7.85	10/31/2005	6.75
7/4/2005	8.20	8/13/2005	7.50	9/22/2005	7.80	11/1/2005	6.75
7/5/2005	7.70	8/14/2005	7.45	9/23/2005	7.75	11/2/2005	6.75
7/6/2005	7.70	8/15/2005	7.45	9/24/2005	9.30	11/3/2005	6.75
7/7/2005	7.50	8/16/2005	7.45	9/25/2005	8.10	11/4/2005	6.75
7/8/2005	7.40	8/17/2005	7.45	9/26/2005	8.00	11/5/2005	6.80
7/9/2005	7.40	8/18/2005	7.35	9/27/2005	7.90	11/6/2005	6.80
7/10/2005	7.40	8/19/2005	7.30	9/28/2005	7.80	11/7/2005	6.75
7/11/2005	7.35	8/20/2005	7.30	9/29/2005	7.80	11/8/2005	6.80
7/12/2005	7.35	8/21/2005	7.15	9/30/2005	8.05	11/9/2005	6.70
7/13/2005	7.30	8/22/2005	7.10	10/1/2005	7.95	11/10/2005	6.65
7/14/2005	7.20	8/23/2005	7.10	10/2/2005	7.75	11/11/2005	6.65
7/15/2005	7.00	8/24/2005	7.10	10/3/2005	7.45	11/12/2005	6.75
7/16/2005	7.00	8/25/2005	7.10	10/4/2005	7.30	11/13/2005	6.75
7/17/2005	6.90	8/26/2005	7.10	10/5/2005	7.05	11/14/2005	6.75
7/18/2005	6.85	8/27/2005	7.10	10/6/2005	6.85	11/15/2005	6.75
7/19/2005	6.95	8/28/2005	7.05	10/7/2005	6.75	11/16/2005	6.65
7/20/2005	7.30	8/29/2005	7.00	10/8/2005	6.70	11/17/2005	6.65
7/21/2005	7.30	8/30/2005	6.95	10/9/2005	6.80	11/18/2005	6.65
7/22/2005	7.30	8/31/2005	6.95	10/10/2005	6.70	11/19/2005	6.65

Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m
11/20/2005	6.65	12/30/2005	6.60	2/8/2006	6.75	3/20/2006	6.55
11/21/2005	6.60	12/31/2005	6.60	2/9/2006	6.60	3/21/2006	6.55
11/22/2005	6.80	1/1/2006	6.60	2/10/2006	6.55	3/22/2006	6.55
11/23/2005	6.65	1/2/2006	6.55	2/11/2006	6.55	3/23/2006	6.55
11/24/2005	6.65	1/3/2006	6.60	2/12/2006	6.50	3/24/2006	6.60
11/25/2005	6.65	1/4/2006	6.60	2/13/2006	6.50	3/25/2006	6.60
11/26/2005	6.70	1/5/2006	6.60	2/14/2006	6.55	3/26/2006	6.50
11/27/2005	6.90	1/6/2006	6.60	2/15/2006	6.65	3/27/2006	6.50
11/28/2005	6.85	1/7/2006	6.60	2/16/2006	6.65	3/28/2006	6.50
11/29/2005	6.85	1/8/2006	6.60	2/17/2006	6.55	3/29/2006	6.50
11/30/2005	6.90	1/9/2006	6.60	2/18/2006	6.50	3/30/2006	6.50
12/1/2005	7.00	1/10/2006	6.60	2/19/2006	6.50	3/31/2006	6.50
12/2/2005	7.00	1/11/2006	6.60	2/20/2006	6.50	4/1/2006	6.50
12/3/2005	6.85	1/12/2006	6.60	2/21/2006	6.50	4/2/2006	6.55
12/4/2005	6.65	1/13/2006	6.60	2/22/2006	6.60	4/3/2006	6.60
12/5/2005	6.60	1/14/2006	6.60	2/23/2006	6.60	4/4/2006	6.65
12/6/2005	6.65	1/15/2006	6.65	2/24/2006	6.60	4/5/2006	6.60
12/7/2005	6.75	1/16/2006	6.70	2/25/2006	6.55	4/6/2006	6.50
12/8/2005	6.70	1/17/2006	6.75	2/26/2006	6.55	4/7/2006	6.50
12/9/2005	6.65	1/18/2006	6.75	2/27/2006	6.50	4/8/2006	6.50
12/10/2005	6.60	1/19/2006	6.65	2/28/2006	6.50	4/9/2006	6.50
12/11/2005	6.60	1/20/2006	6.60	3/1/2006	6.50	4/10/2006	6.50
12/12/2005	6.60	1/21/2006	6.55	3/2/2006	6.55	4/11/2006	6.50
12/13/2005	6.60	1/22/2006	6.55	3/3/2006	6.60	4/12/2006	6.50
12/14/2005	6.60	1/23/2006	6.55	3/4/2006	6.60	4/13/2006	6.50
12/15/2005	6.60	1/24/2006	6.55	3/5/2006	6.55	4/14/2006	6.50
12/16/2005	6.60	1/25/2006	6.55	3/6/2006	6.55	4/15/2006	6.45
12/17/2005	6.65	1/26/2006	6.60	3/7/2006	6.55	4/16/2006	6.45
12/18/2005	6.55	1/27/2006	6.60	3/8/2006	6.55	4/17/2006	6.45
12/19/2005	6.60	1/28/2006	6.55	3/9/2006	6.50	4/18/2006	6.45
12/20/2005	6.90	1/29/2006	6.55	3/10/2006	6.55	4/19/2006	6.45
12/21/2005	6.80	1/30/2006	6.50	3/11/2006	6.55	4/20/2006	6.45
12/22/2005	6.85	1/31/2006	6.45	3/12/2006	6.55	4/21/2006	6.45
12/23/2005	6.90	2/1/2006	6.50	3/13/2006	6.50	4/22/2006	6.40
12/24/2005	6.95	2/2/2006	6.60	3/14/2006	6.50	4/23/2006	6.40
12/25/2005	6.75	2/3/2006	6.60	3/15/2006	6.50	4/24/2006	6.40
12/26/2005	6.65	2/4/2006	6.60	3/16/2006	6.50	4/25/2006	6.50
12/27/2005	6.60	2/5/2006	6.60	3/17/2006	6.55	4/26/2006	6.85
12/28/2005	6.70	2/6/2006	6.55	3/18/2006	6.55	4/27/2006	6.85
12/29/2005	6.80	2/7/2006	6.60	3/19/2006	6.55	4/28/2006	6.80

Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m
4/29/2006	6.70	6/8/2006	6.80	7/18/2006	6.60	8/27/2006	11.70
4/30/2006	6.60	6/9/2006	6.80	7/19/2006	6.60	8/28/2006	10.50
5/1/2006	6.55	6/10/2006	6.80	7/20/2006	6.60	8/29/2006	10.40
5/2/2006	6.55	6/11/2006	6.80	7/21/2006	6.65	8/30/2006	10.60
5/3/2006	6.55	6/12/2006	6.80	7/22/2006	6.85	8/31/2006	9.35
5/4/2006	6.50	6/13/2006	6.80	7/23/2006	6.80	9/1/2006	9.20
5/5/2006	6.55	6/14/2006	6.75	7/24/2006	6.75	9/2/2006	9.75
5/6/2006	6.60	6/15/2006	6.65	7/25/2006	6.75	9/3/2006	12.00
5/7/2006	6.55	6/16/2006	6.65	7/26/2006	6.75	9/4/2006	10.00
5/8/2006	6.55	6/17/2006	6.60	7/27/2006	6.70	9/5/2006	9.30
5/9/2006	6.55	6/18/2006	6.60	7/28/2006	6.70	9/6/2006	9.15
5/10/2006	6.50	6/19/2006	6.60	7/29/2006	10.00	9/7/2006	17.50
5/11/2006	6.60	6/20/2006	6.60	7/30/2006	11.90	9/8/2006	17.50
5/12/2006	6.70	6/21/2006	6.60	7/31/2006	10.80	9/9/2006	13.50
5/13/2006	6.65	6/22/2006	6.55	8/1/2006	10.50	9/10/2006	11.30
5/14/2006	6.60	6/23/2006	6.55	8/2/2006	13.00	9/11/2006	10.40
5/15/2006	6.60	6/24/2006	6.55	8/3/2006	11.20	9/12/2006	9.75
5/16/2006	6.60	6/25/2006	6.55	8/4/2006	10.50	9/13/2006	10.00
5/17/2006	6.55	6/26/2006	6.55	8/5/2006	9.90	9/14/2006	9.75
5/18/2006	6.65	6/27/2006	6.60	8/6/2006	9.00	9/15/2006	9.10
5/19/2006	6.65	6/28/2006	6.65	8/7/2006	13.85	9/16/2006	8.95
5/20/2006	6.60	6/29/2006	6.65	8/8/2006	15.40	9/17/2006	8.90
5/21/2006	6.60	6/30/2006	6.65	8/9/2006	18.70	9/18/2006	8.85
5/22/2006	6.65	7/1/2006	6.65	8/10/2006	15.35	9/19/2006	9.30
5/23/2006	6.75	7/2/2006	6.55	8/11/2006	16.90	9/20/2006	9.40
5/24/2006	6.75	7/3/2006	6.55	8/12/2006	24.30	9/21/2006	9.75
5/25/2006	6.80	7/4/2006	6.55	8/13/2006	19.80	9/22/2006	9.30
5/26/2006	6.80	7/5/2006	6.70	8/14/2006	14.90	9/23/2006	9.25
5/27/2006	6.60	7/6/2006	7.20	8/15/2006	12.40	9/24/2006	9.90
5/28/2006	6.60	7/7/2006	7.20	8/16/2006	17.50	9/25/2006	9.80
5/29/2006	6.60	7/8/2006	6.90	8/17/2006	16.50	9/26/2006	9.00
5/30/2006	6.60	7/9/2006	6.70	8/18/2006	13.40	9/27/2006	8.70
5/31/2006	6.60	7/10/2006	6.70	8/19/2006	13.60	9/28/2006	8.65
6/1/2006	6.60	7/11/2006	6.65	8/20/2006	22.50	9/29/2006	8.65
6/2/2006	6.65	7/12/2006	6.65	8/21/2006	15.80	9/30/2006	8.65
6/3/2006	6.80	7/13/2006	6.60	8/22/2006	14.70	10/1/2006	8.60
6/4/2006	6.90	7/14/2006	6.55	8/23/2006	14.20	10/2/2006	8.05
6/5/2006	6.90	7/15/2006	6.55	8/24/2006	13.50	10/3/2006	7.55
6/6/2006	6.80	7/16/2006	6.55	8/25/2006	11.70	10/4/2006	7.50
6/7/2006	6.80	7/17/2006	6.55	8/26/2006	11.40	10/5/2006	7.50

Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m
10/6/2006	8.45	11/15/2006	6.85	12/25/2006	6.60	2/3/2007	6.70
10/7/2006	8.20	11/16/2006	6.80	12/26/2006	6.55	2/4/2007	6.70
10/8/2006	8.00	11/17/2006	6.80	12/27/2006	6.55	2/5/2007	6.70
10/9/2006	7.70	11/18/2006	6.80	12/28/2006	6.55	2/6/2007	6.70
10/10/2006	7.50	11/19/2006	6.80	12/29/2006	6.55	2/7/2007	6.80
10/11/2006	7.65	11/20/2006	6.90	12/30/2006	6.55	2/8/2007	6.85
10/12/2006	7.70	11/21/2006	6.80	12/31/2006	6.60	2/9/2007	6.85
10/13/2006	7.60	11/22/2006	6.80	1/1/2007	6.60	2/10/2007	6.80
10/14/2006	7.55	11/23/2006	6.80	1/2/2007	6.60	2/11/2007	6.80
10/15/2006	7.70	11/24/2006	6.80	1/3/2007	6.75	2/12/2007	6.80
10/16/2006	7.70	11/25/2006	6.80	1/4/2007	6.80	2/13/2007	6.80
10/17/2006	7.75	11/26/2006	6.80	1/5/2007	6.85	2/14/2007	6.85
10/18/2006	7.75	11/27/2006	6.80	1/6/2007	6.80	2/15/2007	6.80
10/19/2006	7.75	11/28/2006	6.80	1/7/2007	6.80	2/16/2007	6.75
10/20/2006	8.00	11/29/2006	6.80	1/8/2007	6.80	2/17/2007	6.75
10/21/2006	8.15	11/30/2006	6.80	1/9/2007	6.80	2/18/2007	6.75
10/22/2006	8.15	12/1/2006	6.75	1/10/2007	6.80	2/19/2007	6.70
10/23/2006	8.15	12/2/2006	6.75	1/11/2007	6.80	2/20/2007	6.70
10/24/2006	7.70	12/3/2006	6.75	1/12/2007	6.85	2/21/2007	6.70
10/25/2006	7.40	12/4/2006	6.75	1/13/2007	6.85	2/22/2007	6.70
10/26/2006	7.40	12/5/2006	6.75	1/14/2007	6.90	2/23/2007	6.70
10/27/2006	7.30	12/6/2006	6.75	1/15/2007	6.90	2/24/2007	6.70
10/28/2006	7.20	12/7/2006	6.75	1/16/2007	6.90	2/25/2007	6.70
10/29/2006	6.85	12/8/2006	6.75	1/17/2007	6.90	2/26/2007	6.65
10/30/2006	6.90	12/9/2006	6.75	1/18/2007	6.90	2/27/2007	6.65
10/31/2006	6.80	12/10/2006	6.70	1/19/2007	6.90	2/28/2007	6.65
11/1/2006	6.80	12/11/2006	6.75	1/20/2007	6.95	3/1/2007	6.65
11/2/2006	6.80	12/12/2006	6.75	1/21/2007	6.95	3/2/2007	6.65
11/3/2006	6.80	12/13/2006	6.75	1/22/2007	6.95	3/3/2007	6.65
11/4/2006	6.80	12/14/2006	6.75	1/23/2007	6.75	3/4/2007	6.60
11/5/2006	6.80	12/15/2006	6.75	1/24/2007	6.70	3/5/2007	6.60
11/6/2006	6.90	12/16/2006	6.75	1/25/2007	6.70	3/6/2007	6.60
11/7/2006	6.95	12/17/2006	6.75	1/26/2007	6.65	3/7/2007	6.60
11/8/2006	6.90	12/18/2006	6.65	1/27/2007	6.60	3/8/2007	6.60
11/9/2006	6.90	12/19/2006	6.65	1/28/2007	6.60	3/9/2007	6.60
11/10/2006	6.90	12/20/2006	6.65	1/29/2007	6.80	3/10/2007	6.60
11/11/2006	6.80	12/21/2006	6.65	1/30/2007	6.80	3/11/2007	6.60
11/12/2006	6.75	12/22/2006	6.60	1/31/2007	6.75	3/12/2007	6.60
11/13/2006	6.75	12/23/2006	6.65	2/1/2007	6.75	3/13/2007	6.65
11/14/2006	6.80	12/24/2006	6.60	2/2/2007	6.75	3/14/2007	6.65

Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m	Date	River Water Level at Poicha in m
3/15/2007	6.65	4/24/2007	6.70	6/3/2007	6.90
3/16/2007	6.65	4/25/2007	6.70	6/4/2007	6.90
3/17/2007	6.70	4/26/2007	6.65	6/5/2007	6.90
3/18/2007	6.65	4/27/2007	6.65	6/6/2007	6.90
3/19/2007	6.65	4/28/2007	6.60	6/7/2007	6.90
3/20/2007	6.70	4/29/2007	6.60	6/8/2007	6.90
3/21/2007	6.70	4/30/2007	6.60	6/9/2007	6.90
3/22/2007	6.65	5/1/2007	6.55	6/10/2007	6.85
3/23/2007	6.80	5/2/2007	6.55	6/11/2007	6.85
3/24/2007	6.70	5/3/2007	6.55	6/12/2007	6.80
3/25/2007	6.70	5/4/2007	6.55	6/13/2007	6.70
3/26/2007	6.70	5/5/2007	6.55	6/14/2007	6.65
3/27/2007	6.65	5/6/2007	6.55		
3/28/2007	6.65	5/7/2007	6.55		
3/29/2007	6.65	5/8/2007	6.55		
3/30/2007	6.60	5/9/2007	6.50		
3/31/2007	6.70	5/10/2007	6.50		
4/1/2007	6.70	5/11/2007	6.60		
4/2/2007	6.65	5/12/2007	6.60		
4/3/2007	6.60	5/13/2007	6.60		
4/4/2007	6.60	5/14/2007	6.60		
4/5/2007	6.70	5/15/2007	6.60		
4/6/2007	6.70	5/16/2007	6.70		
4/7/2007	6.70	5/17/2007	6.65		
4/8/2007	6.65	5/18/2007	6.65		
4/9/2007	6.65	5/19/2007	6.65		
4/10/2007	6.70	5/20/2007	6.65		
4/11/2007	6.70	5/21/2007	6.65		
4/12/2007	6.75	5/22/2007	6.65		
4/13/2007	6.75	5/23/2007	6.65		
4/14/2007	6.80	5/24/2007	6.65		
4/15/2007	6.80	5/25/2007	6.65		
4/16/2007	6.80	5/26/2007	6.70		
4/17/2007	6.80	5/27/2007	6.70		
4/18/2007	6.75	5/28/2007	6.70		
4/19/2007	6.65	5/29/2007	6.75		
4/20/2007	6.65	5/30/2007	6.80		
4/21/2007	6.70	5/31/2007	6.80		
4/22/2007	6.80	6/1/2007	6.90		
4/23/2007	6.75	6/2/2007	6.90		

Date	River Water Level at Dhuvaran in m	Date	River Water Level at Dhuvaran in m	Date	River Water Level at Dhuvaran in m
6/13/1997	4.75	7/23/1997	1.46	9/1/1997	4.95
6/14/1997	4.93	7/24/1997	1.42	9/2/1997	4.24
6/15/1997	4.99	7/25/1997	1.68	9/3/1997	3.47
6/16/1997	4.84	7/26/1997	2.13	9/4/1997	3.63
6/17/1997	4.50	7/27/1997	2.68	9/5/1997	2.30
6/18/1997	3.99	7/28/1997	3.20	9/6/1997	2.29
6/19/1997	3.40	7/29/1997	3.65	9/7/1997	2.71
6/20/1997	2.81	7/30/1997	3.98	9/8/1997	3.32
6/21/1997	2.03	7/31/1997	4.20	9/9/1997	3.89
6/22/1997	2.17	8/1/1997	4.66	9/10/1997	4.29
6/23/1997	1.89	8/2/1997	4.37	9/11/1997	4.48
6/24/1997	1.83	8/3/1997	4.23	9/12/1997	4.56
6/25/1997	1.98	8/4/1997	3.93	9/13/1997	4.41
6/26/1997	2.25	8/5/1997	3.28	9/14/1997	4.04
6/27/1997	2.60	8/6/1997	3.58	9/15/1997	3.63
6/28/1997	2.96	8/7/1997	2.87	9/16/1997	3.07
6/29/1997	3.27	8/8/1997	2.78	9/17/1997	2.38
6/30/1997	3.47	8/9/1997	3.06	9/18/1997	2.49
7/1/1997	4.03	8/10/1997	3.54	9/19/1997	1.28
7/2/1997	3.59	8/11/1997	4.01	9/20/1997	0.77
7/3/1997	3.59	8/12/1997	4.45	9/21/1997	0.89
7/4/1997	3.53	8/13/1997	4.61	9/22/1997	1.59
7/5/1997	3.43	8/14/1997	4.50	9/23/1997	2.53
7/6/1997	3.26	8/15/1997	4.28	9/24/1997	3.49
7/7/1997	3.00	8/16/1997	3.93	9/25/1997	4.34
7/8/1997	3.16	8/17/1997	3.46	9/26/1997	5.01
7/9/1997	3.13	8/18/1997	2.86	9/27/1997	5.42
7/10/1997	3.32	8/19/1997	2.19	9/28/1997	5.58
7/11/1997	3.66	8/20/1997	2.16	9/29/1997	5.45
7/12/1997	4.13	8/21/1997	1.28	9/30/1997	5.01
7/13/1997	4.46	8/22/1997	0.98	10/1/1997	4.43
7/14/1997	4.56	8/23/1997	1.18	10/2/1997	3.34
7/15/1997	4.57	8/24/1997	1.78	10/3/1997	3.46
7/16/1997	4.42	8/25/1997	2.55	10/4/1997	2.10
7/17/1997	4.12	8/26/1997	3.32	10/5/1997	2.06
7/18/1997	3.68	8/27/1997	4.01	10/6/1997	2.57
7/19/1997	3.15	8/28/1997	4.55	10/7/1997	3.18
7/20/1997	2.55	8/29/1997	4.90	10/8/1997	3.72
7/21/1997	2.21	8/30/1997	5.09	10/9/1997	4.07
7/22/1997	1.83	8/31/1997	5.06	10/10/1997	4.24

Date	River Water Level at Dhuvaran in m	Date	River Water Level at Dhuvaran in m	Date	River Water Level at Dhuvaran in m
10/11/1997	4.27	11/20/1997	2.50	12/30/1997	2.55
10/12/1997	4.26	11/21/1997	3.39	12/31/1997	1.93
10/13/1997	4.04	11/22/1997	4.23	1/1/1998	2.01
10/14/1997	3.62	11/23/1997	4.88	1/2/1998	1.44
10/15/1997	3.14	11/24/1997	5.28	1/3/1998	1.60
10/16/1997	2.53	11/25/1997	5.39	1/4/1998	1.92
10/17/1997	1.87	11/26/1997	5.18	1/5/1998	2.18
10/18/1997	2.16	11/27/1997	4.73	1/6/1998	2.76
10/19/1997	0.97	11/28/1997	4.09	1/7/1998	3.13
10/20/1997	0.94	11/29/1997	3.35	1/8/1998	3.38
10/21/1997	1.56	11/30/1997	3.43	1/9/1998	3.52
10/22/1997	2.55	12/1/1997	2.82	1/10/1998	3.57
10/23/1997	3.54	12/2/1997	1.89	1/11/1998	3.58
10/24/1997	4.45	12/3/1997	1.94	1/12/1998	3.61
10/25/1997	5.14	12/4/1997	2.18	1/13/1998	3.49
10/26/1997	5.56	12/5/1997	2.63	1/14/1998	3.19
10/27/1997	5.65	12/6/1997	2.77	1/15/1998	2.85
10/28/1997	5.44	12/7/1997	3.04	1/16/1998	2.54
10/29/1997	4.92	12/8/1997	3.28	1/17/1998	2.35
10/30/1997	4.15	12/9/1997	3.43	1/18/1998	2.54
10/31/1997	3.23	12/10/1997	3.47	1/19/1998	3.04
11/1/1997	2.87	12/11/1997	3.39	1/20/1998	3.63
11/2/1997	2.59	12/12/1997	3.29	1/21/1998	4.20
11/3/1997	1.96	12/13/1997	3.06	1/22/1998	4.59
11/4/1997	2.35	12/14/1997	2.76	1/23/1998	4.79
11/5/1997	2.93	12/15/1997	2.52	1/24/1998	4.74
11/6/1997	3.24	12/16/1997	2.85	1/25/1998	4.46
11/7/1997	3.56	12/17/1997	2.12	1/26/1998	4.00
11/8/1997	3.73	12/18/1997	2.15	1/27/1998	3.38
11/9/1997	3.84	12/19/1997	2.45	1/28/1998	2.72
11/10/1997	3.84	12/20/1997	3.04	1/29/1998	2.11
11/11/1997	3.73	12/21/1997	3.70	1/30/1998	1.38
11/12/1997	3.57	12/22/1997	4.29	1/31/1998	0.97
11/13/1997	3.20	12/23/1997	4.74	2/1/1998	1.59
11/14/1997	2.67	12/24/1997	4.94	2/2/1998	1.23
11/15/1997	2.17	12/25/1997	4.90	2/3/1998	1.78
11/16/1997	2.64	12/26/1997	4.65	2/4/1998	2.43
11/17/1997	1.49	12/27/1997	4.23	2/5/1998	2.95
11/18/1997	1.40	12/28/1997	3.67	2/6/1998	3.52
11/19/1997	1.75	12/29/1997	3.61	2/7/1998	3.89

Date	River Water Level at Dhuvaran in m	Date	River Water Level at Dhuvaran in m	Date	River Water Level at Dhuvaran in m
2/8/1998	4.14	3/20/1998	4.40	4/29/1998	1.41
2/9/1998	4.29	3/21/1998	4.81	4/30/1998	1.83
2/10/1998	4.33	3/22/1998	4.65	5/1/1998	3.13
2/11/1998	4.20	3/23/1998	4.45	5/2/1998	3.35
2/12/1998	3.93	3/24/1998	4.10	5/3/1998	4.15
2/13/1998	3.13	3/25/1998	3.61	5/4/1998	4.79
2/14/1998	2.77	3/26/1998	2.99	5/5/1998	5.32
2/15/1998	2.17	3/27/1998	2.21	5/6/1998	5.27
2/16/1998	2.08	3/28/1998	0.71	5/7/1998	5.11
2/17/1998	2.57	3/29/1998	1.28	5/8/1998	4.66
2/18/1998	3.27	3/30/1998	0.74	5/9/1998	4.01
2/19/1998	3.98	3/31/1998	0.85	5/10/1998	3.25
2/20/1998	4.48	4/1/1998	2.38	5/11/1998	1.91
2/21/1998	4.78	4/2/1998	2.49	5/12/1998	2.50
2/22/1998	4.79	4/3/1998	3.24	5/13/1998	2.46
2/23/1998	4.57	4/4/1998	4.05	5/14/1998	2.72
2/24/1998	4.17	4/5/1998	4.71	5/15/1998	3.07
2/25/1998	3.58	4/6/1998	5.11	5/16/1998	3.38
2/26/1998	2.87	4/7/1998	5.27	5/17/1998	3.56
2/27/1998	1.68	4/8/1998	5.16	5/18/1998	3.66
2/28/1998	1.52	4/9/1998	4.75	5/19/1998	3.70
3/1/1998	1.42	4/10/1998	4.09	5/20/1998	3.66
3/2/1998	0.97	4/11/1998	3.20	5/21/1998	3.52
3/3/1998	1.49	4/12/1998	1.73	5/22/1998	3.28
3/4/1998	2.30	4/13/1998	2.21	5/23/1998	2.95
3/5/1998	3.06	4/14/1998	2.12	5/24/1998	2.54
3/6/1998	3.80	4/15/1998	2.63	5/25/1998	2.12
3/7/1998	4.34	4/16/1998	3.25	5/26/1998	1.77
3/8/1998	4.73	4/17/1998	3.44	5/27/1998	1.02
3/9/1998	4.93	4/18/1998	3.85	5/28/1998	1.75
3/10/1998	4.92	4/19/1998	4.10	5/29/1998	2.06
3/11/1998	4.66	4/20/1998	4.18	5/30/1998	2.66
3/12/1998	4.19	4/21/1998	4.12	5/31/1998	3.37
3/13/1998	3.38	4/22/1998	3.94	6/1/1998	4.75
3/14/1998	1.68	4/23/1998	3.62	6/2/1998	4.76
3/15/1998	2.02	4/24/1998	3.20	6/3/1998	4.95
3/16/1998	1.94	4/25/1998	2.65	6/4/1998	5.06
3/17/1998	2.46	4/26/1998	2.01	6/5/1998	5.13
3/18/1998	3.23	4/27/1998	1.41	6/6/1998	4.60
3/19/1998	3.90	4/28/1998	1.03	6/7/1998	4.13

