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A Study Of Ground Water Modeling For Shallow Aquifer , In Gandhinagar District, Gujarat

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ABSTRACT : Surface water flow and subsurface flow have traditionally been investigated separately and simulators have been developed over the years, to model each of these systems. Growing interest in conjunctive water management, and need for simulations of surface/subsurface flow and their interactions has lead to the linking of models of the respective domains. Groundwater is important and precious freshwater found under the earth's surface. For effective groundwater management, quantitative and qualitative status of groundwater is usually assessed using various groundwater models. However, these models usually suitable for major aquifers and application in minor aquifers are always lag behind due to the requirement of extensive and detailed groundwater data. Since all groundwater bodies are significantly important, GIS functionality was explored in this study to model groundwater using minimal and accessible input data. GIS was used to represent the subsurface geology particularly the aquifer system and to model groundwater flow. The model was used to estimate the groundwater recharge for the Gandhinagar, Gujarat area. This study of Gandhinagar area, using MODFLOW, showed pertaining to the eight layer of the calibrated model. The first layer is a thin soil cover layer of about 3 m uniform thickness. Top layer is kept under unconfined water Table condition, where as the next layers are given the scope of transforming between water Table to confined state and vice versa depending upon the fluctuation of the computed water level with respect to the bottom boundary of the top layer. Other layers are confined or semi-confined having soil type of sand and clay one after another. Model is calibrated with the steady state condition and validated for the transient conditions and groundwater flow condition and recharge analysis is carried out.

I.Introduction :In all over the world the main source of water is precipitation. The water cycle describes the movement and occurrence of the water in the earth surface. Groundwater is water that occurs under the ground surface of Soil pore spaces and in the fractures of rock formations also called (Lithologic formation) and an usable quantity of water is yielded from a unit of rock called Aquifer. It gets completely saturated with voids of rock at the depth of soil pores spaces or fractures and forms water table. Ground water recharge or deep drainage is hydrologic process where water moves downward from surface water to groundwater. Natural discharge occurs at spring and can form an isolated area of vegetation in desert called Oases. Water is one of the natures five element and used in our day to day life such as agriculture, municipal and industrial use by constructing and operating extraction wells The area of geology that deals with the distribution and movement of groundwater in soil and rocks of earth's crust is called Hydrogeology. Groundwater is re occurred naturally by rain, snow and to a smaller extent by surface water (rivers and lakes). Typically, groundwater is thought of as liquid flowing through shallow aquifers and frozen soil. Irrigation sector has expanded enormously over the past five decades enhancing agricultural production to meet world food and fibre demand. Today, irrigation is practiced worldwide on about 260 million ha. Four countries—India, China, the United States, and Pakistan—account for just over half of the world's irrigated land. Many nations, including Pakistan, rely on irrigated land for more than half of their domestic food production. On irrigated farms, two or three crops per year can be grown and yields are high; therefore, the spread of irrigation has been the key to this century's rise in food production. Globally, irrigated agriculture produces about 40% of agricultural outputs and 60% of grain production.

II.Objectives

1 To study groundwater recharge condition of Gandhinagar district.

2 To prepare model setup for MODFLOW using Arc-GIS 9.3

3 Development of finite difference grid for the water Table aquifer

4 Development of conceptual groundwater flow model using MODFLOW for the area

5 Estimation of groundwater recharges using the calibrated model.

Need of this study

A number of factors have encouraged the remarkable expansion of groundwater use:

- Poor service delivery from public water supply systems has prompted many farmers, and rural and urban households, to turn to their own private supply for irrigation and for drinking water.
- New pump technologies meant that even farmers and households with very modest incomes could afford to sink and operate their own tube well.
- The flexibility and timeliness of groundwater supply presented an attractive alternative to the technically and institutionally less responsive provision of surface water through public systems.
- Government electricity subsidies have shielded farmers from the full cost of pumping creating a modality of groundwater use that has proved very difficult to change.