Date	River Water Level at Dhuvaran in m	Date	River Water Level at Dhuvaran in m	Date	River Water Level at Dhuvaran in m
6/8/1998	3.57	7/18/1998	3.43	8/27/1998	2.88
6/9/1998	2.54	7/19/1998	3.56	8/28/1998	3.68
6/10/1998	2.85	7/20/1998	3.59	8/29/1998	4.71
6/11/1998	2.65	7/21/1998	3.58	8/30/1998	5.11
6/12/1998	2.66	7/22/1998	3.52	8/31/1998	5.27
6/13/1998	2.71	7/23/1998	3.37	9/1/1998	5.54
6/14/1998	2.74	7/24/1998	3.13	9/2/1998	5.01
6/15/1998	2.87	7/25/1998	3.10	9/3/1998	4.34
6/16/1998	3.04	7/26/1998	2.82	9/4/1998	3.65
6/17/1998	3.19	7/27/1998	2.64	9/5/1998	2.21
6/18/1998	3.30	7/28/1998	2.78	9/6/1998	2.77
6/19/1998	3.34	7/29/1998	3.53	9/7/1998	1.54
6/20/1998	3.28	7/30/1998	4.00	9/8/1998	0.86
6/21/1998	3.14	7/31/1998	4.48	9/9/1998	1.05
6/22/1998	2.96	8/1/1998	5.39	9/10/1998	1.27
6/23/1998	2.76	8/2/1998	5.21	9/11/1998	1.99
6/24/1998	2.57	8/3/1998	5.03	9/12/1998	2.86
6/25/1998	2.40	8/4/1998	4.78	9/13/1998	3.57
6/26/1998	2.26	8/5/1998	4.27	9/14/1998	4.05
6/27/1998	2.53	8/6/1998	3.62	9/15/1998	4.45
6/28/1998	2.76	8/7/1998	2.81	9/16/1998	4.70
6/29/1998	3.48	8/8/1998	2.67	9/17/1998	4.78
6/30/1998	3.87	8/9/1998	1.78	9/18/1998	4.67
7/1/1998	4.90	8/10/1998	1.33	9/19/1998	4.34
7/2/1998	4.78	8/11/1998	1.32	9/20/1998	3.77
7/3/1998	4.87	8/12/1998	1.73	9/21/1998	3.00
7/4/1998	4.89	8/13/1998	2.27	9/22/1998	3.28
7/5/1998	4.89	8/14/1998	2.79	9/23/1998	2.02
7/6/1998	4.45	8/15/1998	3.33	9/24/1998	2.13
7/7/1998	3.99	8/16/1998	3.75	9/25/1998	2.86
7/8/1998	3.40	8/17/1998	4.04	9/26/1998	3.70
7/9/1998	2.90	8/18/1998	4.19	9/27/1998	4.41
7/10/1998	2.66	8/19/1998	4.26	9/28/1998	4.87
7/11/1998	2.20	8/20/1998	4.19	9/29/1998	5.34
7/12/1998	2.06	8/21/1998	4.00	9/30/1998	5.12
7/13/1998	2.08	8/22/1998	3.59	10/1/1998	5.02
7/14/1998	2.21	8/23/1998	3.02	10/2/1998	4.33
7/15/1998	2.53	8/24/1998	3.33	10/3/1998	3.54
7/16/1998	2.87	8/25/1998	2.32	10/4/1998	2.79
7/17/1998	3.19	8/26/1998	2.32	10/5/1998	1.91

Date	River Water Level at Dhuvaran in m	Date	River Water Level at Dhuvaran in m	Date	River Water Level at Dhuvaran in m
10/6/1998	2.13	11/15/1998	4.83	12/25/1998	2.95
10/7/1998	0.80	11/16/1998	4.43	12/26/1998	3.14
10/8/1998	0.70	11/17/1998	3.88	12/27/1998	3.29
10/9/1998	1.03	11/18/1998	3.23	12/28/1998	3.34
10/10/1998	1.80	11/19/1998	3.46	12/29/1998	3.61
10/11/1998	2.68	11/20/1998	2.36	12/30/1998	3.34
10/12/1998	3.56	11/21/1998	2.36	12/31/1998	3.18
10/13/1998	4.23	11/22/1998	2.71	1/1/1999	4.62
10/14/1998	4.66	11/23/1998	3.10	1/2/1999	4.98
10/15/1998	4.94	11/24/1998	3.43	1/3/1999	5.09
10/16/1998	5.02	11/25/1998	3.65	1/4/1999	4.98
10/17/1998	4.84	11/26/1998	3.75	1/5/1999	4.64
10/18/1998	4.42	11/27/1998	3.75	1/6/1999	4.15
10/19/1998	3.77	11/28/1998	3.67	1/7/1999	3.51
10/20/1998	2.99	11/29/1998	3.80	1/8/1999	2.81
10/21/1998	3.25	11/30/1998	3.40	1/9/1999	1.50
10/22/1998	2.03	12/1/1998	3.49	1/10/1999	1.68
10/23/1998	2.22	12/2/1998	2.63	1/11/1999	1.23
10/24/1998	2.88	12/3/1998	2.06	1/12/1999	1.17
10/25/1998	3.57	12/4/1998	2.34	1/13/1999	1.47
10/26/1998	4.13	12/5/1998	1.55	1/14/1999	1.98
10/27/1998	4.42	12/6/1998	1.32	1/15/1999	2.55
10/28/1998	4.51	12/7/1998	1.56	1/16/1999	3.16
10/29/1998	4.74	12/8/1998	2.11	1/17/1999	3.63
10/30/1998	4.37	12/9/1998	2.83	1/18/1999	4.03
10/31/1998	3.91	12/10/1998	3.56	1/19/1999	4.23
11/1/1998	3.87	12/11/1998	4.18	1/20/1999	4.24
11/2/1998	2.95	12/12/1998	4.70	1/21/1999	4.38
11/3/1998	2.13	12/13/1998	4.90	1/22/1999	4.31
11/4/1998	2.44	12/14/1998	4.83	1/23/1999	4.05
11/5/1998	1.19	12/15/1998	4.61	1/24/1999	3.62
11/6/1998	0.80	12/16/1998	4.23	1/25/1999	2.10
11/7/1998	0.98	12/17/1998	3.75	1/26/1999	2.77
11/8/1998	1.61	12/18/1998	3.76	1/27/1999	2.62
11/9/1998	2.41	12/19/1998	2.79	1/28/1999	2.96
11/10/1998	3.24	12/20/1998	2.39	1/29/1999	3.51
11/11/1998	3.98	12/21/1998	2.25	1/30/1999	4.08
11/12/1998	4.62	12/22/1998	2.34	1/31/1999	4.65
11/13/1998	4.97	12/23/1998	2.52	2/1/1999	4.78
11/14/1998	4.98	12/24/1998	2.73	2/2/1999	4.78

Date	River Water Level at Dhuvaran in m	Date	River Water Level at Dhuvaran in m	Date	River Water Level at Dhuvaran in m	Date	River Water Level at Dhuvaran in m
2/3/1999	4.59	3/15/1999	2.95	4/24/1999	2.44	6/3/1999	3.33
2/4/1999	4.22	3/16/1999	3.82	4/25/1999	2.48	6/4/1999	3.05
2/5/1999	3.73	3/17/1999	4.59	4/26/1999	2.81	6/5/1999	2.74
2/6/1999	3.16	3/18/1999	5.16	4/27/1999	3.19	6/6/1999	2.50
2/7/1999	2.48	3/19/1999	5.50	4/28/1999	3.52	6/7/1999	2.34
2/8/1999	1.40	3/20/1999	5.59	4/29/1999	3.76	6/8/1999	2.52
2/9/1999	1.32	3/21/1999	5.41	4/30/1999	3.90	6/9/1999	2.79
2/10/1999	1.50	3/22/1999	5.03	5/1/1999	3.96	6/10/1999	3.34
2/11/1999	1.04	3/23/1999	4.14	5/2/1999	3.94	6/11/1999	6.30
2/12/1999	1.49	3/24/1999	3.05	5/3/1999	3.81	6/12/1999	4.67
2/13/1999	2.20	3/25/1999	2.31	5/4/1999	3.54	6/13/1999	5.17
2/14/1999	2.96	3/26/1999	2.36	5/5/1999	3.18	6/14/1999	5.45
2/15/1999	3.67	3/27/1999	2.50	5/6/1999	2.71		
2/16/1999	4.27	3/28/1999	2.96	5/7/1999	2.20		
2/17/1999	4.69	3/29/1999	3.51	5/8/1999	1.70		
2/18/1999	4.97	3/30/1999	3.93	5/9/1999	1.77		
2/19/1999	5.07	3/31/1999	4.18	5/10/1999	1.89		
2/20/1999	4.99	4/1/1999	4.24	5/11/1999	2.44		
2/21/1999	4.62	4/2/1999	4.22	5/12/1999	3.21		
2/22/1999	4.00	4/3/1999	4.14	5/13/1999	4.10		
2/23/1999	2.67	4/4/1999	3.91	5/14/1999	4.87		
2/24/1999	2.77	4/5/1999	3.54	5/15/1999	5.40		
2/25/1999	2.40	4/6/1999	3.05	5/16/1999	5.70		
2/26/1999	2.60	4/7/1999	2.43	5/17/1999	5.68		
2/27/1999	3.13	4/8/1999	1.77	5/18/1999	5.42		
2/28/1999	3.72	4/9/1999	0.84	5/19/1999	4.88		
3/1/1999	4.22	4/10/1999	1.18	5/20/1999	4.14		
3/2/1999	4.50	4/11/1999	1.44	5/21/1999	3.35		
3/3/1999	4.57	4/12/1999	2.13	5/22/1999	2.69		
3/4/1999	4.47	4/13/1999	3.06	5/23/1999	2.59		
3/5/1999	4.23	4/14/1999	4.00	5/24/1999	2.45		
3/6/1999	3.89	4/15/1999	4.81	5/25/1999	2.55		
3/7/1999	3.42	4/16/1999	5.35	5/26/1999	2.76		
3/8/1999	2.82	4/17/1999	5.41	5/27/1999	3.04		
3/9/1999	2.11	4/18/1999	11.45	5/28/1999	3.29		
3/10/1999	1.14	4/19/1999	5.53	5/29/1999	3.51		
3/11/1999	1.11	4/20/1999	4.78	5/30/1999	3.68		
3/12/1999	0.90	4/21/1999	4.15	5/31/1999	3.75		
3/13/1999	1.30	4/22/1999	3.25	6/1/1999	3.73		
3/14/1999	2.07	4/23/1999	2.21	6/2/1999	3.58		

Date	River Water Level at Dhuvaran in m	Date	River Water Level at Dhuvaran in m	Date	River Water Level at Dhuvaran in m
6/13/2003	4.75	7/23/2003	1.46	9/1/2003	4.95
6/14/2003	4.93	7/24/2003	1.42	9/2/2003	4.24
6/15/2003	4.99	7/25/2003	1.68	9/3/2003	3.47
6/16/2003	4.84	7/26/2003	2.13	9/4/2003	3.63
6/17/2003	4.50	7/27/2003	2.68	9/5/2003	2.30
6/18/2003	3.99	7/28/2003	3.20	9/6/2003	2.29
6/19/2003	3.40	7/29/2003	3.65	9/7/2003	2.71
6/20/2003	2.81	7/30/2003	3.98	9/8/2003	3.32
6/21/2003	2.03	7/31/2003	4.20	9/9/2003	3.89
6/22/2003	2.17	8/1/2003	4.66	9/10/2003	4.29
6/23/2003	1.89	8/2/2003	4.37	9/11/2003	4.48
6/24/2003	1.83	8/3/2003	4.23	9/12/2003	4.56
6/25/2003	1.98	8/4/2003	3.93	9/13/2003	4.41
6/26/2003	2.25	8/5/2003	3.28	9/14/2003	4.04
6/27/2003	2.60	8/6/2003	3.58	9/15/2003	3.63
6/28/2003	2.96	8/7/2003	2.87	9/16/2003	3.07
6/29/2003	3.27	8/8/2003	2.78	9/17/2003	2.38
6/30/2003	3.47	8/9/2003	3.06	9/18/2003	2.49
7/1/2003	4.03	8/10/2003	3.54	9/19/2003	1.28
7/2/2003	3.59	8/11/2003	4.01	9/20/2003	0.77
7/3/2003	3.59	8/12/2003	4.45	9/21/2003	0.89
7/4/2003	3.53	8/13/2003	4.61	9/22/2003	1.59
7/5/2003	3.43	8/14/2003	4.50	9/23/2003	2.53
7/6/2003	3.26	8/15/2003	4.28	9/24/2003	3.49
7/7/2003	3.00	8/16/2003	3.93	9/25/2003	4.34
7/8/2003	3.16	8/17/2003	3.46	9/26/2003	5.01
7/9/2003	3.13	8/18/2003	2.86	9/27/2003	5.42
7/10/2003	3.32	8/19/2003	2.19	9/28/2003	5.58
7/11/2003	3.66	8/20/2003	2.16	9/29/2003	5.45
7/12/2003	4.13	8/21/2003	1.28	9/30/2003	5.01
7/13/2003	4.46	8/22/2003	0.98	10/1/2003	4.43
7/14/2003	4.56	8/23/2003	1.18	10/2/2003	3.34
7/15/2003	4.57	8/24/2003	1.78	10/3/2003	3.46
7/16/2003	4.42	8/25/2003	2.55	10/4/2003	2.10
7/17/2003	4.12	8/26/2003	3.32	10/5/2003	2.06
7/18/2003	3.68	8/27/2003	4.01	10/6/2003	2.57
7/19/2003	3.15	8/28/2003	4.55	10/7/2003	3.18
7/20/2003	2.55	8/29/2003	4.90	10/8/2003	3.72
7/21/2003	2.21	8/30/2003	5.09	10/9/2003	4.07
7/22/2003	1.83	8/31/2003	5.06	10/10/2003	4.24

Date	River Water Level at Dhuvaran in m	Date	River Water Level at Dhuvaran in m	Date	River Water Level at Dhuvaran in m
10/11/2003	4.27	11/20/2003	2.50	12/30/2003	2.55
10/12/2003	4.26	11/21/2003	3.39	12/31/2003	1.93
10/13/2003	4.04	11/22/2003	4.23	1/1/2004	2.01
10/14/2003	3.62	11/23/2003	4.88	1/2/2004	1.44
10/15/2003	3.14	11/24/2003	5.28	1/3/2004	1.60
10/16/2003	2.53	11/25/2003	5.39	1/4/2004	1.92
10/17/2003	1.87	11/26/2003	5.18	1/5/2004	2.18
10/18/2003	2.16	11/27/2003	4.73	1/6/2004	2.76
10/19/2003	0.97	11/28/2003	4.09	1/7/2004	3.13
10/20/2003	0.94	11/29/2003	3.35	1/8/2004	3.38
10/21/2003	1.56	11/30/2003	3.43	1/9/2004	3.52
10/22/2003	2.55	12/1/2003	2.82	1/10/2004	3.57
10/23/2003	3.54	12/2/2003	1.89	1/11/2004	3.58
10/24/2003	4.45	12/3/2003	1.94	1/12/2004	3.61
10/25/2003	5.14	12/4/2003	2.18	1/13/2004	3.49
10/26/2003	5.56	12/5/2003	2.63	1/14/2004	3.19
10/27/2003	5.65	12/6/2003	2.77	1/15/2004	2.85
10/28/2003	5.44	12/7/2003	3.04	1/16/2004	2.54
10/29/2003	4.92	12/8/2003	3.28	1/17/2004	2.35
10/30/2003	4.15	12/9/2003	3.43	1/18/2004	2.54
10/31/2003	3.23	12/10/2003	3.47	1/19/2004	3.04
11/1/2003	2.87	12/11/2003	3.39	1/20/2004	3.63
11/2/2003	2.59	12/12/2003	3.29	1/21/2004	4.20
11/3/2003	1.96	12/13/2003	3.06	1/22/2004	4.59
11/4/2003	2.35	12/14/2003	2.76	1/23/2004	4.79
11/5/2003	2.93	12/15/2003	2.52	1/24/2004	4.74
11/6/2003	3.24	12/16/2003	2.85	1/25/2004	4.46
11/7/2003	3.56	12/17/2003	2.12	1/26/2004	4.00
11/8/2003	3.73	12/18/2003	2.15	1/27/2004	3.38
11/9/2003	3.84	12/19/2003	2.45	1/28/2004	2.72
11/10/2003	3.84	12/20/2003	3.04	1/29/2004	2.11
11/11/2003	3.73	12/21/2003	3.70	1/30/2004	1.38
11/12/2003	3.57	12/22/2003	4.29	1/31/2004	0.97
11/13/2003	3.20	12/23/2003	4.74	2/1/2004	1.59
11/14/2003	2.67	12/24/2003	4.94	2/2/2004	1.23
11/15/2003	2.17	12/25/2003	4.90	2/3/2004	1.78
11/16/2003	2.64	12/26/2003	4.65	2/4/2004	2.43
11/17/2003	1.49	12/27/2003	4.23	2/5/2004	2.95
11/18/2003	1.40	12/28/2003	3.67	2/6/2004	3.52
11/19/2003	1.75	12/29/2003	3.61	2/7/2004	3.89

Date	River Water Level at Dhuvaran in m	Date	River Water Level at Dhuvaran in m	Date	River Water Level at Dhuvaran in m
2/8/2004	4.14	3/19/2004	3.90	4/28/2004	1.03
2/9/2004	4.29	3/20/2004	4.40	4/29/2004	1.41
2/10/2004	4.33	3/21/2004	4.81	4/30/2004	1.83
2/11/2004	4.20	3/22/2004	4.65	5/1/2004	3.13
2/12/2004	3.93	3/23/2004	4.45	5/2/2004	3.35
2/13/2004	3.13	3/24/2004	4.10	5/3/2004	4.15
2/14/2004	2.77	3/25/2004	3.61	5/4/2004	4.79
2/15/2004	2.17	3/26/2004	2.99	5/5/2004	5.32
2/16/2004	2.08	3/27/2004	2.21	5/6/2004	5.27
2/17/2004	2.57	3/28/2004	0.71	5/7/2004	5.11
2/18/2004	3.27	3/29/2004	1.28	5/8/2004	4.66
2/19/2004	3.98	3/30/2004	0.74	5/9/2004	4.01
2/20/2004	4.48	3/31/2004	0.85	5/10/2004	3.25
2/21/2004	4.78	4/1/2004	2.38	5/11/2004	1.91
2/22/2004	4.79	4/2/2004	2.49	5/12/2004	2.50
2/23/2004	4.57	4/3/2004	3.24	5/13/2004	2.46
2/24/2004	4.17	4/4/2004	4.05	5/14/2004	2.72
2/25/2004	3.58	4/5/2004	4.71	5/15/2004	3.07
2/26/2004	2.87	4/6/2004	5.11	5/16/2004	3.38
2/27/2004	1.68	4/7/2004	5.27	5/17/2004	3.56
2/28/2004	1.52	4/8/2004	5.16	5/18/2004	3.66
2/29/2004	0.94	4/9/2004	4.75	5/19/2004	3.70
3/1/2004	1.42	4/10/2004	4.09	5/20/2004	3.66
3/2/2004	0.97	4/11/2004	3.20	5/21/2004	3.52
3/3/2004	1.49	4/12/2004	1.73	5/22/2004	3.28
3/4/2004	2.30	4/13/2004	2.21	5/23/2004	2.95
3/5/2004	3.06	4/14/2004	2.12	5/24/2004	2.54
3/6/2004	3.80	4/15/2004	2.63	5/25/2004	2.12
3/7/2004	4.34	4/16/2004	3.25	5/26/2004	1.77
3/8/2004	4.73	4/17/2004	3.44	5/27/2004	1.02
3/9/2004	4.93	4/18/2004	3.85	5/28/2004	1.75
3/10/2004	4.92	4/19/2004	4.10	5/29/2004	2.06
3/11/2004	4.66	4/20/2004	4.18	5/30/2004	2.66
3/12/2004	4.19	4/21/2004	4.12	5/31/2004	3.37
3/13/2004	3.38	4/22/2004	3.94	6/1/2004	4.75
3/14/2004	1.68	4/23/2004	3.62	6/2/2004	4.76
3/15/2004	2.02	4/24/2004	3.20	6/3/2004	4.95
3/16/2004	1.94	4/25/2004	2.65	6/4/2004	5.06
3/17/2004	2.46	4/26/2004	2.01	6/5/2004	5.13
3/18/2004	3.23	4/27/2004	1.41	6/6/2004	4.60

Date	River Water Level at Dhuvaran in m	Date	River Water Level at Dhuvaran in m	Date	River Water Level at Dhuvaran in m
6/7/2004	4.13	7/17/2004	3.19	8/26/2004	2.32
6/8/2004	3.57	7/18/2004	3.43	8/27/2004	2.88
6/9/2004	2.54	7/19/2004	3.56	8/28/2004	3.68
6/10/2004	2.85	7/20/2004	3.59	8/29/2004	4.71
6/11/2004	2.65	7/21/2004	3.58	8/30/2004	5.11
6/12/2004	2.66	7/22/2004	3.52	8/31/2004	5.27
6/13/2004	2.71	7/23/2004	3.37	9/1/2004	5.54
6/14/2004	2.74	7/24/2004	3.13	9/2/2004	5.01
6/15/2004	2.87	7/25/2004	3.10	9/3/2004	4.34
6/16/2004	3.04	7/26/2004	2.82	9/4/2004	3.65
6/17/2004	3.19	7/27/2004	2.64	9/5/2004	2.21
6/18/2004	3.30	7/28/2004	2.78	9/6/2004	2.77
6/19/2004	3.34	7/29/2004	3.53	9/7/2004	1.54
6/20/2004	3.28	7/30/2004	4.00	9/8/2004	0.86
6/21/2004	3.14	7/31/2004	4.48	9/9/2004	1.05
6/22/2004	2.96	8/1/2004	5.39	9/10/2004	1.27
6/23/2004	2.76	8/2/2004	5.21	9/11/2004	1.99
6/24/2004	2.57	8/3/2004	5.03	9/12/2004	2.86
6/25/2004	2.40	8/4/2004	4.78	9/13/2004	3.57
6/26/2004	2.26	8/5/2004	4.27	9/14/2004	4.05
6/27/2004	2.53	8/6/2004	3.62	9/15/2004	4.45
6/28/2004	2.76	8/7/2004	2.81	9/16/2004	4.70
6/29/2004	3.48	8/8/2004	2.67	9/17/2004	4.78
6/30/2004	3.87	8/9/2004	1.78	9/18/2004	4.67
7/1/2004	4.90	8/10/2004	1.33	9/19/2004	4.34
7/2/2004	4.78	8/11/2004	1.32	9/20/2004	3.77
7/3/2004	4.87	8/12/2004	1.73	9/21/2004	3.00
7/4/2004	4.89	8/13/2004	2.27	9/22/2004	3.28
7/5/2004	4.89	8/14/2004	2.79	9/23/2004	2.02
7/6/2004	4.45	8/15/2004	3.33	9/24/2004	2.13
7/7/2004	3.99	8/16/2004	3.75	9/25/2004	2.86
7/8/2004	3.40	8/17/2004	4.04	9/26/2004	3.70
7/9/2004	2.90	8/18/2004	4.19	9/27/2004	4.41
7/10/2004	2.66	8/19/2004	4.26	9/28/2004	4.87
7/11/2004	2.20	8/20/2004	4.19	9/29/2004	5.34
7/12/2004	2.06	8/21/2004	4.00	9/30/2004	5.12
7/13/2004	2.08	8/22/2004	3.59	10/1/2004	5.02
7/14/2004	2.21	8/23/2004	3.02	10/2/2004	4.33
7/15/2004	2.53	8/24/2004	3.33	10/3/2004	3.54
7/16/2004	2.87	8/25/2004	2.32	10/4/2004	2.79

Date	River Water Level at Dhuvaran in m	Date	River Water Level at Dhuvaran in m	Date	River Water Level at Dhuvaran in m
10/5/2004	1.91	11/14/2004	4.98	12/24/2004	2.73
10/6/2004	2.13	11/15/2004	4.83	12/25/2004	2.95
10/7/2004	0.80	11/16/2004	4.43	12/26/2004	3.14
10/8/2004	0.70	11/17/2004	3.88	12/27/2004	3.29
10/9/2004	1.03	11/18/2004	3.23	12/28/2004	3.34
10/10/2004	1.80	11/19/2004	3.46	12/29/2004	3.61
10/11/2004	2.68	11/20/2004	2.36	12/30/2004	3.34
10/12/2004	3.56	11/21/2004	2.36	12/31/2004	3.18
10/13/2004	4.23	11/22/2004	2.71	1/1/2005	3.46
10/14/2004	4.66	11/23/2004	3.10	1/2/2005	2.68
10/15/2004	4.94	11/24/2004	3.43	1/3/2005	2.46
10/16/2004	5.02	11/25/2004	3.65	1/4/2005	1.96
10/17/2004	4.84	11/26/2004	3.75	1/5/2005	2.07
10/18/2004	4.42	11/27/2004	3.75	1/6/2005	1.91
10/19/2004	3.77	11/28/2004	3.67	1/7/2005	2.36
10/20/2004	2.99	11/29/2004	3.80	1/8/2005	3.04
10/21/2004	3.25	11/30/2004	3.40	1/9/2005	3.75
10/22/2004	2.03	12/1/2004	3.49	1/10/2005	4.36
10/23/2004	2.22	12/2/2004	2.63	1/11/2005	4.79
10/24/2004	2.88	12/3/2004	2.06	1/12/2005	5.08
10/25/2004	3.57	12/4/2004	2.34	1/13/2005	5.07
10/26/2004	4.13	12/5/2004	1.55	1/14/2005	4.76
10/27/2004	4.42	12/6/2004	1.32	1/15/2005	4.31
10/28/2004	4.51	12/7/2004	1.56	1/16/2005	3.67
10/29/2004	4.74	12/8/2004	2.11	1/17/2005	2.90
10/30/2004	4.37	12/9/2004	2.83	1/18/2005	2.32
10/31/2004	3.91	12/10/2004	3.56	1/19/2005	1.74
11/1/2004	3.87	12/11/2004	4.18	1/20/2005	1.50
11/2/2004	2.95	12/12/2004	4.70	1/21/2005	1.61
11/3/2004	2.13	12/13/2004	4.90	1/22/2005	1.93
11/4/2004	2.44	12/14/2004	4.83	1/23/2005	2.35
11/5/2004	1.19	12/15/2004	4.61	1/24/2005	2.78
11/6/2004	0.80	12/16/2004	4.23	1/25/2005	3.16
11/7/2004	0.98	12/17/2004	3.75	1/26/2005	3.44
11/8/2004	1.61	12/18/2004	3.76	1/27/2005	3.59
11/9/2004	2.41	12/19/2004	2.79	1/28/2005	3.66
11/10/2004	3.24	12/20/2004	2.39	1/29/2005	3.94
11/11/2004	3.98	12/21/2004	2.25	1/30/2005	3.70
11/12/2004	4.62	12/22/2004	2.34	1/31/2005	3.39
11/13/2004	4.97	12/23/2004	2.52	2/1/2005	3.71

Date	River Water Level at Dhuvaran in m	Date	River Water Level at Dhuvaran in m	Date	River Water Level at Dhuvaran in m	Date	River Water Level at Dhuvaran in m
2/2/2005	2.19	3/14/2005	5.01	4/23/2005	3.82	6/2/2005	3.33
2/3/2005	2.26	3/15/2005	3.76	4/24/2005	4.26	6/3/2005	3.53
2/4/2005	1.79	3/16/2005	2.81	4/25/2005	4.51	6/4/2005	3.57
2/5/2005	2.17	3/17/2005	1.19	4/26/2005	4.55	6/5/2005	3.54
2/6/2005	2.63	3/18/2005	1.44	4/27/2005	4.41	6/6/2005	3.76
2/7/2005	3.48	3/19/2005	0.81	4/28/2005	4.07	6/7/2005	3.67
2/8/2005	4.29	3/20/2005	0.69	4/29/2005	3.81	6/8/2005	3.56
2/9/2005	4.93	3/21/2005	1.16	4/30/2005	3.02	6/9/2005	3.38
2/10/2005	5.30	3/22/2005	1.87	5/1/2005	2.64	6/10/2005	3.14
2/11/2005	5.37	3/23/2005	2.62	5/2/2005	2.54	6/11/2005	2.85
2/12/2005	5.21	3/24/2005	3.29	5/3/2005	2.68	6/12/2005	2.58
2/13/2005	4.69	3/25/2005	3.82	5/4/2005	3.07	6/13/2005	2.21
2/14/2005	3.84	3/26/2005	4.22	5/5/2005	3.51	6/14/2005	1.99
2/15/2005	2.67	3/27/2005	4.42	5/6/2005	4.15		
2/16/2005	2.27	3/28/2005	4.48	5/7/2005	4.42		
2/17/2005	1.36	3/29/2005	4.68	5/8/2005	4.47		
2/18/2005	0.98	3/30/2005	4.22	5/9/2005	4.36		
2/19/2005	0.97	3/31/2005	3.58	5/10/2005	4.09		
2/20/2005	1.45	4/1/2005	3.49	5/11/2005	3.70		
2/21/2005	2.02	4/2/2005	1.19	5/12/2005	3.29		
2/22/2005	2.67	4/3/2005	2.02	5/13/2005	2.74		
2/23/2005	3.24	4/4/2005	2.05	5/14/2005	2.06		
2/24/2005	3.67	4/5/2005	2.71	5/15/2005	1.49		
2/25/2005	3.96	4/6/2005	3.66	5/16/2005	0.58		
2/26/2005	4.13	4/7/2005	4.41	5/17/2005	1.16		
2/27/2005	4.17	4/8/2005	4.90	5/18/2005	1.32		
2/28/2005	4.09	4/9/2005	5.12	5/19/2005	1.79		
3/1/2005	4.46	4/10/2005	5.04	5/20/2005	2.43		
3/2/2005	3.56	4/11/2005	4.70	5/21/2005	3.07		
3/3/2005	2.76	4/12/2005	4.24	5/22/2005	3.67		
3/4/2005	1.27	4/13/2005	3.56	5/23/2005	4.14		
3/5/2005	1.98	4/14/2005	2.68	5/24/2005	4.43		
3/6/2005	1.83	4/15/2005	1.83	5/25/2005	4.52		
3/7/2005	2.54	4/16/2005	0.38	5/26/2005	4.42		
3/8/2005	3.49	4/17/2005	0.88	5/27/2005	4.17		
3/9/2005	4.41	4/18/2005	0.80	5/28/2005	3.79		
3/10/2005	5.06	4/19/2005	1.13	5/29/2005	3.66		
3/11/2005	5.40	4/20/2005	1.80	5/30/2005	2.36		
3/12/2005	5.49	4/21/2005	2.55	5/31/2005	3.18		
3/13/2005	5.18	4/22/2005	3.25	6/1/2005	3.66		

Date	River Water Level at Dhuvaran in m	Date	River Water Level at Dhuvaran in m	Date	River Water Level at Dhuvaran in m
6/13/2005	2.21	7/23/2005	5.12	9/1/2005	3.25
6/14/2005	1.99	7/24/2005	5.17	9/2/2005	3.28
6/15/2005	1.80	7/25/2005	5.01	9/3/2005	3.58
6/16/2005	1.73	7/26/2005	4.57	9/4/2005	3.96
6/17/2005	1.89	7/27/2005	3.93	9/5/2005	4.06
6/18/2005	2.26	7/28/2005	3.63	9/6/2005	4.13
6/19/2005	2.81	7/29/2005	3.24	9/7/2005	4.05
6/20/2005	3.40	7/30/2005	2.45	9/8/2005	3.88
6/21/2005	3.94	7/31/2005	2.08	9/9/2005	3.52
6/22/2005	4.33	8/1/2005	2.90	9/10/2005	3.02
6/23/2005	4.57	8/2/2005	2.46	9/11/2005	2.38
6/24/2005	4.65	8/3/2005	2.68	9/12/2005	2.95
6/25/2005	4.56	8/4/2005	3.09	9/13/2005	1.80
6/26/2005	4.36	8/5/2005	3.40	9/14/2005	2.02
6/27/2005	4.03	8/6/2005	3.63	9/15/2005	2.91
6/28/2005	3.57	8/7/2005	3.75	9/16/2005	3.95
6/29/2005	3.20	8/8/2005	3.75	9/17/2005	4.84
6/30/2005	3.43	8/9/2005	3.65	9/18/2005	5.44
7/1/2005	3.66	8/10/2005	3.46	9/19/2005	5.73
7/2/2005	2.92	8/11/2005	3.14	9/20/2005	5.65
7/3/2005	2.81	8/12/2005	2.81	9/21/2005	5.27
7/4/2005	2.91	8/13/2005	3.05	9/22/2005	4.61
7/5/2005	3.15	8/14/2005	2.15	9/23/2005	3.73
7/6/2005	3.20	8/15/2005	1.91	9/24/2005	2.71
7/7/2005	3.32	8/16/2005	2.17	9/25/2005	2.69
7/8/2005	3.37	8/17/2005	2.90	9/26/2005	1.24
7/9/2005	3.34	8/18/2005	3.77	9/27/2005	0.81
7/10/2005	3.25	8/19/2005	4.62	9/28/2005	1.07
7/11/2005	3.09	8/20/2005	5.25	9/29/2005	1.98
7/12/2005	2.91	8/21/2005	5.59	9/30/2005	2.55
7/13/2005	2.62	8/22/2005	5.61	10/1/2005	3.67
7/14/2005	2.21	8/23/2005	5.35	10/2/2005	3.75
7/15/2005	2.31	8/24/2005	4.78	10/3/2005	4.00
7/16/2005	2.05	8/25/2005	3.95	10/4/2005	4.23
7/17/2005	2.11	8/26/2005	2.95	10/5/2005	4.22
7/18/2005	2.48	8/27/2005	2.95	10/6/2005	4.24
7/19/2005	3.10	8/28/2005	1.68	10/7/2005	4.82
7/20/2005	3.77	8/29/2005	1.59	10/8/2005	3.67
7/21/2005	4.38	8/30/2005	1.64	10/9/2005	3.11
7/22/2005	4.84	8/31/2005	2.03	10/10/2005	2.45

Date	River Water Level at Dhuvaran in m	Date	River Water Level at Dhuvaran in m	Date	River Water Level at Dhuvaran in m
10/11/2005	2.87	11/20/2005	3.23	12/30/2005	3.68
10/12/2005	1.87	11/21/2005	2.60	12/31/2005	4.12
10/13/2005	2.24	11/22/2005	1.99	1/1/2006	4.83
10/14/2005	3.06	11/23/2005	2.13	1/2/2006	4.78
10/15/2005	4.00	11/24/2005	1.12	1/3/2006	4.67
10/16/2005	4.75	11/25/2005	0.91	1/4/2006	4.56
10/17/2005	5.21	11/26/2005	1.07	1/5/2006	4.28
10/18/2005	5.39	11/27/2005	1.55	1/6/2006	4.06
10/19/2005	5.23	11/28/2005	2.15	1/7/2006	3.24
10/20/2005	4.82	11/29/2005	3.07	1/8/2006	2.65
10/21/2005	4.19	11/30/2005	3.52	1/9/2006	2.30
10/22/2005	3.42	12/1/2005	4.27	1/10/2006	2.27
10/23/2005	2.55	12/2/2005	4.27	1/11/2006	2.45
10/24/2005	2.67	12/3/2005	4.26	1/12/2006	2.82
10/25/2005	1.22	12/4/2005	4.23	1/13/2006	3.10
10/26/2005	0.74	12/5/2005	3.94	1/14/2006	3.28
10/27/2005	0.83	12/6/2005	3.77	1/15/2006	3.44
10/28/2005	1.36	12/7/2005	3.42	1/16/2006	3.49
10/29/2005	2.32	12/8/2005	3.63	1/17/2006	3.48
10/30/2005	2.88	12/9/2005	2.76	1/18/2006	3.37
10/31/2005	3.40	12/10/2005	2.63	1/19/2006	3.15
11/1/2005	4.27	12/11/2005	2.78	1/20/2006	2.86
11/2/2005	4.27	12/12/2005	3.16	1/21/2006	2.45
11/3/2005	4.27	12/13/2005	3.46	1/22/2006	1.83
11/4/2005	4.26	12/14/2005	3.61	1/23/2006	1.58
11/5/2005	3.95	12/15/2005	3.73	1/24/2006	1.21
11/6/2005	3.75	12/16/2005	3.76	1/25/2006	1.22
11/7/2005	3.28	12/17/2005	3.67	1/26/2006	1.73
11/8/2005	2.77	12/18/2005	3.47	1/27/2006	2.52
11/9/2005	3.15	12/19/2005	3.23	1/28/2006	3.39
11/10/2005	2.18	12/20/2005	2.91	1/29/2006	5.56
11/11/2005	2.44	12/21/2005	2.53	1/30/2006	5.13
11/12/2005	3.13	12/22/2005	2.13	1/31/2006	4.59
11/13/2005	3.79	12/23/2005	2.06	2/1/2006	5.73
11/14/2005	4.26	12/24/2005	1.41	2/2/2006	5.41
11/15/2005	4.54	12/25/2005	1.16	2/3/2006	4.82
11/16/2005	4.61	12/26/2005	1.21	2/4/2006	4.10
11/17/2005	4.50	12/27/2005	1.59	2/5/2006	3.40
11/18/2005	4.19	12/28/2005	2.19	2/6/2006	2.52
11/19/2005	3.76	12/29/2005	3.16	2/7/2006	1.75

Date	River Water Level at Dhuvaran in m	Date	River Water Level at Dhuvaran in m	Date	River Water Level at Dhuvaran in m
2/8/2006	1.54	3/20/2006	3.24	4/29/2006	5.48
2/9/2006	1.75	3/21/2006	2.71	4/30/2006	4.93
2/10/2006	2.19	3/22/2006	2.03	5/1/2006	4.69
2/11/2006	2.67	3/23/2006	0.58	5/2/2006	3.54
2/12/2006	3.20	3/24/2006	1.38	5/3/2006	2.54
2/13/2006	3.56	3/25/2006	1.79	5/4/2006	1.12
2/14/2006	3.70	3/26/2006	2.73	5/5/2006	1.50
2/15/2006	3.80	3/27/2006	3.81	5/6/2006	1.16
2/16/2006	3.79	3/28/2006	4.75	5/7/2006	1.22
2/17/2006	3.66	3/29/2006	5.72	5/8/2006	1.59
2/18/2006	3.39	3/30/2006	5.92	5/9/2006	2.06
2/19/2006	2.99	3/31/2006	5.79	5/10/2006	2.63
2/20/2006	2.45	4/1/2006	5.75	5/11/2006	3.11
2/21/2006	1.22	4/2/2006	4.83	5/12/2006	3.56
2/22/2006	1.42	4/3/2006	3.73	5/13/2006	3.63
2/23/2006	1.16	4/4/2006	2.67	5/14/2006	3.85
2/24/2006	1.58	4/5/2006	1.32	5/15/2006	3.82
2/25/2006	2.48	4/6/2006	1.28	5/16/2006	3.68
2/26/2006	3.53	4/7/2006	0.97	5/17/2006	3.44
2/27/2006	4.51	4/8/2006	1.21	5/18/2006	3.13
2/28/2006	5.26	4/9/2006	1.73	5/19/2006	2.79
3/1/2006	6.05	4/10/2006	2.35	5/20/2006	1.88
3/2/2006	5.95	4/11/2006	2.92	5/21/2006	2.68
3/3/2006	5.55	4/12/2006	3.47	5/22/2006	2.88
3/4/2006	4.95	4/13/2006	3.82	5/23/2006	3.33
3/5/2006	4.29	4/14/2006	3.94	5/24/2006	3.84
3/6/2006	2.46	4/15/2006	3.99	5/25/2006	4.24
3/7/2006	2.31	4/16/2006	3.90	5/26/2006	4.48
3/8/2006	1.37	4/17/2006	3.67	5/27/2006	4.54
3/9/2006	1.08	4/18/2006	3.32	5/28/2006	4.41
3/10/2006	1.35	4/19/2006	2.82	5/29/2006	4.42
3/11/2006	1.91	4/20/2006	2.27	5/30/2006	3.86
3/12/2006	2.59	4/21/2006	1.02	5/31/2006	3.28
3/13/2006	3.15	4/22/2006	1.92	6/1/2006	3.21
3/14/2006	3.52	4/23/2006	2.31	6/2/2006	2.13
3/15/2006	3.81	4/24/2006	3.10	6/3/2006	1.60
3/16/2006	3.98	4/25/2006	3.98	6/4/2006	1.42
3/17/2006	4.00	4/26/2006	4.70	6/5/2006	1.73
3/18/2006	3.89	4/27/2006	5.14	6/6/2006	1.79
3/19/2006	3.65	4/28/2006	5.31	6/7/2006	2.22

Date	River Water Level at Dhuvaran in m	Date	River Water Level at Dhuvaran in m	Date	River Water Level at Dhuvaran in m
6/8/2006	2.71	7/18/2006	3.73	8/27/2006	3.85
6/9/2006	3.15	7/19/2006	3.23	8/28/2006	3.61
6/10/2006	3.52	7/20/2006	2.79	8/29/2006	3.24
6/11/2006	3.80	7/21/2006	2.65	8/30/2006	3.04
6/12/2006	3.02	7/22/2006	2.78	8/31/2006	2.27
6/13/2006	4.04	7/23/2006	3.02	9/1/2006	3.38
6/14/2006	3.93	7/24/2006	3.32	9/2/2006	1.51
6/15/2006	0.43	7/25/2006	3.54	9/3/2006	1.41
6/16/2006	3.81	7/26/2006	3.71	9/4/2006	1.85
6/17/2006	3.62	7/27/2006	3.72	9/5/2006	2.71
6/18/2006	3.40	7/28/2006	3.66	9/6/2006	3.91
6/19/2006	3.06	7/29/2006	3.49	9/7/2006	4.83
6/20/2006	2.22	7/30/2006	3.54	9/8/2006	5.50
6/21/2006	2.39	7/31/2006	3.02	9/9/2006	5.77
6/22/2006	3.33	8/1/2006	2.96	9/10/2006	5.88
6/23/2006	3.56	8/2/2006	2.34	9/11/2006	5.56
6/24/2006	3.73	8/3/2006	4.06	9/12/2006	4.92
6/25/2006	3.82	8/4/2006	5.71	9/13/2006	4.08
6/26/2006	3.82	8/5/2006	5.42	9/14/2006	4.09
6/27/2006	3.71	8/6/2006	1.96	9/15/2006	2.40
6/28/2006	3.52	8/7/2006	2.76	9/16/2006	1.63
6/29/2006	3.54	8/8/2006	3.61	9/17/2006	1.54
6/30/2006	3.11	8/9/2006	4.18	9/18/2006	1.97
7/1/2006	3.33	8/10/2006	4.95	9/19/2006	2.54
7/2/2006	2.44	8/11/2006	5.34	9/20/2006	3.09
7/3/2006	1.85	8/12/2006	5.46	9/21/2006	3.53
7/4/2006	1.80	8/13/2006	5.37	9/22/2006	3.84
7/5/2006	1.31	8/14/2006	4.93	9/23/2006	4.01
7/6/2006	1.52	8/15/2006	4.13	9/24/2006	4.07
7/7/2006	1.79	8/16/2006	4.01	9/25/2006	3.99
7/8/2006	2.27	8/17/2006	2.87	9/26/2006	3.63
7/9/2006	2.62	8/18/2006	2.17	9/27/2006	3.40
7/10/2006	3.44	8/19/2006	1.99	9/28/2006	2.91
7/11/2006	3.95	8/20/2006	2.26	9/29/2006	2.30
7/12/2006	4.33	8/21/2006	2.71	9/30/2006	2.72
7/13/2006	4.66	8/22/2006	3.19	10/1/2006	2.31
7/14/2006	4.78	8/23/2006	3.57	10/2/2006	1.55
7/15/2006	4.62	8/24/2006	3.84	10/3/2006	2.15
7/16/2006	4.37	8/25/2006	3.95	10/4/2006	3.04
7/17/2006	3.91	8/26/2006	3.91	10/5/2006	4.05

Date	River Water Level at Dhuvaran in m	Date	River Water Level at Dhuvaran in m	Date	River Water Level at Dhuvaran in m
10/6/2006	5.02	11/15/2006	1.26	12/25/2006	3.85
10/7/2006	5.63	11/16/2006	1.64	12/26/2006	3.68
10/8/2006	5.87	11/17/2006	2.12	12/27/2006	3.46
10/9/2006	5.89	11/18/2006	2.60	12/28/2006	3.10
10/10/2006	5.35	11/19/2006	3.04	12/29/2006	2.36
10/11/2006	4.63	11/20/2006	3.38	12/30/2006	2.90
10/12/2006	3.68	11/21/2006	3.61	12/31/2006	3.94
10/13/2006	2.71	11/22/2006	3.65	1/1/2007	3.70
10/14/2006	2.77	11/23/2006	3.65	1/2/2007	3.68
10/15/2006	1.33	11/24/2006	3.51	1/3/2007	3.81
10/16/2006	1.23	11/25/2006	3.33	1/4/2007	3.98
10/17/2006	1.65	11/26/2006	3.01	1/5/2007	3.94
10/18/2006	2.20	11/27/2006	2.79	1/6/2007	3.85
10/19/2006	2.73	11/28/2006	2.60	1/7/2007	3.59
10/20/2006	3.21	11/29/2006	2.77	1/8/2007	3.23
10/21/2006	3.58	11/30/2006	2.86	1/9/2007	2.93
10/22/2006	3.82	12/1/2006	3.43	1/10/2007	2.30
10/23/2006	3.93	12/2/2006	3.59	1/11/2007	1.68
10/24/2006	3.87	12/3/2006	3.96	1/12/2007	1.30
10/25/2006	3.71	12/4/2006	4.36	1/13/2007	0.94
10/26/2006	3.30	12/5/2006	4.71	1/14/2007	0.95
10/27/2006	3.01	12/6/2006	5.61	1/15/2007	1.21
10/28/2006	2.55	12/7/2006	4.42	1/16/2007	1.79
10/29/2006	3.07	12/8/2006	4.12	1/17/2007	2.50
10/30/2006	1.84	12/9/2006	3.73	1/18/2007	3.21
10/31/2006	2.08	12/10/2006	3.15	1/19/2007	3.80
11/1/2006	3.02	12/11/2006	2.55	1/20/2007	4.28
11/2/2006	3.47	12/12/2006	2.31	1/21/2007	4.62
11/3/2006	3.93	12/13/2006	1.61	1/22/2007	4.79
11/4/2006	4.56	12/14/2006	1.45	1/23/2007	4.76
11/5/2006	5.06	12/15/2006	1.19	1/24/2007	4.50
11/6/2006	5.37	12/16/2006	1.30	1/25/2007	3.80
11/7/2006	5.23	12/17/2006	1.61	1/26/2007	3.23
11/8/2006	4.82	12/18/2006	2.07	1/27/2007	2.52
11/9/2006	4.17	12/19/2006	2.57	1/28/2007	2.15
11/10/2006	3.40	12/20/2006	3.02	1/29/2007	2.26
11/11/2006	2.58	12/21/2006	3.40	1/30/2007	2.96
11/12/2006	2.59	12/22/2006	3.68	1/31/2007	3.30
11/13/2006	1.49	12/23/2006	3.84	2/1/2007	3.82
11/14/2006	1.21	12/24/2006	3.87	2/2/2007	3.77

Date	River Water Level at Dhuvaran in m	Date	River Water Level at Dhuvaran in m	Date	River Water Level at Dhuvaran in m	Date	River Water Level at Dhuvaran in m
2/3/2007	3.95	3/15/2007	1.75	4/24/2007	1.30	6/3/2007	3.40
2/4/2007	3.98	3/16/2007	2.59	4/25/2007	1.74	6/4/2007	3.32
2/5/2007	3.86	3/17/2007	3.68	4/26/2007	1.66	6/5/2007	3.18
2/6/2007	3.65	3/18/2007	4.64	4/27/2007	1.94	6/6/2007	3.05
2/7/2007	3.35	3/19/2007	5.35	4/28/2007	2.35	6/7/2007	2.88
2/8/2007	2.82	3/20/2007	5.74	4/29/2007	2.76	6/8/2007	2.31
2/9/2007	2.20	3/21/2007	5.81	4/30/2007	3.10	6/9/2007	2.91
2/10/2007	1.02	3/22/2007	5.53	5/1/2007	3.89	6/10/2007	3.01
2/11/2007	1.25	3/23/2007	4.89	5/2/2007	3.57	6/11/2007	3.28
2/12/2007	0.94	3/24/2007	3.96	5/3/2007	3.65	6/12/2007	4.60
2/13/2007	1.02	3/25/2007	2.21	5/4/2007	3.58	6/13/2007	4.05
2/14/2007	1.49	3/26/2007	2.31	5/5/2007	3.40	6/14/2007	4.33
2/15/2007	2.40	3/27/2007	1.60	5/6/2007	3.13		
2/16/2007	3.38	3/28/2007	1.59	5/7/2007	2.78		
2/17/2007	4.23	3/29/2007	2.03	5/8/2007	2.40		
2/18/2007	4.89	3/30/2007	2.60	5/9/2007	2.07		
2/19/2007	5.34	3/31/2007	3.11	5/10/2007	1.22		
2/20/2007	5.79	4/1/2007	3.95	5/11/2007	2.11		
2/21/2007	5.35	4/2/2007	3.75	5/12/2007	2.54		
2/22/2007	5.06	4/3/2007	3.87	5/13/2007	3.23		
2/23/2007	4.43	4/4/2007	3.91	5/14/2007	3.96		
2/24/2007	3.52	4/5/2007	3.80	5/15/2007	4.60		
2/25/2007	3.00	4/6/2007	3.56	5/16/2007	5.02		
2/26/2007	2.48	4/7/2007	3.15	5/17/2007	5.17		
2/27/2007	1.74	4/8/2007	2.63	5/18/2007	5.07		
2/28/2007	1.87	4/9/2007	2.03	5/19/2007	4.71		
3/1/2007	3.26	4/10/2007	1.02	5/20/2007	4.17		
3/2/2007	3.28	4/11/2007	1.32	5/21/2007	3.52		
3/3/2007	3.68	4/12/2007	1.36	5/22/2007	2.81		
3/4/2007	3.94	4/13/2007	1.98	5/23/2007	2.16		
3/5/2007	4.03	4/14/2007	2.92	5/24/2007	2.05		
3/6/2007	4.00	4/15/2007	3.95	5/25/2007	1.78		
3/7/2007	3.85	4/16/2007	4.80	5/26/2007	1.78		
3/8/2007	3.56	4/17/2007	5.37	5/27/2007	1.97		
3/9/2007	3.11	4/18/2007	5.67	5/28/2007	2.26		
3/10/2007	2.52	4/19/2007	5.60	5/29/2007	2.58		
3/11/2007	1.79	4/20/2007	5.21	5/30/2007	2.90		
3/12/2007	1.55	4/21/2007	4.54	5/31/2007	3.16		
3/13/2007	1.30	4/22/2007	3.66	6/1/2007	3.85		
3/14/2007	1.32	4/23/2007	2.71	6/2/2007	3.43		

ANNEXURE-II

RL's of Ground Level of Wells and River Bed in m from m.s.l.