III. Information about study area

Fig 1. study area

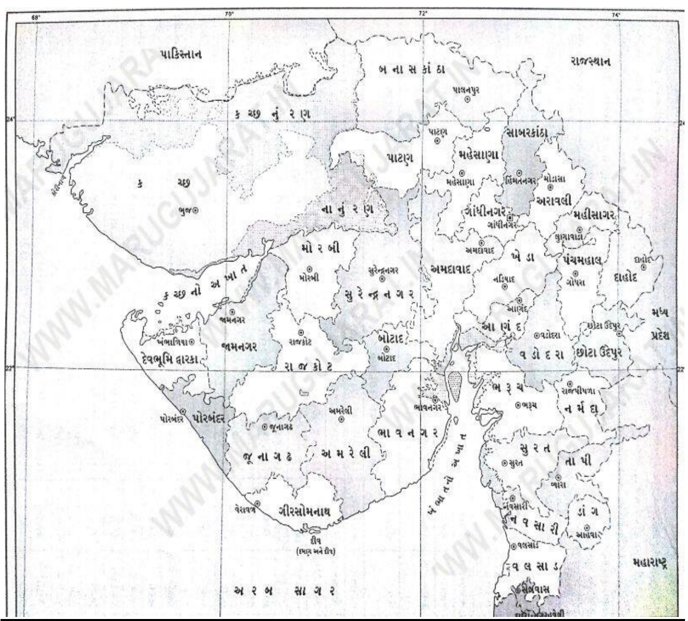

Fig 2.Map of Gnadhinagar

A. About area

Gandhinagar city came into existence as new capital city of Gujarat State in year 1960. Gandhinagar is the capital of the state of Gujarat in western India. Gandhinagar is located approximately 23 km North from Ahmedabad, the largest city of Gujarat, on the west central point of the Industrial corridor between Delhi, the political capital of India, and Mumbai, the financial capital of India. Gandhinagar, Gujarat's new capital city, lies on the west bank of the Sabarmati River, about 464 km away from Mumbai. Thirty sectors, into which the city has been divided, stretch around the central Government complex. Each sector has its own shopping and community center, primary school, health center, government and private housing. There is aprovision for of parks, extensive planting and a recreational area along the river giving the city a green garden-city atmosphere. Gandhinagar is emerging as rapidly developing urban center.

B. Hydrometeorology

Gandhinagar area has a tropical monsoon climate, which is hot and dry, except in the rainy season. Summer days are very hot with mean maximum temperature of 41.30C while, nights are pleasant with mean minimum temperature of 26.30C. The mean maximum and minimum temperatures in winter are 30°C and 15.4°C respectively. The average annual rainfall of the area is 782 mm, although there is a considerable variation from year to year. It occurs generally during the months of June to September. The average relative humidity is 60% with a maximum of 80% to 90% during the rainy season.

C. Physiography & drainage

The area as a whole, in general monotonously flat except few mildly undulating topography owing to the presence of stabilized dunal land forms. The elevation of land surface ranges from 40 to 60m AMSL with master slope towards south. The average elevation of the city area is about 48m AMSL. Isolated high grounds, with elevations more than 60m AMSL, are observed on both sides of river Sabarmati. The most important surface water body in the Gandhinagar area is the river Sabarmati. The Khari River runs almost parallel to the Sabarmati towards east, beyond the city limits. One of the oldest irrigation schemes of Gujarat 'Kharicut canal scheme' passes through eastern part of City, which also serve as 'Storm Water Drainage'during monsoon.

D. Soil type

The area is mostly underlain by blown sand and silt deposits of aeolian character, except localized pockets where it is fluvial. The soil is therefore either coarse sandy or fine sandy loam,
with less clay content and has well to excellent drainability. The soils in the entire area are deep to very deep, with soil depths more than 100 cm.