RL's of Ground Level of Wells in m from m.s.l.

Taluka	Village	Well no	X (Latitude)	Y (Longitude)	Z RL in m from m.s.l.
Khambhat	Kansari	KR-23	251376.4	2472176	17.07
Jabusar	Kavi	NCCA-48	256865.3	2456701	12.09
Khambhat	Bhuval	KR-21	264060.8	2468621	15.98
Khambhat	Gudel	KR-25	244895.8	2478585	16.65
Petlad	Danteli	KR-70	268271.8	2482072	20.9
Khambhat	Kanisha	KR-20	261797.2	2477618	16.46
Khambhat	Haripura	KR-22	271944	2463552	19.43
Borsad	Borsad	KR-19	283767.3	2479632	34.7
Borsad	Bhadran	KR-17	283689.9	2474095	33.22
Borsad	Gajna	KR-18	283803.6	2465232	15.4
Anklav	Anklav	KR-16	297455.3	2475781	31.7
Anand	Vasad	KR-07	303395.9	2488508	38.07
Anand	Bedva	KR-08	298338.2	2495241	44.69
Anand	Sarsa	KR-06	301609.6	2494434	46.67
Jambusar	Sarod	BR-14	280113.4	2453554	7.15
Padra	Dabka	NCCA-44	289541.9	2461920	22.46
Padra	Karankuva	NCCA-45	291753.3	2456108	24.75
Padra	Masar Road	BD-34	287036.9	2450601	17.64
Padra	Jaspur	NCCA-43	306765	2465695	27.96
Vadodara	Dashrath	BD-05	309398.7	2477047	34.77
Vadodara	Sokhda	BD-06	311648.4	2480807	38.69
Savli	Manjusar	BD-48	313994.4	2483237	44.2
Savli	Anjesar	NCCA-14	311864.9	2486741	31.22
Savli	Poicha	NCCA-13	305511.1	2486552	40.37
Jambusar	Sarod	NCCA-47	267217	2453552	15.12
Jambusar	Piludra	NCCA-50	273528.2	2444055	12.36
Anklav	Gambhira	SKHDPZ05	291610.8	2464728	40.95
Khambhat	Chhatardi	SKHDPZ-06	257978.4	2473226	22.39
Khambhat	Khambhat	SKHDPZ-11	255563.9	2471554	16.01

Taluka	Village	Well no	X (Latitude)	Y (Longitude)	Z RL in m from m.s.l.
Petlad	Danteli	KRT031	268403.5	2481926	20.9
Anand	Bedva	KRT129	298129.2	2494989	49.19
Anand	Veherakhadi	KRT132	301859.2	2490654	44.47
Anand	Vadod-1	KRT147	294699.3	2490072	40.28
Borsad	Divel-2	KRT239	290506.8	2479927	41.22
Borsad	Umlav	KRT241	281449.1	2468610	46.76
Borsad	Napatalpad	KRT288	274655.8	2466719	50.35
Borsad	Dehwan-3	KRT300	287043.4	2474987	40.41
Borsad	Pipli	KRT409	285304.8	2470833	48.12
Borsad	Santokpura	KRT419	280103.7	2483939	52.17
Borsad	Kathana	46B3D12	272282.8	2467679	35.33
Khambhat	Kalamsar	KRT-440	267347.3	2467818	11.2
Khambhat	Sakarpura	KRT-436	256680.3	2469953	23.28
Borsad	Virsad	KRT-058	271165.9	2477211	50.23
Borsad	Bamangam	KRT-236	266155.3	2476277	43.19
Jambusar	Piludara	CBRV102	279154.2	2452836	20
Padra	Bhramanvasi	CVDX102	281005.5	2450950	20.3
Khambhat	Kanisha	56-Kanisha	261590.6	2477577	16.46
Borsad	Chamara	31-Chamara	296642.8	2467230	44.57
Borsad	Asarma	KRT-426	296953.7	2472875	49.76
Borsad	Zilod	49-Zilod	294411.1	2469154	46.08
Borsad	Navakhal	KRT-297	294804.2	2470821	42.48
Vadodara	Sindhrot-II	CVDII24	301253.4	2470737	28.53
Anklav	Anklav-I	46B3D09	294428.4	2475898	48.93
Borsad	Amrol	KRT-064	298438.5	2475347	48.41
Borsad	Kahanvadi-2	KRT-274	300365.4	2476995	49.65
Borsad	Bhanpura	KRT-252	299655.7	2480249	50.28
Borsad	Rundel	KRT-401	278429.9	2478035	45.27
Anand	Adas	04-ADAS	297411.8	2487389	35.94

Taluka	Village	Well no	X (Latitude)	Y (Longitude)	Z RL in m from m.s.l.
Borsad	Borsad	SKHDPZ12	284419.9	2479159	34.2
Savli	Bhadarva	SVADPZ-01	308592	2491827	31.44
Padra	Mahuvad-1	SVADPZ-02	294497.4	2460857	25.8
Vadodara	Ankodia	SVADPZ-09	305975.6	2471677	34.69
Vadodara	Ranoli	SVADPZ-11	307492.2	2477860	36.75
Padra	Bhoj	SVADPZ-26	293233.8	2457420	26.23
Khambhat	Pandad	SKHDpz-07	241055.1	2476707	7.63
Padra	Chokari-1	CVDVI55	287104.7	2459372	16.27
Padra	Sangama	CVDIV47	303876.1	2462187	33.03
Padra	Jaspur	CVDVI50	300043	2465558	30.8
Padra	Bhoj	CVDVI53	299542.5	2461101	26.63
Borsad	Napad	KRT-246	290810.2	2487876	35.85
Borsad	Singlav-2	KRT-175	286444.4	2484059	50.61
Savli	Bhadarva	Bhadrva_L	307665.3	2491666	37.53
Savli	Bhdarva	Bhadrva_R	307412.7	2492034	21.22
Vadodara	Anagadh	Anagadh_L	301171.1	2476375	24.3
Vadodara	Anagadh	Anagadh_R	299749.5	2476360	28.46
Anand	Vasad	Vasad_L	302103	2482388	32.4
Anand	Vasad	Vasad_R	301656	2482859	33.31
Anklav	Umeta	Umeta_L	299713.8	2470402	21.68
Anklav	Umeta	Umeta_R	300700.8	2470234	22.06
Padra	Mujpur	Mujpur_L	292974.8	2462660	18.44
Padra	Mujpur	Mujpur_R	292520	2463353	14.77
Padra	Dabka	Dabka_L	285919.1	2463896	9.19
Padra	Dabka	Dabka_R	284978.9	2464496	16.02
Anand	Khanpur	Khanpur_L	309040.4	2493022	19
Anand	Khanpur	Khanpur_R	308631.1	2493204	28
Khambhat	Khadodhi	KRT430	270142.7	2463756	19.49
Anand	Vasad	KRT-02	302786.3	2485902	37.92
Anand	Bedva	KRT-03	301341	2495146	45.39
Anand	Khambholaj	KRT-07	290830.8	2487876	37.27
Anklav	Anklav	KRT-08	294918.3	2474773	32.2
Borsad	Umeta	KRT-09	285381.3	2467515	45.4
Borsad	Gambhira	KRT-10	291919.1	2460813	41.05
Borsad	Gajna	KRT-12	275043.3	2463972	25.3
Khambhat	Nandeli	KRT-13	263752.7	2476137	26.28

Taluka	Village	Well no	X (Latitude)	Y (Longitude)	Z RL in m from m.s.l.
Khambhat	Jalsan	KRT-14	267491.9	2477465	18.28
Khambhat	Kalamsar	KRT-15	266927.6	2468700	11.2
Khambhat	Khadodhi	KRT-16	270167.3	2465428	19.49
Khambhat	Sakarpura	KRT-17	258040.1	2467916	23.28
Khambhat	Metpur	KRT-18	254497.7	2470121	32.65
Khambhat	Ralej	KRT-19	263351.6	2468754	19.46
Vadodara	Nandesari	BDT-01	303764.2	2481858	38.23
Vadodara	Serkhi	BDT-02	302462.2	2471807	41.6
Padra	Dabhasa	BDT-10	299963.6	2461782	32.83
Padra	Gavasad	BDT-11	300636.8	2462017	29.71
Vadodara	Ankodia	FBD/18	306013.1	2471518	35.09
Vadodara	Ranoli	RFB/29	274436.3	2476830	36
Vadodara	Sevasi	FBD/37	306078.3	2468483	34.77
Savli	Mahapura	FBD/44	309560.8	2487688	40.85
Vadodara	Sherkhi	CVD/I/3	302187.2	2472054	41
Padra	Ranu	CVD/I/101	296637.5	2457340	27.51
Vadodara	Nandesari	CVD/II/19	303636.9	2479135	40.85
Padra	Gavasad	CVD/II/35	288048.7	2452171	29.11
Vadodara	Ampad	CVD/II/48	302832.3	2467682	33.6
Savli	Moxi	CVD/VII/102	307827.5	2485694	44.1
Padra	Karankuva	CVD/III/57	292662.6	2456240	25.78
Vadodara	Karachiya	CVD/III/59	307713.3	2475684	35.1
Vadodara	Mahapura	CVD/III/74	304658.3	2467836	31.65
Padra	Dabka	CVD/IV/1	290322.5	2461699	28.45
Padra	Vadu	CVD/IV/3	292244.3	2458129	28
Padra	Narsinhpura	CVD/IV/4	291385.4	2458683	28.46
Padra	Mujpur	CVD/IV/9	292328.8	2462159	28.62
Padra	Dhobikuva	CVD/IV/11	293389.7	2459742	28.7
Padra	Gametha	CVD/IV/33	285167.7	2451989	21.43
Padra	Chitral	CVD/IV/39	287895.5	2454576	27.1
Padra	Vishrampura	CVD/VI/35	290713.4	2455480	26.38
Padra	Luna-II	CVD/VI/38	298876.9	2463059	29.35
Vadodara	Fajalpur	CVD/VI/39	301892.1	2482003	43.7
Savli	Poicha-III	CVD/VI/47	304954	2486384	44.1

Taluka	Village	Well no	X (Latitude)	Y (Longitude)	Z RL in m from m.s.l.
Vadodara	Dodka	CVD/VI/54	307475.7	2483074	43.4
Vadodara	Rajupura / Bhaily	CVD/VI/102	305815.9	2465629	31.2
Vadodara	Padmala	CVD/VI/103	307107.2	2479944	35
Padra	Mahuvad	CVD/VI/104	294778.5	2461063	28.69
Padra	Pavda	CVD/V/3	284742.5	2463060	29.51
Padra	Majatan	CVD/V/60	286986.8	2456771	29.29
Savli	Jalampura	CVD/V/68	304178.4	2488531	30.4
Jambusar	Kahanva	CBR/V/14	284369.8	2453982	23.27
Padra	Dudhawada	CVD/IX/102	281561.7	2456048	27.62
Vadodara	Angadh	CVD/VI/6	297642.3	2478271	44.15
Khambhat	Khambhat	Khambhat	256677.6	2469776	10.15
Jambusar	Degam	Degam	251585	2455521	9.9
Jambusar	Kavi	Kavi	256452.7	2456707	13.2
Padra	Masarroad	Masarroad	289697.9	2449450	16.5
Padra	Kural	Kural	285713.3	2449937	20
Padra	Gawasad	Gawasad	288049.7	2452175	21.8
Vadodara	Padmala	Padmala	307105.2	2479947	39.5
Vadodara	Ranoli	Ranoli	274436.3	2476835	38.5
Vadodara	Bajuva	Bajuva	308200.8	2474711	36.7
Padra	Jaspur	Jaspur	300047.7	2465559	29.4
Padra	Dhobikuva	Dhobikuva	299033.4	2465826	30.5
Padra	Latipur	Latipur	300109.5	2458763	26.5
Padra	Mahuvad	Mahuvad	294775.4	2461064	28
Savli	Bhadarva	Bhadarva	307345.9	2491177	42.57

RL's of the River Bed in m from m.s.l.

Location	X (Latitude)	Y (Longitude)	Z RL in m from m.s.l.	Location	X (Latitude)	Y (Longitude)	Z RL in m from m.s.l.
Rvr	271886.6	2452000	0.539914	Rvr	275395.5	2453500	2.674171
Rvr	272387.9	2452000	0.856147	Rvr	267375.2	2454000	-2.48562
Rvr	272889.2	2452000	1.159957	Rvr	267876.4	2454000	-2.24427
Rvr	273390.4	2452000	1.443207	Rvr	268377.7	2454000	-1.9195
Rvr	270884.1	2452500	-0.08648	Rvr	268879	2454000	-1.55563
Rvr	271385.3	2452500	0.257462	Rvr	269380.3	2454000	-1.18225
Rvr	271886.6	2452500	0.599575	Rvr	269881.5	2454000	-0.80365
Rvr	272387.9	2452500	0.936524	Rvr	270382.8	2454000	-0.42157
Rvr	272889.2	2452500	1.263137	Rvr	270884.1	2454000	-0.03747
Rvr	273390.4	2452500	1.569033	Rvr	271385.3	2454000	0.347035
Rvr	273891.7	2452500	1.834809	Rvr	271886.6	2454000	0.730009
Rvr	269881.5	2453000	-0.78297	Rvr	272387.9	2454000	1.108728
Rvr	270382.8	2453000	-0.42664	Rvr	272889.2	2454000	1.478738
Rvr	270884.1	2453000	-0.06717	Rvr	273390.4	2454000	1.831123
Rvr	271385.3	2453000	0.293316	Rvr	273891.7	2454000	2.121413
Rvr	271886.6	2453000	0.652777	Rvr	274393	2454000	2.363059
Rvr	272387.9	2453000	1.008831	Rvr	274894.3	2454000	2.580642
Rvr	272889.2	2453000	1.358092	Rvr	275395.5	2454000	2.781714
Rvr	273390.4	2453000	1.694227	Rvr	275896.8	2454000	2.968494
Rvr	273891.7	2453000	1.9756	Rvr	265370.1	2454500	-3.35818
Rvr	269380.3	2453500	-1.16218	Rvr	265871.3	2454500	-3.16085
Rvr	269881.5	2453500	-0.79547	Rvr	266372.6	2454500	-2.95504
Rvr	270382.8	2453500	-0.42446	Rvr	266873.9	2454500	-2.73953
Rvr	270884.1	2453500	-0.05102	Rvr	267375.2	2454500	-2.51135
Rvr	271385.3	2453500	0.323227	Rvr	267876.4	2454500	-2.26196
Rvr	271886.6	2453500	0.696548	Rvr	268377.7	2454500	-1.93382
Rvr	272387.9	2453500	1.066843	Rvr	268879	2454500	-1.5679
Rvr	272889.2	2453500	1.430686	Rvr	269380.3	2454500	-1.19036
Rvr	273390.4	2453500	1.777972	Rvr	269881.5	2454500	-0.80584
Rvr	273891.7	2453500	2.066236	Rvr	270382.8	2454500	-0.41695
Rvr	274393	2453500	2.287024	Rvr	270884.1	2454500	-0.02575
Rvr	274894.3	2453500	2.486904	Rvr	271385.3	2454500	0.365687

Rvr	271886.6	2454500	0.754789	Rvr	276899.4	2455000	3.57325
Rvr	272387.9	2454500	1.137787	Rvr	249329.3	2455500	-4.03488
Rvr	272889.2	2454500	1.508514	Rvr	249830.6	2455500	-4.05831
Rvr	273390.4	2454500	1.855616	Rvr	262863.7	2455500	-4.38845
Rvr	273891.7	2454500	2.160038	Rvr	263365	2455500	-4.21922
Rvr	274393	2454500	2.424617	Rvr	263866.3	2455500	-4.04136
Rvr	274894.3	2454500	2.662824	Rvr	264367.5	2455500	-3.85504
Rvr	275395.5	2454500	2.881239	Rvr	264868.8	2455500	-3.66017
Rvr	275896.8	2454500	3.082599	Rvr	265370.1	2455500	-3.4563
Rvr	263365	2455000	-4.14566	Rvr	265871.3	2455500	-3.24247
Rvr	263866.3	2455000	-3.97419	Rvr	266372.6	2455500	-3.01683
Rvr	264367.5	2455000	-3.79449	Rvr	266873.9	2455500	-2.77605
Rvr	264868.8	2455000	-3.60662	Rvr	267375.2	2455500	-2.51445
Rvr	265370.1	2455000	-3.4104	Rvr	267876.4	2455500	-2.22472
Rvr	265871.3	2455000	-3.20521	Rvr	268377.7	2455500	-1.90383
Rvr	266372.6	2455000	-2.98972	Rvr	268879	2455500	-1.55325
Rvr	266873.9	2455000	-2.76108	Rvr	269380.3	2455500	-1.18139
Rvr	267375.2	2455000	-2.51304	Rvr	269881.5	2455500	-0.79617
Rvr	267876.4	2455000	-2.23235	Rvr	270382.8	2455500	-0.40293
Rvr	268377.7	2455000	-1.91667	Rvr	270884.1	2455500	-0.00546
Rvr	268879	2455000	-1.56282	Rvr	271385.3	2455500	0.393082
Rvr	269380.3	2455000	-1.18831	Rvr	271886.6	2455500	0.789431
Rvr	269881.5	2455000	-0.80261	Rvr	272387.9	2455500	1.179573
Rvr	270382.8	2455000	-0.41052	Rvr	272889.2	2455500	1.55797
Rvr	270884.1	2455000	-0.01518	Rvr	273390.4	2455500	1.915309
Rvr	271385.3	2455000	0.38064	Rvr	273891.7	2455500	2.239989
Rvr	271886.6	2455000	0.77382	Rvr	274393	2455500	2.538591
Rvr	272387.9	2455000	1.159979	Rvr	274894.3	2455500	2.814582
Rvr	272889.2	2455000	1.532087	Rvr	275395.5	2455500	3.069775
Rvr	273390.4	2455000	1.879343	Rvr	275896.8	2455500	3.304868
Rvr	273891.7	2455000	2.19658	Rvr	276398.1	2455500	3.519603
Rvr	274393	2455000	2.481243	Rvr	248828	2456000	-3.96509
Rvr	274894.3	2455000	2.739429	Rvr	249329.3	2456000	-3.96827
Rvr	275395.5	2455000	2.976247	Rvr	249830.6	2456000	-3.98667
Rvr	275896.8	2455000	3.193973	Rvr	262362.4	2456000	-4.63185
Rvr	276398.1	2455000	3.393113	Rvr	262863.7	2456000	-4.46491

Rvr	263365	2456000	-4.28896	Rvr	263365	2456500	-4.35453
Rvr	263866.3	2456000	-4.10426	Rvr	263866.3	2456500	-4.16275
Rvr	264367.5	2456000	-3.9109	Rvr	264367.5	2456500	-3.96217
Rvr	264868.8	2456000	-3.70865	Rvr	264868.8	2456500	-3.75249
Rvr	265370.1	2456000	-3.49692	Rvr	265370.1	2456500	-3.53306
Rvr	265871.3	2456000	-3.27458	Rvr	265871.3	2456500	-3.30276
Rvr	266372.6	2456000	-3.03975	Rvr	266372.6	2456500	-3.05988
Rvr	266873.9	2456000	-2.78955	Rvr	266873.9	2456500	-2.80199
Rvr	267375.2	2456000	-2.5202	Rvr	267375.2	2456500	-2.52585
Rvr	267876.4	2456000	-2.22786	Rvr	267876.4	2456500	-2.22573
Rvr	268377.7	2456000	-1.89859	Rvr	268377.7	2456500	-1.89461
Rvr	268879	2456000	-1.54538	Rvr	268879	2456500	-1.5391
Rvr	269380.3	2456000	-1.17364	Rvr	269380.3	2456500	-1.1664
Rvr	269881.5	2456000	-0.78866	Rvr	269881.5	2456500	-0.78116
Rvr	270382.8	2456000	-0.39505	Rvr	270382.8	2456500	-0.38736
Rvr	270884.1	2456000	0.003436	Rvr	270884.1	2456500	0.011545
Rvr	271385.3	2456000	0.4036	Rvr	271385.3	2456500	0.412501
Rvr	271886.6	2456000	0.802394	Rvr	271886.6	2456500	0.812756
Rvr	272387.9	2456000	1.196512	Rvr	272387.9	2456500	1.209677
Rvr	272889.2	2456000	1.581746	Rvr	272889.2	2456500	1.599788
Rvr	273390.4	2456000	1.949795	Rvr	273390.4	2456500	1.973934
Rvr	273891.7	2456000	2.283752	Rvr	273891.7	2456500	2.322842
Rvr	274393	2456000	2.596283	Rvr	274393	2456500	2.652681
Rvr	274894.3	2456000	2.889811	Rvr	274894.3	2456500	2.965415
Rvr	275395.5	2456000	3.16375	Rvr	275395.5	2456500	3.259295
Rvr	275896.8	2456000	3.417128	Rvr	275896.8	2456500	3.532132
Rvr	276398.1	2456000	3.648655	Rvr	276398.1	2456500	3.78169
Rvr	248326.8	2456500	-3.92707	Rvr	247825.5	2457000	-3.92119
Rvr	248828	2456500	-3.90106	Rvr	248326.8	2457000	-3.86594
Rvr	249329.3	2456500	-3.89279	Rvr	248828	2457000	-3.8265
Rvr	249830.6	2456500	-3.90324	Rvr	249329.3	2457000	-3.80594
Rvr	250331.8	2456500	-3.93492	Rvr	249830.6	2457000	-3.80646
Rvr	261359.9	2456500	-5.0305	Rvr	250331.8	2457000	-3.83107
Rvr	261861.1	2456500	-4.87604	Rvr	250833.1	2457000	-3.88343
Rvr	262362.4	2456500	-4.7115	Rvr	260858.6	2457000	-5.27222
Rvr	262863.7	2456500	-4.53752	Rvr	261359.9	2457000	-5.12089

Rvr	261861.1	2457000	-4.95889	Rvr	250833.1	2457500	-3.75667
Rvr	262362.4	2457000	-4.78699	Rvr	251334.4	2457500	-3.83899
Rvr	262863.7	2457000	-4.60577	Rvr	260357.3	2457500	-5.51385
Rvr	263365	2457000	-4.41561	Rvr	260858.6	2457500	-5.36588
Rvr	263866.3	2457000	-4.21666	Rvr	261359.9	2457500	-5.2066
Rvr	264367.5	2457000	-4.00886	Rvr	261861.1	2457500	-5.03694
Rvr	264868.8	2457000	-3.79189	Rvr	262362.4	2457500	-4.85761
Rvr	265370.1	2457000	-3.56512	Rvr	262863.7	2457500	-4.66913
Rvr	265871.3	2457000	-3.3275	Rvr	263365	2457500	-4.4718
Rvr	266372.6	2457000	-3.07753	Rvr	263866.3	2457500	-4.26575
Rvr	266873.9	2457000	-2.81307	Rvr	264367.5	2457500	-4.05088
Rvr	267375.2	2457000	-2.53125	Rvr	264868.8	2457500	-3.82687
Rvr	267876.4	2457000	-2.22864	Rvr	265370.1	2457500	-3.59315
Rvr	268377.7	2457000	-1.89172	Rvr	265871.3	2457500	-3.34881
Rvr	268879	2457000	-1.53367	Rvr	266372.6	2457500	-3.09254
Rvr	269380.3	2457000	-1.15965	Rvr	266873.9	2457500	-2.82244
Rvr	269881.5	2457000	-0.77382	Rvr	267375.2	2457500	-2.53544
Rvr	270382.8	2457000	-0.37981	Rvr	267876.4	2457500	-2.22595
Rvr	270884.1	2457000	0.019221	Rvr	268377.7	2457500	-1.88845
Rvr	271385.3	2457000	0.420374	Rvr	268879	2457500	-1.52842
Rvr	271886.6	2457000	0.821002	Rvr	269380.3	2457500	-1.15285
Rvr	272387.9	2457000	1.218886	Rvr	269881.5	2457500	-0.76624
Rvr	272889.2	2457000	1.613034	Rvr	270382.8	2457500	-0.37193
Rvr	273390.4	2457000	1.999278	Rvr	270884.1	2457500	0.027188
Rvr	273891.7	2457000	2.358416	Rvr	271385.3	2457500	0.428401
Rvr	274393	2457000	2.707749	Rvr	271886.6	2457500	0.828921
Rvr	274894.3	2457000	3.041901	Rvr	272387.9	2457500	1.225742
Rvr	275395.5	2457000	3.357265	Rvr	272889.2	2457500	1.616426
Rvr	275896.8	2457000	3.650884	Rvr	273390.4	2457500	2.003397
Rvr	247324.2	2457500	-3.93173	Rvr	273891.7	2457500	2.38887
Rvr	247825.5	2457500	-3.85632	Rvr	274393	2457500	2.763045
Rvr	248326.8	2457500	-3.79034	Rvr	274894.3	2457500	3.120487
Rvr	248828	2457500	-3.73909	Rvr	275395.5	2457500	3.45843
Rvr	249329.3	2457500	-3.7064	Rvr	275896.8	2457500	3.773967
Rvr	249830.6	2457500	-3.69565	Rvr	246822.9	2458000	-3.94841
Rvr	250331.8	2457500	-3.71078	Rvr	247324.2	2458000	-3.86291

Rvr	247825.5	2458000	-3.77832	Rvr	271385.3	2458000	0.438008
Rvr	248326.8	2458000	-3.70229	Rvr	271886.6	2458000	0.839582
Rvr	248828	2458000	-3.63987	Rvr	272387.9	2458000	1.237485
Rvr	249329.3	2458000	-3.59505	Rvr	272889.2	2458000	1.626103
Rvr	249830.6	2458000	-3.57182	Rvr	273390.4	2458000	2.009597
Rvr	250331.8	2458000	-3.57492	Rvr	273891.7	2458000	2.425781
Rvr	250833.1	2458000	-3.6105	Rvr	274393	2458000	2.823153
Rvr	251334.4	2458000	-3.68644	Rvr	274894.3	2458000	3.202718
Rvr	251835.7	2458000	-3.8119	Rvr	275395.5	2458000	3.563087
Rvr	252336.9	2458000	-3.9951	Rvr	275896.8	2458000	3.901218
Rvr	258352.2	2458000	-6.09865	Rvr	246321.7	2458500	-3.96627
Rvr	258853.5	2458000	-6.00069	Rvr	246822.9	2458500	-3.8781
Rvr	259354.8	2458000	-5.88504	Rvr	247324.2	2458500	-3.78246
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Rvr	262863.7	2458000	-4.72704	Rvr	250833.1	2458500	-3.44758
Rvr	263365	2458000	-4.5227	Rvr	251334.4	2458500	-3.5106
Rvr	263866.3	2458000	-4.30974	Rvr	251835.7	2458500	-3.62964
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Rvr	264868.8	2458000	-3.8573	Rvr	252838.2	2458500	-4.09381
Rvr	265370.1	2458000	-3.617	Rvr	253339.5	2458500	-4.44204
Rvr	265871.3	2458000	-3.36638	Rvr	255845.9	2458500	-6.28841
Rvr	266372.6	2458000	-3.10442	Rvr	256347.1	2458500	-6.40757
Rvr	266873.9	2458000	-2.8296	Rvr	256848.4	2458500	-6.42023
Rvr	267375.2	2458000	-2.53935	Rvr	257349.7	2458500	-6.38339
Rvr	267876.4	2458000	-2.22837	Rvr	257851	2458500	-6.31601
Rvr	268377.7	2458000	-1.88608	Rvr	258352.2	2458500	-6.22562
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Rvr	269380.3	2458000	-1.14516	Rvr	259354.8	2458500	-5.99073
Rvr	269881.5	2458000	-0.75767	Rvr	259856	2458500	-5.85089
Rvr	270382.8	2458000	-0.36306	Rvr	260357.3	2458500	-5.69831
Rvr	270884.1	2458000	0.036276	Rvr	260858.6	2458500	-5.5342

Rvr	261359.9	2458500	-5.35954	Rvr	249329.3	2459000	-3.35031
Rvr	261861.1	2458500	-5.17509	Rvr	249830.6	2459000	-3.30007
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Rvr	264868.8	2458500	-3.88296	Rvr	252838.2	2459000	-3.90751
Rvr	265370.1	2458500	-3.63641	Rvr	253339.5	2459000	-4.31845
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Rvr	266372.6	2458500	-3.11228	Rvr	254342	2459000	-5.28488
Rvr	266873.9	2458500	-2.8329	Rvr	254843.3	2459000	-5.75348
Rvr	267375.2	2458500	-2.54035	Rvr	255344.6	2459000	-6.17471
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Rvr	268377.7	2458500	-1.88178	Rvr	256347.1	2459000	-6.59988
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Rvr	269380.3	2458500	-1.1353	Rvr	257349.7	2459000	-6.51799
Rvr	269881.5	2458500	-0.74731	Rvr	257851	2459000	-6.43764
Rvr	270382.8	2458500	-0.35259	Rvr	258352.2	2459000	-6.337
Rvr	270884.1	2458500	0.046976	Rvr	258853.5	2459000	-6.21876
Rvr	271385.3	2458500	0.449758	Rvr	259354.8	2459000	-6.08502
Rvr	271886.6	2458500	0.854341	Rvr	259856	2459000	-5.93748
Rvr	272387.9	2458500	1.259276	Rvr	260357.3	2459000	-5.77753
Rvr	272889.2	2458500	1.662714	Rvr	260858.6	2459000	-5.6063
Rvr	273390.4	2458500	2.067369	Rvr	261359.9	2459000	-5.42473
Rvr	273891.7	2458500	2.480753	Rvr	261861.1	2459000	-5.23354
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Rvr	274894.3	2458500	3.288476	Rvr	262863.7	2459000	-4.82437
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Rvr	246822.9	2459000	-3.79395	Rvr	264868.8	2459000	-3.90365
Rvr	247324.2	2459000	-3.69318	Rvr	265370.1	2459000	-3.65118
Rvr	247825.5	2459000	-3.59383	Rvr	265871.3	2459000	-3.38875
Rvr	248326.8	2459000	-3.50097	Rvr	266372.6	2459000	-3.11547
Rvr	248828	2459000	-3.41858	Rvr	266873.9	2459000	-2.83025

Rvr	267375.2	2459000	-2.53227	Rvr	253840.8	2459500	-4.7428
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Rvr	269881.5	2459000	-0.73449	Rvr	256347.1	2459500	-6.68347
Rvr	270382.8	2459000	-0.34013	Rvr	256848.4	2459500	-6.67263
Rvr	270884.1	2459000	0.059302	Rvr	257349.7	2459500	-6.61736
Rvr	271385.3	2459000	0.462812	Rvr	257851	2459500	-6.53418
Rvr	271886.6	2459000	0.870334	Rvr	258352.2	2459500	-6.4291
Rvr	272387.9	2459000	1.283338	Rvr	258853.5	2459500	-6.30557
Rvr	272889.2	2459000	1.705449	Rvr	259354.8	2459500	-6.16607
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Rvr	273891.7	2459000	2.539159	Rvr	260357.3	2459500	-5.84641
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Rvr	274894.3	2459000	3.37465	Rvr	261359.9	2459500	-5.48125
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Rvr	246822.9	2459500	-3.7061	Rvr	264868.8	2459500	-3.91924
Rvr	247324.2	2459500	-3.59983	Rvr	265370.1	2459500	-3.66126
Rvr	247825.5	2459500	-3.49501	Rvr	265871.3	2459500	-3.39336
Rvr	248326.8	2459500	-3.39566	Rvr	266372.6	2459500	-3.1145
Rvr	248828	2459500	-3.30529	Rvr	266873.9	2459500	-2.82283
Rvr	249329.3	2459500	-3.22719	Rvr	267375.2	2459500	-2.51441
Rvr	249830.6	2459500	-3.16478	Rvr	267876.4	2459500	-2.18471
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Rvr	251835.7	2459500	-3.18694	Rvr	269881.5	2459500	-0.71892
Rvr	252336.9	2459500	-3.34638	Rvr	270382.8	2459500	-0.32536
Rvr	252838.2	2459500	-3.67545	Rvr	270884.1	2459500	0.073271
Rvr	253339.5	2459500	-4.17328	Rvr	271385.3	2459500	0.476204

Rvr	271886.6	2459500	0.88383	Rvr	254342	2460000	-5.35782
Rvr	272387.9	2459500	1.298249	Rvr	254843.3	2460000	-5.92985
Rvr	272889.2	2459500	1.722845	Rvr	255344.6	2460000	-6.35757
Rvr	273390.4	2459500	2.15234	Rvr	255845.9	2460000	-6.61015
Rvr	273891.7	2459500	2.58514	Rvr	256347.1	2460000	-6.71202
Rvr	274393	2459500	3.022863	Rvr	256848.4	2460000	-6.7249
Rvr	274894.3	2459500	3.457139	Rvr	257349.7	2460000	-6.68327
Rvr	275395.5	2459500	3.88042	Rvr	257851	2460000	-6.60557
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Rvr	276899.4	2459500	5.022872	Rvr	258853.5	2460000	-6.37596
Rvr	279405.7	2459500	5.827343	Rvr	259354.8	2460000	-6.23307
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Rvr	281410.8	2459500	5.601803	Rvr	261359.9	2460000	-5.52853
Rvr	281912.1	2459500	5.523664	Rvr	261861.1	2460000	-5.32582
Rvr	283917.2	2459500	5.05632	Rvr	262362.4	2460000	-5.11413
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Rvr	246321.7	2460000	-3.72727	Rvr	264367.5	2460000	-4.18343
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Rvr	247825.5	2460000	-3.39696	Rvr	265871.3	2460000	-3.39386
Rvr	248326.8	2460000	-3.2928	Rvr	266372.6	2460000	-3.11035
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Rvr	249329.3	2460000	-3.11134	Rvr	267375.2	2460000	-2.50439
Rvr	249830.6	2460000	-3.0401	Rvr	267876.4	2460000	-2.17574
Rvr	250331.8	2460000	-2.98636	Rvr	268377.7	2460000	-1.82895
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Rvr	252336.9	2460000	-3.06259	Rvr	270382.8	2460000	-0.30776
Rvr	252838.2	2460000	-3.40736	Rvr	270884.1	2460000	0.089563
Rvr	253339.5	2460000	-4.0441	Rvr	271385.3	2460000	0.49063
Rvr	253840.8	2460000	-4.71305	Rvr	271886.6	2460000	0.895492

Rvr	272387.9	2460000	1.305277	Rvr	250331.8	2460500	-2.87493
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Rvr	273390.4	2460000	2.161615	Rvr	251334.4	2460500	-2.83325
Rvr	273891.7	2460000	2.619465	Rvr	251835.7	2460500	-2.86542
Rvr	274393	2460000	3.079254	Rvr	252336.9	2460500	-2.95697
Rvr	274894.3	2460000	3.533657	Rvr	252838.2	2460500	-3.32808
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Rvr	275896.8	2460000	4.403018	Rvr	253840.8	2460500	-4.7312
Rvr	276398.1	2460000	4.806734	Rvr	254342	2460500	-5.42711
Rvr	276899.4	2460000	5.181739	Rvr	254843.3	2460500	-6.06357
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Rvr	278403.2	2460000	6.013499	Rvr	256347.1	2460500	-6.72497
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Rvr	280408.3	2460000	5.852216	Rvr	258352.2	2460500	-6.55574
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Rvr	282413.4	2460000	5.499138	Rvr	260357.3	2460500	-5.95069
Rvr	282914.7	2460000	5.421344	Rvr	260858.6	2460500	-5.76383
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Rvr	283917.2	2460000	5.112877	Rvr	261861.1	2460500	-5.35875
Rvr	284418.5	2460000	4.948629	Rvr	262362.4	2460500	-5.14228
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Rvr	245319.1	2460500	-3.85361	Rvr	263365	2460500	-4.68403
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Rvr	246321.7	2460500	-3.64177	Rvr	264367.5	2460500	-4.19294
Rvr	246822.9	2460500	-3.52835	Rvr	264868.8	2460500	-3.93467
Rvr	247324.2	2460500	-3.4145	Rvr	265370.1	2460500	-3.6673
Rvr	247825.5	2460500	-3.30281	Rvr	265871.3	2460500	-3.39018
Rvr	248326.8	2460500	-3.19594	Rvr	266372.6	2460500	-3.10266
Rvr	248828	2460500	-3.09666	Rvr	266873.9	2460500	-2.80442
Rvr	249329.3	2460500	-3.00783	Rvr	267375.2	2460500	-2.49619
Rvr	249830.6	2460500	-2.93265	Rvr	267876.4	2460500	-2.17553

Rvr	268377.7	2460500	-1.81396	Rvr	245820.4	2461000	-3.66728
Rvr	268879	2460500	-1.44376	Rvr	246321.7	2461000	-3.55624
Rvr	269380.3	2460500	-1.0649	Rvr	246822.9	2461000	-3.44186
Rvr	269881.5	2460500	-0.67852	Rvr	247324.2	2461000	-3.32722
Rvr	270382.8	2460500	-0.28645	Rvr	247825.5	2461000	-3.215
Rvr	270884.1	2460500	0.109635	Rvr	248326.8	2461000	-3.10782
Rvr	271385.3	2460500	0.50855	Rvr	248828	2461000	-3.00848
Rvr	271886.6	2460500	0.910058	Rvr	249329.3	2461000	-2.92006
Rvr	272387.9	2460500	1.315365	Rvr	249830.6	2461000	-2.84625
Rvr	272889.2	2460500	1.727412	Rvr	250331.8	2461000	-2.79204
Rvr	273390.4	2460500	2.173918	Rvr	250833.1	2461000	-2.76502
Rvr	273891.7	2460500	2.652969	Rvr	251334.4	2461000	-2.77828
Rvr	274393	2460500	3.13191	Rvr	251835.7	2461000	-2.85839
Rvr	274894.3	2460500	3.604159	Rvr	252336.9	2461000	-3.06601
Rvr	275395.5	2460500	4.064274	Rvr	252838.2	2461000	-3.48586
Rvr	275896.8	2460500	4.507059	Rvr	253339.5	2461000	-4.09863
Rvr	276398.1	2460500	4.926519	Rvr	253840.8	2461000	-4.78811
Rvr	276899.4	2460500	5.314563	Rvr	254342	2461000	-5.48388
Rvr	277400.6	2460500	5.660438	Rvr	254843.3	2461000	-6.14665
Rvr	277901.9	2460500	5.951048	Rvr	255344.6	2461000	-6.60028
Rvr	278403.2	2460500	6.118147	Rvr	255845.9	2461000	-6.65865
Rvr	278904.5	2460500	6.121274	Rvr	256347.1	2461000	-6.73915
Rvr	279405.7	2460500	6.077702	Rvr	256848.4	2461000	-6.775
Rvr	279907	2460500	6.013699	Rvr	257349.7	2461000	-6.75602
Rvr	280408.3	2460500	5.934422	Rvr	257851	2461000	-6.69287
Rvr	280909.6	2460500	5.842824	Rvr	258352.2	2461000	-6.59562
Rvr	281410.8	2460500	5.741188	Rvr	258853.5	2461000	-6.47171
Rvr	281912.1	2460500	5.630598	Rvr	259354.8	2461000	-6.32642
Rvr	282413.4	2460500	5.508231	Rvr	259856	2461000	-6.16355
Rvr	282914.7	2460500	5.400584	Rvr	260357.3	2461000	-5.9859
Rvr	283415.9	2460500	5.288657	Rvr	260858.6	2461000	-5.79553
Rvr	283917.2	2460500	5.146973	Rvr	261359.9	2461000	-5.594
Rvr	284418.5	2460500	4.99149	Rvr	261861.1	2461000	-5.38249
Rvr	284919.8	2460500	4.82561	Rvr	262362.4	2461000	-5.16185
Rvr	244817.8	2461000	-3.86372	Rvr	262863.7	2461000	-4.93268
Rvr	245319.1	2461000	-3.77102	Rvr	263365	2461000	-4.69532

Rvr	263866.3	2461000	-4.44992	Rvr	283415.9	2461000	5.302393
Rvr	264367.5	2461000	-4.19636	Rvr	283917.2	2461000	5.170672
Rvr	264868.8	2461000	-3.93432	Rvr	284418.5	2461000	5.025575
Rvr	265370.1	2461000	-3.66321	Rvr	284919.8	2461000	4.866982
Rvr	265871.3	2461000	-3.38224	Rvr	244316.6	2461500	-3.88109
Rvr	266372.6	2461000	-3.09051	Rvr	244817.8	2461500	-3.79053
Rvr	266873.9	2461000	-2.78745	Rvr	245319.1	2461500	-3.69167
Rvr	267375.2	2461000	-2.47302	Rvr	245820.4	2461500	-3.58541
Rvr	267876.4	2461000	-2.14249	Rvr	246321.7	2461500	-3.47388
Rvr	268377.7	2461000	-1.78745	Rvr	246822.9	2461500	-3.35986
Rvr	270382.8	2461000	-0.26042	Rvr	247324.2	2461500	-3.24612
Rvr	270884.1	2461000	0.135226	Rvr	247825.5	2461500	-3.13533
Rvr	271385.3	2461000	0.532845	Rvr	248326.8	2461500	-3.03024
Rvr	271886.6	2461000	0.931959	Rvr	248828	2461500	-2.93384
Rvr	272387.9	2461000	1.335129	Rvr	249329.3	2461500	-2.84958
Rvr	272889.2	2461000	1.753368	Rvr	249830.6	2461500	-2.78183
Rvr	273390.4	2461000	2.207145	Rvr	250331.8	2461500	-2.73677
Rvr	273891.7	2461000	2.692219	Rvr	250833.1	2461500	-2.72435
Rvr	274393	2461000	3.184058	Rvr	251334.4	2461500	-2.76235
Rvr	274894.3	2461000	3.669454	Rvr	251835.7	2461500	-2.88195
Rvr	275395.5	2461000	4.141933	Rvr	252336.9	2461500	-3.15981
Rvr	275896.8	2461000	4.596378	Rvr	252838.2	2461500	-3.62118
Rvr	276398.1	2461000	5.026441	Rvr	253339.5	2461500	-4.20529
Rvr	276899.4	2461000	5.421212	Rvr	253840.8	2461500	-4.85282
Rvr	277400.6	2461000	5.758235	Rvr	254342	2461500	-5.50234
Rvr	277901.9	2461000	6.00182	Rvr	254843.3	2461500	-6.0844
Rvr	278403.2	2461000	6.126493	Rvr	255344.6	2461500	-6.47627
Rvr	278904.5	2461000	6.156305	Rvr	255845.9	2461500	-6.63893
Rvr	279405.7	2461000	6.130495	Rvr	256347.1	2461500	-6.75224
Rvr	279907	2461000	6.071225	Rvr	256848.4	2461500	-6.79381
Rvr	280408.3	2461000	5.989579	Rvr	257349.7	2461500	-6.77884
Rvr	280909.6	2461000	5.891495	Rvr	257851	2461500	-6.71907
Rvr	281410.8	2461000	5.780872	Rvr	258352.2	2461500	-6.62393
Rvr	281912.1	2461000	5.660953	Rvr	258853.5	2461500	-6.50067
Rvr	282413.4	2461000	5.537452	Rvr	259354.8	2461500	-6.35475
Rvr	282914.7	2461000	5.421742	Rvr	259856	2461500	-6.19022

Rvr	260357.3	2461500	-6.01013	Rvr	281410.8	2461500	5.80574
Rvr	260858.6	2461500	-5.81679	Rvr	281912.1	2461500	5.679799
Rvr	261359.9	2461500	-5.61194	Rvr	282413.4	2461500	5.550916
Rvr	261861.1	2461500	-5.3969	Rvr	282914.7	2461500	5.429619
Rvr	262362.4	2461500	-5.17264	Rvr	283415.9	2461500	5.312282
Rvr	262863.7	2461500	-4.93986	Rvr	283917.2	2461500	5.190042
Rvr	263365	2461500	-4.69899	Rvr	284418.5	2461500	5.055805
Rvr	263866.3	2461500	-4.45021	Rvr	284919.8	2461500	4.906305
Rvr	264367.5	2461500	-4.19348	Rvr	285421	2461500	4.738977
Rvr	264868.8	2461500	-3.92845	Rvr	243815.3	2462000	-3.90436
Rvr	265370.1	2461500	-3.65447	Rvr	244316.6	2462000	-3.81486
Rvr	265871.3	2461500	-3.37047	Rvr	244817.8	2462000	-3.71835
Rvr	266372.6	2461500	-3.07494	Rvr	245319.1	2462000	-3.61566
Rvr	266873.9	2461500	-2.76585	Rvr	245820.4	2462000	-3.50784
Rvr	267375.2	2461500	-2.44163	Rvr	246321.7	2462000	-3.39653
Rvr	267876.4	2461500	-2.10493	Rvr	246822.9	2462000	-3.28393
Rvr	271385.3	2461500	0.56598	Rvr	247324.2	2462000	-3.17251
Rvr	271886.6	2461500	0.964398	Rvr	247825.5	2462000	-3.06493
Rvr	272387.9	2461500	1.363703	Rvr	248326.8	2462000	-2.9641
Rvr	272889.2	2461500	1.774449	Rvr	248828	2462000	-2.87332
Rvr	273390.4	2461500	2.236358	Rvr	249329.3	2462000	-2.7965
Rvr	273891.7	2461500	2.735868	Rvr	249830.6	2462000	-2.7386
Rvr	274393	2461500	3.237404	Rvr	250331.8	2462000	-2.70641
Rvr	274894.3	2461500	3.73029	Rvr	250833.1	2462000	-2.71042
Rvr	275395.5	2461500	4.209197	Rvr	251334.4	2462000	-2.76973
Rvr	275896.8	2461500	4.669372	Rvr	251835.7	2462000	-2.92686
Rvr	276398.1	2461500	5.104914	Rvr	252336.9	2462000	-3.25328
Rvr	276899.4	2461500	5.506301	Rvr	252838.2	2462000	-3.7356
Rvr	277400.6	2461500	5.84885	Rvr	253339.5	2462000	-4.30625
Rvr	277901.9	2461500	6.045604	Rvr	253840.8	2462000	-4.91657
Rvr	278403.2	2461500	6.116289	Rvr	254342	2462000	-5.5172
Rvr	278904.5	2461500	6.164906	Rvr	254843.3	2462000	-6.052
Rvr	279405.7	2461500	6.154698	Rvr	255344.6	2462000	-6.45783
Rvr	279907	2461500	6.103333	Rvr	255845.9	2462000	-6.6726
Rvr	280408.3	2461500	6.023025	Rvr	256347.1	2462000	-6.77459
Rvr	280909.6	2461500	5.921884	Rvr	256848.4	2462000	-6.81252

Rvr	257349.7	2462000	-6.79681	Rvr	278904.5	2462000	6.172126
Rvr	257851	2462000	-6.73741	Rvr	279405.7	2462000	6.167021
Rvr	258352.2	2462000	-6.64261	Rvr	279907	2462000	6.120245
Rvr	258853.5	2462000	-6.51912	Rvr	280408.3	2462000	6.041182
Rvr	259354.8	2462000	-6.37223	Rvr	280909.6	2462000	5.938259
Rvr	259856	2462000	-6.20605	Rvr	281410.8	2462000	5.818329
Rvr	260357.3	2462000	-6.02375	Rvr	281912.1	2462000	5.687392
Rvr	260858.6	2462000	-5.82778	Rvr	282413.4	2462000	5.550471
Rvr	261359.9	2462000	-5.62002	Rvr	282914.7	2462000	5.417811
Rvr	261861.1	2462000	-5.4019	Rvr	283415.9	2462000	5.317614
Rvr	262362.4	2462000	-5.1745	Rvr	283917.2	2462000	5.207583
Rvr	262863.7	2462000	-4.93861	Rvr	284418.5	2462000	5.085105
Rvr	263365	2462000	-4.69475	Rvr	284919.8	2462000	4.9464
Rvr	263866.3	2462000	-4.4432	Rvr	285421	2462000	4.786919
Rvr	264367.5	2462000	-4.18397	Rvr	289431.2	2462000	2.89567
Rvr	264868.8	2462000	-3.9168	Rvr	289932.5	2462000	2.655014
Rvr	265370.1	2462000	-3.64105	Rvr	290433.8	2462000	2.417432
Rvr	265871.3	2462000	-3.35555	Rvr	290935	2462000	2.184867
Rvr	266372.6	2462000	-3.05835	Rvr	291436.3	2462000	1.959024
Rvr	266873.9	2462000	-2.74628	Rvr	243314	2462500	-3.9288
Rvr	267375.2	2462000	-2.41461	Rvr	243815.3	2462500	-3.84164
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Rvr	271886.6	2462000	1.011575	Rvr	244817.8	2462500	-3.64757
Rvr	272387.9	2462000	1.412673	Rvr	245319.1	2462500	-3.54315
Rvr	272889.2	2462000	1.812068	Rvr	245820.4	2462500	-3.43515
Rvr	273390.4	2462000	2.282624	Rvr	246321.7	2462500	-3.3251
Rvr	273891.7	2462000	2.791209	Rvr	246822.9	2462500	-3.21497
Rvr	274393	2462000	3.294127	Rvr	247324.2	2462500	-3.10712
Rvr	274894.3	2462000	3.787146	Rvr	247825.5	2462500	-3.00426
Rvr	275395.5	2462000	4.265749	Rvr	248326.8	2462500	-2.90951
Rvr	275896.8	2462000	4.724749	Rvr	248828	2462500	-2.82655
Rvr	276398.1	2462000	5.157741	Rvr	249329.3	2462500	-2.75985
Rvr	276899.4	2462000	5.556508	Rvr	249830.6	2462500	-2.71498
Rvr	277400.6	2462000	5.910149	Rvr	250331.8	2462500	-2.69909
Rvr	277901.9	2462000	6.094888	Rvr	250833.1	2462500	-2.72193
Rvr	278403.2	2462000	6.135116	Rvr	251334.4	2462500	-2.79767

Rvr	251835.7	2462500	-2.95542	Rvr	273891.7	2462500	2.861778
Rvr	252336.9	2462500	-3.34088	Rvr	274393	2462500	3.35362
Rvr	252838.2	2462500	-3.84684	Rvr	274894.3	2462500	3.839315
Rvr	253339.5	2462500	-4.40624	Rvr	275395.5	2462500	4.311638
Rvr	253840.8	2462500	-4.98574	Rvr	275896.8	2462500	4.763419
Rvr	254342	2462500	-5.54813	Rvr	276398.1	2462500	5.185573
Rvr	254843.3	2462500	-6.05395	Rvr	276899.4	2462500	5.56414
Rvr	255344.6	2462500	-6.46673	Rvr	277400.6	2462500	5.870221
Rvr	255845.9	2462500	-6.69724	Rvr	277901.9	2462500	6.045641
Rvr	256347.1	2462500	-6.79405	Rvr	278403.2	2462500	6.130282
Rvr	256848.4	2462500	-6.8275	Rvr	278904.5	2462500	6.178689
Rvr	257349.7	2462500	-6.80938	Rvr	279405.7	2462500	6.174951
Rvr	257851	2462500	-6.74855	Rvr	279907	2462500	6.128729
Rvr	258352.2	2462500	-6.65264	Rvr	280408.3	2462500	6.049181
Rvr	258853.5	2462500	-6.52796	Rvr	280909.6	2462500	5.944415
Rvr	259354.8	2462500	-6.37958	Rvr	281410.8	2462500	5.821567
Rvr	259856	2462500	-6.21157	Rvr	281912.1	2462500	5.687948
Rvr	260357.3	2462500	-6.0271	Rvr	282413.4	2462500	5.553066
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Rvr	261359.9	2462500	-5.6183	Rvr	283415.9	2462500	5.327003
Rvr	261861.1	2462500	-5.39745	Rvr	283917.2	2462500	5.22502
Rvr	262362.4	2462500	-5.1673	Rvr	284418.5	2462500	5.114234
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Rvr	263866.3	2462500	-4.42851	Rvr	288929.9	2462500	3.115647
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Rvr	264868.8	2462500	-3.89883	Rvr	289932.5	2462500	2.629999
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Rvr	265871.3	2462500	-3.33717	Rvr	290935	2462500	2.149121
Rvr	266372.6	2462500	-3.04145	Rvr	291436.3	2462500	1.913916
Rvr	266873.9	2462500	-2.73259	Rvr	291937.6	2462500	1.684468
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Rvr	272387.9	2462500	1.489336	Rvr	243815.3	2463000	-3.77404
Rvr	272889.2	2462500	1.917517	Rvr	244316.6	2463000	-3.67909
Rvr	273390.4	2462500	2.375356	Rvr	244817.8	2463000	-3.57873