E. Satus of water supply and demand

In decades of 1970-80, water requirement of Gandhinagar urban area was totally met
through series of deep tube wells spread in entire city areas. During decades of 1980-90, to
supplement groundwater resources, surface water supply from Dharoi reservoirs was planned
with construction of riverbed intake wells. With increasing agriculture demand in upstream reach
of Sabarmati river and also due to diminishing base flow in Sabarmati river, project could not be succeeded to lessen stress on groundwater resources. As per water supply data of AMC, before 1986, out of total 400 mld water supplied, contribution from groundwater resources was 350 mld (88 %). With implementation of various surface water sources projects at present, out of total 760 mld water supply, only 30 mld (4 %) is from ground water resources. The water demand is increasing with rise in population. AMC has projected that by year 2031 projected population of 1,01,44,000 persons would require around 1623 MLD from present 760 MLD in AMC area.

IV.DEVELOPMENTOF GROUNDWATER MODEL

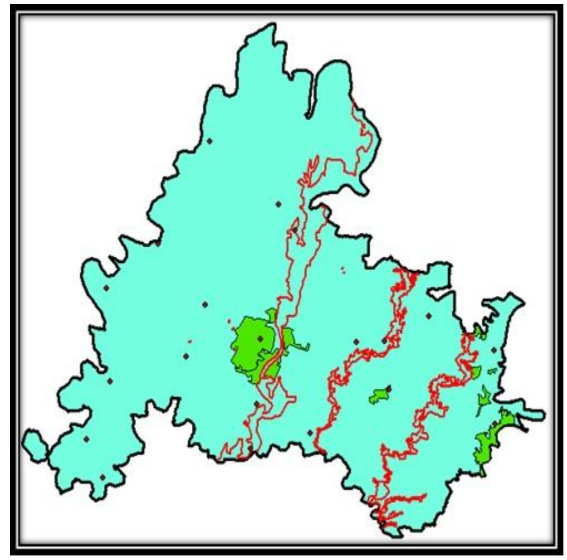

fig 3. Development of ground water model of study are

A.Model geometry

For the creation of groundwater model I used Arc GIS, SURFER and Microsoft Excel. From the Arc Catalog tool of Arc GIS, I have created shape files of polygon, polyline and point. Various boundaries like boundary of Gandhinagar District, boundary of urban area, agricultural are digitized in Arc GIS and saved in polygon shape file. Rivers in the Gandhinagar District are digitized and saved as polyline shape file. The well location is plotted as point shape file. These are the main files required as sitemap in the Visual MODFLOW. Contours of various surfaces and values with its grid and text file format are created in the SURFER software. I have created total 9 layer files of different depth according to the soil type. In which first layer is of topsoil, and then clay, sand, clay, sand, clay, sand, clay, sand respectively. After completing the basic setup for the MODFLOW, these files have been input in the MODFLOW. MODFLOW divide the files into grid file. In my work I have divided the files into 200 rows and 200 columns. In which X-axis starts from 0 to 42500m distance and Y-axis starts from 0 to 36250m distance. In the MODFLOW model layer one is unconfined and all the other layers are confined or semi-confined. Firstly when the setup is prepared other factors has been added into the model. In my work I had calibrated the model in steady state condition and then validated by transient condition. Numbers of time steps are taken as 59and it is from June 2003 to may 2008 for the calibration purpose.

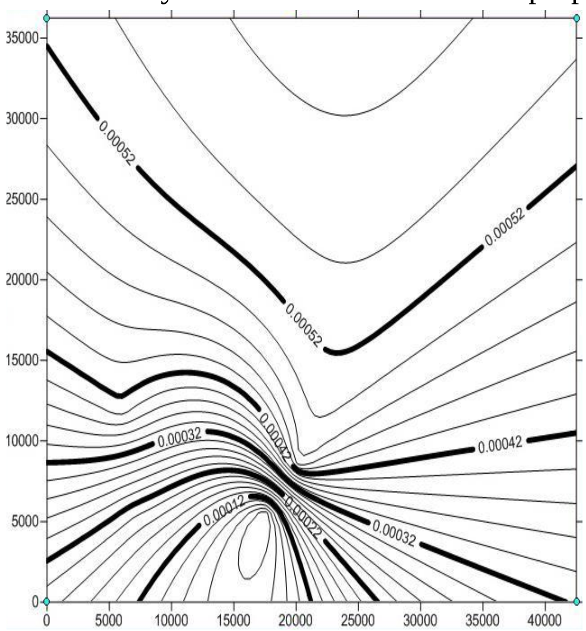

Fig 4 Contour files Conductivity

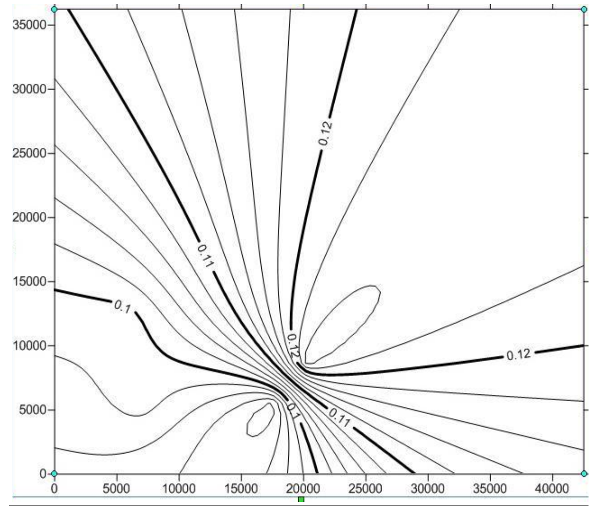

Fig 5 Contour files SPECIFIC YIELD

B.Analysis for rainfall recharge

Data of monthly and daily rainfall for four different rain gauge stations namely Gandhinagar, Kalol, Mans and Raipur Weir are collected. These data are analyzed and the locations are plotted in the Arc GIS for creation of thiessen polygon for the Gandhinagar District boundary. The GIS image of thiessen polygon is shown in fig. 6.

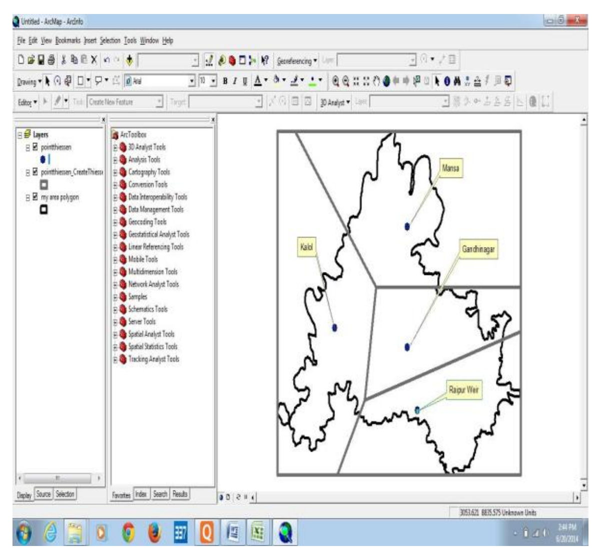

Fig 6 The GIS image of thiessen polygon

C. Analysis for irrigation water requirement

As already mentioned above most of the water applied for the irrigation purpose is from the well only. The values of the water required has been analyzed in excel which is shown in table 1.

Table 1 Average Irrigation Water Requirement in Gandhinagar Area

Sr.no	Year	Average Irrigation water requirement
1.	2003	0.159357143
2.	2004	0.10875
3.	2005	0.10875
4.	2006	0.10875
5.	2007	0.10875
6.	2008	0.10875
7.	2009	0.10875

D .Analysis for recharge as per land use

Model area is not provided with any inactive blocks, which makes the water Table aquifer infinite extent in regard to central region. The self imposed boundaries are the model extents in four sides. The central region of the model, which is the theme area of analyses, is quite away and presumed to have no effect of the model boundaries. From the values of rainfall from different rain gauges are analyzed and added manually in the MODFLOW model. MODFLOW window with these values is shown in fig.6.