Rvr	245319.1	2463000	-3.47448	Rvr	263365	2463000	-4.66145
Rvr	245820.4	2463000	-3.36771	Rvr	263866.3	2463000	-4.40571
Rvr	246321.7	2463000	-3.26002	Rvr	264367.5	2463000	-4.14308
Rvr	246822.9	2463000	-3.1534	Rvr	264868.8	2463000	-3.87364
Rvr	247324.2	2463000	-3.0502	Rvr	265370.1	2463000	-3.59722
Rvr	247825.5	2463000	-2.95325	Rvr	265871.3	2463000	-3.31336
Rvr	248326.8	2463000	-2.86594	Rvr	266372.6	2463000	-3.02109
Rvr	248828	2463000	-2.79239	Rvr	266873.9	2463000	-2.71862
Rvr	249329.3	2463000	-2.73775	Rvr	267375.2	2463000	-2.40317
Rvr	249830.6	2463000	-2.70852	Rvr	267876.4	2463000	-2.06061
Rvr	250331.8	2463000	-2.71283	Rvr	273390.4	2463000	2.462426
Rvr	250833.1	2463000	-2.76122	Rvr	273891.7	2463000	2.932096
Rvr	251334.4	2463000	-2.87138	Rvr	274393	2463000	3.409726
Rvr	251835.7	2463000	-3.08405	Rvr	274894.3	2463000	3.884333
Rvr	252336.9	2463000	-3.47563	Rvr	275395.5	2463000	4.347065
Rvr	252838.2	2463000	-3.97393	Rvr	275896.8	2463000	4.788999
Rvr	253339.5	2463000	-4.5144	Rvr	276398.1	2463000	5.198892
Rvr	253840.8	2463000	-5.06562	Rvr	276899.4	2463000	5.560496
Rvr	254342	2463000	-5.59579	Rvr	277400.6	2463000	5.849926
Rvr	254843.3	2463000	-6.0698	Rvr	277901.9	2463000	6.04353
Rvr	255344.6	2463000	-6.44715	Rvr	278403.2	2463000	6.14698
Rvr	255845.9	2463000	-6.68596	Rvr	278904.5	2463000	6.188959
Rvr	256347.1	2463000	-6.80018	Rvr	279405.7	2463000	6.180867
Rvr	256848.4	2463000	-6.83557	Rvr	279907	2463000	6.131678
Rvr	257349.7	2463000	-6.81558	Rvr	280408.3	2463000	6.04997
Rvr	257851	2463000	-6.75244	Rvr	280909.6	2463000	5.943112
Rvr	258352.2	2463000	-6.65439	Rvr	281410.8	2463000	5.817623
Rvr	258853.5	2463000	-6.52768	Rvr	281912.1	2463000	5.680766
Rvr	259354.8	2463000	-6.37728	Rvr	282413.4	2463000	5.544876
Rvr	259856	2463000	-6.20715	Rvr	282914.7	2463000	5.429152
Rvr	260357.3	2463000	-6.02044	Rvr	283415.9	2463000	5.332336
Rvr	260858.6	2463000	-5.81967	Rvr	283917.2	2463000	5.240102
Rvr	261359.9	2463000	-5.60685	Rvr	284418.5	2463000	5.141087
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Rvr	262362.4	2463000	-5.15094	Rvr	285421	2463000	4.896664
Rvr	262863.7	2463000	-4.91002	Rvr	288929.9	2463000	3.070652

Rvr	289431.2	2463000	2.839688	Rvr	256347.1	2463500	-6.80689
Rvr	289932.5	2463000	2.604666	Rvr	256848.4	2463500	-6.83922
Rvr	290433.8	2463000	2.367311	Rvr	257349.7	2463500	-6.81567
Rvr	290935	2463000	2.127693	Rvr	257851	2463500	-6.74907
Rvr	291436.3	2463000	1.88792	Rvr	258352.2	2463500	-6.64793
Rvr	291937.6	2463000	1.649904	Rvr	258853.5	2463500	-6.51847
Rvr	292438.8	2463000	1.416427	Rvr	259354.8	2463500	-6.36554
Rvr	292940.1	2463000	1.197212	Rvr	259856	2463500	-6.193
Rvr	293441.4	2463000	1.0383	Rvr	260357.3	2463500	-6.00394
Rvr	242812.7	2463500	-3.87142	Rvr	260858.6	2463500	-5.80086
Rvr	243314	2463500	-3.79338	Rvr	261359.9	2463500	-5.58574
Rvr	243815.3	2463500	-3.70628	Rvr	261861.1	2463500	-5.36016
Rvr	244316.6	2463500	-3.61205	Rvr	262362.4	2463500	-5.12537
Rvr	244817.8	2463500	-3.51275	Rvr	262863.7	2463500	-4.88235
Rvr	245319.1	2463500	-3.41014	Rvr	263365	2463500	-4.63185
Rvr	245820.4	2463500	-3.3058	Rvr	263866.3	2463500	-4.37441
Rvr	246321.7	2463500	-3.20151	Rvr	264367.5	2463500	-4.11043
Rvr	246822.9	2463500	-3.0993	Rvr	264868.8	2463500	-3.84017
Rvr	247324.2	2463500	-3.00164	Rvr	265370.1	2463500	-3.56375
Rvr	247825.5	2463500	-2.91149	Rvr	265871.3	2463500	-3.28116
Rvr	248326.8	2463500	-2.83248	Rvr	266372.6	2463500	-2.99207
Rvr	248828	2463500	-2.76918	Rvr	266873.9	2463500	-2.69514
Rvr	249329.3	2463500	-2.72748	Rvr	267375.2	2463500	-2.38395
Rvr	249830.6	2463500	-2.71516	Rvr	267876.4	2463500	-2.03858
Rvr	250331.8	2463500	-2.74245	Rvr	274393	2463500	3.455684
Rvr	250833.1	2463500	-2.82203	Rvr	274894.3	2463500	3.919
Rvr	251334.4	2463500	-2.96982	Rvr	275395.5	2463500	4.371627
Rvr	251835.7	2463500	-3.25001	Rvr	275896.8	2463500	4.804431
Rvr	252336.9	2463500	-3.64201	Rvr	276398.1	2463500	5.206009
Rvr	252838.2	2463500	-4.1162	Rvr	276899.4	2463500	5.561429
Rvr	253339.5	2463500	-4.63203	Rvr	277400.6	2463500	5.852735
Rvr	253840.8	2463500	-5.15681	Rvr	277901.9	2463500	6.060577
Rvr	254342	2463500	-5.66066	Rvr	278403.2	2463500	6.164986
Rvr	254843.3	2463500	-6.11098	Rvr	278904.5	2463500	6.198551
Rvr	255344.6	2463500	-6.4693	Rvr	279405.7	2463500	6.182887
Rvr	255845.9	2463500	-6.69735	Rvr	279907	2463500	6.12872

Rvr	280408.3	2463500	6.044289	Rvr	249830.6	2464000	-2.72962
Rvr	280909.6	2463500	5.93609	Rvr	250331.8	2464000	-2.77901
Rvr	281410.8	2463500	5.809357	Rvr	250833.1	2464000	-2.89291
Rvr	281912.1	2463500	5.668799	Rvr	251334.4	2464000	-3.09381
Rvr	282413.4	2463500	5.521414	Rvr	251835.7	2464000	-3.40076
Rvr	282914.7	2463500	5.408842	Rvr	252336.9	2464000	-3.79807
Rvr	284919.8	2463500	5.061027	Rvr	252838.2	2464000	-4.25827
Rvr	285421	2463500	4.946454	Rvr	253339.5	2464000	-4.75292
Rvr	288428.7	2463500	3.30002	Rvr	253840.8	2464000	-5.25472
Rvr	288929.9	2463500	2.99784	Rvr	254342	2464000	-5.73787
Rvr	289431.2	2463500	2.794829	Rvr	254843.3	2464000	-6.17544
Rvr	289932.5	2463500	2.591634	Rvr	255344.6	2464000	-6.52528
Rvr	290433.8	2463500	2.362431	Rvr	255845.9	2464000	-6.72513
Rvr	290935	2463500	2.125099	Rvr	256347.1	2464000	-6.81705
Rvr	291436.3	2463500	1.886852	Rvr	256848.4	2464000	-6.8396
Rvr	291937.6	2463500	1.650017	Rvr	257349.7	2464000	-6.80971
Rvr	292940.1	2463500	1.190246	Rvr	257851	2464000	-6.73827
Rvr	293441.4	2463500	1.035769	Rvr	258352.2	2464000	-6.63315
Rvr	293942.7	2463500	1.042301	Rvr	258853.5	2464000	-6.5003
Rvr	294443.9	2463500	1.071549	Rvr	259354.8	2464000	-6.34441
Rvr	294945.2	2463500	1.10861	Rvr	259856	2464000	-6.1692
Rvr	242311.5	2464000	-3.87678	Rvr	260357.3	2464000	-5.97769
Rvr	242812.7	2464000	-3.80688	Rvr	260858.6	2464000	-5.77231
Rvr	243314	2464000	-3.7277	Rvr	261359.9	2464000	-5.55501
Rvr	243815.3	2464000	-3.64086	Rvr	261861.1	2464000	-5.32735
Rvr	244316.6	2464000	-3.54794	Rvr	262362.4	2464000	-5.09057
Rvr	244817.8	2464000	-3.45064	Rvr	262863.7	2464000	-4.84566
Rvr	245319.1	2464000	-3.35066	Rvr	263365	2464000	-4.59338
Rvr	245820.4	2464000	-3.2497	Rvr	263866.3	2464000	-4.33432
Rvr	246321.7	2464000	-3.14963	Rvr	264367.5	2464000	-4.06894
Rvr	246822.9	2464000	-3.05261	Rvr	264868.8	2464000	-3.79758
Rvr	247324.2	2464000	-2.96118	Rvr	265370.1	2464000	-3.5205
Rvr	247825.5	2464000	-2.87842	Rvr	265871.3	2464000	-3.23788
Rvr	248326.8	2464000	-2.80815	Rvr	266372.6	2464000	-2.94979
Rvr	248828	2464000	-2.75523	Rvr	266873.9	2464000	-2.65587
Rvr	249329.3	2464000	-2.72608	Rvr	267375.2	2464000	-2.35367

Rvr	275395.5	2464000	4.383684	Rvr	246321.7	2464500	-3.1044
Rvr	275896.8	2464000	4.809243	Rvr	246822.9	2464500	-3.01315
Rvr	276398.1	2464000	5.206882	Rvr	247324.2	2464500	-2.92847
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Rvr	277400.6	2464000	5.860423	Rvr	248326.8	2464500	-2.7922
Rvr	277901.9	2464000	6.077257	Rvr	248828	2464500	-2.74946
Rvr	278403.2	2464000	6.175015	Rvr	249329.3	2464500	-2.73179
Rvr	278904.5	2464000	6.200116	Rvr	249830.6	2464500	-2.74805
Rvr	279405.7	2464000	6.17631	Rvr	250331.8	2464500	-2.81238
Rvr	279907	2464000	6.117019	Rvr	250833.1	2464500	-2.95178
Rvr	280408.3	2464000	6.030812	Rvr	251334.4	2464500	-3.19515
Rvr	280909.6	2464000	5.923593	Rvr	251835.7	2464500	-3.53245
Rvr	281410.8	2464000	5.799863	Rvr	252336.9	2464500	-3.93884
Rvr	281912.1	2464000	5.663652	Rvr	252838.2	2464500	-4.39213
Rvr	282413.4	2464000	5.521674	Rvr	253339.5	2464500	-4.87053
Rvr	284919.8	2464000	5.073859	Rvr	253840.8	2464500	-5.3521
Rvr	285421	2464000	4.961723	Rvr	254342	2464500	-5.81501
Rvr	285922.3	2464000	4.81976	Rvr	254843.3	2464500	-6.23702
Rvr	288428.7	2464000	3.292181	Rvr	255344.6	2464500	-6.585
Rvr	288929.9	2464000	3.009943	Rvr	255845.9	2464500	-6.74957
Rvr	289431.2	2464000	2.828898	Rvr	256347.1	2464500	-6.8225
Rvr	289932.5	2464000	2.612447	Rvr	256848.4	2464500	-6.83416
Rvr	290433.8	2464000	2.376057	Rvr	257349.7	2464500	-6.79675
Rvr	290935	2464000	2.141629	Rvr	257851	2464500	-6.71954
Rvr	291436.3	2464000	1.911308	Rvr	258352.2	2464500	-6.60974
Rvr	294443.9	2464000	1.129759	Rvr	258853.5	2464500	-6.47298
Rvr	294945.2	2464000	1.154557	Rvr	259354.8	2464500	-6.31378
Rvr	295446.5	2464000	1.187158	Rvr	259856	2464500	-6.13572
Rvr	242311.5	2464500	-3.81666	Rvr	260357.3	2464500	-5.9417
Rvr	242812.7	2464500	-3.74463	Rvr	260858.6	2464500	-5.73408
Rvr	243314	2464500	-3.66502	Rvr	261359.9	2464500	-5.51473
Rvr	243815.3	2464500	-3.57897	Rvr	261861.1	2464500	-5.28516
Rvr	244316.6	2464500	-3.48784	Rvr	262362.4	2464500	-5.04659
Rvr	244817.8	2464500	-3.39313	Rvr	262863.7	2464500	-4.79997
Rvr	245319.1	2464500	-3.29646	Rvr	263365	2464500	-4.54604
Rvr	245820.4	2464500	-3.19957	Rvr	263866.3	2464500	-4.2854

Rvr	264367.5	2464500	-4.01848	Rvr	244817.8	2465000	-3.34064
Rvr	264868.8	2464500	-3.74558	Rvr	245319.1	2465000	-3.24779
Rvr	265370.1	2464500	-3.46689	Rvr	245820.4	2465000	-3.15547
Rvr	265871.3	2464500	-3.18244	Rvr	246321.7	2465000	-3.06568
Rvr	266372.6	2464500	-2.89192	Rvr	246822.9	2465000	-2.98069
Rvr	266873.9	2464500	-2.59406	Rvr	247324.2	2465000	-2.90319
Rvr	267375.2	2464500	-2.28325	Rvr	247825.5	2465000	-2.83639
Rvr	275896.8	2464500	4.799699	Rvr	248326.8	2465000	-2.78423
Rvr	276398.1	2464500	5.195938	Rvr	248828	2465000	-2.75168
Rvr	276899.4	2464500	5.557156	Rvr	249329.3	2465000	-2.74517
Rvr	277400.6	2464500	5.862758	Rvr	249830.6	2465000	-2.77281
Rvr	277901.9	2464500	6.078769	Rvr	250331.8	2465000	-2.84417
Rvr	278403.2	2464500	6.172881	Rvr	250833.1	2465000	-2.98424
Rvr	278904.5	2464500	6.187578	Rvr	251334.4	2465000	-3.27868
Rvr	279405.7	2464500	6.155225	Rvr	251835.7	2465000	-3.65038
Rvr	279907	2464500	6.092071	Rvr	252336.9	2465000	-4.06766
Rvr	280408.3	2464500	6.006368	Rvr	252838.2	2465000	-4.51677
Rvr	280909.6	2464500	5.903335	Rvr	253339.5	2465000	-4.98163
Rvr	281410.8	2464500	5.787345	Rvr	253840.8	2465000	-5.44406
Rvr	281912.1	2464500	5.663648	Rvr	254342	2465000	-5.88399
Rvr	284919.8	2464500	5.065519	Rvr	254843.3	2465000	-6.27693
Rvr	285421	2464500	4.940348	Rvr	255344.6	2465000	-6.58249
Rvr	285922.3	2464500	4.772848	Rvr	255845.9	2465000	-6.74911
Rvr	286423.6	2464500	4.527305	Rvr	256347.1	2465000	-6.81672
Rvr	288929.9	2464500	3.05271	Rvr	256848.4	2465000	-6.82034
Rvr	289431.2	2464500	2.883487	Rvr	257349.7	2465000	-6.77559
Rvr	289932.5	2464500	2.632845	Rvr	257851	2465000	-6.69219
Rvr	290433.8	2464500	2.396213	Rvr	258352.2	2465000	-6.57723
Rvr	294945.2	2464500	1.226737	Rvr	258853.5	2465000	-6.4362
Rvr	295446.5	2464500	1.247567	Rvr	259354.8	2465000	-6.27344
Rvr	241810.2	2465000	-3.82673	Rvr	259856	2465000	-6.09243
Rvr	242311.5	2465000	-3.75939	Rvr	260357.3	2465000	-5.89592
Rvr	242812.7	2465000	-3.68575	Rvr	260858.6	2465000	-5.68617
Rvr	243314	2465000	-3.6061	Rvr	261359.9	2465000	-5.46494
Rvr	243815.3	2465000	-3.52124	Rvr	261861.1	2465000	-5.23369
Rvr	244316.6	2465000	-3.43231	Rvr	262362.4	2465000	-4.99355

Rvr	262863.7	2465000	-4.74543	Rvr	244316.6	2465500	-3.38159
Rvr	263365	2465000	-4.49003	Rvr	244817.8	2465500	-3.29334
Rvr	263866.3	2465000	-4.22787	Rvr	245319.1	2465500	-3.20467
Rvr	264367.5	2465000	-3.95932	Rvr	245820.4	2465500	-3.11731
Rvr	264868.8	2465000	-3.68456	Rvr	246321.7	2465500	-3.03327
Rvr	265370.1	2465000	-3.40359	Rvr	246822.9	2465500	-2.95489
Rvr	265871.3	2465000	-3.11604	Rvr	247324.2	2465500	-2.88494
Rvr	266372.6	2465000	-2.82092	Rvr	247825.5	2465500	-2.82666
Rvr	276899.4	2465000	5.532286	Rvr	248326.8	2465500	-2.78401
Rvr	277400.6	2465000	5.858141	Rvr	249329.3	2465500	-2.76758
Rvr	277901.9	2465000	6.083643	Rvr	249830.6	2465500	-2.81079
Rvr	278403.2	2465000	6.156311	Rvr	250331.8	2465500	-2.9046
Rvr	278904.5	2465000	6.15212	Rvr	250833.1	2465500	-3.07493
Rvr	279405.7	2465000	6.112146	Rvr	251334.4	2465500	-3.38697
Rvr	279907	2465000	6.04847	Rvr	251835.7	2465500	-3.77068
Rvr	280408.3	2465000	5.966776	Rvr	252336.9	2465500	-4.19086
Rvr	280909.6	2465000	5.87112	Rvr	252838.2	2465500	-4.63398
Rvr	281410.8	2465000	5.765479	Rvr	253339.5	2465500	-5.08579
Rvr	281912.1	2465000	5.654768	Rvr	253840.8	2465500	-5.52988
Rvr	284919.8	2465000	5.04299	Rvr	254342	2465500	-5.94726
Rvr	285421	2465000	4.905113	Rvr	254843.3	2465500	-6.31413
Rvr	285922.3	2465000	4.722303	Rvr	255344.6	2465500	-6.59348
Rvr	286423.6	2465000	4.480271	Rvr	255845.9	2465500	-6.7446
Rvr	288929.9	2465000	3.005948	Rvr	256347.1	2465500	-6.80285
Rvr	289431.2	2465000	2.811211	Rvr	256848.4	2465500	-6.79807
Rvr	289932.5	2465000	2.619309	Rvr	257349.7	2465500	-6.74566
Rvr	295446.5	2465000	1.323928	Rvr	257851	2465500	-6.65562
Rvr	295947.8	2465000	1.342559	Rvr	258352.2	2465500	-6.53511
Rvr	296449	2465000	1.368072	Rvr	258853.5	2465500	-6.38953
Rvr	241308.9	2465500	-3.83885	Rvr	259354.8	2465500	-6.22311
Rvr	241810.2	2465500	-3.77416	Rvr	259856	2465500	-6.03914
Rvr	242311.5	2465500	-3.70471	Rvr	260357.3	2465500	-5.84026
Rvr	242812.7	2465500	-3.6303	Rvr	260858.6	2465500	-5.62857
Rvr	243314	2465500	-3.55117	Rvr	261359.9	2465500	-5.40572
Rvr	243815.3	2465500	-3.46794	Rvr	261861.1	2465500	-5.17307
				Rvr	262362.4	2465500	-4.93166

Rvr	262863.7	2465500	-4.68233	Rvr	249830.6	2466000	-2.85778
Rvr	277400.6	2465500	5.80762	Rvr	250331.8	2466000	-2.98619
Rvr	277901.9	2465500	6.079157	Rvr	250833.1	2466000	-3.20682
Rvr	278403.2	2465500	6.092321	Rvr	251334.4	2466000	-3.51919
Rvr	278904.5	2465500	6.077241	Rvr	251835.7	2466000	-3.89627
Rvr	279405.7	2465500	6.038927	Rvr	252336.9	2466000	-4.31062
Rvr	279907	2465500	5.981491	Rvr	252838.2	2466000	-4.74467
Rvr	280408.3	2465500	5.908465	Rvr	253339.5	2466000	-5.18324
Rvr	280909.6	2465500	5.823173	Rvr	253840.8	2466000	-5.61006
Rvr	284919.8	2465500	5.012446	Rvr	254342	2466000	-6.00694
Rvr	285421	2465500	4.866911	Rvr	254843.3	2466000	-6.35324
Rvr	285922.3	2465500	4.675639	Rvr	255344.6	2466000	-6.61616
Rvr	286423.6	2465500	4.438169	Rvr	255845.9	2466000	-6.7395
Rvr	288428.7	2465500	3.275929	Rvr	256347.1	2466000	-6.78319
Rvr	288929.9	2465500	2.981773	Rvr	256848.4	2466000	-6.76777
Rvr	289431.2	2465500	2.790296	Rvr	257349.7	2466000	-6.70657
Rvr	295947.8	2465500	1.419593	Rvr	257851	2466000	-6.60921
Rvr	296449	2465500	1.437132	Rvr	258352.2	2466000	-6.48275
Rvr	240807.6	2466000	-3.85065	Rvr	258853.5	2466000	-6.33246
Rvr	241308.9	2466000	-3.78857	Rvr	259354.8	2466000	-6.16238
Rvr	241810.2	2466000	-3.72245	Rvr	259856	2466000	-5.97562
Rvr	242311.5	2466000	-3.6523	Rvr	260357.3	2466000	-5.7746
Rvr	242812.7	2466000	-3.57812	Rvr	260858.6	2466000	-5.56128
Rvr	243314	2466000	-3.50019	Rvr	261359.9	2466000	-5.33716
Rvr	243815.3	2466000	-3.41909	Rvr	284418.5	2466000	5.102356
Rvr	244316.6	2466000	-3.33571	Rvr	284919.8	2466000	4.976259
Rvr	244817.8	2466000	-3.2512	Rvr	285421	2466000	4.82453
Rvr	245319.1	2466000	-3.16701	Rvr	285922.3	2466000	4.632169
Rvr	245820.4	2466000	-3.08487	Rvr	286423.6	2466000	4.402256
Rvr	246321.7	2466000	-3.00682	Rvr	286924.8	2466000	4.14675
Rvr	246822.9	2466000	-2.93531	Rvr	288428.7	2466000	3.309358
Rvr	247324.2	2466000	-2.87319	Rvr	288929.9	2466000	3.046488
Rvr	247825.5	2466000	-2.82384	Rvr	289431.2	2466000	2.83409
Rvr	248326.8	2466000	-2.79125	Rvr	296449	2466000	1.513151
Rvr	248828	2466000	-2.78032	Rvr	296950.3	2466000	1.530442
Rvr	249329.3	2466000	-2.79805	Rvr	240306.4	2466500	-3.85769

Rvr	240807.6	2466500	-3.79969	Rvr	258853.5	2466500	-6.26435
Rvr	241308.9	2466500	-3.73755	Rvr	259354.8	2466500	-6.09081
Rvr	241810.2	2466500	-3.67159	Rvr	259856	2466500	-5.90157
Rvr	242311.5	2466500	-3.60202	Rvr	260357.3	2466500	-5.69882
Rvr	242812.7	2466500	-3.52904	Rvr	260858.6	2466500	-5.48431
Rvr	243314	2466500	-3.45303	Rvr	284919.8	2466500	4.937813
Rvr	243815.3	2466500	-3.37458	Rvr	285421	2466500	4.782506
Rvr	244316.6	2466500	-3.29456	Rvr	285922.3	2466500	4.592342
Rvr	244817.8	2466500	-3.21409	Rvr	286423.6	2466500	4.372476
Rvr	245319.1	2466500	-3.1346	Rvr	286924.8	2466500	4.131321
Rvr	245820.4	2466500	-3.05783	Rvr	287426.1	2466500	3.876414
Rvr	246321.7	2466500	-2.98589	Rvr	287927.4	2466500	3.615498
Rvr	246822.9	2466500	-2.92133	Rvr	288428.7	2466500	3.358135
Rvr	247324.2	2466500	-2.8672	Rvr	288929.9	2466500	3.117151
Rvr	247825.5	2466500	-2.82714	Rvr	297451.6	2466500	1.622267
Rvr	248326.8	2466500	-2.8054	Rvr	240306.4	2467000	-3.80352
Rvr	248828	2466500	-2.80683	Rvr	240807.6	2467000	-3.74715
Rvr	249329.3	2466500	-2.83702	Rvr	241308.9	2467000	-3.68639
Rvr	249830.6	2466500	-2.90454	Rvr	241810.2	2467000	-3.62185
Rvr	250331.8	2466500	-3.05513	Rvr	242311.5	2467000	-3.55393
Rvr	250833.1	2466500	-3.31878	Rvr	242812.7	2467000	-3.483
Rvr	251334.4	2466500	-3.64402	Rvr	243314	2467000	-3.40957
Rvr	251835.7	2466500	-4.0175	Rvr	243815.3	2467000	-3.33427
Rvr	252336.9	2466500	-4.42375	Rvr	244316.6	2467000	-3.25797
Rvr	252838.2	2466500	-4.84747	Rvr	244817.8	2467000	-3.1818
Rvr	253339.5	2466500	-5.27332	Rvr	245319.1	2467000	-3.10717
Rvr	253840.8	2466500	-5.68446	Rvr	245820.4	2467000	-3.03583
Rvr	254342	2466500	-6.06182	Rvr	246321.7	2467000	-2.96995
Rvr	254843.3	2466500	-6.3837	Rvr	246822.9	2467000	-2.9122
Rvr	255344.6	2466500	-6.61586	Rvr	247324.2	2467000	-2.8659
Rvr	255845.9	2466500	-6.72717	Rvr	247825.5	2467000	-2.83516
Rvr	256347.1	2466500	-6.75649	Rvr	248326.8	2467000	-2.82498
Rvr	256848.4	2466500	-6.72879	Rvr	248828	2467000	-2.8412
Rvr	257349.7	2466500	-6.65749	Rvr	249329.3	2467000	-2.89034
Rvr	257851	2466500	-6.55206	Rvr	249830.6	2467000	-2.98141
Rvr	258352.2	2466500	-6.41935	Rvr	250331.8	2467000	-3.15459