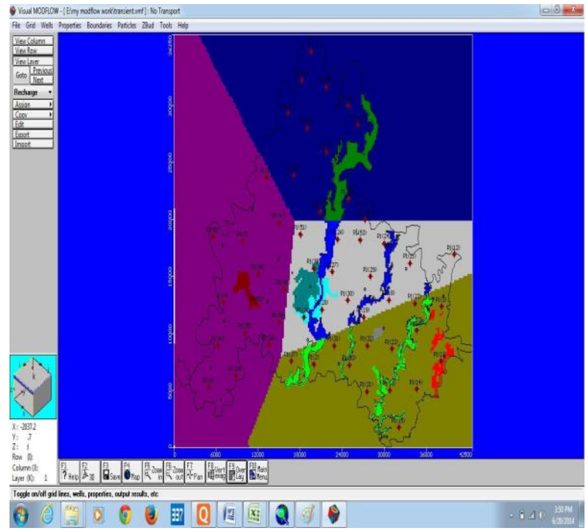

Fig. 7. Recharge in MODFLOW

Table 2 Domestic Water Requirement and Water Use in Area

Sr. No	Year	Average Domestic Water Requirement	Average Domestic Water Use
1.	2003	105138.7736	247259.2987
2.	2004	105849.1708	248929.9697
3.	2005	107066.9944	251793.977
4.	2006	108284.818	254657.9843
5.	2007	109502.6417	257521.9916
6.	2008	110720.4653	260385.9989
7.	2009	111938.2889	263250.0063
8.	2010	112038.2783	264571.1228
9.	2011	112145.3869	265345.1276

V.RESULTS AND DISCUSSION:

The conceptualized geometry is processed for calibration under steady state condition with average water level at Gandhinagar in the month of May. This follows with an assumption that water Table condition in the month of May is influenced negligibly less due to minimum recharge and discharge options. In steady state condition hydraulic conductivity values need to be calibrated as storage coefficients do not apply. Calibration started with initial parameter values stated in Table 2. The zonal hydraulic conductivity values are changed with trial and error, so that an initial water Table condition at the highest boundary condition reaches to an average static water Table condition represented by contours in Fig. 7. The calibrated values are shown in Table 3 with reference to spatial distribution of Fig.7.

Table 3 conductivity value

Sr. No	AQUIFER ZONE		K_{xx} in m per second	K_{yy} in m per second	K_{zz} in m per second	Remarks
	Layer	Zone No				
1	1	1	0.0001	0.0001	1E-5	White
2	1	2	0.00055	0.00055	5.5E-5	Blue
3	2	3	0.00545	0.00545	0.000545	Dark Green
4	2	4	0.0046	0.0046	0.00046	Light Blue
5	2	5	0.0036	0.0036	0.00046	Red
6	2	6	0.0026	0.0026	0.00046	Purple
7	2	7	0.0016	0.0016	0.00046	Yellow
8	2	8	0.0006	0.0006	6E-5	Grey
9	3	9	2.35E-9	2.35E-9	2.35E-10	Black

Top layer is kept under unconfined water Table condition, where as the next layer is given the scope of transforming between water Table to confined state and vice versa depending upon the fluctuation of the computed water level with respect to the bottom boundary of the top layer. No recharge and discharge options other than a single boundary condition of average May water level in the extreme north-east grid has been allowed. This calibration is based upon matching the observed and computed average gradient of the water Table (hydraulic gradient) and nothing to do with matching the point to point values of the observation wells as that could lead to misappropriation in respect of hydrologic condition. The comparison is worth considering the hydraulic conductivity values of Table 3. as calibrated. The behavior of the calibrated model is then tested in the transient condition considering the specific yield distributions in the second
layer as shown in Fig. 5. For validation process, values of Specific Yield Considered are shown in Table 4.

Table 4 Value of Specific Yield

Sr. No	AQUIFER ZONE		S_s in per m	S_y in per m	Eff. Por.	Tot. Por.	Remarks
	Layer	Zone No					
1	1	1	1E-5	0.2	0.15	0.3	White
2	1	2	0.24	2.24	0.28	0.375	Blue
3	2	3	0.12	0.12	0.02	0.55	Dark Green
4	2	4	0.11	0.11	0.02	0.55	Light Blue
5	2	5	0.05	0.05	0.02	0.55	Red
6	3	6	0.27	0.27	0.25	0.375	Purple

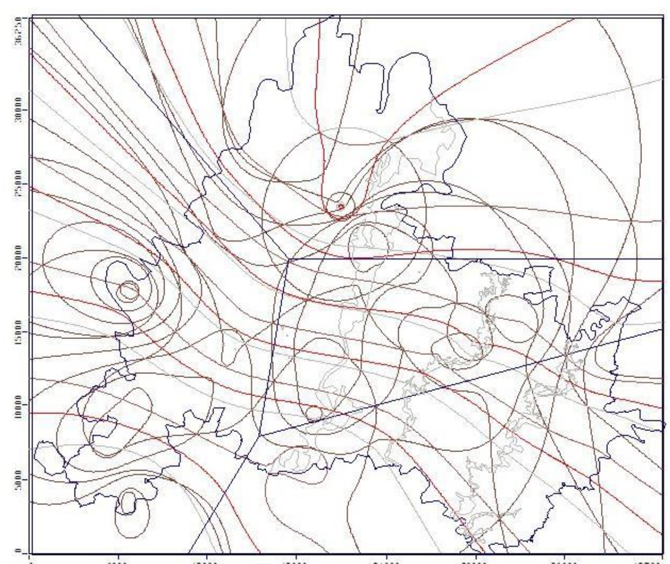

Fig. 8 Unconfined layer calibration

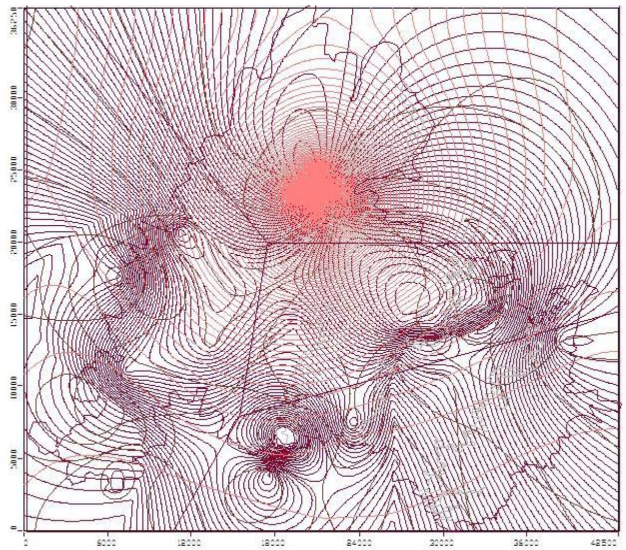

Fig. 9 Confined layer calibration

VII.CONCLUTION

This study demonstrates that from the use of MODFLOW to know the ground water condition and evaluation of its hydrological response for various land use. From the calibration of MODFLOW to know the hydraulics conductivity distribution of water Table under steady state condition, Specific yield distribution, recharge distribution. MODFLOW can be used successfully to simulate the effect of different ground water management practice on ground water regime. Regional flow pattern in the water Table aquifer is also suspected to be effected by the flow regimes of Sabarmati River. Absence of environmental flow in the river may have affected the groundwater condition. Temporal domain for the modelling exercise is individual monsoon season generally comprised of four months viz. June, July, August and September. Recharge to the study domain is through rainfall in monsoon months and due to irrigation return flow in other months. Also comparisons between observed and computed water level by calibration is computed. By using this model compare the water levels of Sabarmati river and Khari river and water level of wells. And know the regional ground water flow direction in the transient recharge. We can predict the ground water level but in this case study the prediction is erroneous due to very small time series available in data. Visual MODFLOW is very effective to know the present scenario of ground water flow, water level of aquifer, wells distribution of spatial recharge, specific yield distribution. It gives very close result to the observed value.

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