Rvr	250833.1	2467000	-3.43021	Rvr	243815.3	2467500	-3.29801
Rvr	251334.4	2467000	-3.75894	Rvr	244316.6	2467500	-3.22577
Rvr	251835.7	2467000	-4.12779	Rvr	244817.8	2467500	-3.15412
Rvr	252336.9	2467000	-4.52546	Rvr	245319.1	2467500	-3.08445
Rvr	252838.2	2467000	-4.93908	Rvr	245820.4	2467500	-3.01851
Rvr	253339.5	2467000	-5.35398	Rvr	246321.7	2467500	-2.95848
Rvr	253840.8	2467000	-5.75261	Rvr	246822.9	2467500	-2.90714
Rvr	254342	2467000	-6.11335	Rvr	247324.2	2467500	-2.86806
Rvr	254843.3	2467000	-6.41139	Rvr	247825.5	2467500	-2.84586
Rvr	255344.6	2467000	-6.61925	Rvr	248326.8	2467500	-2.84664
Rvr	255845.9	2467000	-6.70852	Rvr	248828	2467500	-2.87839
Rvr	256347.1	2467000	-6.72155	Rvr	249329.3	2467500	-2.95106
Rvr	256848.4	2467000	-6.67961	Rvr	249830.6	2467500	-3.07701
Rvr	257349.7	2467000	-6.59689	Rvr	250331.8	2467500	-3.27257
Rvr	257851	2467000	-6.48282	Rvr	250833.1	2467500	-3.54024
Rvr	258352.2	2467000	-6.34382	Rvr	251334.4	2467500	-3.86205
Rvr	258853.5	2467000	-6.18441	Rvr	251835.7	2467500	-4.22272
Rvr	259354.8	2467000	-6.00788	Rvr	252336.9	2467500	-4.61072
Rvr	284919.8	2467000	4.899973	Rvr	252838.2	2467500	-5.01458
Rvr	285421	2467000	4.747508	Rvr	253339.5	2467500	-5.42098
Rvr	285922.3	2467000	4.558621	Rvr	253840.8	2467500	-5.81251
Rvr	286423.6	2467000	4.347785	Rvr	254342	2467500	-6.1644
Rvr	286924.8	2467000	4.121159	Rvr	254843.3	2467500	-6.44357
Rvr	287426.1	2467000	3.884639	Rvr	255344.6	2467500	-6.61832
Rvr	287927.4	2467000	3.644837	Rvr	255845.9	2467500	-6.68545
Rvr	288428.7	2467000	3.409589	Rvr	256347.1	2467500	-6.6767
Rvr	288929.9	2467000	3.187728	Rvr	256848.4	2467500	-6.6175
Rvr	297952.9	2467000	1.712455	Rvr	257349.7	2467500	-6.52228
Rvr	239805.1	2467500	-3.79592	Rvr	257851	2467500	-6.39958
Rvr	240306.4	2467500	-3.74808	Rvr	258352.2	2467500	-6.25484
Rvr	240807.6	2467500	-3.6943	Rvr	284919.8	2467500	4.858997
Rvr	241308.9	2467500	-3.63589	Rvr	285421	2467500	4.709078
Rvr	241810.2	2467500	-3.57365	Rvr	285922.3	2467500	4.524897
Rvr	242311.5	2467500	-3.50818	Rvr	286423.6	2467500	4.324742
Rvr	242812.7	2467500	-3.44001	Rvr	286924.8	2467500	4.113199
Rvr	243314	2467500	-3.36972	Rvr	287426.1	2467500	3.894675

Rvr	287927.4	2467500	3.67443	Rvr	255344.6	2468000	-6.63017
Rvr	288428.7	2467500	3.458436	Rvr	255845.9	2468000	-6.6544
Rvr	288929.9	2467500	3.252666	Rvr	256347.1	2468000	-6.61573
Rvr	298454.1	2467500	1.787833	Rvr	256848.4	2468000	-6.53733
Rvr	298955.4	2467500	1.803598	Rvr	257349.7	2468000	-6.43011
Rvr	239805.1	2468000	-3.73897	Rvr	257851	2468000	-6.30005
Rvr	240306.4	2468000	-3.69354	Rvr	258352.2	2468000	-6.15099
Rvr	240807.6	2468000	-3.64248	Rvr	284919.8	2468000	4.799828
Rvr	241308.9	2468000	-3.58685	Rvr	285421	2468000	4.657266
Rvr	241810.2	2468000	-3.52746	Rvr	285922.3	2468000	4.485909
Rvr	242311.5	2468000	-3.46501	Rvr	286423.6	2468000	4.300231
Rvr	242812.7	2468000	-3.40011	Rvr	286924.8	2468000	4.104925
Rvr	243314	2468000	-3.33341	Rvr	287426.1	2468000	3.904001
Rvr	243815.3	2468000	-3.26567	Rvr	287927.4	2468000	3.701825
Rvr	244316.6	2468000	-3.19778	Rvr	288428.7	2468000	3.503003
Rvr	244817.8	2468000	-3.13085	Rvr	288929.9	2468000	3.31183
Rvr	245319.1	2468000	-3.06622	Rvr	298454.1	2468000	1.848999
Rvr	245820.4	2468000	-3.0056	Rvr	298955.4	2468000	1.861554
Rvr	246321.7	2468000	-2.95113	Rvr	299456.7	2468000	1.878221
Rvr	246822.9	2468000	-2.90561	Rvr	239303.8	2468500	-3.72213
Rvr	247324.2	2468000	-2.87268	Rvr	239805.1	2468500	-3.68448
Rvr	247825.5	2468000	-2.8573	Rvr	240306.4	2468500	-3.64108
Rvr	248326.8	2468000	-2.86631	Rvr	240807.6	2468500	-3.59263
Rvr	248828	2468000	-2.90975	Rvr	241308.9	2468500	-3.53991
Rvr	249329.3	2468000	-3.00175	Rvr	241810.2	2468500	-3.48367
Rvr	249830.6	2468000	-3.15286	Rvr	242311.5	2468500	-3.42459
Rvr	250331.8	2468000	-3.36437	Rvr	242812.7	2468500	-3.36333
Rvr	250833.1	2468000	-3.63218	Rvr	243314	2468500	-3.30058
Rvr	251334.4	2468000	-3.94677	Rvr	243815.3	2468500	-3.23712
Rvr	251835.7	2468000	-4.29735	Rvr	244316.6	2468500	-3.17383
Rvr	252336.9	2468000	-4.67406	Rvr	244817.8	2468500	-3.11178
Rvr	252838.2	2468000	-5.06726	Rvr	245319.1	2468500	-3.05229
Rvr	253339.5	2468000	-5.46619	Rvr	245820.4	2468500	-2.99694
Rvr	253840.8	2468000	-5.85638	Rvr	246321.7	2468500	-2.94779
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Rvr	254843.3	2468000	-6.48825	Rvr	247324.2	2468500	-2.87954

Rvr	247825.5	2468500	-2.86894	Rvr	243314	2469000	-3.27111
Rvr	248326.8	2468500	-2.8825	Rvr	243815.3	2469000	-3.21216
Rvr	248828	2468500	-2.92996	Rvr	244316.6	2469000	-3.15369
Rvr	249329.3	2468500	-3.03328	Rvr	244817.8	2469000	-3.09674
Rvr	249830.6	2468500	-3.20703	Rvr	245319.1	2469000	-3.04251
Rvr	250331.8	2468500	-3.43181	Rvr	245820.4	2469000	-2.99251
Rvr	250833.1	2468500	-3.70105	Rvr	246321.7	2469000	-2.94858
Rvr	251334.4	2468500	-4.00875	Rvr	246822.9	2469000	-2.9131
Rvr	251835.7	2468500	-4.34769	Rvr	247324.2	2469000	-2.88935
Rvr	252336.9	2468500	-4.7104	Rvr	247825.5	2469000	-2.88208
Rvr	252838.2	2468500	-5.08944	Rvr	248326.8	2469000	-2.89861
Rvr	253339.5	2468500	-5.47706	Rvr	248828	2469000	-2.94956
Rvr	253840.8	2468500	-5.86445	Rvr	249329.3	2469000	-3.06032
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Rvr	254843.3	2468500	-6.54383	Rvr	250331.8	2469000	-3.48117
Rvr	255344.6	2468500	-6.62353	Rvr	250833.1	2469000	-3.74881
Rvr	255845.9	2468500	-6.59328	Rvr	251334.4	2469000	-4.0476
Rvr	256347.1	2468500	-6.52563	Rvr	251835.7	2469000	-4.37222
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Rvr	257349.7	2468500	-6.31637	Rvr	252838.2	2469000	-5.07551
Rvr	286423.6	2468500	4.273771	Rvr	253339.5	2469000	-5.4417
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Rvr	287426.1	2468500	3.911491	Rvr	254342	2469000	-6.16679
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Rvr	299456.7	2468500	1.934758	Rvr	299958	2469000	2.008241
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Rvr	239303.8	2469000	-3.66935	Rvr	239805.1	2469500	-3.58368
Rvr	239805.1	2469000	-3.63272	Rvr	240306.4	2469500	-3.544
Rvr	240306.4	2469000	-3.59119	Rvr	240807.6	2469500	-3.5005
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Rvr	241308.9	2469000	-3.49547	Rvr	241810.2	2469500	-3.40406
Rvr	241810.2	2469000	-3.44251	Rvr	242311.5	2469500	-3.35228
Rvr	242311.5	2469000	-3.38702	Rvr	242812.7	2469500	-3.29896
Rvr	242812.7	2469000	-3.32965	Rvr	243314	2469500	-3.2448

Rvr	243815.3	2469500	-3.19057	Rvr	246822.9	2470000	-2.93862
Rvr	244316.6	2469500	-3.13713	Rvr	247324.2	2470000	-2.92374
Rvr	244817.8	2469500	-3.08546	Rvr	247825.5	2470000	-2.92177
Rvr	245319.1	2469500	-3.03672	Rvr	248326.8	2470000	-2.9374
Rvr	245820.4	2469500	-2.99227	Rvr	248828	2470000	-2.98548
Rvr	246321.7	2469500	-2.95376	Rvr	249329.3	2470000	-3.12474
Rvr	246822.9	2469500	-2.92324	Rvr	249830.6	2470000	-3.32054
Rvr	247324.2	2469500	-2.90348	Rvr	250331.8	2470000	-3.54632
Rvr	247825.5	2469500	-2.89862	Rvr	250833.1	2470000	-3.79612
Rvr	248326.8	2469500	-2.91649	Rvr	251334.4	2470000	-4.06574
Rvr	248828	2469500	-2.97468	Rvr	251835.7	2470000	-4.35095
Rvr	249329.3	2469500	-3.09902	Rvr	252336.9	2470000	-4.64669
Rvr	249830.6	2469500	-3.28755	Rvr	252838.2	2470000	-4.94662
Rvr	250331.8	2469500	-3.51811	Rvr	253339.5	2470000	-5.24224
Rvr	250833.1	2469500	-3.77924	Rvr	299456.7	2470000	2.110902
Rvr	251334.4	2469500	-4.06548	Rvr	299958	2470000	2.120267
Rvr	251835.7	2469500	-4.37218	Rvr	300459.3	2470000	2.137147
Rvr	252336.9	2469500	-4.69425	Rvr	241308.9	2470500	-3.37777
Rvr	252838.2	2469500	-5.02574	Rvr	241810.2	2470500	-3.3349
Rvr	253339.5	2469500	-5.35936	Rvr	242311.5	2470500	-3.29067
Rvr	253840.8	2469500	-5.6846	Rvr	242812.7	2470500	-3.24566
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Rvr	299958	2469500	2.064012	Rvr	243815.3	2470500	-3.15609
Rvr	300459.3	2469500	2.083234	Rvr	244316.6	2470500	-3.11312
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Rvr	241308.9	2470000	-3.41449	Rvr	245319.1	2470500	-3.03557
Rvr	241810.2	2470000	-3.36826	Rvr	245820.4	2470500	-3.00333
Rvr	242311.5	2470000	-3.32024	Rvr	246321.7	2470500	-2.97732
Rvr	242812.7	2470000	-3.27106	Rvr	246822.9	2470500	-2.95928
Rvr	243314	2470000	-3.22141	Rvr	247324.2	2470500	-2.95132
Rvr	243815.3	2470000	-3.17202	Rvr	247825.5	2470500	-2.95619
Rvr	244316.6	2470000	-3.12376	Rvr	248326.8	2470500	-2.97797
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Rvr	245319.1	2470000	-3.03459	Rvr	249329.3	2470500	-3.16797
Rvr	245820.4	2470000	-2.99605	Rvr	249830.6	2470500	-3.35627
Rvr	246321.7	2470000	-2.96347	Rvr	250331.8	2470500	-3.56943

Rvr	250833.1	2470500	-3.80263	Rvr	247324.2	2471500	-3.01928
Rvr	251334.4	2470500	-4.0519	Rvr	247825.5	2471500	-3.04479
Rvr	251835.7	2470500	-4.31286	Rvr	248326.8	2471500	-3.09222
Rvr	252336.9	2470500	-4.58022	Rvr	248828	2471500	-3.16954
Rvr	299958	2470500	2.176646	Rvr	249329.3	2471500	-3.28247
Rvr	300459.3	2470500	2.190936	Rvr	249830.6	2471500	-3.42858
Rvr	241810.2	2471000	-3.30373	Rvr	250331.8	2471500	-3.6002
Rvr	242311.5	2471000	-3.26324	Rvr	250833.1	2471500	-3.79014
Rvr	242812.7	2471000	-3.22238	Rvr	251334.4	2471500	-3.99253
Rvr	243314	2471000	-3.1818	Rvr	299456.7	2471500	2.294182
Rvr	243815.3	2471000	-3.14226	Rvr	299958	2471500	2.287135
Rvr	244316.6	2471000	-3.10459	Rvr	244817.8	2472000	-3.06708
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Rvr	245319.1	2471000	-3.03884	Rvr	245820.4	2472000	-3.0349
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Rvr	248326.8	2471000	-3.03672	Rvr	248828	2472000	-3.21455
Rvr	248828	2471000	-3.10822	Rvr	249329.3	2472000	-3.31948
Rvr	249329.3	2471000	-3.23027	Rvr	249830.6	2472000	-3.45029
Rvr	249830.6	2471000	-3.39538	Rvr	250331.8	2472000	-3.60259
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Rvr	250833.1	2471000	-3.80057	Rvr	299958	2472000	2.33339
Rvr	251334.4	2471000	-4.02685	Rvr	245820.4	2472500	-3.04393
Rvr	251835.7	2471000	-4.26208	Rvr	246321.7	2472500	-3.04429
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Rvr	243314	2471500	-3.16464	Rvr	247324.2	2472500	-3.07685
Rvr	243815.3	2471500	-3.12992	Rvr	247825.5	2472500	-3.1141
Rvr	244316.6	2471500	-3.09746	Rvr	248326.8	2472500	-3.16922
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Rvr	246321.7	2471500	-3.01229	Rvr	299456.7	2472500	2.401933
Rvr	246822.9	2471500	-3.00975	Rvr	246822.9	2473000	-3.06953

Rvr	247324.2	2473000	-3.09546	Rvr	302464.3	2483500	4.998842
Rvr	247825.5	2473000	-3.13489	Rvr	302965.6	2483500	4.967315
Rvr	248326.8	2473000	-3.18979	Rvr	302965.6	2484000	4.973177
Rvr	248828	2473000	-3.26161	Rvr	303466.9	2484000	4.954221
Rvr	249329.3	2473000	-3.35079	Rvr	303466.9	2484500	4.960177
Rvr	299456.7	2473000	2.486923	Rvr	303466.9	2485000	4.947825
Rvr	247825.5	2473500	-3.14622	Rvr	303466.9	2485500	4.860916
Rvr	298955.4	2473500	2.63328	Rvr	303968.2	2485500	4.884756
Rvr	299456.7	2473500	2.604278	Rvr	303968.2	2486000	4.83161
Rvr	298955.4	2474000	2.751488	Rvr	303466.9	2486500	4.727148
Rvr	299456.7	2474000	2.731435	Rvr	303466.9	2487000	4.947546
Rvr	299456.7	2474500	2.861138	Rvr	303968.2	2487000	5.03964
Rvr	299456.7	2475000	2.991295	Rvr	303466.9	2487500	5.929417
Rvr	299958	2475500	3.121728	Rvr	303466.9	2488000	7.079162
Rvr	299958	2476000	3.251866	Rvr	303466.9	2488500	8.131396
Rvr	300459.3	2476000	3.261034	Rvr	303466.9	2489000	8.281728
Rvr	300459.3	2476500	3.389611	Rvr	303466.9	2489500	8.280006
Rvr	300960.5	2476500	3.406557	Rvr	303466.9	2490000	8.2644
Rvr	300960.5	2477000	3.533424	Rvr	303968.2	2490000	8.237114
Rvr	301461.8	2477500	3.693324	Rvr	303968.2	2490500	8.233886
Rvr	301461.8	2478000	3.821424	Rvr	304469.4	2490500	8.174285
Rvr	301461.8	2478500	3.958097	Rvr	304970.7	2490500	8.090801
Rvr	301461.8	2479000	4.097337	Rvr	304469.4	2491000	8.178478
Rvr	300960.5	2479500	4.219856	Rvr	304970.7	2491000	8.114943
Rvr	301461.8	2479500	4.237261	Rvr	305472	2491000	8.052643
Rvr	300960.5	2480000	4.359519	Rvr	305973.3	2491500	8.018342
Rvr	301461.8	2480000	4.377309	Rvr	306474.5	2491500	7.985979
Rvr	300960.5	2480500	4.497315	Rvr	306975.8	2491500	7.931299
Rvr	301461.8	2480500	4.517107	Rvr	307477.1	2492000	7.929969
Rvr	300960.5	2481000	4.631508	Rvr	307978.3	2492000	7.889791
Rvr	300960.5	2481500	4.758005	Rvr	307978.3	2492500	7.929474
Rvr	301461.8	2481500	4.791133	Rvr	308479.6	2493000	7.91335
Rvr	301461.8	2482000	4.912515				
Rvr	301461.8	2482500	4.991055				
Rvr	301963.1	2483000	5.020288				
Rvr	302464.3	2483000	4.993015				

ANNEXURE-III

RL's of the Bottom of Wells in an Unconfined Aquifer in m from m.s.l.

Taluka	Village	Well no	X Latitude	Y Longitude	Bottom R L in m from m.s.l.
Khambhat	Kansari	KR-23	256803.69	2471326.90	-14.02
Khambhat	Bhuvel	KR-21	264060.8125	2468621.00	-10.0
Khambhat	Gudel	KR-25	244895.8125	2478585.00	-15.59
Petlad	Danteli	KR-70	268272.9	2482068.61	-5.38
Khambhat	Kanisha	KR-20	261564.14	2477128.29	-9.0
Khambhat	Haripura	KR-22	270508.31	2463701.40	-8.42
Borsad	Borsad	KR-19	283767.25	2479632.25	-2.25
Borsad	Bhadran	KR-17	283689.9063	2474095.00	-6.5
Borsad	Gajna	KR-18	283803.5625	2465232.25	-11.0
Anklav	Anklav	KR-16	294427.55	2475901.85	0.50
Anand	Vasad	KR-07	303395.9375	2488507.50	5.0
Anand	Bedva	KR-08	298338.2188	2495240.50	6.0
Anand	Sarsa	KR-06	301609.5625	2494433.75	5.75
Jambusar	Sarod	NCCA-47	280030.9063	2453555.00	-12.35
Jambusar	Sarod	BR-14	280113.4375	2453554.00	-12.35
Padra	Dabka	NCCA-44	289541.875	2461919.50	-11.71
Padra	Masar Road	BD-34	287036.875	2450600.50	-6.36
Vadodara	Dashrath	BD-05	309398.6563	2477047.00	8.0
Vadodara	Sokhda	BD-06	311648.4375	2480807.00	12.0
Savli	Manjusar	BD-48	313994.4063	2483237.25	12.0
Padra	Jaspur	NCCA-43	299932.24	2465442.61	-7.0
Savli	Anjesar	NCCA-14	311864.938	2486740.50	9.0
Savli	Poicha	NCCA-13	305511.11	2486551.80	5.5
Padra	Karankuva	NCCA-45	291753.25	245608.25	-17.35
Jambusar	Kavi	NCCA-48	256865.3	2456700.75	-15.20
Jambusar	Piludra	NCCA-50	273528.218	2444055.18	-14.04

ANNEXURE –IV

Lithology of Wells

Taluka	Village	Well no	X (Latitude)	Y (Longitude)	Z (Depth in m from m.s.l.)	Material
Borsad	Borsad	SKHDPZ12	284419.88	2479158.93	0 to 3.06	Top Soil, Brown, Fine.
		SKHDPZ12	284419.88	2479158.93	3.06 to 12.19	Sand Brown, Medium to Coarse, Sub angular to angular
		SKHDPZ12	284419.88	2479158.93	12.19 to 18.29	sand, Brown, Medium to Coarse, Sub angular to angular
		SKHDPZ12	284419.88	2479158.93	18.29 to 24.59	Clay, Yellow, Sticky
		SKHDPZ12	284419.88	2479158.93	24.59 to30.48	Sand, Medium Rounded to Sub rounded,
		SKHDPZ12	284419.88	2479158.93	30.48 to 48.78	Sand, Medium, Sub angular-Sub rounded
		SKHDPZ12	284419.88	2479158.93	48.78 to 52.5	Gravel, Yellow, Coarse, Sub angular-Sub rounded,
		SKHDPZ12	284419.88	2479158.93	52.5 to 60	Clay, Yellow, Sticky
Anklav	Gambhira	SKHDPZ05	291610.81	2464728.04	0 to 5	Top Soil, Yellow, Brown, Loose
		SKHDPZ05	291610.81	2464728.04	5 to 15.24	Sand, Grey, Black, White, Medium to Coarse, Rounded to Sub rounded
		SKHDPZ05	291610.81	2464728.04	15.24 to 27.43	Kankar, Grey, Black, White, Medium to Coarse, Rounded to Sub rounded
		SKHDPZ05	291610.81	2464728.04	27.43 to 38	Sand, White, Grey, Medium to Coarse Rounded to Sub rounded,

Taluka	Village	Well no	X (Latitude)	Y (Longitude)	Z (Depth in m from m.s.l.)	Material
		SKHDPZ05	291610.81	2464728.04	38 to 40	Clay, Yellow, Sticky
		SKHDPZ05	291610.81	2464728.04	40 to 60.97	Sand, White, Yellow, Fine to Medium, Rounded to Sub rounded
Jambusar	Kavi	NCCA-48	256865.29	2456700.69	0 to 9	Top Soil, Blackish.
		NCCA-48	256865.29	2456700.69	9 to 15	Sand, Medium grained
Jambusar	Sarod	NCCA-47	280030.92	2453555.05	0 to 3.05	Top Soil, black
		NCCA-47	280030.92	2453555.05	3.05 to 14	Clay, black sticky.
		NCCA-47	280030.92	2453555.05	14 to 21	Sand, medium grained
Padra	Karankuva	NCCA-45	291753.24	2456108.20	0 to 6.09	Top Soil, black
		NCCA-45	291753.24	2456108.20	6.09 to 18	Clay, yellow sticky
		NCCA-45	291753.24	2456108.20	18 to 31	Sand with kankar
Savli	Bhadarva	SVADPZ01	308592.01	2491826.70	0 to 8	Top Soil, brown, fine, rounded
		SVADPZ01	308592.01	2491826.70	8 to 23	Sand, brown, fine, rounded
		SVADPZ01	308592.01	2491826.70	23 to 26	Clay, brown, very fine, sticky
		SVADPZ01	308592.01	2491826.70	26 to 44	Sand, brownish yellow, fine, equiangular
		SVADPZ01	308592.01	2491826.70	44 to 48	Clay, brown, very fine, sticky
		SVADPZ01	308592.01	2491826.70	48 to 65	Sand, yellow, coarse, sub angular- sub rounded
Vadodara	Ankodiya	SVADPZ09	305975.61	2471676.71	0 to 3	Top Soil, brown, fine, rounded
		SVADPZ09	305975.61	2471676.71	3 to 6.1	Sand, dull brown, fine, rounded to sub rounded
		SVADPZ09	305975.61	2471676.71	6.1 to 9.15	Clay, brown , very fine , rounded to sub rounded

Taluka	Village	Well no	X (Latitude)	Y (Longitude)	Z (Depth in m from m.s.l.)	Material
		SVADPZ09	305975.61	2471676.71	9.15 to 15.25	Sand, dull brown, fine, rounded
		SVADPZ09	305975.61	2471676.71	15.25 to 27.4	Kankar, dull brown, fine to medium, sub angular
		SVADPZ09	305975.61	2471676.71	27.4 to 33.5	Kankar, dull brown, coarse, sub angular to angular
		SVADPZ09	305975.61	2471676.71	33.5 to 39.5	Clay, brown, fine, sticky
		SVADPZ09	305975.61	2471676.71	39.5 to 42.7	Kankar, dull brown, medium, angular
		SVADPZ09	305975.61	2471676.71	42.7 to 45.7	Clay, brown, very fine, sticky
		SVADPZ09	305975.61	2471676.71	45.7 to 48.8	Kankar, dull brown, medium, sub angular to angular
		SVADPZ09	305975.61	2471676.71	48.8 to 59.45	Clay, brown, very fine, sticky
		SVADPZ09	305975.61	2471676.71	59.45 to 69.2	Sand, dull brown, coarse, rounded to sub rounded
		SVADPZ09	305975.61	2471676.71	69.2 to 71.65	Clay, brown, very fine, sticky
Vadodara	Ranoli	SVADPZ11	307492.17	2477859.49	0 to 3.5	Top Soil, brown, fine, rounded
		SVADPZ11	307492.17	2477859.49	3.5 to 6.1	Clay, yellow, fine, sticky
		SVADPZ11	307492.17	2477859.49	6.1 to 9.1	Sand, dull brown, very fine, rounded
		SVADPZ11	307492.17	2477859.49	9.1 to 12.2	Sand, brown, fine, rounded
		SVADPZ11	307492.17	2477859.49	12.2 to 27.45	Kankar, dull brown, coarse, sub angular to angular
		SVADPZ11	307492.17	2477859.49	27.45 to 30.5	Kankar, dull brown, medium, sub angular to angular

Taluka	Village	Well no	X (Latitude)	Y (Longitude)	Z (Depth in m from m.s.l.)	Material
		SVADPZ11	307492.17	2477859.49	30.5 to 36.6	Clay, yellow, very fine, sticky
		SVADPZ11	307492.17	2477859.49	36.6 to 42.7	Sand, brown, fine to medium, sub angular to angular
		SVADPZ11	307492.17	2477859.49	42.7 to 52.75	Clay, , yellowish brown, very fine, sticky
		SVADPZ11	307492.17	2477859.49	52.75 to 62.5	Sand, yellow, coarse, sub angular to angular
		SVADPZ11	307492.17	2477859.49	62.5 to 67	Clay, yellow, very fine, sticky
Khambhat	Khambhat	SKHDPZ11	255563.91	2471554.21	0 to 3.05	Top Soil, yellow, fine, sub angular
		SKHDPZ11	255563.91	2471554.21	3.05 to 6.5	Clay & Sand, , yellow, fine
		SKHDPZ11	255563.91	2471554.21	6.5 to14.23	Sand, , Yellow, medium to Coarse, Sub angular-Sub rounded
		SKHDPZ11	255563.91	2471554.21	14.23 to 20	Clay, yellow, sticky
		SKHDPZ11	255563.91	2471554.21	20 to 32	Sand, yellow, medium, rounded to sub rounded
Khambhat	chhatardi	SKHDPZ06	257978.41	2473225.54	0 to 9.14	Top Soil, yellow
		SKHDPZ06	257978.41	2473225.54	9.14 to 23	Sand, brown & grey, medium, rounded to sub rounded
		SKHDPZ06	257978.41	2473225.54	23 to 25	Clay, yellow, sticky
		SKHDPZ06	257978.41	2473225.54	25 to 33.53	Sand, yellow, brownish, medium, rounded to sub rounded
Savli	Poicha	NCCA-13	305511.11	2486551.80	0 to 5	Top Soil, brownish

Taluka	Village	Well no	X (Latitude)	Y (Longitude)	Z (Depth in m from m.s.l.)	Material
		NCCA-13	305511.11	2486551.80	5 to 11	Sand, fine to medium grained, brownish, sub angular- sub rounded
		NCCA-13	305511.11	2486551.80	11 to 21	Clay yellowish sticky,
		NCCA-13	305511.11	2486551.80	21 to 43	Sand, medium grained, brownish, sub rounded
		NCCA-13	305511.11	2486551.80	43 to 44.19	Clay, brown sticky
Savli	Anjesar	NCCA-14	311864.94	2486740.53	0 to 3	Top Soil, brown
		NCCA-14	311864.94	2486740.53	3 to 15.24	Sand, brown, fine with few kankers
		NCCA-14	311864.94	2486740.53	15.24 to 24.38	Sand, brown, medium, sub angular,
		NCCA-14	311864.94	2486740.53	24.38 to 44.19	Sand, brown, medium to coarse, sub angular- sub rounded
Padra	Dabka	NCCA-44	289541.86	2461919.48	0 to 9	Top Soil, brownish
		NCCA-44	289541.86	2461919.48	9 to 18	Sand, fine grained
		NCCA-44	289541.86	2461919.48	18 to 27	Sand, medium grained
Padra	Jaspur	NCCA-43	306764.97	2465694.50	0 to 3.05	Top Soil, brownish
		NCCA-43	306764.97	2465694.50	3.05 to 15.3	Sand, fine grained
		NCCA-43	306764.97	2465694.50	15.3 to 29.80	Clay, yellow, sticky
		NCCA-43	306764.97	2465694.50	29.8 to 37	Sand, medium grained
Padra	Bhoj	SVADPZ26	293233.85	2457420.37	0 to 3.04	Top Soil, brown, fine, rounded
		SVADPZ26	293233.85	2457420.37	3.04 to 36.59	Clay, yellow, very fine, sticky
		SVADPZ26	293233.85	2457420.37	36.59 to 39.63	Sand, brown, fine to medium, rounded to sub rounded

Taluka	Village	Well no	X (Latitude)	Y (Longitude)	Z (Depth in m from m.s.l.)	Material
		SVADPZ26	293233.85	2457420.37	39.63 to 51.83	Clay, yellow, very fine, sticky
		SVADPZ26	293233.85	2457420.37	51.83 to 57.93	Sand, grey, medium, rounded to sub rounded
		SVADPZ26	293233.85	2457420.37	57.93 to 67.07	Clay, yellow, very fine, sticky
		SVADPZ26	293233.85	2457420.37	67.07 to 70.12	Sand, grey, medium, rounded to sub rounded
		SVADPZ26	293233.85	2457420.37	70.12 to 76.22	Clay, yellow, very fine, sticky
Khambhat	Khadodhi	KRT430	270142.66	2463755.40	0 to 3.05	Top Soil, brown, fine, rounded
		KRT430	270142.66	2463755.40	3.05 to 6.09	Silt, brown, fine, rounded
		KRT430	270142.66	2463755.40	6.09 to 26	Kankar, brown, medium, rounded
		KRT430	270142.66	2463755.40	26 to 30	Clay, yellow, fine, rounded
		KRT430	270142.66	2463755.40	30 to 38	Kankar, brown, medium, rounded
		KRT430	270142.66	2463755.40	38 to 45	Clay, yellow, fine, rounded
		KRT430	270142.66	2463755.40	45 to 56.5	Kankar, brown, medium, sub angular
		KRT430	270142.66	2463755.40	56.5 to 65	Clay, yellow, fine, rounded
		KRT430	270142.66	2463755.40	65 to 77	Kankar, brown, medium, sub angular
		KRT430	270142.66	2463755.40	77 to 85	Clay, yellow, fine, rounded
		KRT430	270142.66	2463755.40	85 to 94	Kankar, brown, medium, rounded
		KRT430	270142.66	2463755.40	94 to 95.5	Clay, yellow, fine, rounded
		KRT430	270142.66	2463755.40	95.5 to 101.5	Kankar, brown, medium, rounded
		KRT430	270142.66	2463755.40	101.5 to 111	Clay, yellow, fine, rounded
		KRT430	270142.66	2463755.40	111 to 117	Sand, brown, fine, rounded

Taluka	Village	Well no	X (Latitude)	Y (Longitude)	Z (Depth in m from m.s.l.)	Material
		KRT430	270142.66	2463755.40	117 to 123	Clay, yellow, fine, rounded
		KRT430	270142.66	2463755.40	123 to 125	Sand, brown, fine, rounded
		KRT430	270142.66	2463755.40	125 to 128	Clay, yellow, fine, rounded
		KRT430	270142.66	2463755.40	128 to 138	Sand, brown, fine, rounded
		KRT430	270142.66	2463755.40	138 to 147	Clay, yellow, fine, rounded
Anand	Bedva	KRT129	298129.16	2494988.58	0 to 3.04	Top Soil, yellow, fine, rounded
		KRT129	298129.16	2494988.58	3.04 to 48.76	Sand, brown, medium, rounded
		KRT129	298129.16	2494988.58	48.76 to 54.8	Clay, yellow, fine, rounded
		KRT129	298129.16	2494988.58	54.8 to 82.13	Sand, brown, medium, rounded
		KRT129	298129.16	2494988.58	82.13 to 88.39	Clay, yellow, fine, rounded
		KRT129	298129.16	2494988.58	88.39 to 100.58	Sand, brown, medium, rounded
		KRT129	298129.16	2494988.58	100.58 to 109.72	Clay, yellow, fine, rounded
		KRT129	298129.16	2494988.58	109.72 to 121.92	Sand, brown, coarse, sub angular
		KRT129	298129.16	2494988.58	121.02 to 126.49	Clay, yellow, fine, rounded
		KRT129	298129.16	2494988.58	126.49 to 128.01	Clay, grey, fine, rounded
Petlad	Danteli	KRT031	268403.51	2481926.34	0 to 3.04	Top Soil, grey, fine, rounded
		KRT031	268403.51	2481926.34	3.04 to 24.32	Sand, brown, fine, rounded
		KRT031	268403.51	2481926.34	24.32 to 45.64	Clay, yellow, fine, rounded
		KRT031	268403.51	2481926.34	45.64 to 60.96	Sand, brown, medium, rounded
		KRT031	268403.51	2481926.34	60.96 to 67.05	Clay, yellow, fine, rounded
		KRT031	268403.51	2481926.34	67.05 to 73.12	Sand, brown, fine, rounded

Taluka	Village	Well no	X (Latitude)	Y (Longitude)	Z (Depth in m from m.s.l.)	Material
		KRT031	268403.51	2481926.34	73.12 to 103.6	Clay, yellow, fine, rounded
		KRT031	268403.51	2481926.34	103.6 to 112.72	Sand, brown, medium, rounded
		KRT031	268403.51	2481926.34	112.72 to 124.96	Clay, yellow, fine, rounded
		KRT031	268403.51	2481926.34	124.96 to 146.26	Sand, brown, medium, rounded
		KRT031	268403.51	2481926.34	146.26 to 149.26	Clay, yellow, fine, rounded
Anand	Veherakhadi	KRT132	301859.20	2490653.74	0 to 6.09	Top Soil, yellow, fine, rounded
		KRT132	301859.20	2490653.74	6.09 to 12.19	Clay, yellow, fine, rounded
		KRT132	301859.20	2490653.74	12.19 to 27.43	Sand, brown, coarse, sub angular
		KRT132	301859.20	2490653.74	27.43 to 36.58	Clay, yellow, fine, rounded
		KRT132	301859.20	2490653.74	36.58 to 85.34	Sand, brown, coarse, sub angular
		KRT132	301859.20	2490653.74	85.34 to 91.44	Clay, yellow, fine, rounded
		KRT132	301859.20	2490653.74	91.44 to 106.76	Sand, brown, coarse, sub angular
		KRT132	301859.20	2490653.74	106.76 to 112.78	Clay, yellow, fine, rounded
Anand	Vadod	KRT147	294699.34	2490071.97	0 to 3.04	Top Soil, yellow, fine, rounded
		KRT147	294699.34	2490071.97	3.04 to 51.82	Sand, brown, fine, rounded
		KRT147	294699.34	2490071.97	51.82 to 67.06	Clay, yellow, fine, rounded
		KRT147	294699.34	2490071.97	67.06 to 79.25	Sand, brown, coarse, sub angular
		KRT147	294699.34	2490071.97	79.25 to 82.5	Clay, yellow, fine, rounded
		KRT147	294699.34	2490071.97	82.5 to 88.39	Sand, brown, coarse, sub angular
		KRT147	294699.34	2490071.97	88.39 to 97.54	Clay, yellow, fine, rounded

Taluka	Village	Well no	X (Latitude)	Y (Longitude)	Z (Depth in m from m.s.l.)	Material
		KRT147	294699.34	2490071.97	97.54 to 106.68	Sand, brown, coarse, sub angular
		KRT147	294699.34	2490071.97	106.68 to 115.82	Clay, yellow, fine, rounded
		KRT147	294699.34	2490071.97	115.82 to 124.97	Sand, brown, medium, sub angular
		KRT147	294699.34	2490071.97	124.97 to 128.02	Clay, yellow, fine, rounded
		KRT147	294699.34	2490071.97	128.02 to 137.16	Sand, brown, coarse, sub angular
		KRT147	294699.34	2490071.97	137.16 to 140.21	Clay, yellow, fine, rounded
		KRT147	294699.34	2490071.97	140.21 to 146.3	Sand, brown, medium, sub angular
		KRT147	294699.34	2490071.97	146.3 to 152.4	Clay, grey, fine, rounded
Borsad	Divel	KRT239	290506.74	2479927.24	0 to 6.09	Top Soil, yellow, fine, rounded
		KRT239	290506.74	2479927.24	6.09 to 24.38	Silt, brown, fine, rounded
		KRT239	290506.74	2479927.24	24.38 to 42.67	Clay, yellow, fine, rounded
		KRT239	290506.74	2479927.24	42.67 to 54.86	Sand, brown, fine, rounded
		KRT239	290506.74	2479927.24	54.86 to 70.1	Clay, yellow, fine, rounded
		KRT239	290506.74	2479927.24	70.1 to 97.54	Sand, brown, medium, rounded
		KRT239	290506.74	2479927.24	97.54 to 109.73	Clay, yellow, fine, rounded
		KRT239	290506.74	2479927.24	109.73 to 121.92	Sand, brown, medium, rounded
		KRT239	290506.74	2479927.24	121.92 to 128.02	Clay, yellow, fine, rounded
		KRT239	290506.74	2479927.24	128.02 to 137.16	Sand, brown, coarse, sub angular
		KRT239	290506.74	2479927.24	137.16 to 143.26	Clay, yellow, fine, rounded
		KRT239	290506.74	2479927.24	143.26 to 155.44	Sand, brown, medium, rounded

Taluka	Village	Well no	X (Latitude)	Y (Longitude)	Z (Depth in m from m.s.l.)	Material
		KRT239	290506.74	2479927.24	155.44 to 158.49	Clay, yellow, fine, rounded
Borsad	Umlav	KRT241	281449.08	2468610.36	0 to 3.04	Top Soil, brown, fine, rounded
		KRT241	281449.08	2468610.36	3.04 to 42.67	Clay, yellow, fine, rounded
		KRT241	281449.08	2468610.36	42.67 to 60.96	Sand, brown, fine, rounded
		KRT241	281449.08	2468610.36	60.96 to 67.05	Clay, yellow, fine, rounded
		KRT241	281449.08	2468610.36	67.05 to 91.44	Sand, brown, fine, rounded
		KRT241	281449.08	2468610.36	91,44 to 94.48	Clay, yellow, fine, rounded
		KRT241	281449.08	2468610.36	94.48 to 123.44	Sand, brown, fine, rounded
		KRT241	281449.08	2468610.36	123.44 to 129.84	Clay, yellow, fine, rounded
Borsad	Sntokpura	KRT419	280103.65	2483939.11	0 to 9.14	Top Soil, brown, fine, rounded
		KRT419	280103.65	2483939.11	9.14 to 24.38	Clay, brown, fine, rounded
		KRT419	280103.65	2483939.11	24.38 to 33.53	Sand, brown, fine, rounded
		KRT419	280103.65	2483939.11	33.53 to 48.77	Clay, yellow, fine, rounded
		KRT419	280103.65	2483939.11	48.77 to 57.91	Sand, brown, fine, rounded
		KRT419	280103.65	2483939.11	57.91 to 60.96	Kankar, brown, medium, sub angular
		KRT419	280103.65	2483939.11	60.96 to 70.1	Clay, yellow, fine, rounded
		KRT419	280103.65	2483939.11	70.1 to 91.44	Sand, brown, fine, rounded
		KRT419	280103.65	2483939.11	91.44 to 118.87	Clay, yellow, fine, rounded
		KRT419	280103.65	2483939.11	118.87 to 128.02	Sand, brown, fine, rounded
		KRT419	280103.65	2483939.11	128.02 to 137.16	Clay, yellow, fine, rounded
		KRT419	280103.65	2483939.11	137.16 to 149.35	Sand, brown, fine, rounded
		KRT419	280103.65	2483939.11	149.35 to 155.45	Clay, yellow, fine, rounded

Taluka	Village	Well no	X (Latitude)	Y (Longitude)	Z (Depth in m from m.s.l.)	Material
Borsad	Pipli	KRT409	285304.81	2470833.03	0 to 4.57	Top Soil, brown, fine, rounded
		KRT409	285304.81	2470833.03	4.57 to 11	Kankar, grey, medium, sub angular
		KRT409	285304.81	2470833.03	11 to 13	Clay, yellow, fine, rounded
		KRT409	285304.81	2470833.03	13 to 23.5	Kankar, brown, coarse, sub angular
		KRT409	285304.81	2470833.03	23.5 to 39	Clay, yellow, fine, rounded
		KRT409	285304.81	2470833.03	39 to 48	Sand, brown, coarse, rounded
		KRT409	285304.81	2470833.03	48 to 50	Clay, yellow, fine, rounded
		KRT409	285304.81	2470833.03	50 to 52	Kankar, brown, coarse, rounded
		KRT409	285304.81	2470833.03	52 to 58.5	Clay, yellow, fine, rounded
		KRT409	285304.81	2470833.03	58.5 to 65	Kankar, brown, coarse, rounded
		KRT409	285304.81	2470833.03	65 to 77	Clay, yellow, fine, rounded
		KRT409	285304.81	2470833.03	77 to 94.5	Sand, brown, fine, rounded
		KRT409	285304.81	2470833.03	94.5 to 95.5	Clay, yellow, fine, rounded
		KRT409	285304.81	2470833.03	95.5 to 126	sand, brown, coarse, rounded
		KRT409	285304.81	2470833.03	126 to 128	Clay, yellow, fine, rounded
		KRT409	285304.81	2470833.03	128 to 133	sand, brown, coarse, sub angular
Borsad	Dehwan	KRT300	287043.45	2474986.76	0 to 3.05	Top Soil, brown, fine, rounded
		KRT300	287043.45	2474986.76	3.05 to 30.48	Sand, brown, fine, rounded
		KRT300	287043.45	2474986.76	30.48 to 71.52	Clay, yellow, fine, rounded
		KRT300	287043.45	2474986.76	71.52 to 75.59	Sand, brown, fine, rounded
		KRT300	287043.45	2474986.76	75.59 to 105.15	Clay, yellow, fine, rounded

Taluka	Village	Well no	X (Latitude)	Y (Longitude)	Z (Depth in m from m.s.l.)	Material
		KRT300	287043.45	2474986.76	105.15 to 111.86	Sand, brown, fine, rounded
		KRT300	287043.45	2474986.76	111.86 to 114.91	Clay, yellow, fine, rounded
		KRT300	287043.45	2474986.76	114.91 to 152.7	Sand, brown, medium, rounded
		KRT300	287043.45	2474986.76	152.7 to 161.54	Clay, yellow, fine, rounded
Borsad	Napatalpad	KRT288	274655.84	2466718.49	0 to3.05	Top Soil, brown, fine, rounded
		KRT288	274655.84	2466718.49	3.05 to 21.33	Kankar, brown, fine, rounded
		KRT288	274655.84	2466718.49	21.33 to 51.82	Clay, yellow, fine, rounded
		KRT288	274655.84	2466718.49	51.82 to 60.96	Sand, brown, fine, rounded
		KRT288	274655.84	2466718.49	60.96 to 64.08	Clay, yellow, fine, rounded
		KRT288	274655.84	2466718.49	64.08 to 76.2	Sand, brown, fine, rounded
		KRT288	274655.84	2466718.49	76.2 to 85.34	Clay, yellow, fine, rounded
		KRT288	274655.84	2466718.49	85.34 to 108.2	Sand, brown, medium, sub angular
		KRT288	274655.84	2466718.49	108.2 to 112.78	Clay, yellow, fine, rounded

ANNEXURE-V

The sample calculations for recharge of Vadodara taluka for the year 2003

I Monsoon Recharge:

a. Area
   - (i) Total Geographical area = 670.00 sq.kms.
   - (ii) Net suitable alluvial area for groundwater recharge 'A' = 502.50 sq. kms.

b. Specific yield S_y (fraction)

   For alluvial = 0.09

   (Computed from pumping tests in unconfined aquifer by GWRDC)

c. Rainfall
   - (i) Norma l monsoon Rainfall(IMD)years 1963to2007 = 894mm
   - (ii) Average monsoon rainfall years 2003to 2007 = 1361mm
   - (iii) Normalization factor NF= $\frac{(i)}{(ii)}$ =0.66

     But as per norms of GWRDC range of NF is 0.9 to 1.10

     So consider NF =0.90

d. Water table fluctuation (WTF) year 2003for alluvial area = 3.46m

e. Rainfall recharge by WTF= $A * WTF * S_y$ =502.5* 3.46*0.09 = 156.48 MCM/year

II Recharge due to seepage from canals and tanks etc.

a. Recharge from canals.

   Using wetted area of canal in Million sq. m., average running days of canal and seepage factor depending upon unlined or lined canal the seepage in MCM/year is calculated.

   The monsoon recharge from canal seepage = 0.19 MCM/year

   And the non monsoon recharge from canal seepage = 1.01 MCM/year

   Total recharge from canals=0.19 + 1.01 = 1.21 MCM/year

b. Recharge from surface water bodies.

   Considering average water spread area in sq. km. of number of village tanks, percolation tanks and check dams and respective seepage factors the seepage in MCM/year is calculated.

The monsoon recharge from tanks etc. due to seepage = 2.63 MCM/year

And the non-monsoon recharge from tanks etc. due to seepage = 0.0 MCM/year

Total recharge from surface water bodies = 2.63 MCM/year

So R_s =Recharge due to monsoon seepage from canals and tanks =0.19+2.

= 2.82 MCM/year

And non-monsoon recharge from canal seepage =1.01 MCM/year.

III Recharge due to seepage from surface water irrigation

The type of the crop, total area irrigated for respective crop in hectare, average depth of water applied to each type of crop and seepage factor are used to calculate seepage from surface water irrigation. Main crops are Bajari, Juvar, Pulses, Wheat, Castor, Vegetables and Fodder etc.

The recharge due to monsoon seepage from surface water irrigation (R_{ig})

= 0.20 MCM/year

And the recharge due to non-monsoon seepage from surface water irrigation

= 2.24 MCM/year

Total recharge from surface water irrigation = 0.20+ 2.24 =2.44 MCM/year

IV Potential Recharge

Recharge from flood prone area:

The yearly flooded area (in sq. km), duration of flooding (in days) and seepage factor are used to estimate the recharge from flood prone area in MCM/year.

It is found as 1.48 MCM/year.

So potential recharge = 1.48 MCM/year

V Gross annual groundwater draft

Calculation of gross groundwater in MCM/year is done using type of wells, no. of wells, pump sets with electric motor having various horse powers, diesel pumps, number of running hours per day, no. of running days and average unit draft of groundwater structure. Gross draft for Vadodara taluka from hydrogeological data of Gujarat state (2002) is 104.12 MCM/year. This data is extrapolated considering development for year 2003 as 117.86 MCM/year.

Gross Kharif (monsoon) draft =20 % of gross annual groundwater draft =0.20 * 117.86

=23.57 MCM/year

And gross non-monsoon draft =80 % of gross annual groundwater draft=0.8 *117.86

=94.29 MCM/year

VI Recharge due to monsoon seepage from groundwater irrigation

(R_{igw}) =30 % of gross kharif draft= 0.30 *23.57 =7.07 MCM/year

VII Monsoon Recharge:

Rainfall recharge= = $A * WTF * S_y$ = 156.48MCM/year

Gross kharif draft = D_w =23.57 MCM/year

Recharge due to monsoon seepage from canals and tanks = R_g = 2.82 MCM/year

Recharge due to monsoon seepage from groundwater irrigation =R_{igw} =7.07 MCM/year

Recharge due to monsoon seepage from surface water irrigation = R_{is} = 0.20 MCM/year

Normalisation factor NF =0.90

Monsoon recharge (in MCM/year) =

$$[\{(A * WTF * S_y) + D_w - (R_s + R_{igw} + R_{is})\} * NF] + R_s + R_{is}$$

$= [\{(156.48) + 23.57 - (2.82 + 7.07 + 0.20)\} * 0.90] + 2.82 + 0.20$

$= [\{(156.48) + 23.57 - (2.82 + 7.07 + 0.20)\} * 0.90] + 2.82 + 0.20$

$= [\{180.05 - (10.09)\} * 0.90] + 3.02$

=152.964+3.02

=155.984 MCM/year

Potential recharge from flood prone area = 1.48 MCM/year

Total monsoon recharge =157.464 MCM/year

VIII Total non–monsoon recharge

(a) 15 % of the non monsoon draft considered as non monsoon recharge in MCM/year

=0.15* 94.29 = 14.1435 MCM/year

(b) Non-monsoon recharge from canal seepage and from surface water irrigation

= 1.01+ 2.24 = 3.25 MCM/year

SO total Non-monsoon recharge =17.3935 MCM/year

IX Monsoon recharge in m/day

Total monsoon recharge = 157.464 MCM/year

Gross kharif draft (D_w) = 23.57 MCM/year

Net monsoon recharge =157.464-23.57 =133.894 MCM/year

Monsoon recharge in m/day = $\frac{\text{Net monsoon recharge in MCM/year}}{\text{Total geographical area in sq.km} * \text{Total no.of monsoon days}}$

$= \frac{133.894}{670 * 122}$

= 0.001638 m/day

X Non- monsoon recharge in m/day

Total non- monsoon recharge = 17.3935 MCM/year

Gross non- monsoon draft = 94.29 MCM/year

Net non- monsoon recharge =17.3935-94.29 = (-) 76.896 MCM/year

Non- monsoon recharge in m/day = $\frac{\text{Net non monsoon recharge in MCM/year}}{\text{Total geographical area in sq.km} * \text{Total no.of non monsoon days}}$

$$= \frac{(-)76.896}{670 * 243}$$

= (-) 0.0004723 m/day

Same procedure has been followed for all talukas and years 1997,1998,2003,2004, 2005 and 2006.